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Semantic and affective processing in psychopaths: An event-related potential (ERP) study

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Abstract

We tested the hypothesis that psychopathy is associated with abnormal processing of semantic and affective verbal information. In Task 1, a lexical decision task, and in Task 2, a word identification task, participants responded faster to concrete than to abstract words. In Task 2, psychopaths made more errors identifying abstract words than concrete words. In Task 3, a word identification task, participants responded faster to positive than to negative words. In all three tasks, nonpsychopaths showed the expected event-related potential (ERP) differentiation between word stimuli, whereas psychopaths did not. In each task, the ERPs of the psychopaths included a large centrofrontal negative-going wave (N350); this wave was absent or very small in the nonpsychopaths. The interpretation and significance of these differences are discussed.

Descriptors: Psychopathy, Language, Event-related potentials, Affective processes, Semantic processes

Psychopathy is a personality disorder defined by a constellation of affective, interpersonal, and behavioral characteristics, including, egocentricity, manipulativeness, deceitfulness, shallow affect, lack of empathy, guilt or remorse, and a propensity to violate social and legal expectations and norms (Hare, 1991, 1993, 1996a). The factors related to the development and maintenance of the disorder are not well understood, but recent theory and research suggest that the cognitions, language, and experiences of psychopaths appear to lack depth and affective meaning (Christianson et al., 1996; Cleckley, 1976; Day & Wong, 1996; Gillstrom, 1994; Hare, 1993; Hayes, 1995; Intrator et al., 1997; Patrick, 1994; Williamson, Harpur, & Hare, 1990, 1991). The proposition that psychopathy is associated with abnormalities in semantic and affective processing is not new. Indeed, Cleckley (1976) speculated that psychopaths suffer from a form of "semantic aphasia" in which the semantic and emotional components of cognition are disturbed and poorly integrated. These cognitive impairments may be part of the reason why psychopaths are so resistant to psychological treatment (Rice, Harris, & Cormier, 1992; see Hare, 1993, for a review). A large part of modern cognitive therapy that has been applied to the treatment of psychopaths involves teaching conceptually abstract information (e.g., empathy, role-playing, rational thinking). Our clinical observation of these treatment programs has revealed that psychopaths have difficulty comprehending this information (see also Gillstrom, 1994; Williamson, 1991). Specifically, psychopaths are more likely than others to attempt to interpret abstract information by presenting it in more concrete terms. Understanding the nature of these impairments may lead to alternative, and hopefully superior, forms of treatment.

Early empirical research sought to elucidate these cognitive impairments by examining the relationship between psychopathy and hemispheric lateralization. There is a now a relatively large body of evidence that suggests psychopathy is associated with weak or unusually lateralized cerebral hemispheres, specifically relating to processing language stimuli (Day & Wong, 1996; Hare, 1979; Hare & Jutai, 1988; Hare & McPherson, 1984; Jutai, Hare, & Connolly, 1987).

More recently, Williamson et al. (1991) conducted a study linking psychopathy to a deficit in emotional language processing. They recorded behavioral responses and event-related potentials (ERPs) while psychopaths and nonpsychopaths performed a lexical decision task. The letter strings consisted of neutral and emotional (positive and negative) words and pronounceable nonwords. Lexical decision studies with noncriminals indicate that responses to both positive words and negative words are faster and more accurate than are those to neutral words (Graves, Landis, & Goodglass, 1981; Strauss, 1983). Further, the early and late components of the ERP are larger in response to affective words than to neutral words (Begleiter, Gross, & Kissin, 1967; Kiehl, Mangun, & Hare, 1995). Williamson et al. found that, like noncriminals, nonpsychopathic criminals were sensitive to the affective manipulations of

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the lexical decision task. They responded faster and more accurately to emotional words than to neutral words, and showed the expected ERP differentiation between the two word types. Psychopaths were more accurate to emotional than neutral words but failed to show any consistent reaction time or ERP differences between the word types. Furthermore, the morphology of their ERPs to both emotional and neutral words was strikingly different from that of the nonpsychopaths. One of these differences involved a slow, late positive component, which Williamson et al. termed the *late positive complex* (LPC). This ERP component is also commonly referred to as the positive slow wave and includes not only the slow wave, but also overlapping P3 components, such as P3a and P3b. The LPC of the psychopaths was relatively small and brief, and was preceded by a large centrofrontal negative wave, which the authors termed the *N500*. The psychopaths' N500 was particularly interesting because it was found for all word types (positive, negative, and neutral words), suggesting that psychopaths processed all language stimuli differently than nonpsychopaths. Williamson et al. concluded that the slow reaction times, short-lived LPC, and abnormal N500 reflect the psychopaths' difficulty in integrating word meanings (emotional and nonemotional) within linguistic, perhaps semantic, neural architectures (Gillstrom & Hare, 1988). However, this conclusion should be regarded as tentative because a recent single photon emission computed tomography (SPECT) study failed to support the notion that psychopaths are insensitive to the emotional significance of language stimuli (Intrator et al., 1997).

The Williamson et al. (1991) findings, combined with our clinical observations of the psychopaths' difficulty in understanding conceptually abstract information, led us to explore the psychopaths' ability to differentiate the semantic relationships between words. Specifically, we wanted to investigate whether psychopaths are sensitive to the subtle semantic differences between concrete and abstract words (Tasks 1 and 2) and between positive and negative words (Task 3). Task 1 was a lexical decision paradigm similar to that used by Williamson et al. (1991). However, in the present task there was no affective manipulation (all of the words were neutral); instead, the words were either concrete (e.g., chair) or abstract (e.g., justice). Research with noncriminals, following the lead of Paivio (1986, 1991), indicates that there may be separate processing systems for verbal and image based language. A number of studies have shown that reaction times are faster for concrete words than abstract words and that the late components of the ERP are more negative for concrete words than abstract words (James, 1975; Kounios & Holcomb, 1994; Kroll & Merves, 1986). In Task 2, a new set of concrete and abstract words was presented and participants were required to discriminate between the two word types. On the assumption that psychopaths do not make use of semantic linguistic information (e.g., Hare & Jutai, 1988), our primary predictions for these two tasks were that psychopaths would show less ERP differentiation between the concrete and abstract words than would nonpsychopaths. We also predicted that psychopaths would show an abnormal late ERP negativity to both concrete and abstract words (e.g., Williamson et al., 1991). Our main interest in this study was psychopaths and nonpsychopaths ERPs to the word stimuli. However, we did expect that psychopaths would show little or no behavioral differentiation between concrete and abstract stimuli for both tasks and would have more difficulty than nonpsychopaths in making the discrimination in Task 2 (e.g., Hare & Jutai, 1988).

In Task 3, participants discriminated between positive and negative words, matched for concreteness. It is often assumed that much the same mental operations are involved in the processing of both positive and negative words. Task 3 investigated this assumption. One unpublished study (Williamson et al., 1990) found that psychopaths had difficulty in differentiating between positive and negative affect. We sought to extend these results by recording behavioral responses and ERPs during performance of a similar task. The inclusion of this emotional task in our experiment permitted us to evaluate in the same experimental sample whether any behavioral and ERP differences observed in Tasks 1 and 2, which used nonemotional stimuli, could also be observed with emotional stimuli. We expected that the psychopaths would show poorer behavioral performance for this task than would the nonpsychopaths. We also expected that the psychopaths would show little or no ERP differentiation between the positive and negative words. The nonpsychopaths were expected to show an enhanced late positivity (most likely a larger P300) to the negative words as to positive words. As in Tasks 1 and 2, we hypothesized that both word types would elicit a larger negative wave (e.g., N500) for the psychopaths than for the nonpsychopaths.

Method

Participants

The participants were 29 male inmates from the Regional Health Center (RHC), a federal maximum security forensic psychiatric facility near Vancouver, British Columbia. They were volunteers in a violent offender or sex-offender treatment program. Participants were selected for the study if they were between 18 and 60 years of age, had normal, or corrected-to-normal vision, were free from any known neurological impairment, had no DSM-IV Axis I diagnosis (American Psychiatric Association, 1994), had learned English as a first language, and were right handed (Annett, 1970).

Two clinicians used a semistructured interview and institutional files to independently complete the Hare Psychopathy Checklist–Revised (PCL-R; Hare, 1991) on each inmate. The PCL-R is a reliable and valid instrument for the assessment of psychopathy in criminal populations (Hare, 1980, 1991, 1996b; Hare et al., 1990; Harpur, Hakstian, & Hare, 1988; Harpur, Hare, & Hakstian, 1989; Hart & Hare, 1989; see Fulero, 1996, for a review). Each of the 20 items on the PCL-R is scored on a 3-point scale (0–2) according to the extent to which it applies to the inmate. The mean and standard deviation of PCL-R total scores (which can range from 0 to 40) for the entire sample were 25.1 and 8.7, respectively. Inmates with a PCL-R score of 30 or above ($n = 8$) were defined as psychopaths, and those with a PCL-R score of 20 or below ($n = 9$) were defined as nonpsychopaths, following the recommended cut-off points on the PCL-R given by Hare (1991). We included the data of the remaining 12 inmates, whose PCL-R scores fell between those of the psychopaths and nonpsychopaths, as a mixed group. The mean PCL-R score was 34.7 ($SD = 1.5$) for psychopaths, 26.9 ($SD = 2.2$) for mixed, and 14.28 ($SD = 5.6$) for nonpsychopaths. The kappa coefficient for two independent raters for classification into psychopathic, mixed, and nonpsychopathic groups by PCL-R scores was 1.00. Mean age and years of formal education were 29, 30, and 33, and 10.1, 11.2, and 9.7 years for psychopaths, mixed, and nonpsychopaths, respectively. The three groups did not differ significantly in age, education, or reported level of drug and alcohol use. Twenty-eight participants were Caucasian and one was North American Indian. IQ measures were not directly administered to the participants; however, the screening process for the treatment program required that all inmates be of average to above average intelligence. Additionally, inmate applications for the treatment program were successful only if the participants were able to read and write at the secondary school level (minimum 8 years of education). We also had participants score the word stimuli on concreteness (Tasks 1 and 2) and pleasantness (Task 3) at the end of the experiment to ensure that they could read and recognize all of the words. No participants experienced any difficulty reading or understanding the word lists (see below). We paid each inmate $5.00 for the PCL-R interview and $10.00 for the experiment. The total of $15.00 was equivalent to 2 days prison wage. As an additional incentive, we told the participants that the individual who had the best overall reaction time and accuracy for the three tasks would receive an extra $10.00.

Stimuli

Task 1 and 2. Stimulus words (3–8 letters in length) were selected from the word norms of Toglia and Battig (1978) and were either concrete or abstract. Words rated as more than .75 *SD*s above or below the mean concreteness rating contained in the word norms were defined as concrete and abstract, respectively. The word lists for each task (50 concrete and 50 abstract) did not differ in word frequency or length (Francis & Kucera, 1982). Furthermore, only affectively neutral words (at or within 1 *SD* of the mean pleasantness rating given in Toglia & Battig, 1978) were selected to eliminate any confound of emotionality (see Williamson et al., 1991, for a review of the effects of emotionality on language processing). For Task 1 we developed sets of pronounceable pseudowords by selectively altering one letter of each of the concrete and abstract words. None of the words in Task 1 was used in Task 2.

Task 3. Stimulus words were either positive or negative (60 of each) in connotation, and were selected from the 7-point pleasantness ratings given in Toglia and Battig (1978). Words rated as more that 1.3 *SD* above or below the mean pleasantness rating were defined as positive (e.g., love) and negative (e.g., hate), respectively. The word lists did not differ significantly in length (3–8 letters), imagery, or concreteness (Toglia & Battig, 1978), or frequency (Francis & Kucera, 1982). None of the words in Task 3 was used in Task 1 or Task 2.

Physiological Recording

We analyzed scalp potentials recorded from tin electrodes (ElectroCap International) placed over frontal (F3, F4), central (C3, Cz, C4), and parietal (P3, Pz, P4, Poz) sites according to the International 10-20 System of electrode placement. All electrodes were referenced to an electrode located at the right mastoid process. One additional channel, left mastoid to right mastoid, was recorded for the purposes of allowing digital re-referencing to an average of left and right mastoids (Nunez, 1981, 1990). Electrical impedance was kept below 5 kΩ throughout the experiment.

The EEG channels (Grass Model 8-18C) were amplified with a bandpass of 0.1–70 Hz, digitized online at a rate of 256 samples per second, and recorded on computer hard disk. EEG was then digitally filtered with a 30 Hz low pass filter to reduce electromyographic contamination. The sampling epoch was 1,300 ms, beginning with a 100-ms prestimulus baseline period. Blinks were monitored from the two prefrontal electrodes (Fp1 and Fp2). Artifact rejection was performed before averaging to reject trials contaminated by blinks ($>50\ \mu V$), excessive muscular activity, or amplifier blocking. After the exclusion of one participant (a nonpsychopath) from Task 1, these rejected trials did not exceed 10% of trials in any condition and there were no group differences in the number of trials averaged in any condition.

Procedure

The experiment was conducted in a dimly lit room in a secluded, quiet part of the institution. After attachment of the electrodes the participant was seated in a comfortable chair approximately 60 cm from the computer monitor. The letters were all in uppercase, 1 cm in height, white on black background, horizontally oriented, and presented centrally in a white rectangular box (2.5×6.50 cm). To help control for blink artifact, we adopted a procedure similar to that described by Kounios and Holcomb (1994). Before each trial the word "blink," in lower case blue letters, appeared for 1,500 ms in the center of the rectangular box, indicating to the participant that it was permissible for him to blink. Between 1,000 and 1,700 ms after the word "blink" disappeared from the screen a letter-string (the target stimulus) appeared in the center of the screen for 300 ms. Approximately 1,200 ms after the target stimulus disappeared the word blink reappeared to signal the start of a new trial. We instructed the participant not to blink or move during each trial, except to press the appropriate button. The response in each task was a binary decision (word/nonword, concrete/abstract, positive/negative, for Tasks 1, 2, and 3, respectively). The participant was not told that the words were either concrete or abstract for Task 1. The two response options were marked on a computer keyboard. The participant used the index finger of each hand to press the appropriate key as quickly and accurately as possible; the hand used to make a particular response was counterbalanced across participants. In each task, the stimuli were presented in blocks of trials (Task 1, four blocks of 50 trials each; Task 2, two blocks of 50 trials each; Task 3, two blocks of 60 trials each) with a 2–3-min rest period between blocks. The order of items in each block was random. Task 1 was always completed first (to help ensure that the nature of the words was unknown to the participants). The order of presentation for Tasks 2 and 3 was counterbalanced across participants. There was a 5-min rest session between tasks. Before each task the participant performed a block of 10 practice trials, repeated twice, to ensure he understood the instructions. At the end of the experiment participants were asked to rate the task words on the relevant 7-point scales used in Toglia and Battig (1978).

ERP Data Reduction

Our primary interest in this experiment was to determine if psychopaths would show the expected ERP differentiation between concrete and abstract words (Task 1 and 2) and between positive and negative words (Task 3). We also wanted to determine if psychopathy was associated with an abnormal late frontocentral ERP negativity when processing word stimuli. In all three tasks, word stimuli elicited a frontalcentral ERP negativity with an approximate peak latency of 350 ms. We termed this waveform the *N350* and quantified it as the mean amplitude of the 300–400-ms window (relative to the 100-ms prestimulus baseline) in each task. We examined the effect of word type by measuring the mean amplitude of the 400–800-ms ERP time window in each of the three tasks. This time window was chosen because it corresponded to the concrete/abstract differences seen in previous research (Kounios & Holcomb, 1994; Paller, Kutas, Shimamura, & Squire, 1987). We confirmed the mean amplitude results with peak measurements in the same time windows, but space limitations prevent us from describing them in any detail.[1]

[1]Results from the peak analyses are available upon request from the corresponding authors.

Data Analysis

Reaction times and ERPs were analyzed only on trials on which the participant responded correctly. Any incorrect response, double response (e.g., pressing both buttons during a single trial) or response delayed by more that 1,500 ms after stimulus onset was counted as an error. This procedure helped ensure that there were no outliers contributing to the behavioral results.

We performed separate Group (psychopath vs. mixed vs. nonpsychopath) × Word type (concrete vs. abstract for Tasks 1 and 2; positive vs. negative for Task 3) analyses of variance (ANOVAs) on the reaction time and accuracy data.

Similar ANOVAs were performed on the amplitude of the ERP windows. Separate ANOVAs were performed for lateral and midline recording sites. These analyses included an additional factor for site (frontal [F3, F4], central [C3, C4], and parietal [P3, P4] for lateral analyses; central [Cz], parietal [Pz], and posterior parietal [POz] for midline analyses). For lateral sites, there was also a factor for hemisphere (left and right). We included the mixed group in the overall ANOVA but had specific hypotheses only regarding the psychopathic and nonpsychopathic groups.[2] These specific hypotheses were tested by planned comparisons. In the 300–400-ms window (all tasks) planned comparisons were performed at frontal and central sites to determine if the N350 was larger in psychopaths than in nonpsychopaths. We also compared the middle group with the combined psychopath and nonpsychopath groups in this time window. These comparisons served as tests of intermediacy of effects for the mixed group. In the 400–800-ms windows, one-way (word type) within group ANOVAs were performed to determine which groups showed behavioral and electrocortical differentiation between concrete and abstract words (Task 1 and 2) and positive and negative words (Task 3). All statistical tests were evaluated at a significance level of .05.

Other effects of interest were tested using simple effects analyses or post hoc Tukey multiple comparisons. The Geisser–Greenhouse correction was used for any repeated measures containing more than one degree of freedom in the numerator (Geisser & Greenhouse, 1958). Lastly, the McCarthy and Wood (1985) correction was performed on any significant interaction involving site or hemisphere and is reported only in cases in which the interaction became nonsignificant.[3]

[2]Space limitations prevent us from including plots and detailed analyses of the Mixed group. Figures of the Mixed groups ERPs and window *M* and *SD* tables and summaries for all analyses are available upon request from the corresponding authors.

[3]Although our main hypothesis concerned only real word stimuli, supplemental analyses were performed on the behavioral and ERP data for the pseudoword stimuli for Task 1. These analyses were included because a number of investigators (see Kounios & Holcomb, 1994) have shown behavioral and ERP differences exist between pseudoconcrete and pseudoabstract stimuli. Our analyses of these data indicated that real-word stimuli (concrete and abstract words) were responded to faster [main effect of lexical, $F(1,26) = 82.35$] than to pseudoword stimuli, regardless of group. There was no difference in reaction time between the pseudoconcrete stimuli and the pseudoabstract stimuli. There were no significant effects involving accuracy.

For the ERPs, group differences in pseudowords generally paralleled group differences in real words. In particular, pseudowords elicited more ERP negativity at frontal sites for psychopaths than nonpsychopaths in the 300–400-ms window. A more detailed description of the analyses and ERP plots of the pseudowords is available upon request from the corresponding authors.

Results

Task 1

Behavioral data. Participants responded faster to concrete words than to abstract words, main effect of word type, $F(1,26) = 6.41$. Participants also responded more accurately to the concrete words than abstract words, main effect of word type, $F(1,26) = 5.65$ (see Table 1). None of the effects involving group was significant.

ERPs. Grand-mean ERPs for the psychopaths and nonpsychopaths are presented in Figure 1 for concrete and abstract words.

300–400-ms window. Analyses of the ERP amplitudes for this time window revealed a main effect of group for lateral, $F(2,25) = 4.53$, and midline sites, $F(2,25) = 3.61$, and a Group × Site interaction for midline sites, $F(4,50) = 3.32$. As predicted, psychopaths showed greater ERP negativity over frontal and central sites than did nonpsychopaths. The planned comparisons were significant at lateral frontal, $F(1,25) = 10.93$, and central sites, $F(1,25) = 7.84$. At the midline, the difference was significant only for the central site, $F(1,25) = 12.36$. Comparisons of the mixed group versus the other groups were nonsignificant at all sites $ps > .50$, indicating that the amplitude of the N350 for the mixed group fell between that of the psychopaths and nonpsychopaths.

There also was, in general, more ERP negativity elicited at frontal and central sites than at parietal and posterior parietal sites, main effect of site: lateral, $F(2,50) = 10.63$; midline, $F(2,50) = 9.74$. This latter effect was greater over the left hemisphere than the right hemisphere, main effect of hemisphere, $F(1,25) = 11.96$; and Site × Hemisphere interaction, $F(2,50) = 4.43$.

400–800-ms window. The Group × Word type interaction for the omnibus ANOVA was significant for lateral analyses, $F(2,25) = 4.01$, but not for midline analyses, $F(2,25) = 2.10$, $p > .15$. One-way ANOVAs (word type) for each group at the lateral sites confirmed our prediction that nonpsychopaths, $F(1,7) = 17.91$, but not psychopaths, $F(1,7) = .31$ $p > .60$, would show ERP

Table 1. *Reaction times (ms) and percentage correct for Psychopaths (P) and Nonpsychopaths (NP) in the Three Tasks*

Procedure/ stimulus type	Reaction time		Percentage correct	
	P	NP	P	NP
Task 1				
Concrete	671 (100.0)	672 (53.6)	93 (3.2)	93 (7.1)
Abstract	684 (98.6)	686 (59.4)	89 (10.5)	90 (3.9)
Pseudoconcrete	776 (121.0)	776 (122.0)	91 (7.5)	87 (7.8)
Pseudoabstract	795 (131.0	775 (135.0)	89 (4.9	88 (6.4)
Task 2				
Concrete	774 (118.2)	757 (136.5)	90 (6.3)	87 (8.6)
Abstract	860 (95.0)	807 (116.7)	83 (8.5)	91 (6.8)
Task 3				
Positive	723 (118.6)	727 (102.7)	92 (8.2)	94 (11.9)
Negative	822 (150.5)	760 (126.7)	84 (6.8)	92 (4.8)

Note: Values listed are means (*SD*) for concrete and abstract words and pseudoconcrete and pseudoabstract stimuli in the lexical decision task (Task 1); concrete and abstract words for the discrimination task (Task 2); and positive and negative words for the discrimination task (Task 3).

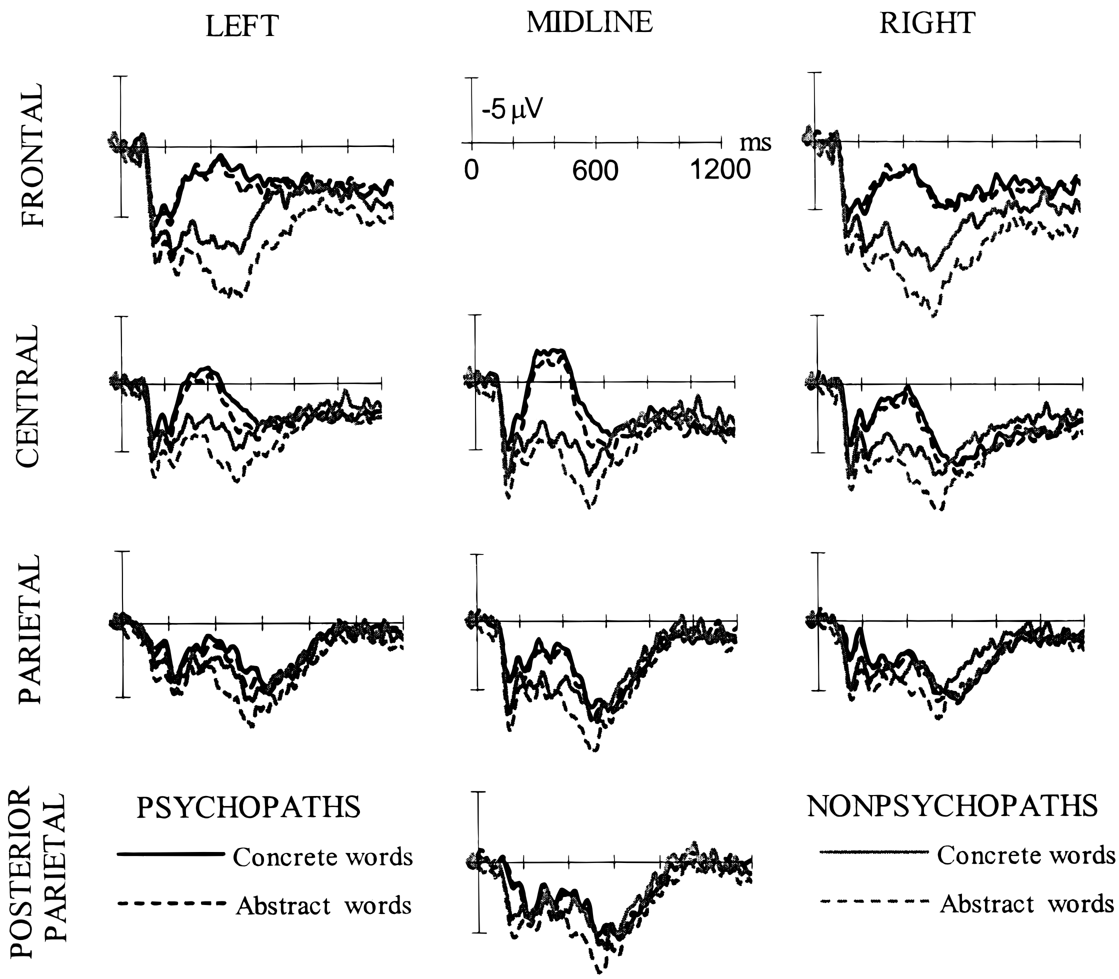

Figure 1. Grand-average event-related potentials (ERPs) for psychopaths (black) and nonpsychopaths (gray) to concrete (solid) and abstract (dashed) words for the lexical decision task (Task 1).

differences between concrete and abstract words. Although the Group × Word type interaction was not significant for the midline analyses, individual group tests indicated that nonpsychopaths, $F(1,7) = 12.14$, but not psychopaths, $F(1,7) = .20$, $p > .67$, showed significant ERP differences between concrete and abstract words. The mixed group also failed to show ERP differences between concrete and abstract words, lateral, $F(1,11) = .97$, $p > .34$; midline, $F(1,11) = 2.19$, $p > .17$.

In general, the ERPs were more negative to concrete words than abstract words, main effect of word type: lateral, $F(1,25) = 10.79$; midline, $F(1,25) = 7.23$, with this effect having a centrofrontal distribution, Word type × Site interaction: midline, $F(2,50) = 8.40$. Stimuli were more negative over the left hemisphere than the right hemisphere, an effect greater at frontal and central sites than at parietal sites, main effect of site: lateral, $F(2,50) = 4.16$; midline, $F(2,50) = 4.78$; main effect of hemisphere, $F(1,25) = 13.53$; and Site × Hemisphere interaction, $F(2,50) = 8.38$.

Correlation analyses. Two correlation coefficients were calculated for the entire sample ($n = 28$) to examine the relationship between PCL-R scores and the amplitude of the N350 (300–400-ms window) at the midline central scalp site (Cz). The correlation coefficients were $r = -.39$ and $-.38$ for the concrete and abstract words, respectively ($p < .03$ in each case).

Summary. The ERP waveforms of the nonpsychopaths were consistent with those reported in similar studies conducted with noncriminals (e.g., Kounios & Holcomb, 1994; Paller et al., 1987). In the nonpsychopaths, concrete words elicited larger negative ERP components than did abstract words in the 400–800-ms window over frontal, central, and parietal sites. The ERPs of the psychopaths were similar to those reported by Williamson et al. (1991). In each case, psychopaths: (1) showed a large centrofrontal negative-going potential (N350); and (2) failed to demonstrate any significant differentiation between word types. Furthermore, the amplitude of the N350 was significantly correlated with overall psychopathy scores.

Task 2

Behavioral measures. Across participants, concrete words were responded to faster than abstract words, main effect of word type, $F(1,26) = 24.84$ (see Table 1). Analyses of the accuracy data revealed a significant Group × Word type interaction, $F(2,26) = 3.50$. One-way ANOVAs for each group indicated that psychopaths were more likely to make errors when an abstract word was presented than when a concrete word was presented, psychopaths, $F(1,7) = 7.92$, nonpsychopaths, $F(1,8) = 2.77$, $p > .14$, and mixed group, $F(1,11) = .01$, $p > .93$, respectively.

ERPs. Grand-mean ERPs for the psychopaths and nonpsychopaths to concrete and abstract words for this task are presented in Figure 2.

300–400-ms window. In this epoch, significant Group × Site interactions were obtained for both lateral, $F(4,52) = 4.24$, and midline sites, $F(4,52) = 3.47$. Planned comparisons indicated that the difference between psychopaths and nonpsychopaths was significant at lateral frontal, $F(1,26) = 5.78$, and midline central sites, $F(1,26) = 4.82$, but not at lateral central sites, $F(1,26) = 3.04$, $p > .15$. Post hoc Tukey tests indicated that there were no group differences at the other electrode sites. As in Task 1, comparisons of the mixed group versus the other groups were nonsignificant at lateral frontal and central and midline central sites, all ps $> .32$, indicating that the amplitude of the N350 for the mixed group fell between that of the psychopaths and nonpsychopaths.

In general, the ERPs to concrete words were more negative than to abstract words, main effect of word type: lateral, $F(1,26) = 11.26$; midline, $F(1,26) = 7.11$. At midline sites this difference was greater at central than at parietal or posterior parietal sites, Word type × Site interaction: $F(2,52) = 9.48$; main effect of site, $F(2,52) = 5.02$. There was more ERP negativity over the left than the right hemisphere, main effect of hemisphere, $F(1,26) = 19.55$, and this negativity was greater at posterior than anterior sites, Site × Hemisphere interaction: $F(2,52) = 4.58$; main effect of site: $F(2,52) = 14.64$.

400–800-ms window. In this epoch, the Group × Word type interactions were nonsignificant for both midline, $F(2,26) = 1.25$, $p < .30$, and lateral sites, $F(2,26) = 2.60$, $p < .10$. However, individual group tests revealed significant ERP differences between concrete and abstract words for the nonpsychopaths, midline, $F(1,8) = 6.96$; lateral, $F(1,8) = 12.40$, but not psychopaths or the mixed group, all ps $> .30$.

A significant Group × Site interaction at lateral sites, $F(4,52) = 2.50$, followed by post hoc Tukey tests, indicated that psychopaths also had a smaller P600 than nonpsychopaths at frontal sites ($p < .01$). We note however that this effect may have been modulated by prolonged negativity due to the large N350 in the psychopaths' waveforms.

There were several other effects in this epoch. The ERPs to concrete words were more negative than those to abstract words and this difference was more pronounced at left hemisphere frontal and central sites than at the analogous right hemisphere sites, main

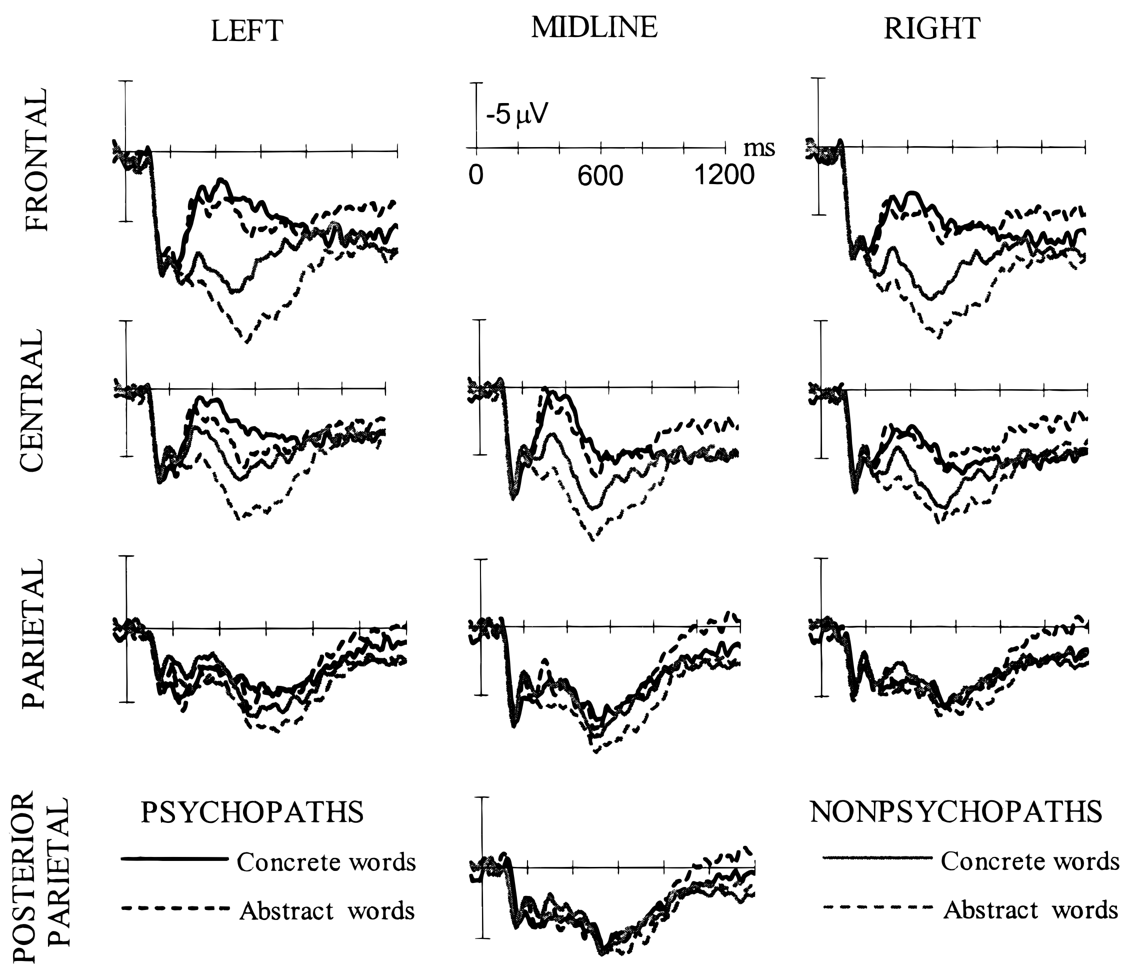

Figure 2. Grand-average event-related potentials (ERPs) for psychopaths (black) and nonpsychopaths (gray) to concrete (solid) and abstract (dashed) words for the discrimination task (Task 2).

effect of site: midline, $F(2,52) = 7.72$; lateral, $F(2,52) = 11.35$; main effect of hemisphere, $F(1,26) = 12.06$; Word $\times$ Site interactions: midline, $F(2,52) = 5.22$; lateral, $F(2,52) = 6.93$; Word $\times$ Hemisphere interaction: $F(1,26) = 4.91$; Site $\times$ Hemisphere interaction: $F(2,52) = 10.26$; Word $\times$ Site $\times$ Hemisphere interaction: $F(2,52) = 5.72$.

Correlation analyses. Correlation coefficients between psychopathy and the amplitude of the N350 (mean of the 300–400-ms window measured at Cz) approached significance for abstract words only $r = -.30$, $p = .058$ (for concrete words $r = -.22$, $p = .13$).

Summary. The ERPs for the nonpsychopaths were similar to the ERPs of noncriminals engaged in a similar task (Kounios & Holcomb, 1994: Experiment 2, Block 1). Concrete words elicited more ERP negativity than abstract words in the 400–800-ms epoch and this difference was greater over anterior sites than posterior sites. A small N350 was clearly present in the waveforms of the nonpsychopaths, followed by a large P600, peaking maximally at central and parietal sites. In contrast, the waveforms of the psychopaths included a much larger N350 and a smaller P600. The scalp topography of the N350-P600 complex was similar to that found in Task 1, suggesting that it may reflect a general processing strategy adopted by psychopaths when performing word tasks (see Discussion).

Task 3

Behavioral measures. Participants' responses to positive words were faster, $F(1,26) = 24.74$, and more accurate, $F(1,26) = 10.06$, than to negative words (see Table 1). None of the performance differences between groups was significant.

ERPs. Grand-mean ERPs to the positive and negative words for the psychopaths and nonpsychopaths are presented in Figure 3.

300–400-ms window. As in the previous two tasks, a large N350 was evident in the waveforms of the psychopaths (see Figure 3). Planned comparisons following significant main effects of group, lateral, $F(2,26) = 8.60$; midline, $F(2,26) = 4.89$, and Group $\times$ Site interactions, lateral, $F(4,52) = 5.42$; midline, $F(4,52) = 4.92$, indicated that the N350 was larger for psychopaths than for nonpsychopaths only at frontal, $F(1,26) = 19.48$, and central sites, lateral, $F(1,26) = 15.61$; midline, $F(1,26) = 23.85$. Post hoc Tukey tests indicated that there were no differences between psychopaths and nonpsychopaths at any other scalp sites (all $ps > .05$). As in Task 1 and 2, the comparisons of the mixed

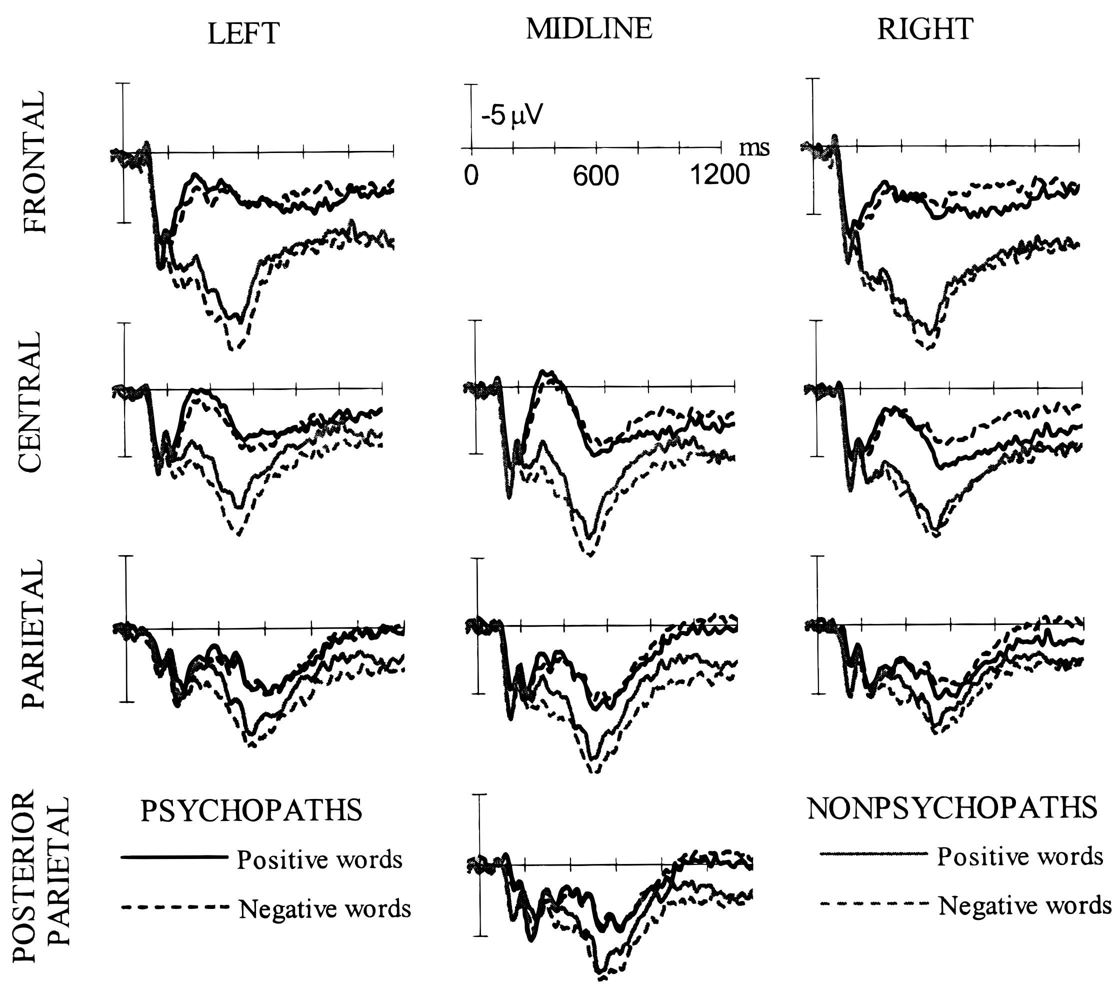

Figure 3. Grand-average event-related potentials (ERPs) for psychopaths (black) and nonpsychopaths (gray) to positive (solid) and negative (dashed) words for the discrimination task (Task 3).

group versus the other groups were nonsignificant at frontal and central sites, all $ps > .22$, indicating that the amplitude of the N350 for the mixed group fell between that of the psychopaths and nonpsychopaths.

Overall, the N350 was larger for positive than for negative words, main effects of Word type: lateral, $F(1,26) = 8.11$; midline, $F(1,26) = 12.10$, and this difference was larger over the left than the right hemisphere, Word × Hemisphere interaction: $F(1,26) = 24.90$; main effect of hemisphere: $F(1,26) = 24.90$.

400–800-ms window. Significant Group × Word interactions were found at midline, $F(2,26) = 4.06$, and lateral sites, $F(2,26) = 3.25$. One-way ANOVAs for the nonpsychopaths revealed, as predicted, that negative words elicited a larger P600 than positive words, midline, $F(1,8) = 11.03$; lateral, $F(1,8) = 19.58$. Neither the psychopaths nor the mixed group showed significant ERP differentiation between positive and negative words in this time window, all $ps > .25$. Post hoc Tukey analyses of a main effect of group at lateral sites indicated that psychopaths also had a smaller P600 than did nonpsychopaths ($p < .03$).

Across all participants word type ERP differentiation was greater over the left than the right hemisphere, Word × Hemisphere interaction: $F(1,26) = 5.04$. The ERPs were more positive in the right hemisphere than the left hemisphere, Site × Hemisphere interaction: $F(2,52) = 9.79$; main effect of hemisphere: $F(1,26) = 15.81$, and this positivity was more pronounced at anterior sites than at posterior sites, main effect of site: lateral, $F(2,52) = 8.95$; midline, $F(2,52) = 7.24$.

Correlation analyses. Significant correlations were obtained between total psychopathy (PCL-R) score and the amplitude of the N350 at Cz ($r = -.47$, $p = .005$ for positive words; $r = -.45$; $p = .007$ for negative words).

Summary. The P600 for the nonpsychopaths was significantly larger for negative words than for positive words. There were no ERP word type differences for the psychopaths or the mixed group in the 400–800-ms window. In addition, psychopaths also differed from nonpsychopaths in the amplitude of the N350 and P600 (see Figure 3).

Word ratings. Both groups rated concrete and abstract words (Tasks 1 and 2) significantly different on the 7-point concreteness scale (e.g., Toglia & Battig, 1978). Average ratings for concrete and abstract words for psychopaths were 6.35 and 1.77, and for nonpsychopaths they were 6.57 and 1.57. Both groups also rated positive and negative words (Task 3) significantly different on the 7-point pleasantness scale (e.g., Toglia & Battig, 1978). The respective means for positive and negative words for psychopaths were 5.96 and 1.99, and for nonpsychopaths they were 6.20 and 1.79. There were no differences between groups in either condition. These findings support the argument that the observed behavioral and ERP differences between psychopaths and nonpsychopaths did not occur because of reading difficulties.

Discussion

This study was designed to examine the ability of psychopaths to process and differentiate semantic and affective components of language. Although only some of the relevant group interactions were significant, individual group tests generally supported the prediction that psychopaths would not show significant ERP differentiation between concrete and abstract words (Task 1 and 2) and between positive and negative words (Task 3). In Task 1 and 2, participants responded faster to concrete than to abstract words. In Task 2, psychopaths made more errors when categorizing abstract words than concrete words, suggesting that psychopaths were more likely to respond "concrete" to word stimuli when making a concrete or abstract discrimination. This finding is consistent with the argument (Gillstrom, 1994; Hare & Jutai, 1988) that psychopaths have difficulty in processing abstract information. The limited nature of the behavioral differences between groups does not necessarily imply that the groups are processing the stimuli with similar cognitive operations. Indeed, the ERP data suggests otherwise.

There are several possible interpretations of the lack of significant ERP word type effects for the psychopaths. First, it may be that psychopaths simply do not differentiate word stimuli in a matter similar to that found with nonpsychopaths and noncriminals. Second, psychopaths may show ERP differentiation between word stimuli, but we failed to observe these differences because of limited spatial sampling (e.g., only nine EEG channels). Future research should consider using a greater spatial array of electrodes to address this possibility. Third, psychopaths may differ from others in the time course and degree of activation necessary to differentiate between word stimuli. These latter interpretations are strengthened by the presence of behavioral differences between word types for the psychopaths. It may also be the case that psychopaths were using an alternative strategy to perform the tasks. The exact nature of this strategy is not known, however, it is possible that motivation played a role in modulating the participants' strategy as a monetary incentive was offered for the best performance.

For Task 1 and 2, the ERPs of the nonpsychopaths were similar to those found with noncriminals. Concrete words elicited more ERP negativity than abstract words in the 400–800-ms epoch and this difference was greater over anterior sites than at posterior sites. One apparent difference between the ERP results produced by the nonpsychopaths and previous findings with noncriminals (Kounios & Holcomb, 1994; Experiment 2) was that the ERP word type effect (concrete more negative than abstract) was greater in the right hemisphere than in the left hemisphere, whereas in our study the ERP word type effect was larger in left hemisphere than the right hemisphere (at frontal and central sites only). Although we attempted to conceptually replicate the Kounios and Holcomb (1994) study (at least in the nonpsychopaths), our methodology differed from theirs in a number of important ways, including word lists, time windows analyzed, electrode position (our sites were less lateral than theirs), and reference electrode location and derivation. We note however, that the hemispheric localization of concrete and abstract words is a matter of current controversy (see Beauregard et al., 1997, and Kiehl, Liddle, et al., 1999, for more).

Besides the absence of word type effects in their ERPs, the psychopaths differed from the nonpsychopaths in the amplitude of the N350 in all three tasks. Compared with the very pronounced N350 of the psychopaths, the N350 of the nonpsychopaths was very small and was overlapped by a large P600. The similarity between the N350 in the present experiment and the N500 in the Williamson et al. (1991) study deserves additional comment. This similarity occurred despite the fact that the two studies differed in a number of ways. First, we used a Go/Go paradigm, rather that the Go/No Go task used by Williamson et al., in order to rule out the possibility that the N500 was a reflection of poor response inhibition (Kiehl, Smith, Hare, & Liddle, 1999; Newman, 1987;

Newman & Kosson, 1986; Newman, Patterson, & Kosson, 1987). Second, Williamson et al. presented each word (vertically) three times in each visual field, whereas we used large word lists (presented horizontally) to eliminate the possible effect of word repetition on the amplitude of the negative wave (Barrett & Rugg, 1990; Rugg, 1985, 1987). Finally, we used central rather than bilateral word presentation to control for hemispheric and cross-hemisphere transmission effects, and a relatively long presentation time (300 ms). Despite these procedural differences, the N350 and the N500 were similar in scalp topography, both with a centro-frontal distribution. The two waveforms did differ in latency. The most parsimonious interpretation of the latency difference between the N350 and the N500 is that the tasks used in the two studies differed in difficulty. The mean reaction time for psychopaths in the Williamson et al. study was approximately 885 ms, whereas the mean reaction time for the psychopaths in the present study (Task 1: real word stimuli) was 678 ms. This 208-ms difference in reaction times and the similar difference in latency of the N500 and N350 suggests that the waveforms are more similar than different.

Williamson et al. (1991) offered two explanations for the functional significance of the N500. The first explanation was based on the fact that their participants were faced with a Go/No-go task that required them to either make (Go) or inhibit (No-go) a response to the words and nonwords, respectively. Because there is evidence that psychopaths sometimes have difficulty in inhibiting or modulating dominant response tendencies (Newman & Kosson, 1986; Newman et al., 1987; and more recently, Lapierre, Braun, & Hodgins, 1995), Williamson et al. speculated that the N500 of their psychopaths reflected poor response inhibition. However, the psychopaths in the present study exhibited a large negative wave in a lexical decision task (Task 1) that used a Go/Go response, as well as in tasks (Tasks 2 and 3) that did not involve response inhibition. Thus, to the extent that the N500 and the N350 represent similar cognitive processes, it appears that the present results mitigate the probability that the two components are due to response inhibition.

The second explanation offered by Williamson et al. (1991) was that the N500 observed in their psychopaths was functionally similar to the N400 described by Kutas and Hillyard (1980, 1983, 1984). Although the functional significance of the N400 is still a matter of controversy, recent evidence suggests that the amplitude of the N400 may reflect processes related to the integration of a word within ongoing cognitive context (Holcomb, 1993). Using this interpretation, it would appear that psychopaths differ from nonpsychopaths in the degree and extent of cognitive processes required to perform language tasks. This interpretation is speculative however, as we are not aware of any studies exploring the relationship between the N400 and psychopathy. Clearly, this is an area in which further research is needed, the results of which might aid in the interpretation of the functional significance of the psychopaths' N350.

One alternative explanation presents itself. The task requirements in the present experiment typically evoked large positive potentials (of the P3 family) over frontal, central, and parietal sites. These positive potentials are usually larger (up to 20 μV) than the N400 (5–8 μV) and tend to overlap and reduce the overall "negativity." It is plausible that the large N350, and by inference the N500 in Williamson et al. (1991) occurred in psychopaths because of a lack of the attenuating effects of what ordinarily would be large positive potentials. Whether these potentials involve separate or multiple late positive complexes (e.g., P3a, P3b, P600, or LPC) we are unsure. There is very little research on these ERP components and psychopathy and further research is needed to help clarify the relationship between psychopathy and the P300. Interestingly, a study recently completed in our laboratory indicates that the visual P300 elicited by low-probability target stimuli is reduced in psychopaths compared with nonpsychopaths (Kiehl, Hare, Liddle, & McDonald, 1999).

It is important to note that there are several limitations to this study that should be addressed in future research. First, the present study used small sample sizes, which raises the possibility that the absence of clear behavioral differences between groups and ERP differences between word stimuli for psychopaths may have been due to low power. The small sample size also raises the possibility that the psychopaths' ERP effects are sample specific. Second, we did not include a nonprisoner control group, which can, in some cases, make it difficult to reconcile discrepancies between data from the nonpsychopaths with data from noncriminals. Third, explicit measures of verbal IQ, reading ability, and language fluency were not directly assessed, which raises the possibility that some of the observed differences between groups may have been influenced by these measures. We note however, that there were no group differences in education level or impairment in postexperimental ratings of the word stimuli.

In summary, although emotional processes play a crucial role in the etiology and maintenance of psychopathy, it is becoming evident that the syndrome is also associated with differences in processing the semantic aspects of language. The results of Tasks 1 and 2, for example, neither of which involved emotional material, were broadly consistent with other research indicating that psychopaths process and use semantic information differently than do nonpsychopaths and noncriminals (Gillstrom, 1994; Hare, 1993; Williamson, 1991).

Finally, this research may have important implications for the treatment and management of psychopaths. If psychopathy is associated with cognitive impairments in the processing of language, then modern cognitive therapies, which attempt to teach conceptually abstract information (e.g., empathy, role-playing, rational thinking), may place psychopaths at a distinct disadvantage in these programs and may indicate that they need alternative forms of treatment (Rice et al., 1992). However, it should be noted that this interpretation is speculative and more studies using greater numbers of participants are needed before any strong conclusions can be reached.

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