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Phonological processing in psychopathic offenders

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Abstract

Recent research has demonstrated that psychopathic offenders exhibit dynamic cognitive and behavioral deficits on a variety of lab tasks that differentially activate left hemisphere resources. The Left Hemisphere Activation (LHA) hypothesis is a cognitive perspective that aims to address these deficits by conceptualizing psychopathy as a disorder in which behavior and cognitive processing change dynamically as a function of the differential taxation of left hemisphere resources. This study aimed to investigate whether psychopathic traits are associated with electrophysiological anomalies under conditions that place differential demands on left hemisphere language processing systems. We examined in a sample of 43 incarcerated individuals the evocation of the N320, an event-related potential (ERP) elicited by nontarget stimuli during a phological/phonetic decision task that has been shown to elicit greater activation and cognitive processing within the left hemisphere than the right hemisphere. Findings for a subsample of 18 offenders low in psychopathic traits were generally consistent with previous findings in healthy individuals, suggesting similar electrophysiological activity during phonological processing. However, psychopathic traits impacted the amplitude of the N320. Higher levels of

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psychopathic traits were associated with reduced left-lateralization in phonological processing as well as enhanced ERP differentiation between pronounceable and nonpronounceable stimuli. These findings provide physiological evidence of a relationship between psychopathic traits and anomalous language processing at the phonological level of word processing.

Keywords

electroencephalography (EEG); event-related potential (ERP); N320; language; Left Hemisphere Activation (LHA) hypothesis; psychopathy; antisocial personality disorder

1. Introduction

Psychopathic individuals have long been characterized by seemingly inexplicable, erratic behavior. Indeed, Cleckley (1976) documented this behavior in his book, *The Mask of Sanity*, describing his patients as apparently intelligent, charming, and sane in one moment and engaging in irrational behavior that baffled and frustrated their physicians and loved ones the next. However, several of the leading perspectives on psychopathy such as the emotion deficit perspective and the low fear hypothesis posit static impairments that do not readily explain this extreme fluctuation in functioning. In contrast to these views, research over the past thirty years has provided substantial evidence consistent with cognitive hypotheses that posit dynamic cognitive deficits in psychopathic offenders (e.g., Bernstein, Newman, Wallace, & Luh, 2000; Larson et al., 2013; Lorenz & Newman, 2002; Patterson & Newman, 1993) which directly address the erratic nature of psychopathic offender's disinhibited behavior.

The Left Hemisphere Activation (LHA) hypothesis seeks to explain this phenomenon by describing psychopathy as a disorder in which the individual's behavior changes dynamically as a function of the taxation of left-lateralized neural resources by the task or situation. According to this perspective, psychopathic traits are associated with a dramatic drop in cognitive efficiency in the face of substantial and differential demands on left hemisphere resources. Under most other conditions, including conditions placing differential demands on right hemisphere systems or equal demands on left and right hemisphere resources, psychopathic traits are associated with relatively intact cognitive functioning (Kosson, 1998).

Findings from a number of studies examining cognitive and physiological abnormalities in psychopathic offenders have been consistent with the LHA hypothesis (i.e., Hare & Jutai, 1988; Hare & McPherson, 1984; Hare, Williamson, & Harpur, 1988; Kiehl, Hare, McDonald, & Brink, 1999; Kosson, 1998; Lorenz & Newman, 2002; Suchy & Kosson, 2005). Interestingly, multiple studies have shown that psychopathic traits are associated with unusual language processing (e.g., Hare & Jutai, 1988; Hare & McPherson, 1984; Kiehl et al., 1999; Lorenz & Newman, 2002), which has been found to be left hemisphere-lateralized in most healthy individuals (e.g., Bentin, Mochetant-Rostaing, Giard, Echallier, & Pernier, 1999; Simon, Bernard, Largy, Lalonde, & Rebai, 2004; Price, 2000; Indefrey & Levelt, 2004). Hare and McPherson (1984) found a reduced right-ear advantage among psychopathic individuals on a dichotic listening task. Lorenz and Newman (2002) found that psychopathic individuals exhibited reduced emotion facilitation on a lexical-decision task; however, this effect was specific to right-handed responses, which would have differentially activated left hemisphere resources, and was not seen in left-handed responses. Additionally, Hare and Jutai (1988) found that offenders with elevated levels of psychopathic traits did not display the normal right visual field (RVF)/left-hemisphere (LH) advantage for the classification of words into abstract categories that the controls did. Instead, psychopathic traits were associated with a left visual field (LVF)/right-hemisphere (RH) advantage, suggesting that psychopathy predicts reduced lateralization of complex language processing to the left hemisphere (Hare & Jutai, 1988).

Physiological evidence further corroborates these behavioral findings. Kiehl et al. (1999) found that psychopathic offenders did not exhibit the expected ERP differentiation between semantic and affective verbal information; in addition, these individuals exhibited a larger negative ERP than nonpsychopathic offenders that was significantly greater over the left hemisphere than the right hemisphere, suggesting physiological anomalies during language processing at left hemisphere sites. In summary, the above findings suggest that, among offenders, the presence of psychopathic traits is associated with unusual brain activity during language processing, particularly in tasks requiring the use of broad associations or entailing heavy processing demands (Hiatt & Newman, 2006).

Most studies of language processing in psychopathy, however, have focused on semantic processing and on the affective component of language. Fewer studies have examined non-affective language processing or more basic components of language functions in psychopathy. Indeed, we are aware of only two published studies examining phonological processing in psychopathy. Both assessed language functions behaviorally. The first examined a broad range of verbal functions and language skills and found that phonological processing (see below for a discussion on the stages of visual word processing) did not differ between psychopathic and nonpsychopathic individuals (de Almeida Brites, Ladera, Perea, & Garcia, 2014). A second study later replicated these findings for overall psychopathy score (Selenius & Strand, 2015). However, Selenius and Strand (2015) also examined the two broad dimensions of psychopathy separately: Factor 1, which consists of the affective and interpersonal traits, and Factor 2, comprised of the antisocial lifestyle traits. They reported a positive relationship between Factor 1 scores and phonological processing, suggesting that greater levels of the affective and interpersonal traits of psychopathy are associated with better performance on phonological processing tasks. Given the relative paucity of research regarding verbal skills in psychopathy at this time, additional research examining these skills is warranted.

1.2. Visual Word Processing and the N320

Visual word recognition is a complex process that integrates several distinct cognitive operations, including the visual encoding of letters, translation of letter shapes into a sequence of orthographic patterns, activation of the lexical and phonological structure of the sequence, and interpretation of the semantic meaning (Bentin et al., 1999). Although the exact nature of the cognitive operations involved in visual word recognition has not yet fully been clarified, the notion of psycholinguistic levels is both accepted and incorporated into most theories of visual word recognition. However, discerning between psycholinguistic levels is difficult using discrete measures of performance on language tasks such as reaction time.

Thus, researchers have begun utilizing neurophysiological measures to better discriminate between cognitive operations in visual word recognition. Bentin et al. (1999) utilized several tasks designed to promote electrophysiological activity at four psycholinguistic levels, including visual, phonological/phonetic, phonological/lexical, and semantic. In the phonological/phonetic decision task, healthy participants were presented with words, pseudowords (phonologically legal or pronounceable nonwords), and nonwords (phonologically illegal or nonpronounceable strings of letters). The task aimed to assess neurophysiological activity during phonetic processing, an early stage of word processing. As electrophysiological activity was recorded via electroencephalogram (EEG), participants were asked to count the number of words and pseudowords rhyming with a target French word, “vitrail.”

The most conspicuous ERP elicited during the task was a negative peak occurring approximately 320 msec following the presentation of phonetically legal nontarget stimuli, or non-rhyming words and pseudowords. The N320 was found to be bilaterally distributed over the middle temporal lobe, but the amplitude of the response was significantly greater over the left temporal lobe than over the right. Bentin et al. (1999) suggested that the N320 may be associated with phonetic transformation performed on pronounceable orthographic patterns. Bentin et al.’s (1999) findings have been replicated in studies utilizing similar rhyming paradigms and electrophysiological measures (i.e., Jacquier, Rouibah, & Hoen, 2005; Simon et al., 2004) and neuroimaging techniques (i.e., Booth, Burman, Meyer, Gitelman, Parrish, & Mesulam, 2003; see also Petersen, Fox, Posner, Mintun, & Raichle, 1989).

1.3. Goals and Hypotheses of the Present Study

The present study aimed to test predictions made by the LHA hypothesis by investigating whether psychopathic traits are associated with anomalous electrophysiological activity during a phonological/phonetic task that has previously been shown to elucidate larger negative potentials over the left temporal lobe than the right temporal lobe among healthy individuals (Bentin et al., 1999; Simon et al., 2004). An event-related potential design was utilized to examine whether electrode site, stimulus category, hemisphere, and Psychopathy Checklist-Revised (PC-R; Hare, 2003) score were associated with differences in the mean amplitude of the N320 during nontarget stimulus presentation. First, it was predicted that offenders without psychopathic traits would exhibit greater N320 amplitude over left temporal sites than right temporal sites in response to pronounceable nontarget stimuli (i.e., non-rhyming words and non-rhyming pseudowords) as was found by Bentin et al. (1999) among healthy subjects. Secondly, psychopathic traits were predicted to modulate N320 amplitude at left temporal sites, as posited by the LHA hypothesis. Because the LHA hypothesis does not specify whether the reduced cognitive efficiency reflected either over- or under-activation of left hemisphere brain areas and instead predicts general dysfunction on tasks eliciting left hemisphere neural resources, we made no a priori predictions about the direction of psychopathy-related differences in N320 amplitude.

Finally, supplementary analyses examined whether any psychopathy effects were specific to PCL-R Factor 1 or PCL-R Factor 2 and to address whether scores on potentially confounding variables contributed to any psychopathy effects. We conducted analyses to evaluate whether individual differences in age, intelligence, or ethnicity should be controlled.

In addition, we conducted analyses in which we controlled for substance misuse histories. Substance misuse is common among people with psychopathic traits. Because it often shares substantial variance with psychopathy, it is not an ideal covariate (Miller & Chapman, 2001; Walsh et al., 2009). Nevertheless, it is of interest to examine whether any psychopathy-related physiological anomalies remain evident even after controlling for such variance.

2. Method

2.1. Participants

Demographic characteristics of the participants are summarized in Table 1. Participants were 43 male inmates from a county jail in Waukegan, Illinois. The protocol was approved by an ethics committee at Rosalind Franklin University of Medicine and Science and by the jail in which data were collected. All participants provided written informed consent and were compensated monetarily for their participation. Ages ranged from 18 – 42 years ($M = 25.60$, $SD = 6.31$). Participant eligibility was determined based on the following criteria. Participants: 1) were 18 years of age or older; 2) displayed no signs of psychotic symptoms as determined by study raters during testing and the PCL-R interview; 3) were not currently taking psychotropic medication or other medications affecting the central nervous system; 4) spoke English as their primary language; 5) were right-handed; 6) had normal or corrected-to-normal vision; 7) had estimated IQs of 70 or greater; and 8) had no prior history of traumatic brain injury as operationalized by loss of consciousness.

Based on the sample mean PCL-R rating of 23.5 (see Table 1), the 18 men with PCL-R total scores less than or equal to 23.5 were included in the analysis of phonological processing among offenders low in psychopathic traits. The mean PCL-R total score for this subsample was 16.92 (SD = 4.16). This subsample appeared roughly comparable to the full sample in estimated IQ scores (mean = 90.67, SD =10.09) with a somewhat larger proportion of Latinx and smaller proportion of European American individuals than the full sample (The distribution was 50.0% African American, 33.33 % European American, 11.11 % Latinx, 5.56% Other).

Measures

<u>Psychopathy Checklist-Revised (PCL-R; Hare, 2003).:</u> Trained expert-raters utilized a semi-structured interview and institutional probation files to independently complete the PCL-R (Hare, 2003) on each inmate. The PCL-R is a reliable and valid instrument for the assessment of psychopathy in criminal populations (Hare, 1980, 1991, 1996; Hare et al., 1990; Harpur, Hakstian, & Hare, 1988; Hart & Hare, 1989). Each of the 20 items on the PCL-R is scored on a 3-point scale (0 – 2), with the total PCL-R score ranging from 0 – 40 depending on the degree of psychopathic traits the individual exhibits. The mean and standard deviation of PCL-R total scores for the entire sample were 23.50 and 6.71, respectively.

Structured Clinical Interview for the Diagnostic and Statistical Manual (DSM) of the American Psychiatric Association (APA) (SCID-I).: Alcohol and substance use disorders were assessed using alcohol and substance use-related modules of the SCID-I (First, Gibbon, Spitzer, & Williams, 1995). The SCID-I allows for quantification of lifetime abuse or dependence for alcohol and multiple categories of psychoactive substances. Each participant was given a substance misuse score corresponding to his most severe substance abuse or dependence problem. This score ranged from 0 (indicating no abuse) to 1 (substance abuse) to 2, 3, or 4 (mild, moderate, or severe substance dependence). All participants were incarcerated at the time of data collection and reported abstaining from substance use throughout the duration of their incarceration. Inmate files were consistent with participant report as no participants had received violations due to illicit use of substances in the jail. Observer scores were not available for enough participants to examine interrater agreement in this sample ($n = 2$); however, in a larger sample of inmates at the same jail, *SCID* ratings demonstrated acceptable interrater agreement (single rater, $N = 116$, Fleiss multirater kappa = .76, $p < .001$).

Handedness questionnaire (Chapman & Chapman, 1987).: A 13-item questionnaire adapted from Chapman and Chapman (1987) was utilized to assess handedness of the participants. Each item is scored as “1” for right, “2” for either, or “3” for left with a possible score ranging from 13 (strongest right-hand preference) to 39 (strongest left-hand preference). The test-retest reliability ($r = .993$) and internal consistency (Cronbach’s alpha = .97) of this questionnaire have been found to be high (Nalçaci, Kalaycioglu, Gunes, & Cicek, 2002).

Shipley Institute of Living Scale-Revised (SILS; Zachary, 1986).: The SILS (Zachary, 1986) is a brief measure of intelligence consisting of a 40-item vocabulary subtest and 20-item abstract problem-solving subtest. Performance on the SILS was converted into Wechsler Adult Intelligence Scale-Revised (WAIS-R) Full Scale IQ (FSIQ) estimates using normative tables provided within the measure.

2.2. Procedure

Participants completed a phonological/phonetic decision task modeled on that used by Bentin et al. (1999). During the task, participants were seated approximately 100 cm from a computer screen on which they were presented with a series of letter strings while electrophysiological activity was recorded. They were asked to silently count the number of words and pseudowords rhyming with the word “tray.” Three types of stimuli were presented: words, pseudowords (or phonetically legal [pronounceable] nonwords), and nonwords (or phonetically illegal [unpronounceable] strings of letters). Each stimulus consisted of a string of four to eight letters.

Stimuli were presented in a rectangular window in the center of the screen for a duration of 500 msec, followed by an intertrial interval of 750 msec. Participants were asked to avoid blinking as much as possible. Participants were given a short practice block to orient them to the task. The main task consisted of four blocks of 71 stimuli each, or 284 total stimuli, Including instructions and 37 practice trials, the task interval lasted approximately 8 minutes plus approximately 3–5 minutes of rest intervals, one between each block. At the end of each block, participants were asked to report the number of target stimuli (i.e., 10 rhyming letter strings per block) they detected.

Electrophysiological recording.—Electrophysiological activity was recorded by 32 silver-chloride electrodes placed on a cap (Electrocap International) in accordance with the International 10–20 system of electrode placement (nose as reference), with the addition of the following sites: FPz, FT7, FC3, FCz, FC4, FT8, TP7, CPz, TP8, and Oz. As noted below, the sites at which activity were examined were T3, T4, T5, and T6. Signals were bandpass filtered at 0.1 to 100 Hz and sampled at 256 Hz. Amplifier gain was set to 20 μV/div. Impedance was assessed prior to data collection and was maintained at less than 10 kOhms throughout data collection.

2.3. ERP data processing

Data preparation and analysis were performed in Matlab (Version 2014a) in combination with the EEGLab (Delorme & Makeig, 2004) and ERPLab toolboxes (Lopez-Calderon & Luck, 2014; MATLAB 2014a, The MathWorks Inc.). Eye-blink artifact removal was accomplished using an independent component analysis (ICA) technique in the EEGLab software. Blink components were visually identified and removed from the data. The mean number of ICs deleted was 2.20 (range = 0–9). Bad channels were identified as having activity four standard deviations away from the mean and were replaced using spline interpolation. Trials in which there was an amplitude change of more than 150 μV over a 200-msec period were removed from the data, using a sliding window tool applied across the entire epoch, in steps of 100 ms. These criteria led to the deletion of 0.66% of trials or an average of 1.87 of the 284 trials (range = 0 to 24.30%).

EEG data analysis.—Consistent with Bentin et al.’s (1999) experimental design for the phonological/phonetic task among healthy subjects, data were analyzed from four temporal sites, two anterior (T3 and T4) and two posterior (T5, and T6). Event-related potentials (ERPs) were averaged separately across each stimulus type over an analysis period of 1000 msec, including a 100-msec prestimulus period that was used to baseline correct epochs. Consistent with Bentin et al.’s (1999) design, frequencies lower than 0.8 Hz and higher than 16 Hz were digitally filtered out after averaging. The N320 was quantified as the mean amplitude in the 270 to 370 msec window (relative to stimulus onset) as defined by Bentin et al. (1999).

Statistical analysis procedures.—Statistical analyses were performed using SPSS Version 22 (SPSS, IBM Corp.). Correlational analyses between FSIQ, PCL-R scores, and performance data were conducted as a manipulation check to examine whether participants were engaged and performed the task accurately and to determine the relationship between performance and PCL-R score. Participants' performance on the task was evaluated through error scores across each block. Each error score was calculated as the extent of deviation (as an absolute value) between the participant's reported response and the correct number of rhyming targets for each block (i.e., 10 rhyming targets). For example, a participant reporting either 8 or 12 rhyming targets following a single block would have an absolute value error score of 2.

In analyses assessing the impact of psychopathic traits on phonological processing, we employed psychopathy as a dimensional construct. Although many early studies operationalized psychopathy as a grouping construct (i.e., treating individuals as nonpsychopathic, as possessing a moderate level of psychopathic traits, or as psychopathic), more recent studies have suggested that, like other personality disorders, psychopathy as measured by the PCL-R is a dimensional rather than categorical (i.e., taxonic) construct (Edens, Marcus, Lilienfeld, & Poythress, 2006; Guay, Knight, Ruscio, & Hare, 2018). Consequently, most recent EEG studies (Anderson, Steele, Maurer, Bernat, & Kiehl, 2015; Maurer et al., 2016a; Maurer et al., 2016b; Steele, Maurer, Bernat, Calhoun, & Kiehl, 2016) and neuroimaging studies (Harenski, Edwards, Harenski, & Kiehl, 2014; Philippi et al., 2015; Seara-Cardoso, Viding, Lickley, & Sebastian, 2015) treat psychopathy as a dimensional construct.

Principal analyses were covariance pattern models. These are multilevel models in which the variance-covariance matrix of residuals is examined, but all effects are treated as fixed effects. In these analyses, hemisphere (left vs. right), stimulus type (pronounceable vs. nonpronounceable), and site (anterior [T3/T4] vs. posterior [T5/T6]) were repeated measures fixed factors, and PCL-R total score was a continuous fixed factor. Because substance use and psychopathy are highly comorbid, substance misuse is a possible confound in psychopathy analyses. For this reason, we also conducted a follow up analysis, in which a rating of each participants' most severe substance misuse was included as an additional covariate.

The dependent variable was the mean amplitude of the N320 between 270 and 370 msec. To address the first aim of whether the N320 was larger for pronounceable stimuli over left temporal than over right temporal sites among offenders – when psychopathy is not a factor – we estimated the multilevel model for the within-subjects variables including only the half of the sample with the PCL-R total score below the sample median.

To select the best fitting mixed model, we compared several multilevel models that included site, stimulus type, and hemisphere. We conducted four analyses that modeled the covariance of residualized scores across the levels of repeated measures factors: as either independent of each other, as compound symmetric, as auto-regressive, or without any constraints (i.e., an unstructured variance-covariance matrix). The variance-covariance parameter adjustment yielding the lowest Akaike Information Criterion (AIC) for a model was the one selected for the estimation of the model (see Supplementary Table 1).

To examine the impact of psychopathic traits on the N320, we repeated the analysis with the full sample, including psychopathy as a continuous predictor. Because neither the four-way interaction nor any three-way interactions approached significance (all *F*s < 1), these higher-order interactions were trimmed from the final model. An additional analysis examined the impact of controlling for individual differences in severity of substance misuse. Because such misuse covaries substantially with Factor 2 traits in larger samples (including samples from this jail; Walsh, Allen, & Kosson, 2009), this analysis was considered supplementary.

3. Results

3.1. Behavioral analyses

Correlational analyses were conducted as a manipulation check to examine whether participants were engaged and performed the task accurately. The mean error score across blocks was .23 ($SD = .17$), indicating that participants on average provided responses within the range of 32 to 48 (relative to the correct response of 40). Within each of the 4 blocks, the mean deviations were .26, .28, .25, and .20 for blocks 1, 2, 3, and 4, respectively, suggesting that performance remained similar (or improved slightly) throughout the task. Altogether, these findings suggest that participants in general were engaged and performed the task accurately. Neither the mean error score across blocks nor error scores within each block was affected by FSIQ. Although the correlation between PCL-R scores and error score was not significant, the effect size was moderate and negative ($r = -.31$, $p = .05$).

Additional correlational analyses were conducted to determine whether age, FSIQ, and ethnicity had significant relationships with psychopathy score and with N320 amplitude. Findings indicated these demographic characteristics were not important predictors of N320 amplitude in general, as none of them significantly predicted N320 amplitude when collapsed across hemisphere, stimulus type, and electrode site. As such, these variables were not included as covariates in subsequent analyses.

3.2. EEG analyses

Results of these analyses are summarized in Table 2.

3.2.1 Examining the Replicability of the N320 Effects in a Sample of Offenders Low in Psychopathic Traits—

As noted above, we examined the AIC for an unstructured covariance matrix versus matrices with compound symmetry, with first-order auto-regressive properties, and with all residuals independent. The AIC was lowest for the model with an unstructured covariance matrix. Consequently, this was the model used.

The analysis revealed significant effects for hemisphere, $F(1, 17) = 11.52$, $p = .003$, and site $F(1, 17) = 5.52$, $p = .031$. The Hemisphere X Stimulus type interaction was also significant, $F(1, 17) = 6.34$, $p = .022$. The main effects indicate that the N320 was generally more negative over the left hemisphere and anterior sites than over right hemisphere and posterior temporal sites. The interaction of hemisphere and stimulus type indicated greater negativity as a function of stimulus pronounceability over left temporal than over right temporal sites.

3.2.2 Examining the Effects of Psychopathy on the N320—

When the analysis was repeated for the full sample, the AIC was again lowest for the model with an unstructured covariance matrix. Figure 1 displays averaged ERPs for pronounceable and nonpronounceable nontarget stimuli at T3, T4, T5, and T6 (see Supplementary Figure 1 for averaged ERPs for pronounceable and nonpronounceable nontarget stimuli across all channels). The analysis revealed a significant main effect of hemisphere ($F[1,41.16] = 11.64$, $p = .001$, $\eta_{partial}^2 = .22$), with N320 amplitude more negative over the left ($M = .20$) than over the right hemisphere ($M = .99$) when collapsing across stimulus type and electrode site (mean difference = −.80, $p = .001$). The Hemisphere X Stimulus type interaction was also significant ($F[1,41] = 13.68$, $p = .001$, $\eta_{partial}^2 = .25$), indicating a significantly more negative N320 amplitude for pronounceable than nonpronounceable stimuli at left temporal sites (difference = −.94, $p = .001$) but not at right temporal sites (difference = −.09, $p = .693$). Electrode site also interacted with stimulus type ($F[1,41] = 7.41$, $p = .009$, $\eta_{partial}^2 = .15$), indicating a more negative N320 for pronounceable stimuli at posterior sites (difference = −.78, $p = .001$) but not at anterior sites (difference = −.25, $p = .289$). Psychopathy Checklist-Revised score did not have a significant main effect on N320 amplitude ($F[1,40] = .21$, $p = .650$, $\eta_{partial}^2 < .01$).

Analyses revealed two significant interactions involving psychopathy. Both were examined using analyses of simple slopes conducted at 1 SD below, at the mean, and at 1 SD above the mean PCL-R score. As shown in Figure 2, a Psychopathy X Stimulus type interaction ($F[1,40] = 5.15$, $p = .029$, $\eta_{partial}^2 = .11$) revealed that the effect of stimulus type became increasingly negative as psychopathy scores increased. The effect of stimulus type was nonsignificant at low PCL-R scores ($b = .04$, $p = .895$), but, at medium and high PCL-R scores, the more negative N320 for pronounceable than for nonpronounceable stimuli became significant (*b*s = −.42 [$p = .033$], −.84 [$p = .003$], for medium and high levels of psychopathy, respectively).

The Psychopathy X Hemisphere interaction was also significant ($F[1,40] = 5.78$, $p = .021$, $\eta_{partial}^2 = .13$; see Figure 3). Analyses of simple slopes showed that the effect of hemisphere -- the more negative N320 in the left hemisphere than in the right hemisphere -- was significant at low levels of psychopathy (difference = −1.29, $p < .001$, 95% CI = −1.85, −0.73) and at average levels of psychopathy (difference = −0.81, $p < .001$, CI = −1.20, −0.42) but was no longer significant at high levels of psychopathy (difference = −0.34, $p = .222$, CI = −0.90, 0.22).

3.2.3 Supplementary Analyses—We repeated analyses using Factor 1 ratings or Factor 2 ratings instead of total psychopathy ratings. There were again no higher-order interactions, and again the unstructured matrix yielded the lowest AIC values. Each analysis yielded one effect related to psychopathy. The analysis including Factor 1 ratings yielded a Factor 1 X Hemisphere interaction ($F[1,40] = 4.44$, $p = .041$, $\eta_{partial}^2 = .10$). The analysis including Factor 2 ratings yielded a Factor 2 X Stimulus Type interaction ($F[1,40] = 10.65$, $p = .002$, $\eta_{partial}^2 = .21$). As shown in Supplementary Tables 2 and 3, no other effects involving F1 or F2 were significant.

Finally, we conducted an additional supplementary analysis to examine whether the findings were impacted by controlling for individual differences in substance use disorder symptoms. We repeated the trimmed covariance pattern analysis, adding substance misuse as an additional covariate. Despite the slight reduction in sample size and degrees of freedom, the pattern of findings was quite similar to that in the preceding analyses. The covariate was not significant, ($F[1, 35] = .19$, $p = .670$, $\eta_{partial}^2 < .01$). The main effect for hemisphere and the various interactions revealed the same patterns as in the principal analysis (summarized above) with the exception that the Psychopathy X Stimulus type interaction was no longer significant ($F[1,36] = 3.60$, $p = .066$, $\eta_{partial}^2 = .09$).

4. Discussion

The present study aimed to evaluate the robustness of the N320 effect previously observed in healthy individuals in a sample of incarcerated male offenders without substantial psychopathic features, and to examine the impact of psychopathic features on N320 effects.

Utilizing a phonological/phonetic decision task modeled after tasks used by Bentin et al. (1999) and Simon et al. (2004) in healthy samples, participants were asked to silently count the number of target stimuli that rhymed with the word “tray.” It was predicted nonpsychopathic offenders would, like healthy controls, demonstrate a greater N320 over the left temporal cortex than over the right. It was also hypothesized that, among offenders, higher levels of psychopathic traits would be associated with anomalous N320 amplitude over the left temporal lobe, as predicted by the LHA hypothesis.

Although our chief focus was on cortical activity rather than performance, behavioral scores were examined to ensure participants were engaged and performing the task correctly. The relatively low error rate suggested participants had been engaged and had adequately attended to task demands. Psychopathic traits were not significantly associated with performance on the rhyming task, but the effect size was moderate ($r = -.31$, $p = .05$).

Electrocortical findings for offenders low in psychopathy were consistent with previous findings for phonological processing within healthy samples (e.g., Angrilli, Dobel, Rockstroh, Stegagno, & Elbert, 2000; Bentin et al., 1999; Simon et al., 2004; Simon, Bernard, Lalonde, & Rebai, 2006). These findings suggest phonological processing in incarcerated offenders is generally similar to that observed in community samples of individuals and provide additional evidence for the robustness of the N320 effects associated with decoding phonemes.

Analyses of the effects of psychopathy on modulation of the N320 indicated two important effects. First, the difference in N320 amplitude recorded at left versus right temporal sites grew smaller as PCL-R score increased, suggesting a reduction in language lateralization associated with psychopathy. These findings are consistent with those of prior studies examining later stages of word processing and more complex language processing tasks, which have demonstrated abnormal language lateralization in psychopathic individuals. For example, Hare and McPherson (1984) observed reduced right-ear advantage in a verbal dichotic listening task. Hare and Jutai (1988) reported that psychopathic offenders demonstrated the expected right visual field advantage during a simple categorization task; however, during a more complex abstract categorization task, they demonstrated an unexpected, large left visual field advantage. Based on these and similar findings, Hare, Williamson, and Harpur (1988) originally proposed that psychopathic offenders are characterized by reduced language lateralization. Although such asymmetry differences are today more typically understood as reflecting differences in the activation of hemisphere-specific resources (e.g., Bruder, 1995; Bruder et al., 2004), current findings suggest that the reduction in hemisphere-asymmetric activation reported in offenders with psychopathic traits for other kinds of language processing extends to the domain of phonological processing. Integrating across studies, the functional reduction in lateralized processing appears reliable on both complex tasks that require semantic processing (e.g., Hare & Jutai, 1988) as well as simpler tasks that require only the earlier stage of phonological processing.

In addition, higher levels of psychopathy were associated with a greater difference in N320 amplitude between pronounceable and nonpronounceable stimuli. This finding differs from findings of prior studies investigating later stages of language processing in psychopathy. At the lexical level, Williamson, Harpur, and Hare (1991) found poorer ERP differentiation between neutral and emotional words among psychopathic offenders than among offenders without psychopathic traits. At the semantic level, Kiehl et al. (1999) found poor ERP differentiation between abstract versus concrete words among psychopathic offenders completing a word discrimination task. Taken together, these earlier studies suggest psychopathic offenders exhibit poor ERP differentiation between different kinds of verbal stimuli at later stages of processing. In contrast, current findings link psychopathic traits to enhanced ERP differentiation between verbal stimuli at an earlier phonological level of processing.

These findings add to our understanding of the neural substrate underlying left hemisphere activation deficits. They provide the first direct evidence of physiological anomalies 25 in psychopathy predicted by the LHA hypothesis. At the same time, current findings demonstrate that the mechanisms underlying language processing in psychopathy are more complex than suggested by the LHA hypothesis. The suggestion of greater right temporal involvement in the rhyme processing of right-handed individuals with psychopathic traits than in the rhyme processing of individuals without these traits is consistent with the possibility of greater activity in a homologous region of right temporal cortex to compensate for deficient activity in a region of left temporal resources. However, the greater differentiation between pronounceable versus nonpronounceable letter sequences indicates the underlying mechanism is more complex than a simple reduction in the aptitude of some hemisphere-specific resources with or without compensation.

In the absence of any higher-order interactions, we cannot unambiguously point to left hemisphere mechanisms underlying the increasing negativity for pronounceable stimuli associated with psychopathic traits. Even so, the hemisphere effect indicating greater N320s over left temporal than right temporal sites and the Hemisphere X Stimulus type interactions revealing greater differentiation between pronounceable stimuli and nonpronounceable stimuli at left hemisphere than right hemisphere sites fit with other research which argues persuasively that much of phonological processing is left lateralized (Banich, 1998; Hodgson, Ralph, & Jackson, 2021; Rumsey et al., 1997). It was because of this recognition that this paradigm was chosen for this study. Nevertheless, the evidence for some right temporal activity during phonemic analysis associated with psychopathic traits also appears consistent with evidence of some right temporal involvement in analyses of low-complexity phonemes (Tremblay, Monetta, & Joanette, 2004, 2009; see also Halderman, 2011). The loss of statistical significance in an analysis controlling for substance misuse suggests that variance shared between substance misuse and psychopathy contributes to the greater ERP differentiation associated with psychopathic traits.

Selenius and Strand (2015) argued that superior phonological processing is one explanation for the glibness often observed among psychopathic individuals. They suggested it could help to explain why offenders with the core interpersonal and affective features of psychopathy appear to find words easily despite a lack of deeper semantic understanding (e.g., Blair, Richell, Mitchell, Leonard, Morton, & Blair, 2006; Cleckley, 1976) or cohesive ties within their speech (e.g., Brinkley, Newman, Harpur, & Johnson, 1999). The implications of enhanced ERP differentiation at the level of phonological processing are not entirely clear, but there are at least two logical possibilities. First, they could reflect an anomaly in phonological decoding (e.g., reflecting greater activation of right temporal resources) which contributes to the poorer later-stage verbal processing seen in psychopathic offenders. Alternatively, the differences in phonological processing may be unrelated to the differences seen in tasks previously designed to induce differential LHA. At the very least the greater ERP differentiation between pronounceable and nonpronounceable stimuli appears at odds with LHA hypothesis predictions of reduced cognitive efficiency in psychopathy. Additional studies are needed to clarify whether the early electrophysiological anomalies observed here are related to either superior phonological processing (as suggested by Selenius & Strand, 2015) or to the inferior semantic processing at later stages reported by others.

Unfortunately, current behavioral data are not helpful in addressing these conflicting ideas because the behavioral task we selected for use in this study appears relatively non-discriminating. The direction of the nonsignificant performance difference we observed appears opposite to that predicted by the LHA hypothesis but somewhat consistent with Selenius and Strand's (2015) report of superior phonological processing skills associated with the affective and interpersonal traits. However, the inconsistency of prior findings on psychopathy and phonological processing precludes clear conclusions: the other prior study we could locate reported a lack of differences in phonological performance associated with psychopathy but noted that deficits in phonological processing were associated with incarceration (e.g., de Almeida Brites, Ladera, Perea, & García, 2014; see also Vanova et al., 2020). It is plausible that examination of additional confounding variables may provide additional insights into the nature of any performance differences in phonemic processing.

Even consistent evidence of normal performance in phonological awareness or phonological memory would appear to distinguish this component of language from the pattern of performance deficits observed for psychopathic offenders in a wide variety of left lateralized tasks, e.g., lateralized divided attention, lateralized perception, verbal dichotic listening (Hare & McPherson, 1984; Kosson, 1998; Kosson et al., 2005; Lopez et al., 2007), as well as in narrative coherence (Brinkley, Bernstein, & Newman, 1999). Additional studies utilizing more discriminating measures of phonological skill may help to clarify whether the pattern of psychopathy-related performance differences is different for some components of phonological processing than for others.

Limitations.

The present study has several additional limitations. Despite the study demonstrating ample power to detect psychopathy-related effects and the sample size being comparable to samples in most prior EEG studies involving psychopathic offenders, the present sample size was relatively small. Additionally, data were collected only among male inmates incarcerated in a single county jail. As such, results may not be generalizable to the overall criminal population or to the overall population of psychopathic individuals. Replicating this study with non-offenders or female psychopathic offenders would determine whether the effects seen here are generalizable versus sample-specific.

As noted above, the lack of discriminating power of the behavioral task we employed makes it difficult to conclude there is no link between electrocortical activity and phonological processing performance. Future studies that utilize more discriminating behavioral tasks in addition to electrophysiological data may also help to clarify the relationship between neural activity and differences in performance on tasks demanding phonological processing.

Finally, the spatial resolution of ERPs is relatively undefined, making it difficult to definitively implicate the neural origins of the electrophysiological activity observed in this study. However, studies using fMRI and other imaging methods provide additional evidence for the differential involvement of regions within left temporal cortex and frontal cortex in some aspects of phonological processing (Burton, Small, & Blumstein, 2000; Safi et al., 2012; see also Binder, 2015). Future studies may utilize these methods to more accurately specify brain structures responsible for anomalous neural activity evoked by the rhyming task among psychopathic offenders.

The present study is the first study utilizing electrophysiological measures to observe differences in neural activity between psychopathic and nonpsychopathic offenders during a language task designed to elicit phonological word processing. The rhyming task utilized within this study has been shown to elicit the targeted scalp-recorded ERP across both healthy and clinical samples (e.g., Angrilli et al., 2000; Bentin et al., 1999; Jacquier, Rouibah, & Hoen, 2005; Simon et al., 2004). In conclusion, the present findings provide physiological evidence that psychopathic traits are related to reduced language lateralization at the phonological level of word processing.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights:

- Psychopathy has previously been associated with unusual language processing.
- This study examines the N320 in psychopathy during a rhyming task.
- Psychopathy is associated with reduced lateralization during phonological processing.
- Psychopathy is associated with a greater distinction between pronounceable and nonpronounceable stimuli.

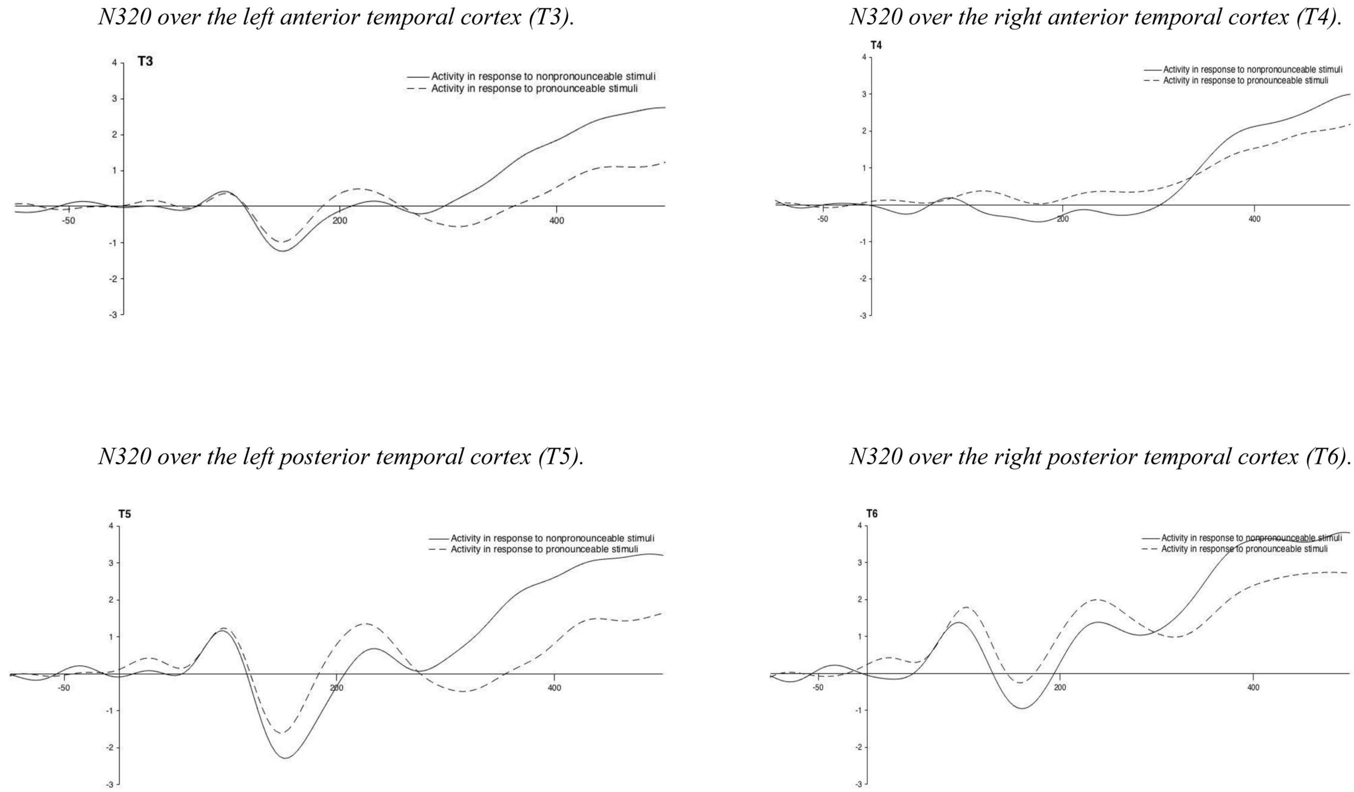

Figure 1.

Averaged ERPs elicited by pronounceable nontarget stimuli and nonpronounceable stimuli across all participants during a rhyming task at T3, T4, T5, and T6.

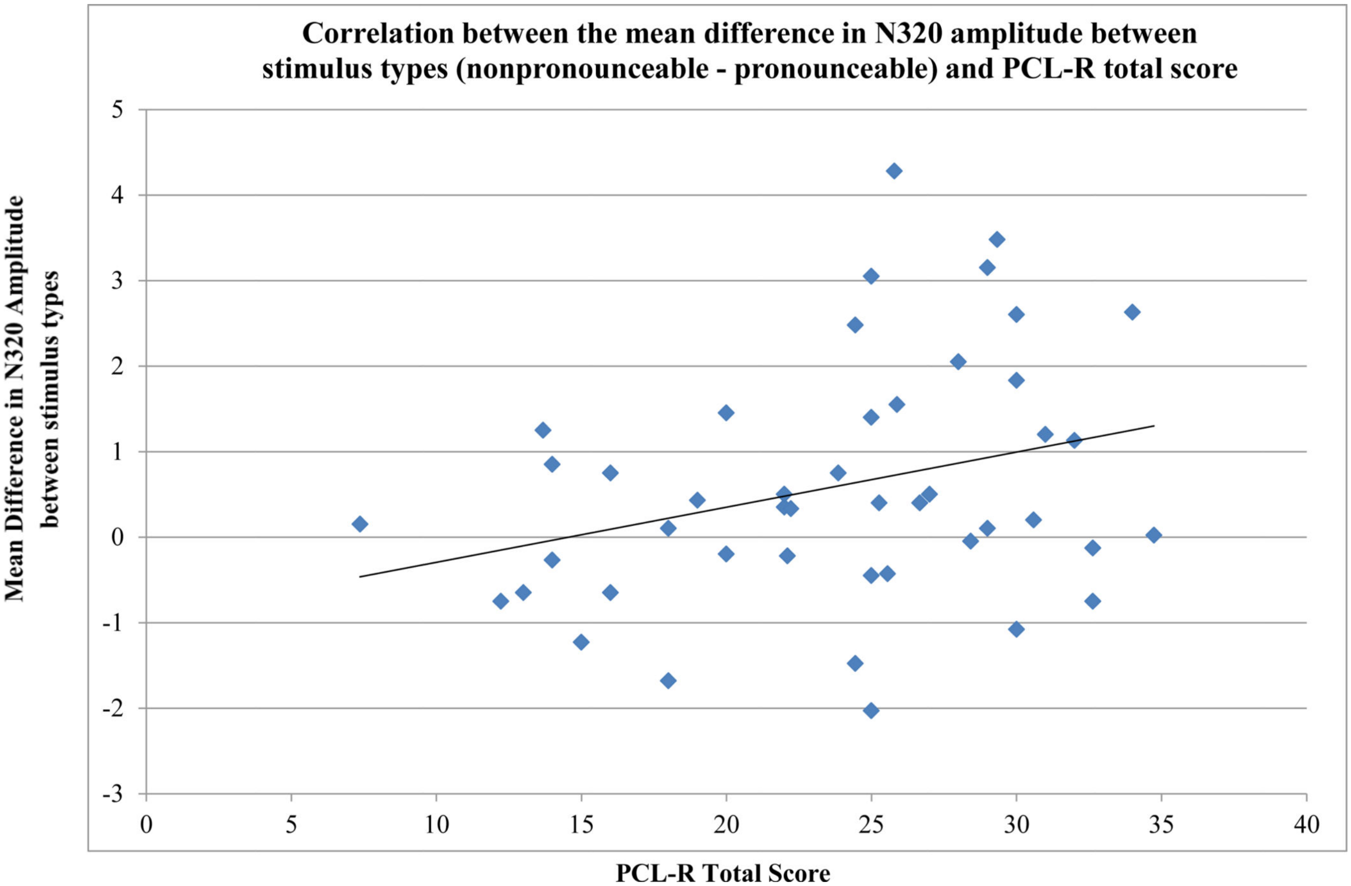

Figure 2.

Scatterplot illustrating the significant positive correlation ($r = .31$, $p = .04$) between the mean difference in N320 amplitude between stimulus types (i.e., nonpronounceable vs. pronounceable) across all electrodes and total PCL-R score. As PCL-R total scores increase, the difference in N320 amplitude between nonpronounceable and pronounceable stimuli increases.

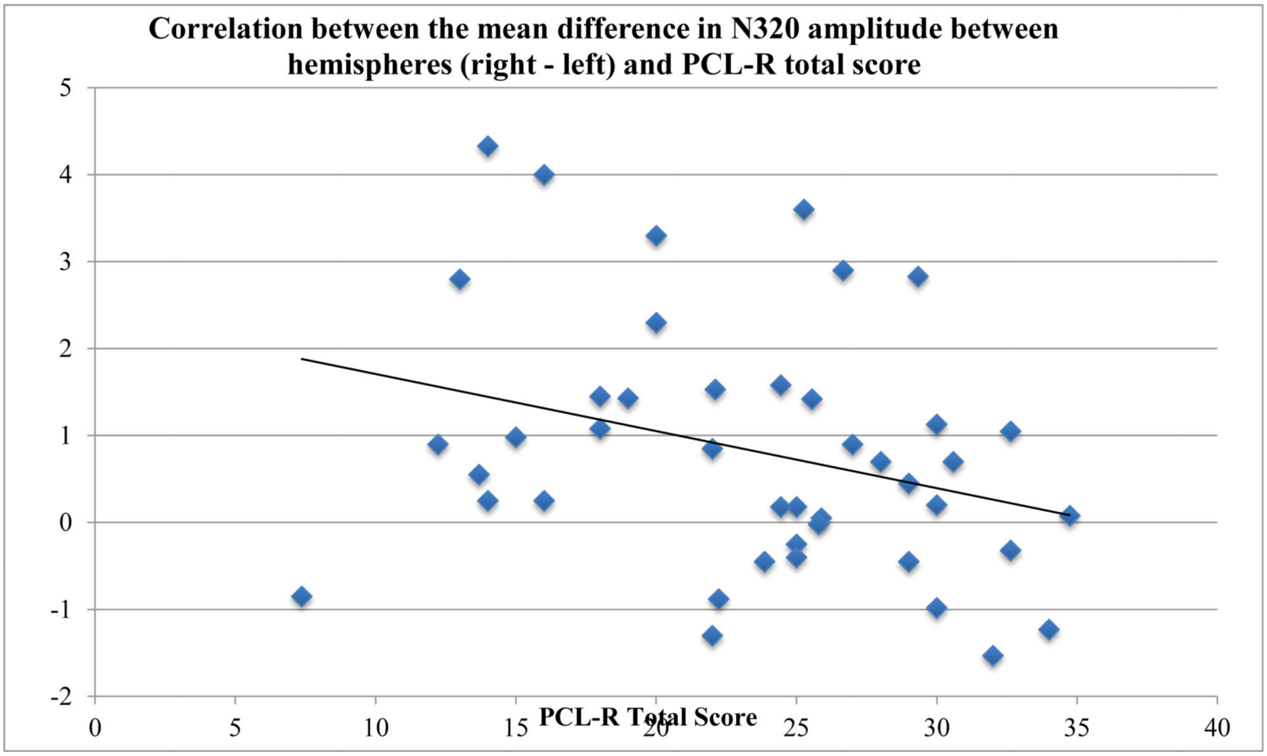

Figure 3.

Scatterplot illustrating the negative correlation ($r = -.31$, $p = .05$) between the mean difference in N320 amplitude between hemispheres (i.e., right and left) across all electrodes and total PCL-R score. As PCL-R total scores increase, the difference in N320 amplitude between left and right hemispheres decreases.

Table 1:

Descriptive statistics and frequencies of demographic data.

	N	**Range**	**Mean ± SD**
Age	43	18 – 42 years	25.60 ± 6.31
Estimated Full-Scale Intelligence Quotient	43	70 – 108	91.16 ± 10.20
Psychopathy Checklist-Revised Total Score	43	7.37 – 34.74	23.50 ± 6.71
Ethnic / Racial Group	*N*	Percentage	Cumulative Percentage*
Caucasian	18	42.9	42.9
African American	20	47.6	90.5
Latino	2	4.8	95.3
Other	2	4.8	100.0

Table 2.

Effects of stimulus pronounceability, hemisphere, electrode site (anterior vs. posterior temporal site) and psychopathy on mean N320 amplitude.

Main Effects	df	F	p	$\eta_{partial}^2$
Intercept	(1, 40.85)	1.00	.324	
Stimulus type	(1,40.80)	2.06	.159	.05
Hemisphere **	(1,41.16)	11.64	.001	.22
Electrode site	(1,41.07)	2.36	.132	.05
Psychopathy	(1,40)	.21	.650	<.01
Two-way Interactions				
Stimulus type X Electrode site **	(1,41)	7.41	.009	.15
Hemisphere X Electrode site *	(1,41)	2.83	.100	.06
Stimulus type X Hemisphere **	(1,41)	13.68	.001	.25
Stimulus type X Psychopathy *	(1,40)	5.15	.029	.11
Hemisphere X Psychopathy *	(1,40)	5.78	.021	.13
Electrode site X Psychopathy	(1,40)	.21	.649	<.01

*Note. The initial analysis included four three-way interactions and one four-way interaction. None of these higher-order interactions approached significance (all F*s < 1). These interactions were trimmed before the final model was examined.

*Significant at the p < .05 value.

**Significant at the p < .01 value.