Behavioural and Neural Correlates of Emotion Recognition as a Function of Psychopathic Personality Traits

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Abstract

Psychopathy is associated with well-known characteristics such as a lack of empathy and impulsive behaviour, but it has also been associated with impaired recognition of emotional facial expressions. The use of event-related potentials (ERPs) to examine this phenomenon could shed light on the specific time course and neural activation associated with emotion recognition processes as they relate to psychopathic traits. In the current study we examined the P1, N170, and vertex positive potential (VPP) ERP components and behavioural performance with respect to scores on the Self-Report Psychopathy (SRP-III) questionnaire. Thirty undergraduates completed two tasks, the first of which required the recognition and categorization of affective face stimuli under varying presentation conditions. Happy, angry or fearful faces were presented under with attention directed to the mouth, nose or eye region and varied stimulus exposure duration (30, 75, or 150 ms). We found that behavioural performance to be unrelated to psychopathic personality traits in all conditions, but there was a trend for the N170 to peak later in response to fearful and happy facial expressions for individuals high in psychopathic traits. However, the amplitude of the VPP was significantly negatively associated with psychopathic traits, but only in response to stimuli presented under a nose-level fixation. Finally, psychopathic traits were found to be associated with longer N170 latencies in response to stimuli presented under the 30 ms exposure duration.

In the second task, participants were required to inhibit processing of irrelevant affective and scrambled face distractors while categorizing unrelated word stimuli as living or nonliving. Psychopathic traits were hypothesized to be positively associated with behavioural performance, as it was proposed that individuals high in psychopathic traits would be less likely to automatically attend to task-irrelevant affective distractors, facilitating word categorization. Thus, decreased interference would be reflected in smaller N170 components, indicating less neural activity associated with processing of distractor faces. We found that overall performance decreased in the presence of angry and fearful distractor faces as psychopathic traits increased. In addition, the amplitude of the N170 decreased and the latency increased in response to affective distractor faces for individuals with higher levels of psychopathic traits.

Although we failed to find the predicted behavioural deficit in emotion recognition in Task 1 and facilitation effect in Task 2, the findings of increased N170 and VPP latencies in response to emotional faces are consistent with the proposition that abnormal emotion recognition processes may in fact be inherent to psychopathy as a continuous personality trait.

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Introduction

Psychopathy, as a disorder of personality, is characterized by interpersonal and affective traits such as glibness and superficial charm, a grandiose sense of self-worth, pathological lying, conning and manipulative behaviour, a lack of remorse and guilt, shallow affect, callousness and a lack of empathy (Blair, Mitchell, and Blair, 2005). It has been proposed (Blair et al., 2005, Blair 2008a) that the abnormal behavioural and emotional traits observed in psychopathic individuals are the result of dysfunction or deformation of the amygdala, which has been implicated in fear-based learning, generating physiological (i.e., autonomic, endocrine) responses to emotional states, and perception of the affective significance of emotional facial expressions (Nieuwenhuys, Voogd & Van Huijzen, 2008). Blair and colleagues have further proposed that the amygdala functions atypically (Blair, Morris, Frith, Perrett & Dolan, 1999; Blair, 2001) from an early age as the result of some genetic predisposition (Blonigen, Carlson, Krueger & Patrick, 2003; Viding, Blair, Moffitt & Plomin, 2005), and that these functional abnormalities lead to impaired emotional learning. They argue that this impaired emotional learning results in the emotional and behavioural manifestations that are commonly used to diagnose psychopathy (i.e., the Psychopathy Checklist (PCL-R); Hare, 1991, 2003), as well as observed impairments in passive avoidance learning (Arnett, Howland, Smith & Newman, 1993; Blair, Mitchell, Leonard, Budhani, Peschardt & Newman, 2004a; Newman & Kosson, 1986; Newman, Patterson, Howland & Nichols, 1990) and the recognition of fearful expressions (Dolan & Fullam, 2006; Fullam & Dolan, 2006; Kosson, Suchy, Mayer & Libby, 2002; Blair et al., 2004b; Hastings, Tangney & Stuewig, 2008).

Behavioural Correlates of Emotion Recognition in Psychopathy

In line with these findings, many researchers have also reported significantly impaired emotion recognition performance by a variety of populations with a range of psychopathic traits. For example, incarcerated psychopaths have been shown to be significantly less accurate at identifying fearful, and to a lesser degree, sad faces when compared to controls during both static (Dolan & Fullam, 2006; Fullam & Dolan, 2006; Kosson et al., 2002) and graded emotion recognition tasks (Blair et al., 2004b; Hastings et al., 2008). Similar effects of impaired fear recognition have been observed in both children and adolescents evidencing the psychopathic tendencies of callousness and reduced emotionality (Blair, Colledge, Murray & Mitchell, 2001; Stevens, Charman & Blair, 2001), providing further support for the developmental nature of psychopathy and its related deficits. Finally, researchers have recently been able to demonstrate these emotion recognition deficits in subclinical, non-incarcerated adults and adolescents identified as being high in psychopathic personality traits (Dadds et al., 2006; Dadds, El Masry, Wimalaweera & Guastella, 2008). The robustness of such findings and their replication across multiple populations suggest that abnormalities in the recognition of affective facial expressions may be fundamentally associated with psychopathic personality traits, even at subclinical levels. This, again, is consistent with the amygdala dysfunction hypothesis regarding the etiology of psychopathy.

Marsh, Kozak and Ambady (2007) examined this effect from an alternative perspective by looking at the relationship between fearful expression recognition and prosocial behaviour. Across three separate studies the researchers observed that the ability to recognize fear was related to participants' willingness to engage in prosocial behaviours, such as donating money. Furthermore, Marsh et al. showed that fear recognition was a better predictor of prosocial behaviour than gender, mood state, or self-report empathy scores.

Neural Correlates of Emotion Recognition in Psychopathy

Consistent with the suggestion that amygdala dysfunction may be at the root of emotion recognition deficits in psychopathy, Gordon, Baird and End (2004) observed that undergraduate students high in psychopathic personality traits show significantly less activation in the amygdala and medial prefrontal cortex during an emotion recognition task when compared to controls low in psychopathic traits. Similarly, in a sample of institutionalized schizophrenic patients high in psychopathic traits, Dolan and Fullam (2009) reported findings of reduced BOLD signal changes in the amygdala in response to fearful facial expressions. Fullam and Dolan (2006) also showed that individuals with a co-morbid diagnosis of psychopathy and schizophrenia present with similar deficits in emotion recognition as non-schizophrenic psychopathic populations. As well, Marsh et al. (2008) reported that children and adolescents high in callous-unemotional traits showed reduced connectivity between the amygdala and the ventromedial prefrontal cortex, a region implicated in emotion regulation, reinforcement based learning and decision making (Blair, 2008b). Moreover, the degree to which connectivity was reduced was negatively related to the severity of callous-unemotional symptoms.

Evidence of abnormal emotion recognition in psychopathic individuals has also been found in regions of the brain identified as being selectively responsive to faces. Deeley et al. (2006) used an implicit emotion recognition task to test a group of psychopathic inmates and found that compared to controls, psychopathic participants showed significantly decreased activity in the fusiform gyrus in response to fearful faces. Interestingly, in response to happy facial expressions psychopathic participants showed patterns of activity comparable to those of control subjects. The results of this study are particularly informative because the fusiform gyrus has been shown to have extensive reciprocal connections with the amygdala (Nieuwenhuys et al., 2008). Recent research has demonstrated that facilitation of spatial attention by masked fearful faces is achieved through these connections, as well as connections with the anterior cingulate cortex (ACC; Carlson & Reinke, 2010; Carlson, Reinke & Habib, 2009).

As the previously described research indicates, the observed emotion recognition deficits in psychopathic populations appear to be specific to negative affective expressions (Blair et al., 2001; Dolan & Fullam, 2006; Fullam & Dolan, 2006; Hastings et al., 2008; Kosson et al., 2002; Stevens et al. 2001), with a particular deficit for fearful expressions (Blair et al., 2001; Blair et al., 2004b; Dadds et al., 2006; Dadds et al., 2008; Munro, Dywan, Harris, McKee, Unsal & Segalowitz, 2007; Stevens et al. 2001). Marsh and Blair (2008) confirmed the selective nature of this deficit in a meta-analysis of twenty studies of affect recognition in antisocial populations, including psychopaths. The authors report that deficits associated with recognizing expressions of fear were significantly greater than any observed deficits for any other affective expression, suggesting that specific deficits in the neurocognitive mechanisms underlying the processing and recognition of fearful expressions may be similarly associated with antisocial behaviour. Past research has shown that damage, dysfunction or abnormalities in the amygdala often result in impaired fear recognition abilities (Adolphs, Gosselin, Buchanan, Tranel, Schyns, & Damasio, 2005; Brierly, Medford, Shaw & David, 2004;

Kemmis, Hall, Kingston & Morgan, 2007; Lawrence, Kuntsi, Coleman, Campbell & Skuse, 2003).

The Current Study

The goal for this thesis was to propose and test a potential mechanism of dysfunction by which emotion recognition deficits in psychopathy may be explained. Specifically, it was hypothesized that these deficits may be, in part, accounted for by an absence of rapid, automated affective processing in individuals high in psychopathic personality traits that may be attributed to dysfunction of the amygdala, which in turn results in dysfunction of the subcortical (non-geniculostriate) thalamic visual pathway, as described by LeDoux (2000) and Schuenke, Schulte and Schumacher (2007). This subcortical pathway allows for rapid transmission of relevant emotional information through the lateral nucleus of the amygdala, directly from the posterior regions of the thalamus (i.e., pulvinar; Morris, DeGelder, Weiskrantz & Dolan, 2001; Morris, Öhman & Dolan, 1999; Schuenke et al., 2007) to the appropriate sensory and associative areas of the neocortex (Figure 1). In turn, the amygdala projects low-level, affective information to the sensory and associative cortices, effectively influencing the evaluation and response to the incoming stimuli at the cortical level. Similarly, information processed through the slower cortical pathway then feeds back to the amygdala for further, more detailed evaluation.

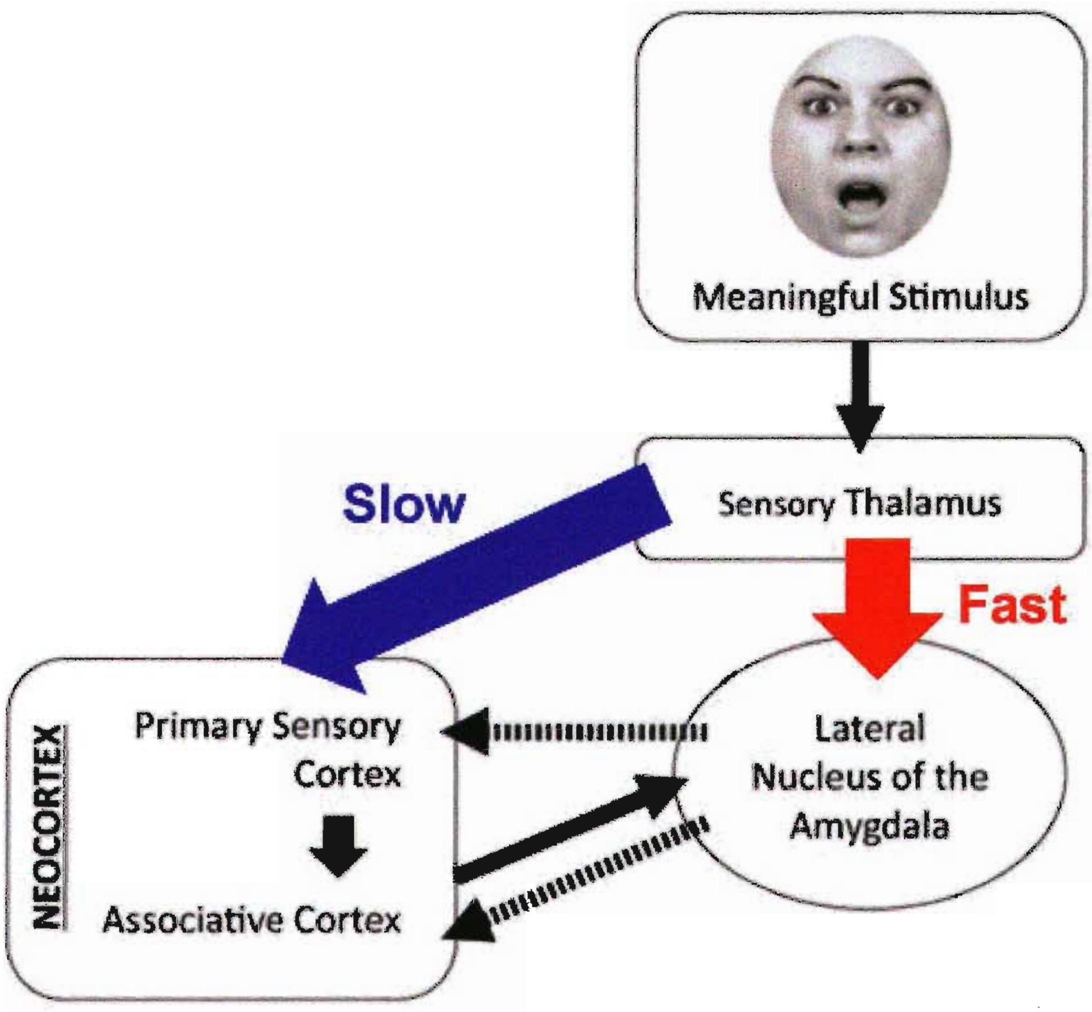

Figure 1. Model of the rapid subcortical thalamic "fast path" through the amygdala, compared to slower cortical pathway.

In the case of psychopathy, there are several possible means of dysfunction in this "fast path" transmission, such as abnormal development of specific nuclei in the amygdala that are responsible for the transmission of affective information. For example, in a recent study, Yang, Raine, Narr, Colletti and Toga (2009) used structural magnetic resonance imaging (MRI) to look for physical abnormalities in both the entire amygdala structure as well as in specific nuclei of the amygdala in individuals high in psychopathic traits. Similar to the previously described findings, these researchers observed a bilateral reduction in overall amygdala volume (17% reduction in left amygdala, 19% reduction in right amygdala). Of particular importance, surface deformations were found in the lateral nucleus of the amygdala, the first nucleus to receive initial input from the sensory thalamus, which then projects to other nuclei of the amygdala (Carlson, 2007). Deformations were also observed in the basolateral, central and cortical nuclei of the amygdala. Finally, Yang et al. observed that psychopathy scores, especially affective and interpersonal subscale scores, were positively related to the amount of volume reduction in the amygdala, suggesting a direct relationship between the magnitude of deformation in the amygdala and severity of psychopathic traits.

Testing a rapid and automated process such as emotion recognition is well suited to the use of electroencephalography (EEG) or, more specifically, event-related potentials (ERPs). Although this methodology does not allow for the direct imaging of subcortical structures such as the amygdala, it does have excellent temporal resolution, which will allow us to examine rapid emotion recognition processes on the scale of milliseconds. As such, the current study was focused on three specific ERP components known to be responsive to face stimuli, specifically, the P1, N170 and vertex positive potential (VPP). To date these components have not been used to examine the emotion recognition process in psychopathic populations.

P1. The P1 (or P100) component is a positive voltage change peaking at approximately 100 ms after stimulus onset, and is largest over occipital sites. The P1 has been identified as a marker of selective attention to relevant stimuli and general arousal (Luck, 2005). Additionally, the P1 has been shown to be modulated by face stimuli (Mercure, Dick & Johnson, 2008; Taylor, 2002) and has been used as a marker of early visual impairment in schizophrenic patients in response to facial expressions of emotion (Caharel et al., 2007). This line of research is of particular interest because we can draw tentative conclusions based on these findings as to whether individuals high in psychopathic traits show early global deficits in visual processing or, as the literature has suggested, whether they show later (i.e., N170), more specific deficits in emotion recognition.

N170 and VPP. The N170 is a negative going potential that peaks at approximately 170 ms after stimulus exposure and is maximal over lateral occipitotemporal sites, with slightly larger voltage changes occurring at right hemisphere sites (Rossion, Delvenne, Debatisse, Goffaux, Bruyer, Crommelinck, & Guérit, 1999). Similarly, the VPP is a positive-going potential that occurs at approximately the same time as the N170 at frontocentral sites. The N170 and VPP are thought to represent opposite ends of a dipole created by neural generators located in the fusiform gyri (FFG; Shibata, Nishijo, Tamura, Miyamoto, Eifuku, Endo & Ono, 2002; Sprengelmeyer & Jentzsch, 2006) and/or superior temporal sulcus regions (STS; Itier & Taylor, 2004). As such, the two components often behave similarly. Both components have been shown to be selectively responsive to face stimuli, such that faces elicit significantly larger voltage changes than other stimulus categories (e.g., houses, cars, hands, etc; Bentin, Allison, Puce, Perez & McCarthy, 1996; Luck, 2005; Key, Dove & Maguire, 2005).

The sensitivity of the N170 component to emotional stimuli has been debated in the literature, with some researchers reporting no evidence of modulation as a function of affective stimulus content (e.g., Balconi & Lucchiari, 2005). Conversely, work by Batty and Taylor (2003) showed an increase in N170 amplitude in response to fearful faces, as well as earlier latencies in response to positive versus negative expressions. Similarly, intensity of emotional expression has been found to similarly modulate the amplitude of the N170 component (Sprengelmeyer & Jentzsch, 2006; Utama, Takemoto, Koike & Nakamura, 2009).

Both the N170 and VPP were ideal components for study in the current thesis, because of their sensitivity to face stimuli, and their proposed neural generators. Previously described research by Carlson and Reinke (2010) also found that backward masked fearful faces presented in the right visual field (RVF) elicited enhanced N170 components in the contralateral hemisphere, suggesting that spatial attention modulates the amplitude of the N170. Taken in context with Carlson et al.'s (2009) finding that facilitation of spatial attention by masked fearful faces is mediated by the amygdala, visual cortex and ACC, it is possible that the increase in N170 amplitude may reflect increased engagement of this attentional network. Similarly, Deeley et al. (2006) identified abnormal BOLD responses to fearful faces in the fusiform face areas of incarcerated psychopaths. In light of the previously described research the N170, and possibly VPP, may be useful markers for identifying abnormal neural responses to emotional faces (including fear) in participants high in psychopathic traits.

Task 1: Emotion Recognition Deficits as a By-Product of Abnormal Attention Allocation

If individuals high in psychopathic personality traits do in fact process emotional facial expressions differently from controls, it may, in turn, be expected that they would produce N170 components that are significantly different from those of individuals who are low in psychopathic personality traits. Schyns, Petro and Smith (2007) have recently conducted an in-depth examination of the information processing characteristics of the N170 component in response to several facial expressions. In doing so, these researchers have effectively provided a prototype of what the N170 waveform might be expected to look like in a normative sample; based on the specific emotional expression they are viewing.

Utilizing the "Bubble Technique" described by Gosselin and Schyns (2001) to expose participants to random visual samples of emotional face stimuli, Schyns et al. (2007) observed that healthy individuals show a uniform pattern of attention allocation, or "scanning", when viewing emotional facial expressions. This pattern of attention allocation begins at the eye region and moves down the face until appropriate diagnostic information for the specific emotional expression being viewed has been acquired. Schyns et al. further elaborated on their behavioural findings by concurrently examining the morphological characteristics of the N170 in response to different emotional facial expressions. In addition, Schyns et al. observed that the "eyes-down" attentional allocation pattern of information acquisition correlated with the morphology of the N170, such that the N170 reached its peak amplitude at approximately the same time that the diagnostic information necessary for emotion recognition was integrated. For example, when processing a fearful facial expression, the key diagnostic information for identifying the expression as one of fear lies in the wide-open eyes; therefore, processing of this emotion can stop once the information from the eyes has been integrated, at which point the N170 component will reach its peak amplitude. On the other hand, the diagnostic information for identifying a happy facial expression lies in the upturned corners of the mouth, which take longer to reach based on the "eyes-down" attentional allocation pattern described by Schyns et al. This in turn leads to longer N170 latencies for happy expressions compared to fearful expressions. Similar patterns were also observed for expressions of disgust, such that they resulted in longer N170 latencies than those for fearful facial expressions, but shorter latencies than those for happy facial expressions, as the key diagnostic information for disgust lies in the wrinkled nose, which falls below the eyes (diagnostic of fearful expressions), but above the mouth (diagnostic of happy expressions).

Effect of Emotional Expression

Hypotheses. One of the primary goals of the current thesis was to replicate the previously described findings of Schyns et al. (2007). As such, it was expected that fearful expression would elicit earlier N170 latencies compared to happy facial expressions. Similarly, it was hypothesized that angry expressions would elicit N170 components with latencies that fall somewhere between those elicited by fearful and happy distractors faces, as the key diagnostic information for anger is often distributed between the eye and mouth regions (Adolphs et al., 2005).

Similarly, based on Schyns et al.'s (2007) identification of the eyes as the initial focus for the processing of emotional expressions, it was proposed that part of the dysfunction in emotional processing observed in psychopaths might be due to abnormal attention allocation during visual scanning of facial stimuli. This, in turn, would result in a failure to direct the individual's attention to the eye region when identifying an emotional expression. Specifically, it was hypothesized that psychopathic personality traits would be positively related to the latency of the N170 component, reflecting the fact that individuals high in psychopathic traits take longer to acquire key diagnostic information relevant for emotion recognition due to abnormal attentional scanning of the face. Consistent with this hypothesis, previous research has shown that expressions of fear are particularly difficult for psychopathic subjects to identify because, as described earlier, the key diagnostic information for fearful expressions lays in the eyes. In light of these previous findings, it was further expected that psychopathic personality traits will be negatively associated with recognition accuracy and positively associated with response times for fearful, but not angry or happy facial expressions.

In line with these hypotheses, a series of studies by Dadds and colleagues (Dadds et al., 2006; 2008) have shown that children with psychopathic tendencies pay significantly less attention to the eye region when viewing emotional faces and are subsequently less accurate on emotion identification tasks when compared to controls. Particularly relevant is Dadds et al.'s finding that when these children were directed to pay specific attention to the eye region during emotion identification their accuracy improved to levels comparable to controls. These findings suggest that at least part of the observed emotion recognition deficit can be explained by a lack of attention to the eye region when evaluating emotional expressions. The findings of Dadds et al. are also consistent with the research of Richell, Mitchell, Newman, Leonard, Baron-Cohen and

Blair (2003), which showed that psychopaths performed as well as controls when asked to complete the "Reading the Mind in the Eyes" Theory of Mind Test (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). This task requires participants to identify the mental state of an individual based solely on information from a photograph of their eye region alone.

Also consistent with the current hypotheses, reduced attention to the eye region (Adolphs et al., 2005) and impaired emotion recognition (Adolphs, Tranel, Damasio, & Damasio, 1994; Broks et al., 1998; Calder, Young, Rowland, Perrett, Hodges, & Etcoff, 1996) have been observed in patients with amygdala damage. These findings are also in line with the Blair et al.'s (2005) neurocognitive hypothesis of psychopathy, as discussed previously (Blair et al., 2005; Blair, 2008a, Blair, 2008b; Raine, 2008, Weber, Habel, Amunts, & Schneider, 2008).

Manipulation of Attention Allocation

To further test the hypothesis that emotion recognition deficits in psychopathy may be the result of a failure to attend to the eye region, a manipulation of the location of pre-stimulus fixation in the presentation space was used in response to the results of Schyns et al. (2007). Specifically, a fixation cross was shifted vertically in the presentation area so as to vary the region of the face that fell under the fixation during stimulus presentation. For example, the fixation cross was located such that the eyes, nose, or mouth fell directly under the area identified by the fixation point. As such, the proposed task consisted of three different fixation conditions: a central-fixation (nose) condition, an eye-fixation condition, and a mouth-fixation condition. Fixation was randomized throughout the task to prevent participants from learning to shift their attention to fixate on a specific region, regardless of fixation manipulation.

Effect of fixation hypotheses. Based on the Schyns et al. (2007) findings it was hypothesized that directed fixation to the mouth region would slow emotion processing in participants, especially for fearful expressions, which would be reflected in decreased accuracy and longer response times during emotion categorization and an increase in the latency of the corresponding N170 peak. It was proposed that this may occur due to the fact that directing attention away from the eye region should effectively disrupt the "eyes down" attentional allocation pattern identified by Schyns et al. Alternatively, it was expected that fixation to areas other than the eyes will speed processing and decrease the latency of the N170 peak in response to emotions that have key diagnostic information associated with that area, such as a mouth fixation over a happy facial expression. In this case, although the "eyes-down" attention allocation pattern is disrupted, the individual's attention will be drawn to the area most relevant to identifying the emotion in question, thereby eliminating the need for attentional scanning to search for such information.

Following this line of reasoning, if individuals high in psychopathic traits are failing to attend to the eyes when evaluating emotional expressions, as is currently proposed, it may be possible to predict the characteristics of their N170 component compared to normative controls based on the Schyns et al. (2007) findings. For example, psychopathic traits are expected to be positively related to the latency of the N170, especially in response to fearful faces, as lack of attention to the eye region will lead to longer attentional scan times before enough diagnostic information can be integrated to reach an identification decision. It was also proposed that the deficits in the subcortical pathway to the amygdala may account for, at least in part, the proposed abnormal attention allocation patterns and lack of attention to the eye region, such that psychopathic individuals fail to acquire key diagnostic information quickly enough to inform the rapid processing that is conducted through this pathway in normative subjects.

The findings of Dadds et al. (2006; 2008) suggest that directing attention to the eye region may improve fearful expression recognition in individuals high in psychopathic traits. Based on these observations, it was hypothesized that the latency of the N170 would not be significantly affected in response to emotional expressions during the eye-fixation condition for individuals high in psychopathic tendencies. Similarly, it was hypothesized that the latency of the N170 would not be related to psychopathic traits in the mouth fixation condition, as it was expected that processing would be impaired for individuals low in psychopathic traits as well in this condition. Specifically, it was hypothesized that, in response to fearful facial expressions, psychopathic individuals would produce N170 components that take significantly longer to peak in the central fixation condition, reflecting a slower process of integrating key information necessary for identifying fearful expressions.

Manipulation of Stimulus Exposure Duration

Contrary to the previously described research showing emotion recognition deficits in psychopathic participants, some researchers have observed that psychopaths can recognize emotional expressions as well as normative controls. Specifically, it has been shown that psychopathic participants can perform as well, or better, than nonpsychopathic participants when asked to categorize and rate the intensity of emotional facial expressions (Book, Quinsey & Langford, 2007), to identify affective expressions (Day & Wong, 1996), and to locate a target expression among several affective expressions (Glass & Newman, 2006). Instead of interpreting the absence of a significant difference in performance between psychopaths and controls as evidence that no deficit exists, Glass and Newman have suggested that there may be specific task conditions under which psychopathic individuals will perform poorly. The authors recommend that the conditions that effectively reveal these emotional deficits in psychopaths require further exploration and specification if the underlying mechanisms of dysfunction are to be understood.

In the current thesis an attempt was made to address this issue and to propose task conditions that exacerbate the emotion recognition deficits present in psychopathy. A recent study conducted by Munro et al. (2007) used an affective flanker task to examine the electrophysiological correlates of error monitoring in psychopaths. Prior to testing, participants were presented with the emotional expressions to be used in the proceeding flanker task, to ensure that participants could correctly identify them. This pre-testing phase revealed that, when given unlimited time to respond, psychopaths were able to accurately identify both fearful and angry facial expressions at levels comparable to a non-incarcerated, nonpsychopathic control group. However, when asked to identify those same stimuli during the speeded response flanker task, the psychopathic group committed significantly more errors specific to fearful expressions when compared to controls. The findings of Book et al. (2007), as well as the observations of Munro et al., have led to the hypothesis that emotion recognition deficits may be exacerbated when psychopaths are required to recognize emotional stimuli under short exposure durations. In light of these findings, we examined the possibility that, when given enough time, individuals high in psychopathic traits are able to recruit top-down, cognitive resources to accurately identify affective stimuli, but may lack the rapid, automated processing of emotional information that is seen in normative samples, and facilitated by the previously described subcortical thalamic pathway to the amygdala.

Effect of exposure duration hypotheses. Previous research has shown that healthy individuals are able to identify fearful facial expressions at better than chance levels even at brief presentation durations (i.e., 33 ms; Eimer, Kiss & Holmes, 2008; Pessoa, Japee & Ungerleider, 2005). It has been proposed (Ledoux, 2000; Liddell, Williams, Rathjen, Shevrin, & Gordon, 2004) that these individuals are able to perform at better than chance levels because of the amygdala-thalamus subcortical pathway, which facilitates processing of affectively salient information necessary to classify emotional expressions. Thus, it was expected that participants low in psychopathic traits would perform at better than chance levels during this task, even at short exposure durations, as reported in previous studies employing a backward masking technique. Contrasting with this, it was hypothesized that participants high in psychopathic personality traits would show decreased accuracy and increased response times during emotion categorization in the short exposure condition (i.e., 30 ms exposure duration) due to abnormalities in this "fast path" to the amygdala. On the other hand, it was expected that individuals high in psychopathic traits would perform as well as controls during long exposure durations (i.e., the 75 and 150 ms exposure durations), as observed in previous studies (Book et al., 2007; Day & Wong, 1996). In addition, it was proposed that psychopathic traits would be positively associated with the latency of both the N170 and VPP for all face stimuli, as previously hypothesized. It was further expected that this relationship would be particularly evident in the 30 ms duration condition, as individuals high in psychopathic traits should have increased difficultly acquiring the important information necessary for recognition emotional expressions due to the previously described abnormal attention allocation patterns.

Methods

Participants

The original sample of participants consisted of 31 undergraduate students (17 males, 14 females) from Brock University, with a mean age of 20.9 years (SD = 2.4 years) and included twenty-seven right-handed (87%) and four left-handed participants (13%).

Participants were recruited from two university student populations. Initially, seven undergraduate females selected from an existing pool of undergraduate students at Brock University who had previously completed a screening questionnaire package for an unrelated study. Participants were selected based on the previously measured personality trait of Machiavellianism, as scores on the Mach-IV scale (Christie & Geis, 1970) have been shown to be reliable measure of global psychopathy in nonclinical populations (McHoskey, Worzel, & Szyarto, 1998).

To obtain the pool of potential participants used for recruitment the initial pool of 116 prescreened females was divided into three groups based on Mach-IV scores (42 high, 33 moderate, and 41 low Machiavels). Potential participants were then contacted by the researcher, provided with details regarding the current study and invited to participate. Individuals indicating interest were then recontacted by the researcher and administered a short neuropsychological screening questionnaire to determine if they were eligible to participate (Appendix A). Exclusion criteria for the current study included existing neurological or psychiatric conditions, the use of medication that may be expected to affect neurological functioning, and a previous history of head injury, as these factors can affect electrophysiological and cognitive functioning. Individual testing sessions were then arranged with participants who met criteria for participation in the study. Individuals who did not meet screening criteria were thanked for their interest and advised of other on-going research studies in which they might potentially participate.

Recruitment for the current study was expanded from the original sampling pool for two reasons. The primary and more practical reason for expanding recruitment was because the original sampling pool was not yielding a sufficient number of participants. The second, theoretical motivation for expanding recruitment was due to the fact that research has suggested that psychopathic personality traits are more prevalent in males, compared to females (Blair et al., 2005). Thus, it was desirable to include male participants in the current study.

In response to the above-mentioned issues, an additional 17 male and 7 female undergraduate students were recruited using the Brock University Psychology department's online research pool. Potential participants signed up for individual testing sessions posted by the researcher using the online research administration system. Registered individuals were then contacted by the researcher and assessed according to the previously described eligibility criteria. The researcher then reconfirmed the testing session with participants meeting eligibility criteria. Again, individuals who did not meet criteria were thanked for their time, and advised of other opportunities for potential participation.

All participants had normal or corrected-to-normal vision and were free from disorders of the nervous system (e.g., epilepsy), language deficits (e.g., dyslexia), motor response difficulties, and psychiatric difficulties. Upon completion of the study participants were compensated with 2 hours of participation credit or a twenty-dollar monetary honorarium.

In the current sample, one female participant had incomplete EEG data due to a recording error; therefore, the final data set used for the present analyses is composed of the 30 remaining participants (17 males, 13 females).

Materials

Personality measures.

Self-Report Psychopathy Scale (SRP-III). The Self-Report Psychopathy scale (Paulhus, Hemphill & Hare, in press) is a 64-item paper and pencil measure that assesses subclinical levels of psychopathic personality traits in non-incarcerated, normative populations. The scale consists of four subscales, representing the recently identified four factor structure of psychopathy (Williams, Paulhus & Hare, 2007). These subscales include the interpersonal manipulation subscale (IPM), callous affect (CA), erratic lifestyle (ELS), and antisocial behaviour (ASB). Specifically, the IPM subscale assesses interpersonal traits such as grandiosity and deceitful behaviour and consists of items such as, "I can talk people into anything". Affective traits, such as a lack of empathy and remorse, are assessed by the CA subscale, which contains items such as, "I never feel guilty over hurting others". In addition, the ELS subscale contains items such as, "I've often done something dangerous just for the thrill of it," and is intended to assess traits like impulsivity and irresponsibility. Finally, the ASB subscale assesses traits such as poor behavioural control and general antisocial behaviour and includes items such as, "I have tricked someone into giving me money." Each subscale consists of sixteen items which are rated on a five-point Likert-type scale from "1" (disagree strongly) to "5" (agree strongly).

Twenty-one scale items, distributed across all four subscales, are reverse coded. All sixteen items from each subscale are summed to obtain scores for each of the four factors, ranging from 16 to 80, which can then be summed to obtain a total scale score, ranging from 64 to 320. Higher scores on the SRP-III reflect higher levels of psychopathic personality traits. The SRP-III has proven to be highly reliable measure, with recent reports of Cronbach's alphas of .81 (IPM), .81 (CA), .79 (ELS) and .85 (ASB) for each the subscales respectively, and an alpha of .88 for the overall scale (Paulhus et al., in press).

It should be noted that for the purposes of the current study, item 64 of the SRP-III, "I have violated my probation from prison" (ASB subscale) was not included in the administration of the questionnaire, as it is phrased in such a way that it assumes previous incarceration, which would not apply to the current sample. Thus, the total SRP-III scores in the current study have a potential range of 63-315, and the ASB subscale has a potential range of 15-75. Mean total and subscale scores, standard deviations and normality statistics for the current sample can be found in Table 1.

	Mean	*SD*	Normality	
			Skewness	Kurtosis
CA subscale	36.9	9.70	0.93	0.45
IPM subscale	39.9	12.36	0.37	-0.99
ELS subscale	46.4	10.91	0.31	-0.99
ASB subscale	29.9	12.34	0.94	0.17
SRP total	153.1	37.16	0.50	-0.77

Note: Skewness SE=0.427; kurtosis SE = 0.833

Table 1. Means, standard deviations and normality statistics for SRP-III total and subscale scores

Health screening questionnaire. A short health-screening questionnaire (Appendix B) was administered to participants by the researcher upon arrival at the testing session. Participants were asked whether they have in the past or continue to have issues with reading and number skills, attention and concentration, activity level, mood, or sleep. In addition, participants were asked to report on any recent major stress, surgery, and any other health concerns they may have. Finally, participants reported the number and type of any prescription and non-prescription medications they were currently taking, rated their average weekly intake of various stimulants (i.e., nicotine) and suppressants (i.e., alcohol), as well as their exercise and dietary habits.

Stimuli

Affective facial expression stimuli. Twenty emotional face stimuli consisting of twenty different models (8 male, 12 female), depicting one of four emotional expressions (angry, happy, fearful and neutral), were selected from a set of emotional facial expressions created by Gur et al. (2002). Using Adobe Photoshop CS graphic editing software, the selected images were converted from colour to grayscale format. Next, individuating characteristics (i.e., freckles, skin imperfections, etc.) were removed to ensure that the only identifying information available across individual stimuli was facial affect. Finally, an oval-shaped frame was place over the modified face stimuli in order to remove the external facial contour and hairline (Santamaria, 2003). The final stimuli were 225 pixels wide by 275 pixels high (Figure 2).

To ensure that the final stimuli were in fact expressing the intended emotions, five student volunteers were asked to individually rate each expression in the final stimuli set. Specifically, raters were asked to indicate on a 5-point Likert scale, from "1" (Not at all) to "5" (Very) the degree to which each stimulus looked happy, angry, neutral, and scared (Appendix C). Based on analysis of the stimulus ratings, one "angry" face stimulus was replaced, as average ratings did not meet the inclusion criteria of a mean of at least 3.5 in a single emotion category. In other words, ratings for the excluded image were distributed across the four emotion categories, indicating an ambiguous stimulus. A new angry expression was then rated by the same group of volunteers, and received satisfactory rating for inclusion in the current study, such that the final stimulus set used consisted of 5 angry, 5 happy, and 5 fearful.

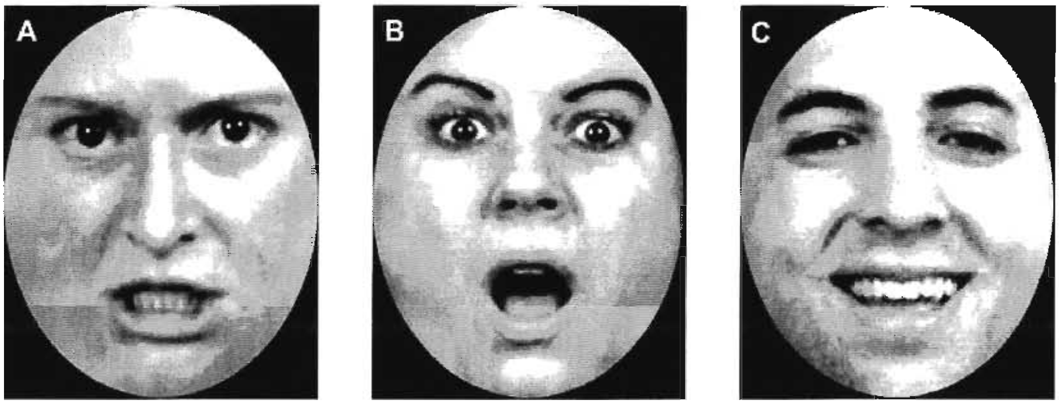

Figure 2. Examples of angry (A), fearful (B), and happy (C) facial expression stimuli.

Despite the fact that Schyns et al. (2007) included neutral facial expressions in their stimulus set we omitted this category from both tasks used in the current study in favour of reducing the length of time required to complete each task.

Car stimuli. Five front-end images of different cars were included in the emotion recognition task as a baseline condition. Specifically, like faces, cars possess an established first-order relation between their constituent parts (e.g., a windshield above a grill, which is between two headlights, etc.), meaning that they share basic structural similarities with faces, at a basic perceptual level. The car stimuli used in the current study were selected from an online photo archive (Figure 3). The selected car images were subject to the same modifications as the affective facial expression stimuli described above.

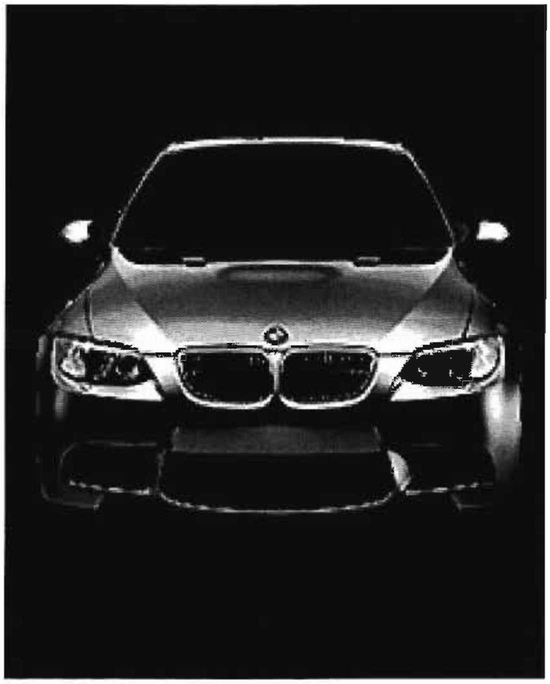

Figure 3. Example of car stimuli used in the emotion recognition task (Task 1).

Task

Masked emotion recognition task. A backward-masked emotion recognition task was designed for the dual purpose of assessing the rapid automatic processing of affective expressions that would be required for accurate identification at short presentation durations, as well as to replicate and extend the findings of Schyns et al. (2007) regarding the morphology of the N170 to different expressions of emotion.

At the beginning of each trial participants were presented with a central fixation cross for 500 ms, after which they were presented with an image of an emotional facial expression (happy, angry, fearful), or a front-view image of a car for a variable presentation duration ranging from subliminal (30 ms) to supraliminal (75 ms and 150 ms). Immediately after the target presentation, a white noise mask was presented for 150 ms to mask the initial target emotion, followed by a blank screen for a duration of 1200, 1275 or 1320 ms, contingent on the duration of the target presentation, such that each trial lasted for a total of 2000 ms (Figure 4). Participants had 1000 ms from the onset of the target stimuli in which to categorize the target as "fear" for fearful facial expressions or "not fear" for both angry and happy facial expressions, as well as car stimuli by pressing one of two correspondingly labeled buttons on a response box. The task took approximately 45 minutes to complete and consisted of 30 trials for each of the 36 conditions [Emotion (4) x Fixation (3) x Duration (3)], such that each participant completed 1,080 trials in total. In the current task, each individual stimulus (i.e., individual faces, car images) was presented a total of 54 times, such that each stimulus occurred nine times in each of the six permutations of the fixation and duration conditions.

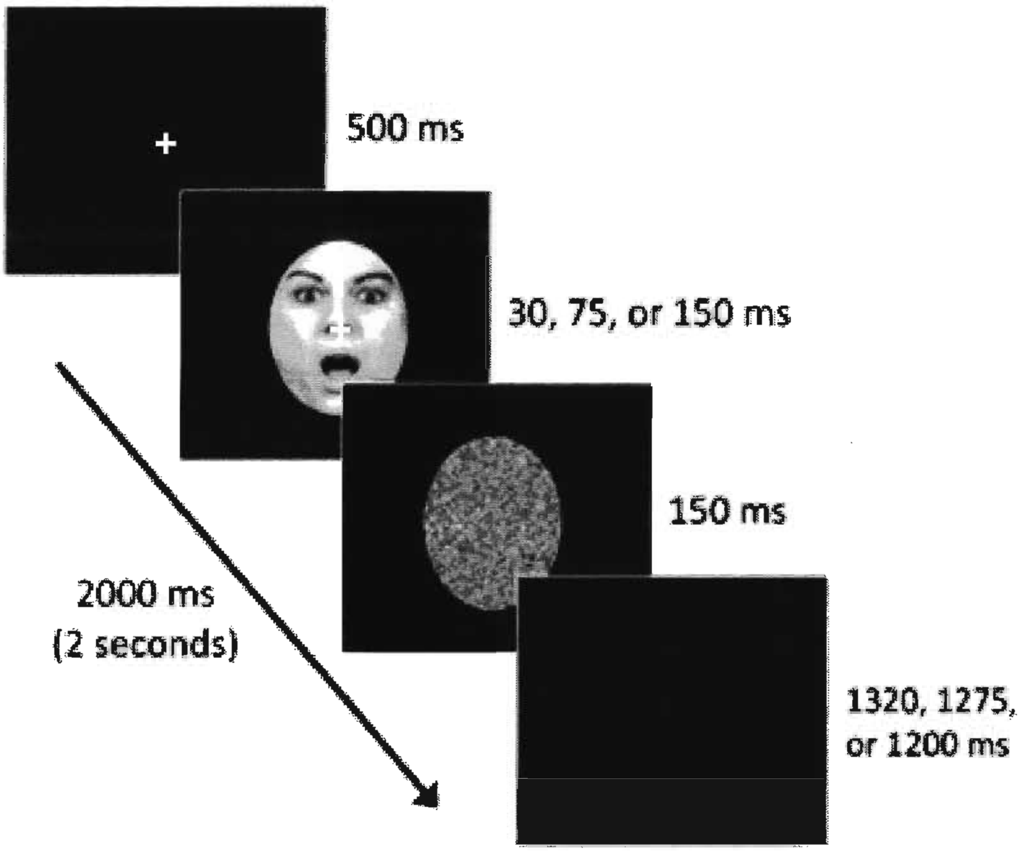

Figure 4. Example of single trial in masked emotion recognition task (Task 1).

Procedure

Upon arrival at the testing session, participants read and signed a consent form and were administered a short health-screening questionnaire. Once consent was obtained, participants were prepared for EEG acquisition.

Prior to beginning the previously described tasks, participants completed a short stimulus familiarization task in which they were exposed to the fifteen affective facial expressions used in the later tasks. Participants were required to identify each emotional face, as it appeared, as "happy, "angry", or "fearful". Response time to each stimulus was unlimited and self-paced, as face stimuli remained on the screen until the participant made a response. Each of the fifteen affective stimuli used in the current study were displayed once during the familiarization process.

Once participants were acquainted with the stimuli, participants completed the masked emotion recognition task, which took approximately 45 minutes to complete, followed by the affective interference task, which lasted approximately 15 minutes. Task order was not counterbalanced in the current study, so all participants performed the tasks in this order.

Upon completion of the previously described EEG tasks, the electrode net was removed and participants were allowed to wash and dry their hair if they wished. Afterwards, participants completed a paper-and-pencil personality questionnaire package containing the SRP-III, as well as several other exploratory personality measures that were not examined in the current study. When participants had completed the questionnaire package they were debriefed as to the purpose of the current study, assigned course participation credit or paid the $20 honorarium, and thanked for their participation.

All procedures used in the current study received clearance from the Brock University Research Ethics Board (File # 09-106).

EEG Data Acquisition and Processing

Continuous EEG data were collected using a 128-channel HydroCel Geodesic Sensor Net (Electrical Geodesics, Inc., Eugene, Oregon). All electrodes were online referenced to the vertex (Cz) and recorded data were amplified using a Net Amps 200 amplifier (Electrical Geodesics, Inc., Eugene, Oregon) with a band-pass filter of 0.01 to

100 Hz. EEG data were sampled at 500 Hz per second and impedances were kept below 50 kΩ. Ocular movements were monitored by electrodes placed below and on the outer corners of each eye.

The continuous EEG data were divided into segments beginning 200 ms prior to stimulus onset and ending 1000 ms after stimulus onset. Data were filtered offline at 1 to 30 Hz and re-referenced to the average reference. An automated Gratton & Coles ocular correction (Gratton, Coles & Donchin, 1983) was performed on the data to correct trials containing eye artifacts. Additionally, the data were further inspected for movement artifacts and contaminated segments, which were removed from future analyses. The remaining segments were then averaged together within each condition to obtain ERP waveforms.

Grand averages were computed for each condition in both tasks, which were then imported into Brain Electrical Source Analysis (BESA) software. Scalp topographies of the voltage distributions for each condition were then generated and visually inspected to identify the electrode sites and general latency at which the P1, N170 and VPP components reached their maximum absolute voltage.

For the emotion recognition task, the P1 was observed as a bilateral peak voltage at approximately 130 ms at occipital sites consistent with sites O1 and O2 in the standard 10/20 system (Jasper, 1958). The peak voltages for the N170 components were observed at approximately 180 ms at bilateral occipitotemporal sites roughly corresponding to P7/P8. Similarly, the VPP component was found to be maximal at 180 ms at frontocentral sites corresponding to FCz. Maximum voltage distributions for the affective interference task were similar to those in the emotion recognition task.

Using ERPScore software (Segalowitz, 1999), peak voltages and peak latencies for each component were manually identified and scored at each of the previously identified maximal sites. Peak and latency values were then imported into Excel and the maximum peak voltage was identified for each individual participant in each condition, for each component. This method was chosen in lieu of calculating an average voltage for each component from the selected sites to avoid the loss of variance in the averaging process.

Data Analysis

Prior to testing the current hypotheses, preliminary analyses were conducted to test the statistical assumptions of normality, homogeneity of variance and sphericity in the current data set. The assumption of normality was met for all relevant data (all skewness and kurtosis statistics $< |2|$). All cases in which the assumptions of homogeneity and/or sphericity failed to be met were corrected using a Greenhouse-Geisser correction (Greenhouse & Geisser, 1959).

Individual differences analyses. To examine whether there was a relationship between individual differences in psychopathic personality traits and both behavioural and neural responses to emotional stimuli in each task, residual scores were first calculated for each emotion by regressing out the effects of car stimuli for the first task, and scrambled face stimuli for the second task. The resulting residual scores provide response data that are unique to the face stimuli, while removing any effects common to both face and non-face stimuli.

Once the appropriate residual scores were calculated, Pearson *r* correlation coefficients were calculated between these variables and both the total SRP-III scale score, as well as each of its four subscale scores.

Within subjects analyses. To test our replication of Schyns et al.'s (2007) findings, as well as to assess whether manipulation of fixation disrupted the automaticity of emotion recognition, a 3 (Emotion: happy, anger, fear) x 3 (Fixation: centre, eyes, mouth) repeated-measures ANOVA was conducted. For analyses of the N170 and P1 components, an additional factor of laterality was included, as both components were measured at left and right hemisphere sites. Two-tailed, paired-sample *t*-tests were used to follow up all significant ($\alpha = .05$) effects.

Results

Manipulating Attention Allocation During Emotion Recognition

In addition to replicating Schyns et al.'s (2007) observations of the N170 component, behavioural responses, the P1 and VPP components were also examined. Data analyses showed that our task manipulations for both Task 1 and Task 2 had little to no effect on the latency or amplitude of the P1 component. Similarly, there were no observed relationships between the P1 and psychopathic personality traits. Therefore, these analyses have been excluded from the remainder of this manuscript.

Effect of emotional expression.

Behavioural effects.

Accuracy. Emotional expression was found to have an effect on recognition accuracy, $F(2, 58) = 31.16, p < .001$, such that participants were significantly more accurate at identifying happy facial expressions ($M =$ 95.6%, $SD =$ 6.90%) than either fearful faces (*M* = 80.7%, *SD* = 13.13%), $t(29) = 5.86$, $p < .001$, 95% CI[1] [9.7%, 20.2%], or angry (*M* = 67.7%, *SD* = 19.55%), $t(29) = 9.54$, $p < .001$, 95% CI [21.9%, 33.8%]. Similarly, fearful faces were identified with greater accuracy than angry faces, $t(29) = 2.73$, $p = .011$, 95% CI [3.2%, 22.6%].

Response time. As with emotion recognition accuracy, a main effect of emotion was found for response times in responding to emotional face stimuli. Specifically, participants responded significantly faster to happy facial expressions (*M* = 581 ms, *SD* = 98.2 ms) compared to both fearful (*M* = 638 ms, SD= 86.6 ms), $t(29) = 4.31$, $p < .001$, 95% CI [29.5 ms, 82.7 ms], and angry facial expressions (*M* = 643 ms, *SD* = 98.0 ms), $t(29) = 5.97$, $p < .001$, 95% CI [40.9 ms, 83.6 ms].

N170 effects.

Peak amplitudes. A main effect of emotion was found for N170 amplitudes in response to emotional faces, $F(2, 58) = 9.66$, $p < .001$ (Figure 5), such that components were larger for fearful faces compared to happy faces, $t(29) = 4.42$, $p < .001$, 95% CI [0.13 µv, 0.53 µv]. There were no observed differences in N170 amplitude between angry faces and either fearful or happy faces ($p > .15$). Relevant means and standard deviations can be found in Table 2.

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1 All reported confidence intervals are 95% confidence intervals of the difference scores used to calculate paired *t*-test statistics.

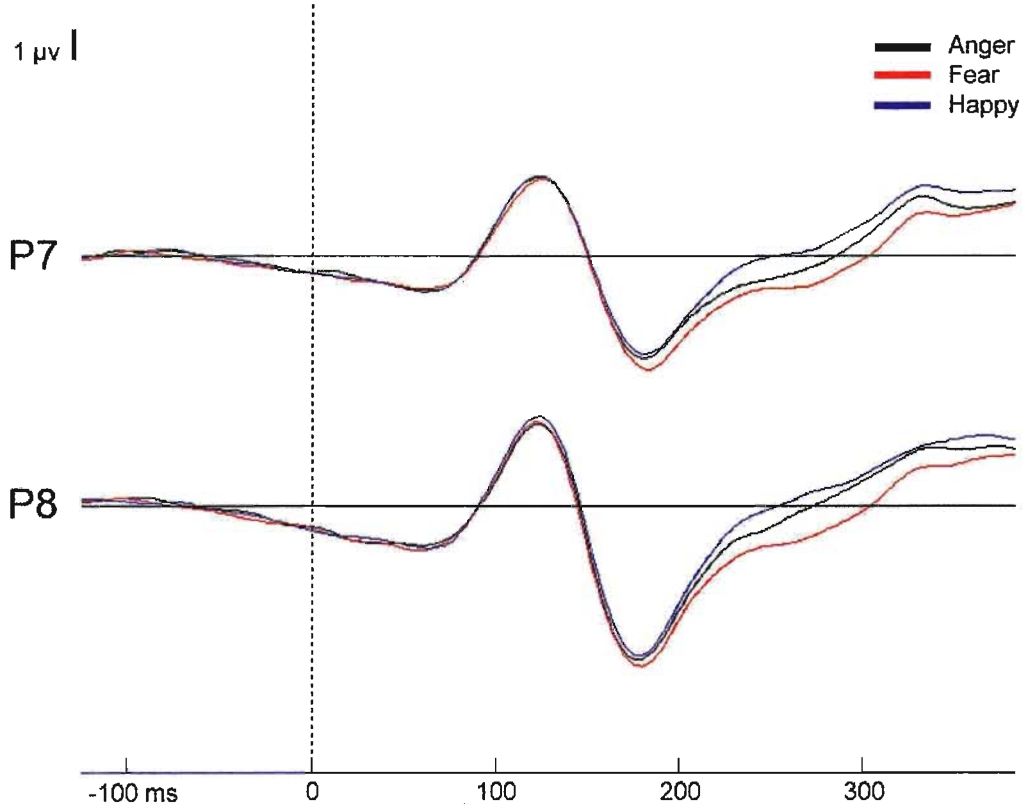

Figure 5. N170 amplitude effects in response to emotional face stimuli in Task 1.

	Left N170	Right N170	VPP
Anger			
Mean	-5.6 µv	-6.2 µv	4.9 µv
SD	3.07 µv	3.62 µv	1.98 µv
Fear			
Mean	-5.8 µv	-6.4 µv	4.9 µv
SD	2.95 µv	3.66 µv	1.99 µv
Happy			
Mean	-5.3 µv	-5.9 µv	4.6 µv
SD	2.71 µv	3.42 µv	1.87 µv

Table 2. N170 and VPP peak amplitude means and standard deviations at sites P7 and P8, and FCz, respectively, in response to emotional facial expressions in Task 1.

Latencies. No effect of emotion was observed on the latency of the N170 component, $F(2, 58) = 0.84, p = .435$ (Figure 6). This is contrary to the findings of Schyns et al. (2007), who observed that the latency of the N170 was contingent on the emotion being expressed.

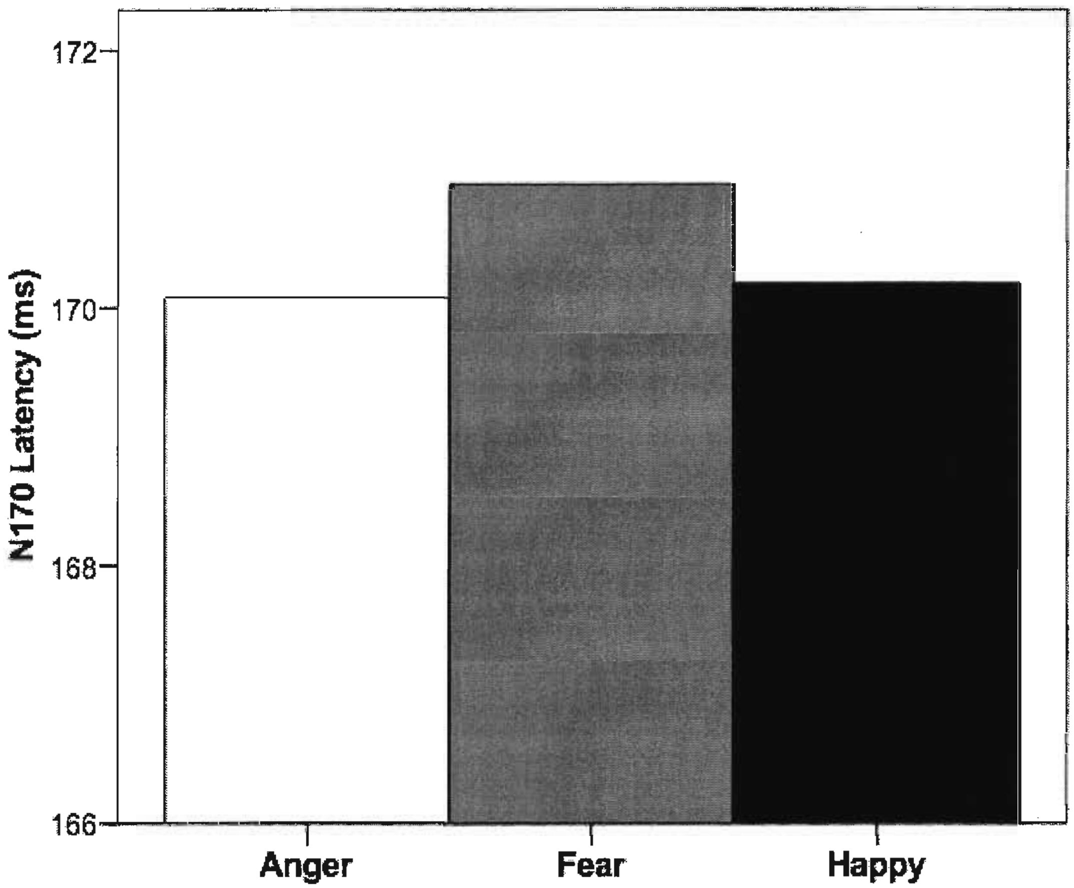

Figure 6. N170 latency effects in response to emotional face stimuli in Task 1.

VPP effects. Unlike the effect of emotion observed for the N170 component, both VPP amplitudes, $F(2, 58) = 1.80, p = .144$, and latencies, $F(2, 58) = .02, p = .982$, were not found to be sensitive to emotional expression.

Emotional face stimuli ratings analyses. Although the current observations are consistent with the literature, these results should be interpreted cautiously because it is possible that this effect is, at least in part, influenced by differences in discriminability across the face stimuli in each emotion category. To examine this further, a comparison of the mean ratings obtained prior to testing for each emotional face stimulus was conducted. Significant differences between mean ratings of fearful expressions (M = 3.7, SD = 0.63) and happy expressions (M = 4.6, SD = 0.27) were found, $t(8) = 2.92$, p = .019, 95% CI [0.19, 1.60], indicating that independent raters rated the happy facial expressions as expressing "happiness" more consistently than they rated the fearful faces as expressing fear. A similar trend was observed for angry (M = 3.6, SD = 0.95) compared to happy face stimuli as well, $t(8) = 2.29$, p = .052, 95% CI [0.01, 2.04].

Effect of fixation manipulation.

Behavioural effects.

Accuracy. An interaction between emotion and fixation was observed, $F(4, 116)$ = 4.13, p = .004 (Figure 7). Specifically, an effect was observed for fearful faces across fixation condition, such that recognition accuracy for fearful expressions was significantly lower in the mouth fixation condition (M = 77%, SD = 14.9%), as hypothesized, compared to both central (M = 82%, SD = 13.7%), $t(29) = 2.71$, p = .011, 95% CI [1.2%, 7.8%], and eye fixation conditions (M = 83%, SD = 12.7%), $t(29)$ = 4.71, $p < .001$, 95% CI [3.2%, 8.2%].

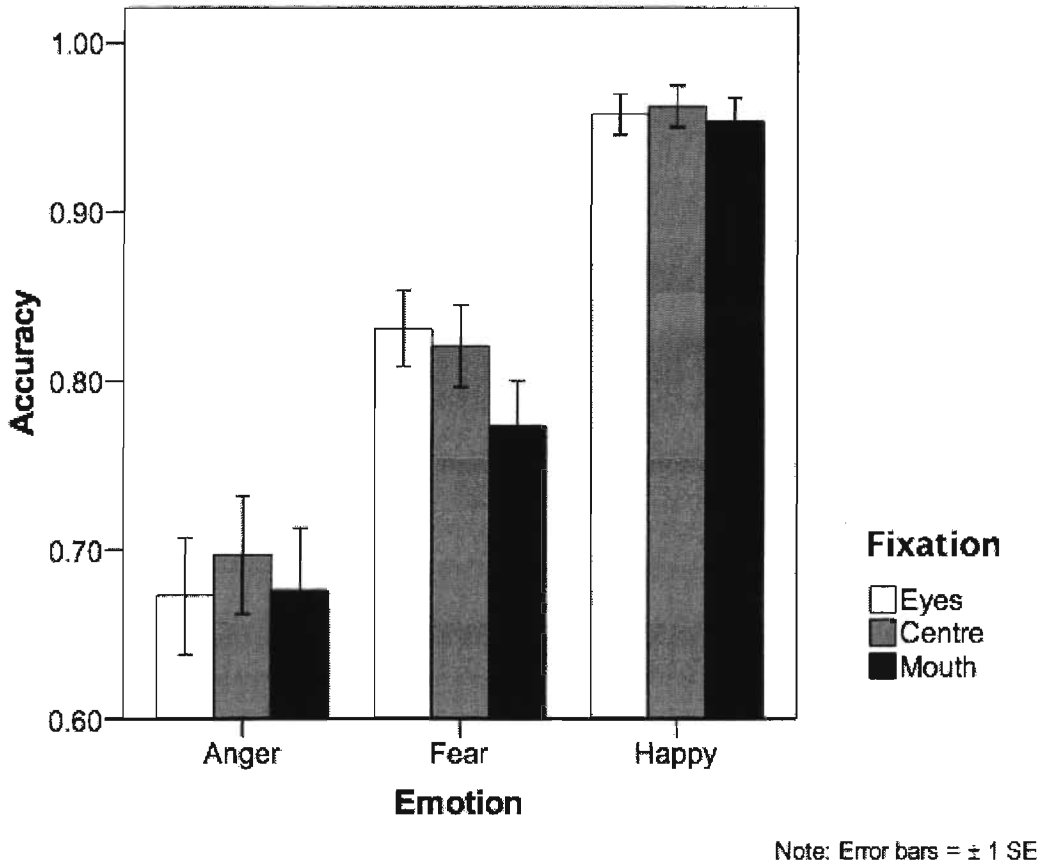

Figure 7. Graph of emotion x fixation interaction effects on emotion recognition accuracy in Task 1.

Similarly, a main effect of fixation, $F(2, 58) = 8.23$, $p = .001$, was found, such that emotional faces displayed under the mouth fixation condition (M = 79.9%, SD = 9.72%) were identified with less accuracy than those displayed under both central (M = 82.4 %, SD = 8.91%), $t(29) = 3.60$, $p = .001$, 95% CI [1.1%, 3.9%], and eye fixation conditions (M = 81.8%, SD = 8.19%), $t(29) = 3.17$, $p = .004$, 95% CI [0.7%, 3.2%].

Response time. The manipulation of fixation location did not have a significant effect on participants' RTs, $F(2, 58) = 2.20$, $p = .119$. In addition, no significant interactions between emotional expressions and fixation condition were observed, $F(4, 116) = 1.07, p = .372$.

N170 effects.

Peak amplitudes. Peak amplitudes of the N170 were found not to be responsive to manipulations of fixation location, $F(2, 58) = 0.22, p = .807$.

Latencies. A main effect of fixation was observed for N170 latencies (Figure 8), such that N170 components elicited by faces presented under the central fixation condition ($M =$ 178 ms, $SD = 9.9$ ms) peaked earlier than N170 components elicited by faces presented under the mouth fixation condition ($M =$ 180 ms, $SD = 9.3$ ms), $t(29) = 2.80, p = .009$, 95% CI [0.61 ms, 3.93 ms].

No interactions between emotion, fixation, or laterality were observed for either the latency or peak amplitudes of the N170 component (all $p > .75$). Similarly, neither peak amplitudes, $F(1, 29) = 1.47, p = .235$, nor latencies, $F(1, 29) = 0.80, p = .379$, of the N170 component were found to differ between hemispheres. These findings are somewhat unusual, as the N170 is commonly observed to be larger over right hemisphere sites (Bentin, 1996; Luck, 2005).

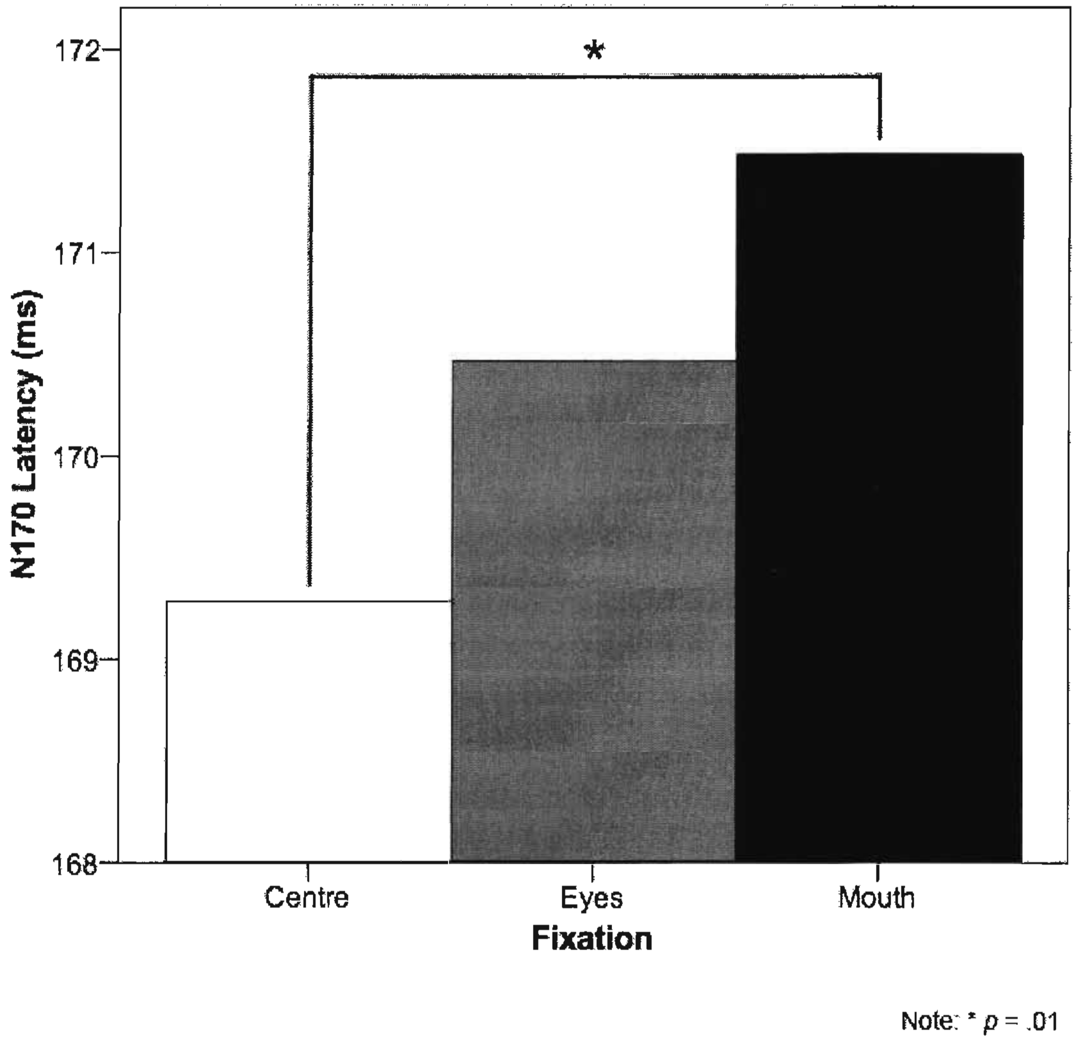

Figure 8. N170 latency effects in response to manipulations of fixation location in Task 1.

VPP effects. As in the N170 component, fixation location was not found to have an effect on the amplitude, $F(2, 58) = 0.15, p = .859$, or latency, $F(2, 58) = 1.03, p = .479$, of the VPP. Similarly, there was no observed interaction between emotional expression and fixation condition for either peak VPP amplitude, $F(4, 116) = 1.19, p = .319$, or latency, $F(4, 116) = 1.81, p = .132$.

Individual Differences in Emotion Recognition

As previously mentioned, standardized residual variables were calculated for all conditions by regressing out responses to car or scrambled face stimuli from responses to emotional stimuli. This statistical procedure effectively produces variables that reflect response data that are unique to face stimuli for both duration and fixation manipulations. Based on previous observations of Munro et al. (2007), we were interested in individual differences in the effect of the duration of stimulus exposure. Specifically, it was hypothesized that psychopathic traits would relate to both behavioural and neural responses to emotional faces under the short exposure duration (i.e., 30 ms), but not longer durations (i.e., 75 ms & 150 ms). In addition to examining responses to emotional faces and manipulation of duration, we were also interested in individual differences in response to manipulating the location of fixation while identifying emotional expressions.

Effect of emotional expression.

Behavioural effects. Our hypotheses that recognition performance would be negatively related to psychopathic traits was not supported given that participants' accuracy in identifying emotional facial expressions was not significantly related to psychopathic personality traits (all $p > .10$). Similarly, the amount of time taken to categorize emotional stimuli did not significantly relate to psychopathic personality traits (all $p > .09$).

N170 effects. Neither peak amplitudes (all $p > .25$) nor latency (all $p > .06$) of the N170 was correlated with psychopathic personality traits, although evidence of a trend suggested a possible relationship between the erratic lifestyle factor and N170 latency for fearful faces, $r = .34, p = .062$. Similarly, a trend between happy facial expressions and both global psychopathy traits, $r = .34$, $p = .062$, and the interpersonal manipulation traits, $r = .34$, $p = .067$, was found. These trends suggest that as the presence of psychopathic personality traits, especially erratic lifestyle and interpersonal manipulation traits, increase, so does the amount of time it takes for the N170 to peak. This is particularly interesting, as it is in line with our predictions based on the findings of Schyns et al. (2007).

VPP effects. Similar to the N170, there were no relationships between peak amplitude (all $p > .06$) or the latency (all $p > .16$) of the VPP and psychopathic personality traits.

Effect of fixation manipulation.

Behavioural effects. Contradictory to our hypotheses, no association was found between psychopathic personality traits and participants' behavioural performance (all $p > .15$). Specifically, no significant relationships were observed between either participants' accuracy or response times for identifying emotional faces and either global psychopathy or individual factors of psychopathic traits in any of the fixation manipulation conditions.

N170 effects. No relationship was observed between psychopathic personality traits and either the amplitude and latency of the N170 component (all $p > .09$). These findings are contrary to the hypothesis that individuals high in psychopathic traits would show differences in N170 amplitude and latency, specifically in the central fixation condition, but not in the eye or mouth conditions.

VPP effects. Interpersonal manipulation traits were found to be negatively related with the amplitude of the VPP in the central fixation condition, $r = -.37$, $p = .042$ (Figure

9), such that individuals reporting more interpersonal manipulation traits also produced smaller VPP components in response to emotional faces presented under central fixation conditions. These findings are in line with our hypothesis that psychopathic individuals would be less responsive to emotional face stimuli when presented under a central fixation. There was no observed relationship between the latency of the VPP and psychopathic personality traits (all $p > .09$).

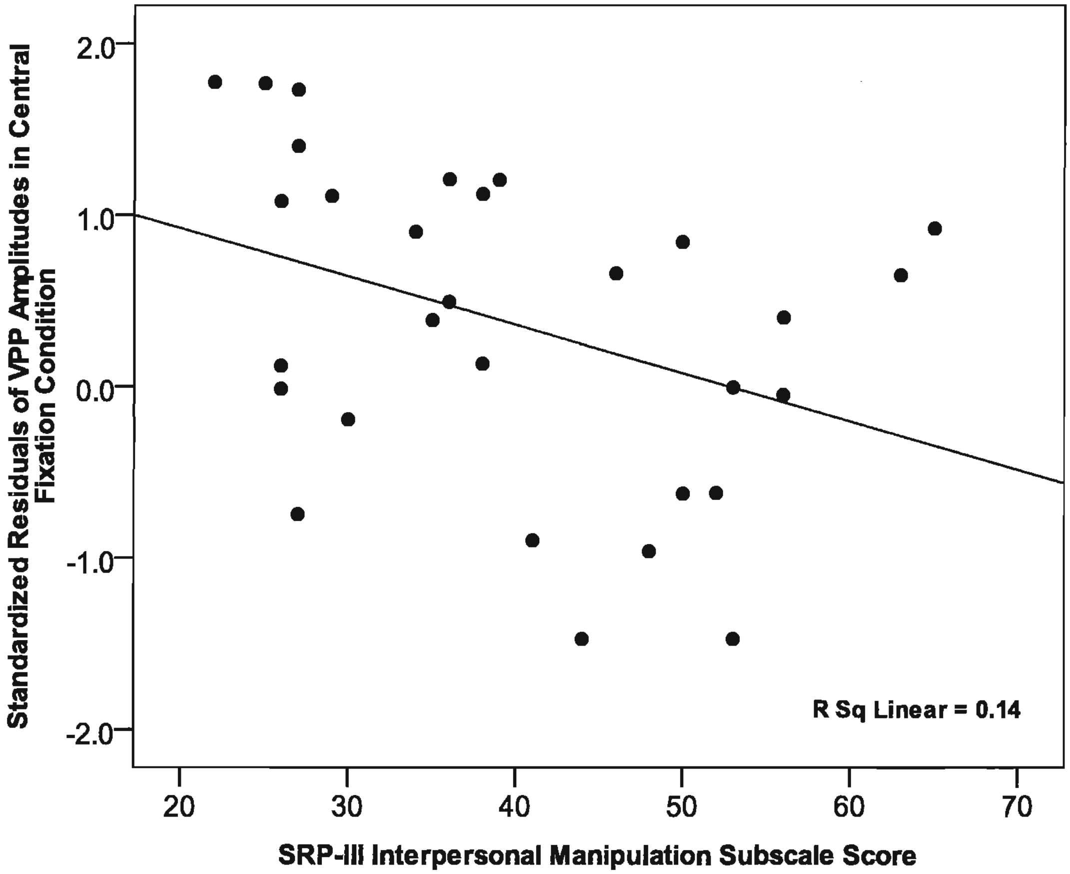

Figure 9. Scatter plot of VPP amplitudes in central fixation condition correlated with interpersonal manipulation traits (Task 1).

Effect of stimulus exposure duration.

Behavioural effects. As with the previous conditions, neither accuracy (all $p > .18$) nor response time (all $p > .24$) for identifying emotional expressions were found to be significantly related to the psychopathic personality traits, again in opposition to the current hypothesis.

N170 effects. No significant relationship was found between psychopathic traits and the peak amplitude of the N170 component (all $p > .20$). This is inconsistent with the current hypothesis that individuals high in psychopathic traits would show decreased N170 components in response to emotional faces displayed at subliminal durations.

However, the latency of the N170 at right hemisphere sites was found to be related to erratic lifestyle traits for stimuli presented in the 30 ms exposure condition, $r = .43$, $p = .018$ (Figure 10). Specifically, the N170 peaked later for individuals who reported more erratic lifestyle traits. Interpreted in the context of Schyns et al. (2007), these findings suggest that individuals who are higher in erratic lifestyle traits take longer to acquire key diagnostic information from emotional expressions when subliminally presented.

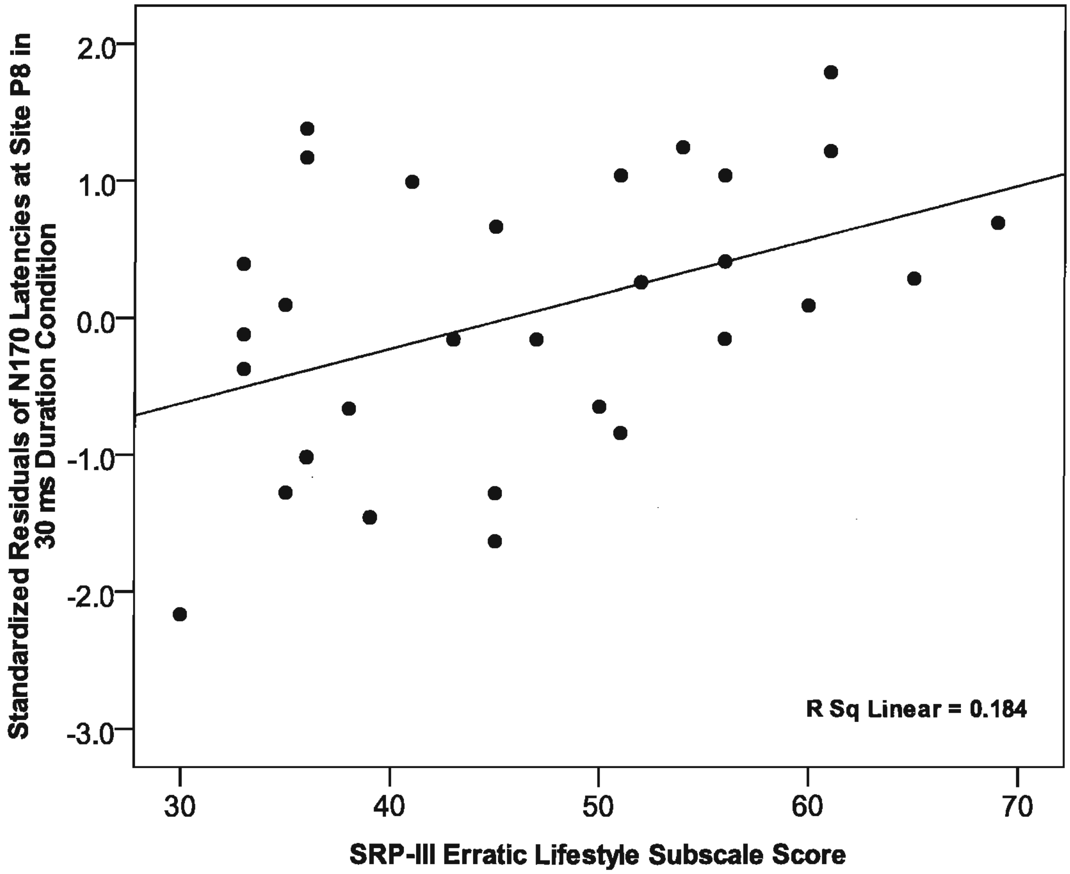

Figure 10. Scatter plot of N170 latencies at right hemisphere sites in 30 ms exposure duration condition correlated with erratic lifestyle traits (Task 1).

VPP effects. There were no observed relationships between peak amplitudes or latencies of the VPP with psychopathic personality traits (all $p > .08$). As with the N170 results, these findings are inconsistent with the current hypothesis that as psychopathic traits increase, the amplitude of face-sensitive ERP components would decrease, evidencing less saliency of the face stimuli.

Task 1 Discussion

Manipulating Attention Allocation During Emotion Recognition

One of the primary goals for this thesis was to replicate and extend Schyns et al. (2007) findings of subtle N170 latency differences in response to different emotional expressions. To achieve this, the location of attention fixation (i.e., a fixation cross) was manipulated appear at one of three locations on the face, specifically, the eye, nose, or mouth region as the emotional expressions of fear, anger and happiness were presented on a computer screen.

Effect of emotional expression. Data from the current study indicated that participants were significantly faster and more accurate at identifying happy facial expressions compared to both angry and fearful expressions. These findings are consistent with the emotion recognition literature in that individuals commonly show better recognition for happy facial expressions compared to other emotions (Gao & Maurer, 2009; Kirouac & Dore, 1983; Widen & Russell, 2008). It should be noted that, although consistent with previous research, these findings may have been inflated by the previously described discrepancy in the discriminability of the emotional face stimuli used in the current study.

Similarly, the observed differences in emotion recognition accuracy may have also been influenced by the nature of the expression categories used, such that the current study employed two negatively valenced expressions (fear and anger) and only one positively valenced expression (happy). This disparity may have influenced recognition accuracy because participants may have experienced more difficulty when discriminating between anger and fear, which are more likely to be confused with each other, due to their similarity in valance and arousal (Russell, Lewicka & Niit, 1989; Gao, Maurer, & Nishimura, 2010).

Larger peak amplitudes were elicited in both the N170 and VPP components in response to fearful and angry facial expressions compared to happy ones. These findings are consistent with the observations of Schyns et al. (2007), although they must be interpreted cautiously because Schyns et al. did not report on the statistical reliability of these amplitude differences.

Again, these results must be interpreted cautiously in light of the previously described differences in the current face stimuli set. For example, it could be argued that the happy expressions used in the current study were more easily recognized and therefore elicited smaller peak amplitudes, reflecting the less effortful processing needed to categorize these faces. On the other hand, it has been argued that larger face-related ERPs occur in response to negative emotional expressions (i.e., fear and anger) compared to both neutral and positive facial expressions (Frühholz, Fehr & Herrmann, 2009, Eimer & Holmes, 2007). Enlarged components in response to threat-related stimuli make particular evolutionary sense, as they may reflect the increased salience and greater allocation of attentional resources to these stimuli.

Contrary to the effects of emotional expression on the amplitudes of the N170 and VPP, we failed to find any effect of emotion on the latencies of these components. This is contrary to our hypothesis that fearful, and possibly angry faces, would produce significantly faster N170 components compared to happy stimuli, as previously observed by Schyns et al. (2007). Failure to replicate these findings may be due to the fact that we used significantly fewer trials per emotional expression category (~50 trials per emotion type), compared to the 3,000 trials per expression used Schyns et al. As the effects reported by Schyns et al. are particularly subtle (i.e., right N170 peaks at ~194ms for fearful expressions, ~198ms for happy expressions), it is likely that many more trials are needed to isolate this difference in latency, because it may otherwise be overshadowed by random noise and latency jitter in the individual segments of EEG.

Effect of fixation manipulation. Despite the absence of an effect of emotion on the latency of the N170, the current findings with respect to fixation are in line with Schyns et al.'s (2007) observations of the "eyes-down" attention allocation pattern employed by participants when trying to identify an emotional expression. Specifically, an interesting interaction between fixation location and type of emotional expression was found. Specifically, our analyses indicated that the mouth fixation condition was particularly disruptive to recognition of fearful expressions, as was predicted. This is again consistent with Schyns et al.'s (2007) observation that the key diagnostic information for the recognition of fearful facial expressions lays in the eye region. It is suspected that presentation of fearful faces in the mouth fixation condition redirected participants' attention away from this key diagnostic information and disrupted the standard attention allocation pattern that would normally facilitate the acquisition of this information, which in turn resulted in decreased accuracy in the identification of fearful expressions.

In addition, we observed that emotional expressions presented under a mouth-level fixation cross were identified less accurately than faces presented under either central or eye-level fixations. It should be noted that no impairment for identification of angry expressions was found, as was predicted. This may be due to the fact that the diagnostic information necessary for the recognition of anger expressions is often divided between both the eye and mouth regions. Similarly, the current findings confirmed the hypothesis that recognition of happy facial expressions would not be impaired during presentation in the mouth fixation condition, because the information used for identifying happy expressions is largely found in the mouth area (i.e., smiling).

A similar effect of fixation was also observed on the latency of the N170, but not the VPP, such that components elicited by faces presented in the central fixation condition peaked earlier than those elicited by face presented in the mouth fixation condition. This is again congruent with predictions made based on the findings of Schyns et al. (2007), as well as the previously described effect of fixation on recognition accuracy. In the case of the current findings, it is suggested that the time taken to redirect attention to complete the "normal" attention allocation pattern subsequently delays the acquisition of key diagnostic information and, in turn, the latency of the peak of N170. Alternatively, the notable absence of a difference in N170 latency between the eye and the central or mouth fixation conditions may be due to the variable location of diagnostic information across emotional expressions, as described by Schyns et al., such that presentation of stimuli in the eye fixation was advantageous on some trials (i.e. fear/anger trials), but not on others (i.e., happy trials). Specifically, the presentation of faces under eye-level fixation would still allow for normal attentional scanning of the emotional expressions, so no delay in the latency of the N170 is observed.

While consistent with the current predictions, these findings should be considered cautiously. Recently, McPartland, Cheung, Perszyk and Mayes (2010) similarly demonstrated that manipulation of attention allocation modulates not just the latency, but also the amplitude of the N170 component. Researchers also manipulated fixation of attention to either the upper (eye), central, or lower (mouth) region while participants passively viewed neutral face stimuli. In addition, McPartland et al. also included a fixation free condition as a naturalistic control condition. Unlike the current study, fixation location was found to modulate the amplitude of the N170, such that faces presented under both upper and lower fixation conditions produced both larger and later N170 components. The authors interpret these results as reflecting differences in attentional disengagement when fixating on different regions of the face.

Although these observations only partially support the findings of the current study, it is argued that both attention allocation and attentional disengagement are processes that are very likely further modulated in the presence of affective information (affective versus neutral faces), and that, as the present study suggests, modulation of attention may be further differentiated based on the type of affective information (e.g., arousal, valence, intensity). Discussion of the results of the individual differences analyses can be found in the General Discussion section, as they are the primary focus of the current thesis.

Task 2: Impaired or Just Different? Individual Differences in Visual Attention Mechanisms

Clinical psychopathy, although not currently listed in the Diagnostic and Statistic Manual of Mental Disorders (DSM-IV-T; American Psychiatric Association, 2000), is considered a disorder of personality composed of a set of enduring, extensive and rigid patterns of behaviour and thought that frequently result in violations of social and legal norms. Although these behavioural manifestations of psychopathy are clearly dysfunctional and frequently cause a great deal of distress to those that encounter the psychopathic individual, it is suggested that the unique neural and cognitive mechanisms that are associated with this disorder, such as impaired emotion recognition (Kosson et al., 2002; Blair et al., 2004b; Hastings et al., 2008) or reduced autonomic responsiveness to affective stimuli (Aniskiewicz, 1979; Blair, 1999), are not necessarily dysfunctional as is often suggested (Kiehl, Hare, Liddle & McDonald, 1999; Kosson & Newman, 1986). Specifically, the current thesis is that the abnormal cognitive and neural underpinnings of psychopathy represent individual differences in brain development and that under specific conditions these unique mechanisms can actually be advantageous to the individual. For example, it has been suggested that traits such as callousness and superficial charm are particularly advantageous for individuals in the corporate world and research has shown that individuals high in psychopathic traits are not only drawn to, but frequently excel in business settings (Babiak & Hare, 2007).

To test this hypothesis of selective advantages of psychopathic personality traits, an affective interference task was designed requiring participants to categorize neutral word stimuli while simultaneously trying to ignore the emotional face distractors on top of which the word stimuli are presented. The interference paradigm used in the current study was closely modeled on the previous work of both de Fockert, Rees, Frith and Lavie (2001), who designed the initial interference paradigm, and later work of Pecchinenda and Heil (2007), who extended the paradigm by adding socially relevant distractors.

The purpose of the original de Fockert et al. (2001) study was to examine whether working memory (WM) load could affect the degree to which face distractors are processed during word categorization in a selective attention task. Participants were presented with the names of pop stars (e.g., Mick Jagger) and politicians (e.g., Bill Clinton) on top of pictures of people from each category that were either congruent or incongruent with the target name. Participants were required to categorize the name stimuli as either a pop star or a politician and to ignore the underlying image while simultaneously completing an unrelated WM task with either a high or low cognitive load. de Fockert et al. (2001) found that a high WM load resulted in slower categorization of name stimuli and greater activation of brain regions related to face processing when compared to performance under a low WM load. These results were interpreted as evidence of greater interference by face distractors under a high WM load due to the higher WM load utilizing addition attentional resources that would otherwise be allocated to inhibitory control over the intrusion of irrelevant distractors.

In addition to behavioural measures, de Fockert et al. (2001) conducted a second study using fMRI to examine potential BOLD signal differences in brain regions associated with face processing. It was observed that in the high WM load condition, areas such as the fusiform gyrus and superior temporal sulcus showed greater BOLD activity than they did during the low WM load condition. Researchers interpreted this finding as further evidence of greater interference by distractor faces during the high WM load condition, on the basis that increased activity in these regions likely reflects more in-depth processing of face distractor stimuli.

Pecchinenda and Heil (2007) sought to extend the de Fockert paradigm by including socially relevant stimuli, and modified the original task to include emotional expressions as distractors and affective words as target stimuli in the selective attention task. Positively and negatively valenced target words were presented on top of either happy, angry, or neutral faces, and subjects were required to categorize the target word as positive or negative while ignoring distractor faces and completing an unrelated WM task of either high or low cognitive load.

Contrary to de Fockert et al.'s (2001) findings, Pecchinenda and Heil (2007) observed no significant differences in performance between the high and low WM load conditions when using affectively valenced stimuli. When the researchers compared the affective distractor trials to the neutral face trials, they found that interference appeared to be occurring in both high and low WM load conditions, as opposed to not occurring at all. The authors interpreted this as evidence that participants were processing the affective expression distractors automatically regardless of the task goals, the participant's intentions, or available WM resources, as discussed previously (LeDoux, 2000).

The automaticity of affective processing has been shown to lead to a phenomenon known as the "affect facilitation effect", characterized by faster and more accurate responding (Graves, Landis, & Goodglass, 1981; Strauss, 1983) and larger ERP components (Begleiter, Gross, & Kissin, 1967; Liddell et al., 2004) to affective stimuli when compared to neutral stimuli. Previous research indicates that psychopaths fail to show this normal pattern of facilitation to affective word stimuli (Williamson, Harpur & Hare, 1991; Kiehl, Hare, McDonald & Brink, 1999), such that response times and ERP components elicited by affective words do not resemble the faster response times or modulated ERP components produced by control participants. On the contrary, psychopaths' response times and ERP components to affective stimuli do not differ significantly from those elicited by neutral stimuli.

Affective Interference: Hypotheses

The concurrent working memory task employed by both de Fockert et al. (2001) and Pecchinenda and Heil (2007) was omitted from the current study because this study was designed solely to examine with individual differences in the ability to inhibit task-irrelevant affective information. Similarly, because the current study involved individual differences in affective face recognition, the affective word categorization task employed by Pecchinenda and Heil (2007) was changed to a living-nonliving word categorization task because additional affective material could confound the results of the study, making it difficult to draw conclusions from the data.

Thus, the current study was designed to extend the findings of Pecchinenda and Heil (2007) by including a measure of interference at the neural level, specifically measuring the N170 and VPP components. It was hypothesized that the N170 and VPP would be larger in amplitude and peak earlier in response to trials that contain affective distractors faces compared to scrambled faces. Similarly, it was expected that participants' word categorization performance would suffer in the presence of affective distractor faces compared to scrambled faces, reflected in poorer accuracy and slower response times during word categorization. This is in line with the initial findings of de Fockert et al.'s (2001) second study that showed increased BOLD signal activity in the FFG as a marker of increased interference by face distractors under high WM load conditions.

In addition, this study involved a measurement of neural activity as an index of interference with the inclusion of socially relevant affective stimuli. Using ERP technology, it was possible to use the N170 component, known to be sensitive to face stimuli, to rate the degree to which a distractor face is processed during the selective attention task. Specifically, if the thalamic "fast path" is indeed missing or dysfunctional in psychopaths, it is proposed that those high in psychopathic traits would be more accurate and have faster response times during word categorization than controls because affective distractors would produce less interference in these participants and in turn facilitate categorization of target stimuli. It was expected that this will be reflected in smaller N170 peak amplitudes, indicating less neural activity related to the processing of the distractor faces. Alternatively, control subjects would be unable to prevent processing the distractor faces, reflected in larger N170 components, and their categorization performance should suffer due to the automatic processing of affective stimuli through the amygdala-thalamus subcortical pathway. It was further anticipated that these proposed differences would be greatest in the presence of fearful, and possibly angry, distractor expressions.

In light of previous findings that suggest psychopaths fail to show the affect facilitation effect, it was hypothesized that individuals in the current study who are high in psychopathic personality traits would show less interference, both behaviourally and neurally, from affective distractor faces compared to individuals low in psychopathic traits. It would follow that participants low in psychopathic traits should show patterns similar to those observed by Pecchinenda and Heil (2007), such that they cannot inhibit processing of the affective distractors due to the automatic nature of affective processing that is observed in normative samples. It was proposed that this involuntary processing of the affective distractors would be reduced in individuals high in psychopathic traits, which in turn would facilitate their ability to categorize word stimuli without interference.

Methods

Participants and Materials

The participant sample and materials used in Task 2 are the same as for the previous task and are described in details in the Task 1 methods section.

Stimuli

Affective facial expression stimuli. Affective face stimuli used in the current task were the same as those used in Task 1. A detailed description of theses stimuli can be found in the methods section of Task 1.

Scrambled face stimuli. Five scrambled face stimuli (Figure 11) were created using five neutral facial expressions from the previously described Gur et al. (2002) face stimuli. Face stimuli were modified as described above with the exception that, prior to application of the oval frame, faces were scrambled as per the methods described by Bentin et al. (1996). In addition to the stimulus construction procedures described previously and by Bentin et al., a blur filter was applied to the final scrambled image to reduce visual contrast created by the scrambling process.

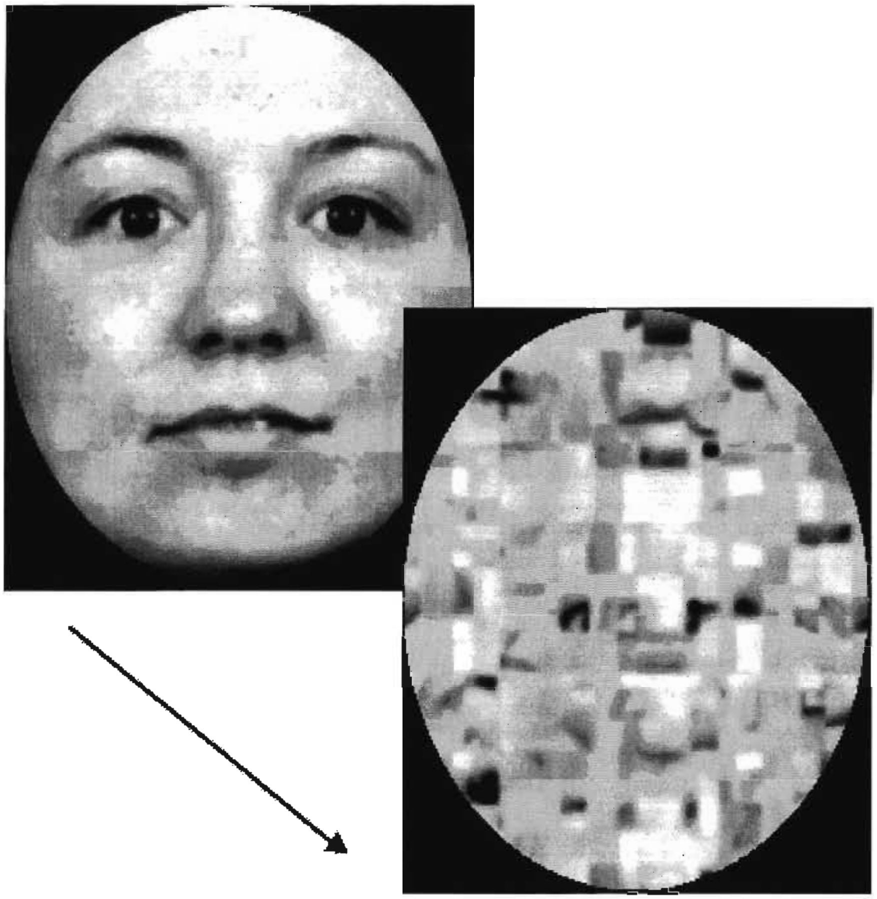

Figure 11. Example of scrambled face stimuli used in the affective interference task (Task 2).

Living and nonliving word stimuli. Four hundred nouns, 200 depicting living things (i.e., cow, doctor) and 200 depicting nonliving things (i.e., guitar, blanket, shoe), were compiled from five separate word databases (MRC Psycholinguistic Database, Coltheart, 1981; Paivio, Yuille & Madigan (1968) Word Pool; Toronto Word Pool, Friendly, Franklin, Hoffman, & Rubin, 1982; Bird, Franklin & Howard (2001) word list; and Clark and Paivio (2004) word list). The living and nonliving word lists did not differ in word length, number of syllables, Kucera-Francis Word Frequency (Kucera & Francis, 1967), familiarity, concreteness, or meaningfulness ratings (all p>.15) (Table 3).

	Living		Nonliving			
	M	*SD*	*M*	*SD*	*t*	*p*
Word length	6.1	1.88	5.9	1.91	1.03	.305
Number of syllables	2.8	1.34	2.9	1.69	-0.42	.679
K-F Word Frequency	35.3	43.84	53.6	85.16	-1.46	.147
Familiarity	411.1	210.00	402.5	247.88	-1.31	.191
Concreteness	507.3	218.26	542.3	191.47	-0.47	.645
Meaningfulness	6.58	1.097	6.75	0.872	0.32	.753

Note: K-F = Kucera-Francis word frequency rating (Kucera & Francis, 1967)

Table 3. Means, standard deviations of word stimuli characteristics for living and nonliving word lists and *t* statistics and related *p* values for word list comparison.

Task

Affective interference task. The second task, herein referred to as the affective interference task, was a modification of a paradigm created by de Fockert et al. (2001) and extended to include affective stimuli by Pecchinenda and Heil (2007).

In the current study, participants viewed a centralized fixation cross for 500 ms, after which they were presented with a target word superimposed across the center (approximately at nose level) of a happy, angry, fearful or scrambled distractor face for 500 ms, followed by a blank screen for 1000 ms. Participants were asked to categorize each target word as "living" or "non-living" by pressing one of two appropriately labeled buttons on a response box, while ignoring the underlying distractor faces. Participants had 1500 ms from the onset of the target stimulus in which to make a response (Figure 12). The task consisted of 50 trials for each of the eight conditions [Emotion (4) x Word Type (2)], such that each participant completed a total of 400 trials.

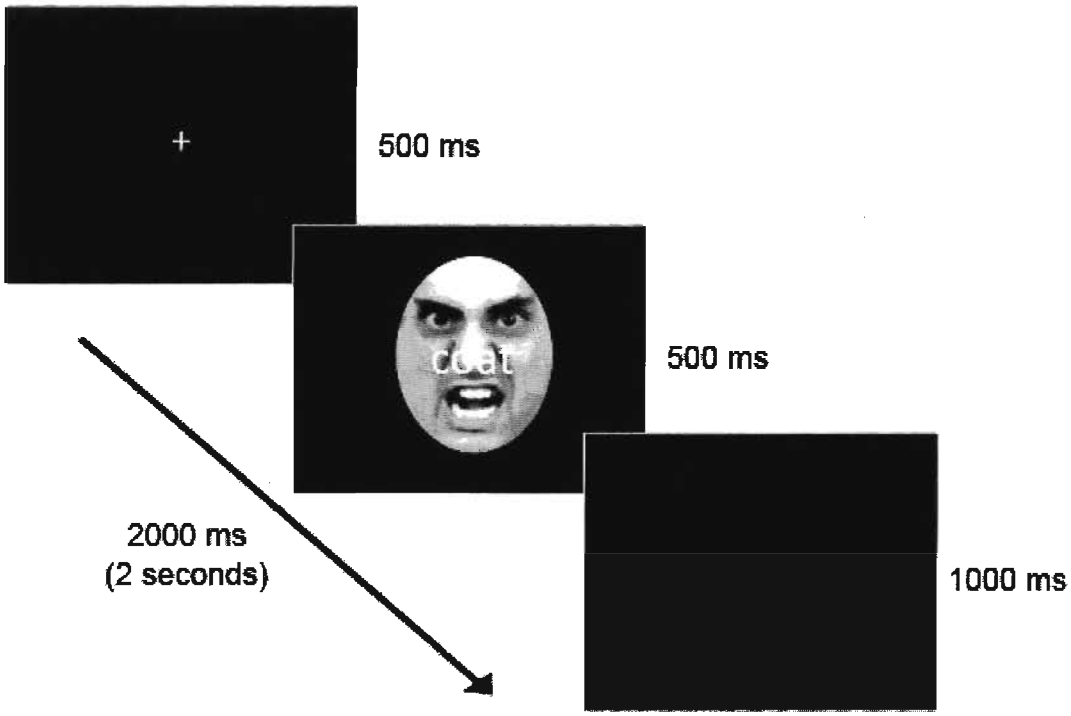

Figure 12. Example of single trial in affective interference task (Task 2).

Procedure, EEG Data Acquisition and Processing and Data Analysis

The procedures, EEG methods and individual difference analyses used for this task were the same as those used in Task1 and a detailed description can be found in the methods section of Task 1.

Within subjects analyses. To test our replication and extension of the findings of de Fockert et al. (2000) and Pecchinenda and Heil (2007), a 4 (Emotion: happy, anger, fear, scrambled) x 2 (Word Type: living, nonliving) repeated-measures ANOVA was conducted. As with the previous task, analyses of the N170 and P1 components included an additional factor of site, as both components were scored at two lateralized sites. Two-tailed, paired-sample *t*-tests were used to follow up all significant ($\alpha = .05$) effects.

It should also be noted that due to the fact that we had no hypotheses regarding the relation between psychopathic personality traits and characteristics of the P1 component, the corresponding analyses are not presented here, but can be accessed in Appendix D. Nonetheless, the characteristics of the P1 for the within subjects analyses are presented here, because they may provide a broader picture about the time course of emotion recognition processes under the conditions imposed by the current tasks.

Results

The Effect of Task-irrelevant Affective Distractors in a Semantic Categorization Task

In addition to replicating the findings of Pecchinenda and Heil (2007), we hoped to extend these findings by examining the neural correlates associated with the completion of the affective interference task based on methodologies used in the original de Fockert et al. (2001) study. To replicate the findings of Pecchinenda and Heil (2007), we examined participants' response time data because the previous study was a purely behavioural one and focus had been on this variable specifically.

Effect of distractor type.

Behavioural effects.

Accuracy. Distractor type was not found to have an effect on word categorization performance, $F(3, 87) = 0.28$, $p = .839$, indicating that participants did not show evidence of greater interference in response to emotional face distractors compared to scrambled face distractors.

Response time. Distractor stimulus type was found to have an effect on the amount of time participants took to categorize word stimuli, $F(3, 87) = 9.22, p < .001$. In line with the findings of Pecchinenda and Heil (2007) participants responded significantly faster to word stimuli presented on top of scrambled faces ($M =$ 793 ms, SD = 116.8 ms) compared to angry ($M =$ 816 ms, SD = 118.9ms), $t(29) = 4.64$, $p<.001$, 95% CI [12.8 ms, 33.1 ms], fearful ($M =$ 811 ms, SD = 110.9 ms), $t(29) = 4.32, p < .001$, 95% CI [9.6 ms, 27.0 ms], and happy distractor faces ($M =$ 819 ms, SD = 114.3 ms), $t(29) = 4.97, p < .001$, 95% CI [15.1 ms, 36.2 ms]. No differences in response times were observed among emotional distractor faces (all $p > .29$).

No significant interactions between distractor type and word category were observed for word categorization accuracy, $F(3, 87) = 0.18, p = .907$ or participants' response times, $F(3, 87) = 0.85, p = .471$.

N170 effects.

Peak amplitudes. As shown in Figure 13, distractor type was found to modulate the peak amplitude of the N170 component, $F(3, 87) = 30.07, p < .001$, such that scrambled face distractors elicited significantly smaller N170 amplitudes compared to angry, $t(29) = 6.24, p < .001$, 95% CI [1.27 µv, 2.51 µv], fearful, $t(29) = 6.20, p < .001$, 95% CI [1.49 µv, 2.96 µv], and happy face distractors, $t(29) = 5.25, p < .001$, 95% CI [1.10 µv, 2.50 µv]. Mean N170 amplitudes and standard deviations can be found in Table 4. Additionally, it was observed that fearful face distractors produced larger N170 peaks compared to both angry, $t(29) = 2.58, p = .015$, 95% CI [0.07 µv, 0.60 µv], and happy face distractors, $t(29) = 2.79, p = .009$, 95% CI [0.11 µv, 0.74 µv].

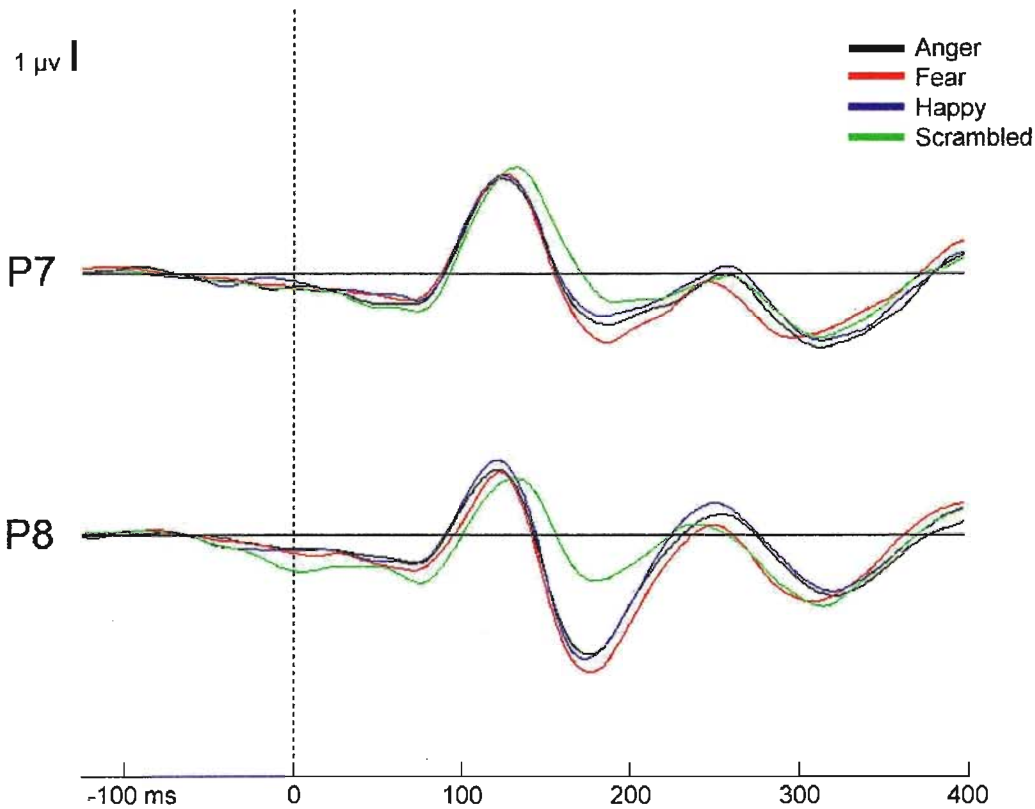

Figure 13. N170 amplitude effects in response to emotional and scrambled face distractors in Task 2.

	N170		VPP	
	Peak	Latency	Peak	Latency
Anger				
Mean	-4.6 µv	179 ms	3.2 µv	180 ms
SD	2.60 µv	14.8 ms	1.83 µv	13.5 ms
Fear				
Mean	-4.9 µv	179 ms	3.4 µv	180 ms
SD	2.87 µv	12.9 ms	1.86 µv	12.4 ms
Happy				
Mean	-4.5 µv	178 ms	3.4 µv	179 ms
SD	2.71 µv	15.2 ms	1.78 µv	14.0 ms
Scrambled				
Mean	-2.65 µv	184 ms	2.0 µv	183 ms
SD	2.49 µv	15.1 ms	1.83 µv	12.8 ms

Table 4. N170 and VPP amplitude and latency means, collapsed across site, in response to emotional distractor faces in Task 2.

In addition, an interaction between distractor type and electrode site was also observed for N170 amplitudes, which largely reflected the previously described main effect of site. Specifically, peak amplitudes were generally larger at right hemisphere sites, although it was observed that angry distractor faces elicited significantly larger peak amplitudes ($M =$ -3.7 µv, $SD = 2.18$ µv) than happy distractor faces ($M =$ -3.2 µv, $SD = 2.03$ µv) at left hemisphere sites only, $t(29) = 2.09$, $p = .046$, 95% CI [0.01 µv, 0.76 µv], suggesting that, with greater statistical power, the N170 may further distinguish between emotional expressions at both left and right hemisphere sites.

Finally, an effect of electrode site was observed, $F(1, 29) = 12.48, p = .001$ (Figure 14, such that N170 peaks over right hemisphere sites ($M = -5.0$ µv, $SD = 2.85$ µv) were larger than peaks over left hemisphere sites ($M = -3.4$ µv, $SD = 2.09$ µv). This is a commonly observed phenomenon in the N170 literature (Luck, 2005; Key et al., 2005).

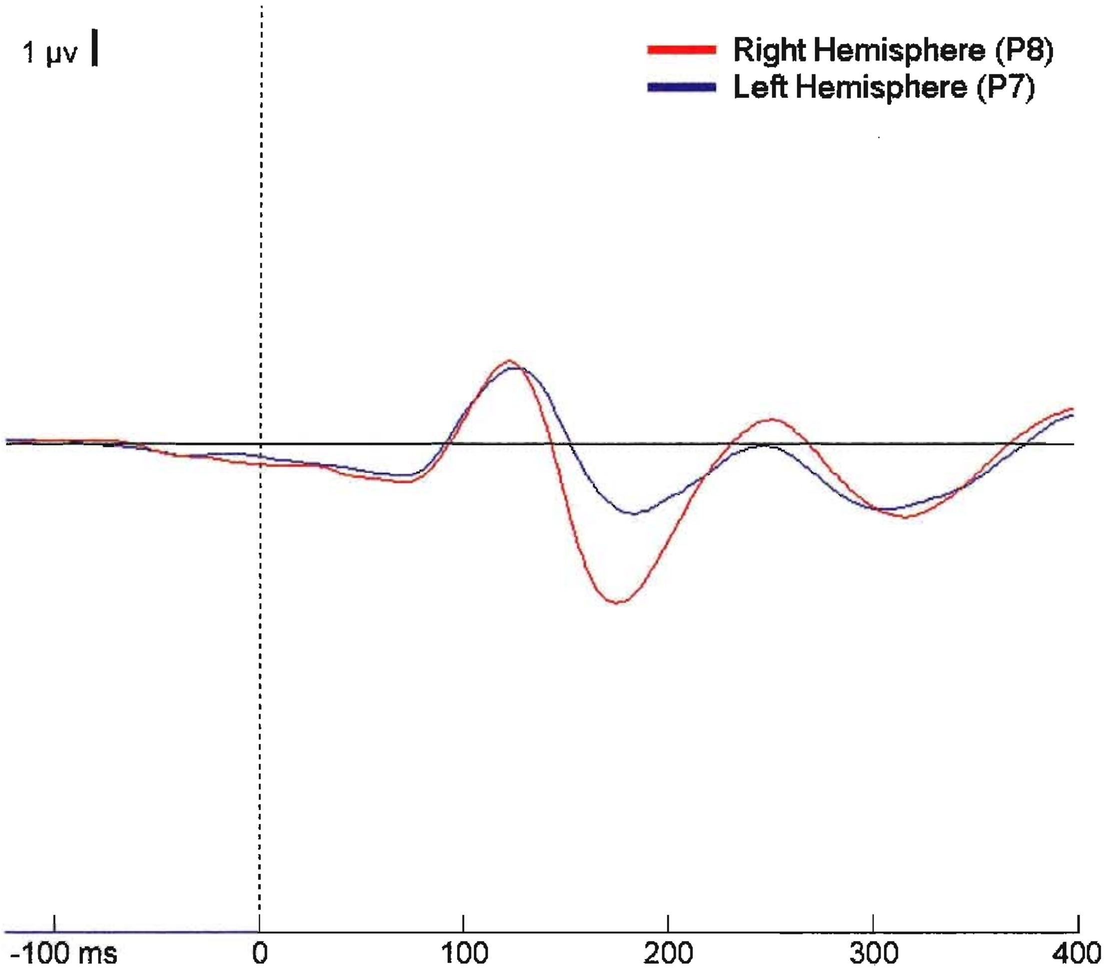

Figure 14. N170 laterality effect in response to emotional face stimuli in Task 2.

Latencies. Distractor type was also found to influence the latency of the N170 component $F(3, 87) = 4.46, p = .006$ (Figure 15), such that N170 components elicited by scrambled face distractors peaked significantly later than components elicited by angry,

$t(29) = 2.05$, $p = .049$, 95% CI [0.1 ms, 8.7 ms], fearful, $t(29) = 2.76$, $p = .010$, 95% CI [1.3 ms, 8.9 ms], and happy face distractors, $t(29) = 2.40$, $p = .023$, 95% CI [0.8 ms, 10.2 ms]. No interaction effects on the latency of the N170 between distractor type, word stimulus category, or laterality were observed (all $p > .11$).

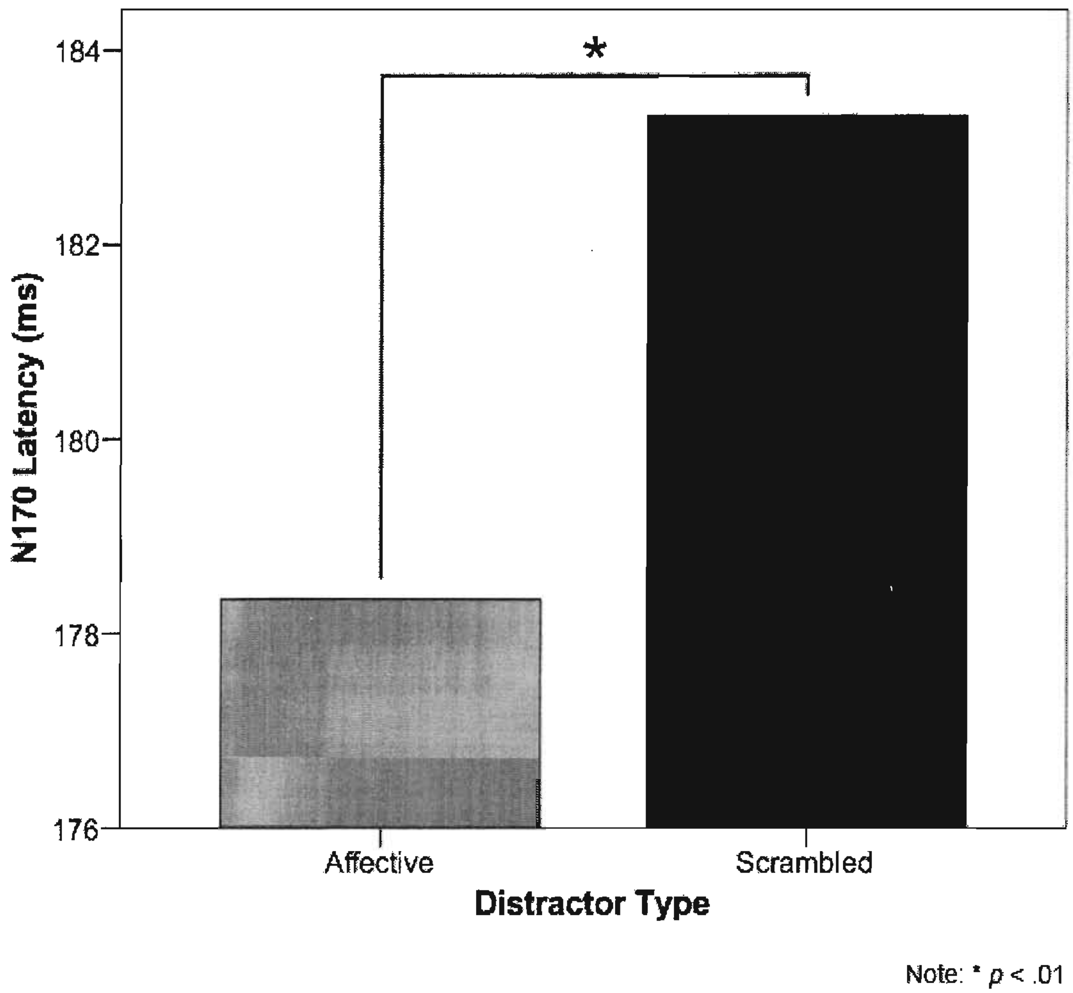

Figure 15. N170 latency effects in response to emotional and scrambled face distractors in Task 2.

VPP effects.

Peak amplitudes. As with the N170, peak VPP amplitudes were found to respond differentially to distractor type, $F(3, 87) = 34.46, p < .001$ (Figure 16). As was expected, scrambled faces elicited significantly smaller VPP peaks compared to angry, $t(29) = 8.04$, $p < .001$, 95% CI [0.92 µv, 1.55 µv], fearful, $t(29) = 8.20, p < .001$, 95% CI [1.08 µv, 1.79 µv], and happy distractor faces, $t(29) = 8.00, p < .001$, 95% CI [1.02 µv, 1.71 µv]. This again may suggest that distractor stimuli are in fact being processed, regardless of task demands. However, distractor type and word stimulus category did not significantly interact to affect peak VPP amplitudes, $F(3, 87) = 0.64, p = .595$.

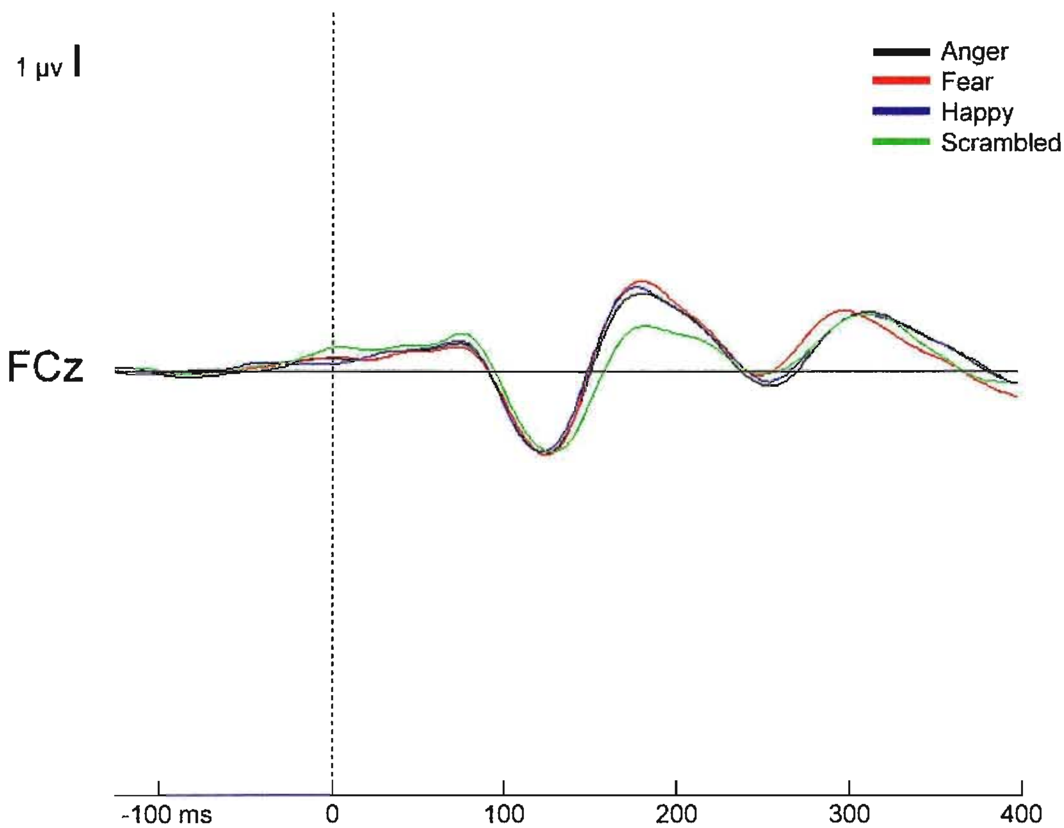

Figure 16. VPP amplitude effects in response to emotional and scrambled face distractors in Task 2.

Latencies. No effects of distractor type were observed for the latency of the VPP component, $F(3, 87) = 1.50$, $p = .219$. Similarly, no significant interaction between distractor type and word category was observed for the latency of the VPP, $F(3, 87) = 2.16$, $p = .099$.

Effect of word stimulus type.

Behavioural effects.

Accuracy. Word stimulus category was found to affect response accuracy, $F(1, 29) = 18.70$, $p < .001$, such that participants identified nonliving word stimuli (M = 91.0%, SD = 7.47%) with greater accuracy than living word stimuli (M = 85.4%, SD = 9.32%), $t(29) = 4.32$, $p < .001$, 95% CI [3.0%, 8.0%].

Response time. An additional effect of word stimulus type was also observed, $F(1, 29) = 32.74$, $p < .001$, such that living words (M = 794 ms, SD = 112.6 ms) were identified significantly faster than nonliving words, (M = 825 ms, SD = 117.0 ms). This is a common finding in lexical decision making paradigms.

N170 effects. No significant differences in the amplitude, $F(1, 29) = 2.98$, $p = .095$, or latency, $F(1, 29) = 0.001$, $p = .981$, of the N170 were observed between living and nonliving word stimuli. These findings were expected, as the N170 is not known to be selectively responsive to word stimuli. However, a trend suggesting an effect of laterality was observed for N170 latencies, $F(1, 29) = 4.15$, $p = .051$, such that N170 components peaked significantly earlier at right hemisphere sites (M = 177 ms, SD = 10.6 ms) compared to left hemisphere sites (M = 183 ms, SD = 14.3 ms).

VPP effects. No effects of word stimulus category were observed for the peak amplitude, $F(1, 29) = 1.93$, $p = .175$, or latency, $F(1, 29) = 0.44$, $p = .514$, of the VPP component.

Individual Differences in Emotion Recognition

Effect of emotional expression. As with the emotion recognition task, the relationship between the effect of emotional distractors on both behavioural and neural responses and measures of psychopathic traits was explored.

Behavioural effects.

Accuracy. Callous affect was found to be related to participants' accuracy at categorizing word stimuli in the presence of both angry, $r = -.41$, $p = .025$ (Figure 17), and fearful distractors, $r = -.36$, $p = .049$ (Figure 18), such that categorization accuracy decreased as callous traits increased.

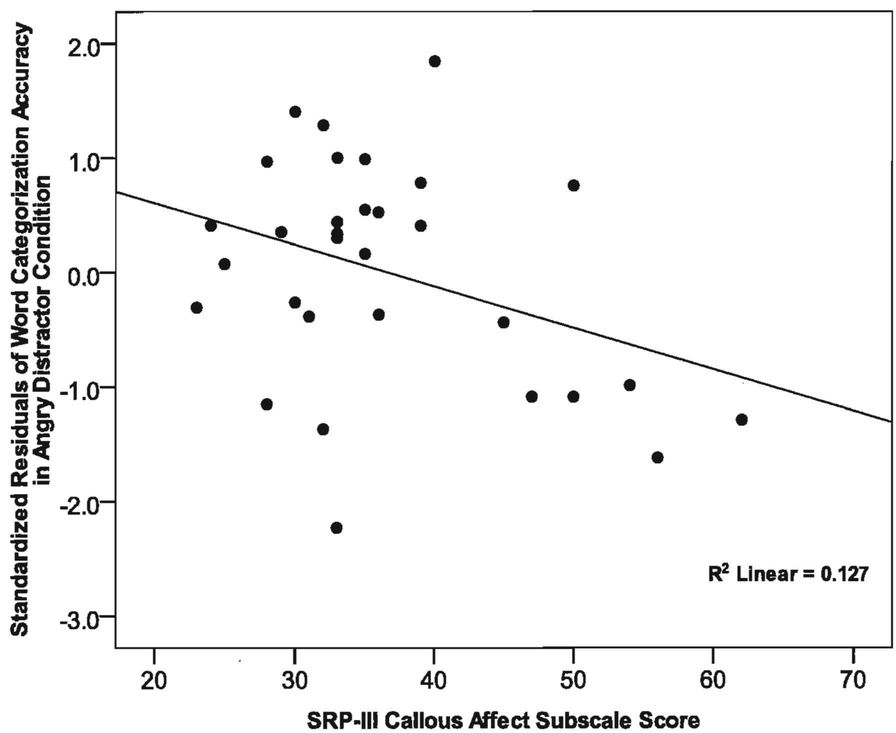

Figure 17. Scatter plot of word categorization accuracy in the presence of angry distractor faces correlated with callous affect traits (Task 2).

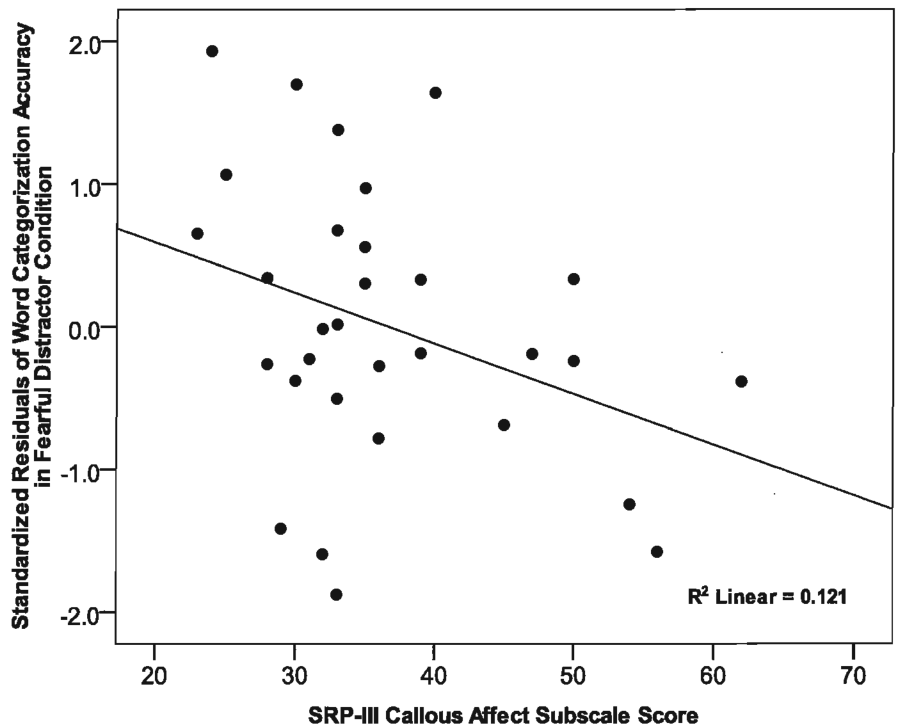

Figure 18. Scatter plot of word categorization accuracy in the presence of fearful distractor faces correlated with callous affect traits (Task 2).

Response time. Additionally, the amount of time taken for participants to categorize word stimuli in the presence of both angry, $r = .57, p < .001$ (Figure 19), and fearful distractors, $r = .38, p = .040$ (Figure 20), was found to be positively related to manipulative traits, such that response times were longer for individuals high in interpersonal manipulation. A similar trend was observed for callous affect traits with both angry, $r = .34, p = .068$, and fearful distractors, $r = .36, p = .053$, suggesting that slower response times in the presence of negative affective distractors may be associated with the affective traits of psychopathy, as opposed to the behavioural traits of erratic lifestyle and antisocial behaviour, which were unrelated to both performance accuracy and response times.

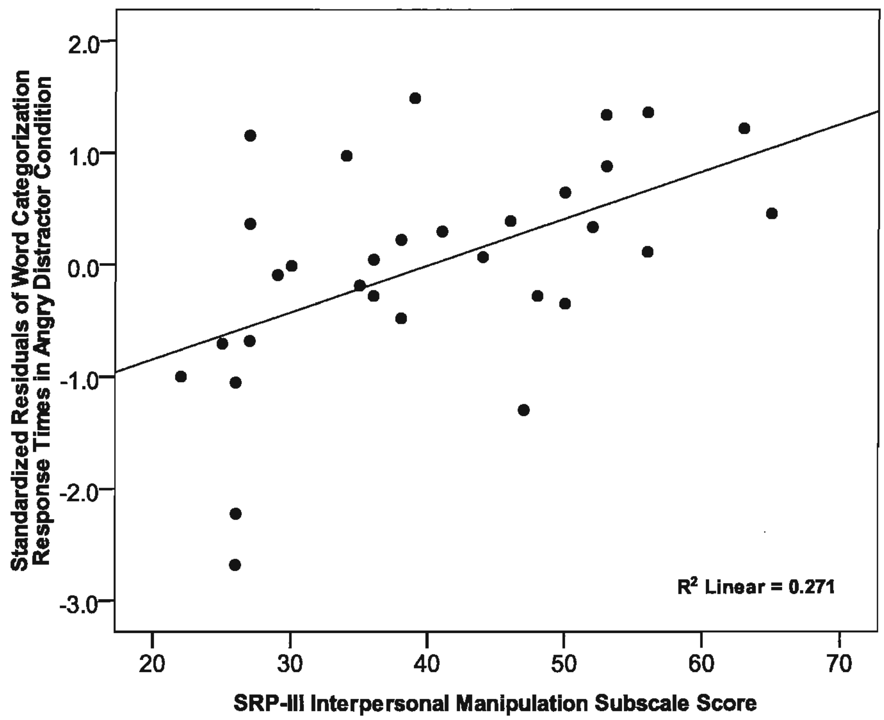

Figure 19. Scatter plot of word categorization response time in the presence of angry distractor faces correlated with interpersonal manipulation traits (Task 2).

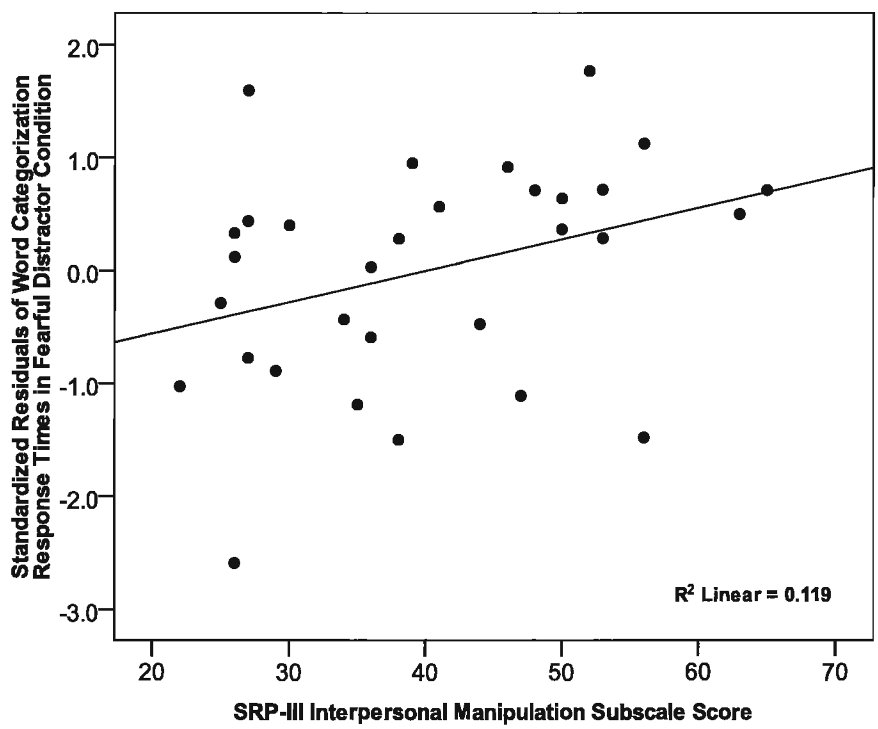

Figure 20. Scatter plot of word categorization response time in the presence of fearful distractor faces correlated with interpersonal manipulation traits (Task 2).

N170 & VPP effects.

Peak amplitudes. Several relationships were observed between psychopathic traits and both the N170 and VPP components, many of which overlapped between the two components. First, peak N170 amplitudes correlated with antisocial behavioural traits in the presence of happy distractors at left hemisphere sites, $r = -.38, p = .038$ (Figure 21), and fearful distractors at right hemisphere sites, $r = -.38, p = .041$ (Figure 22). Similar trends were observed for fearful distractors at left hemisphere sites, $r = -.33, p = .071$, and for both angry, $r = -.34, p = .066$, and happy distractor faces, $r = -.32, p = .090$, at right hemisphere sites. Similarly, VPP amplitudes in response to angry distractor faces were also found to associated with antisocial traits, $r = .39, p = .032$ (Figure 23).

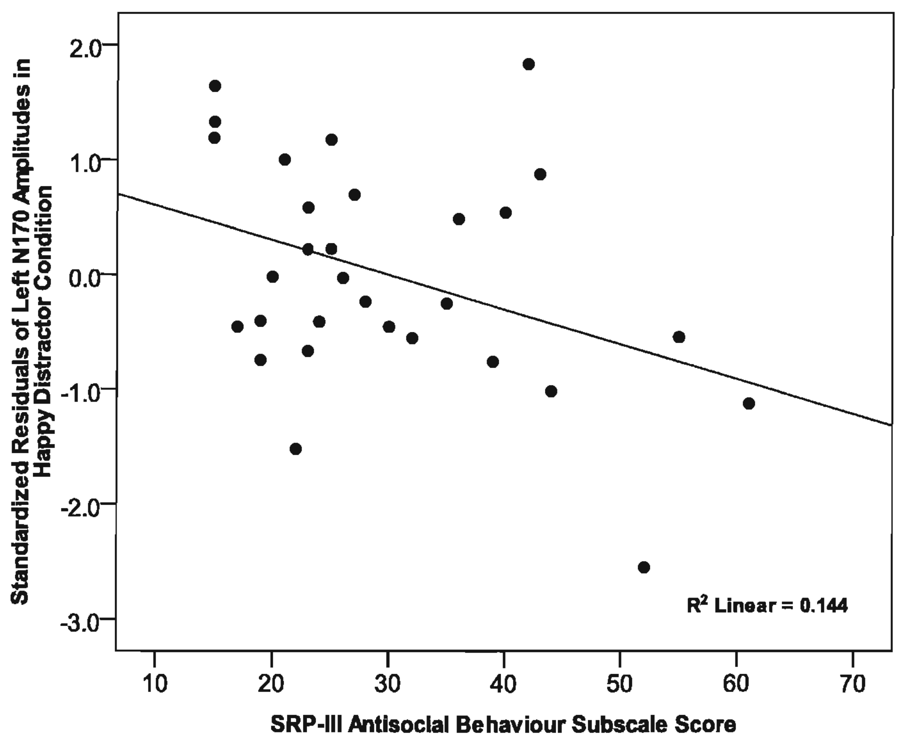

Figure 21. Scatter plot of N170 amplitudes at left hemisphere sites in the presence of happy distractor faces correlated with antisocial behaviour traits (Task 2).

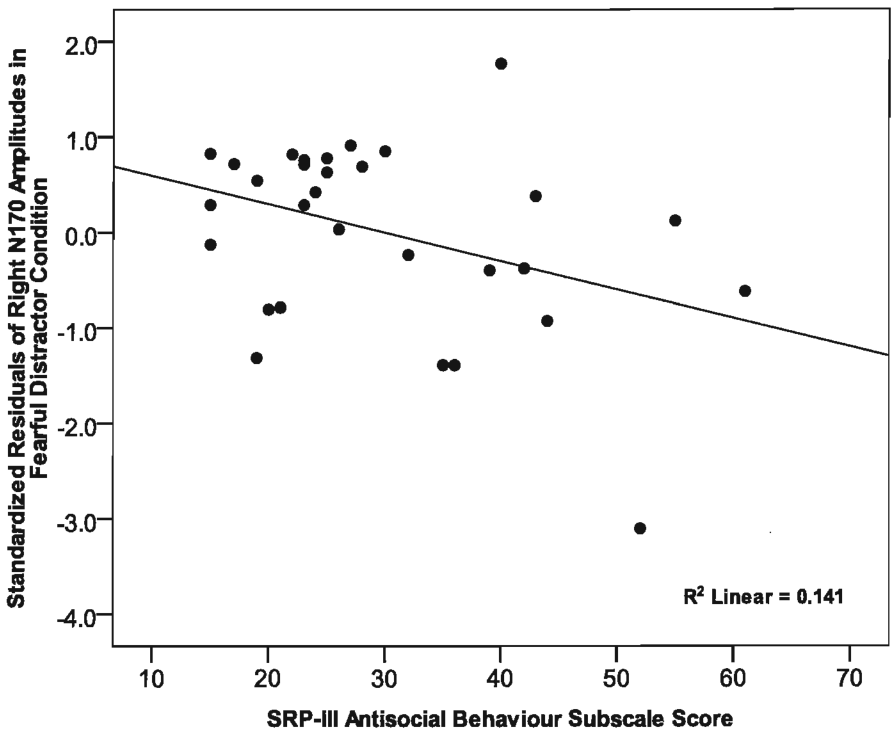

Figure 22. Scatter plot of N170 amplitudes at right hemisphere sites in the presence of fearful distractor faces correlated with antisocial behaviour traits (Task 2).

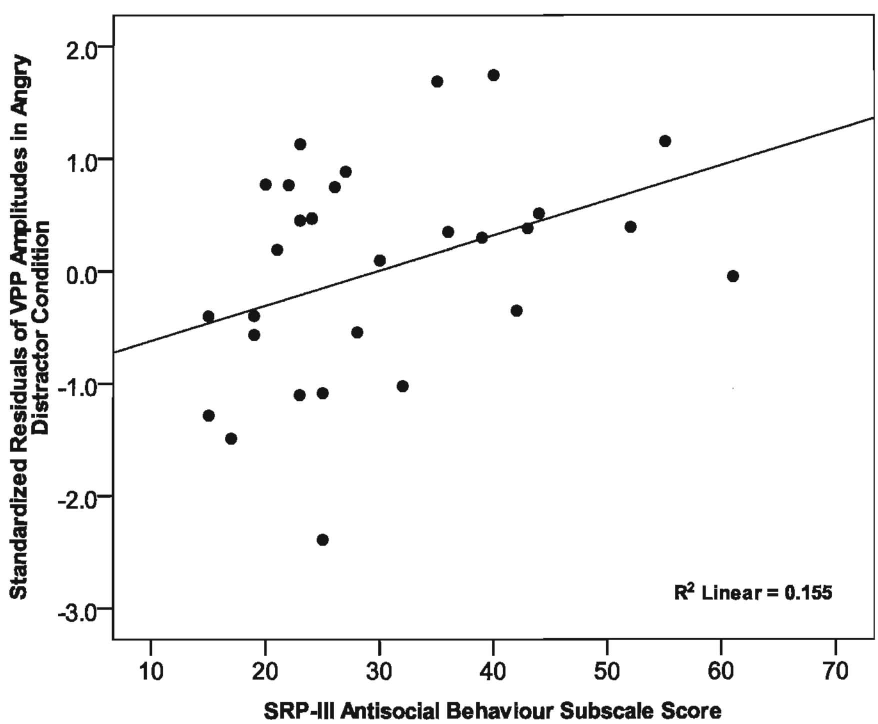

Figure 23. Scatter plot of VPP amplitudes in the presence of angry distractor faces correlated with antisocial behaviour traits (Task 2).

Latencies. Several significant relationships between the latency of both the N170 and VPP and psychopathic traits were observed. Specifically, the latency of the N170 at right hemisphere sites was positively related to the factors of callous affect and erratic lifestyle for all emotional distractor faces (Figures 24 and 25). In addition, N170 latencies in response to happy distractor faces were also associated with erratic lifestyle traits at left hemisphere sites (Figure 26). Pearson *r* statistics and their associated *p*-values can be found in Table 5.

	Left N170		Right N170		VPP	
	Peak	Latency	Peak	Latency	Peak	Latency
SRP total						
Anger	-.22	.07	-.31	.33	.26	.24
Fear	-.23	.15	-.31	.38*	.27	.28
Happy	-.24	.23	-.26	.42*	.24	.40*
CA subscale						
Anger	-.12	.08	-.18	.38*	.06	.33
Fear	-.15	.09	-.20	.48**	.16	.39*
Happy	-.02	.19	-.18	.42*	.14	.50**
IPM subscale						
Anger	-.15	< -.01	-.29	.27	.16	.14
Fear	-.08	.08	-.27	.33	.03	.24
Happy	-.16	.10	-.24	.38*	.15	.30
ELS subscale						
Anger	-.17	.33	-.18	.40*	.22	.47**
Fear	-.20	.33	-.14	.37*	.36	.40*
Happy	-.21	.47**	-.10	.41*	.24	.54**
ASB subscale						
Anger	-.25	-.13	-.34	.07	.39*	-.09
Fear	-.33	.01	-.38*	.10	.35	-.05
Happy	-.38*	.03	-.32	.18	.27	.04

Notes: * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

Table 5. Pearson r correlation coefficients for N170 and VPP amplitudes and latencies in response to affective face distractors and SRP-III total and subscale scores (Task 2).

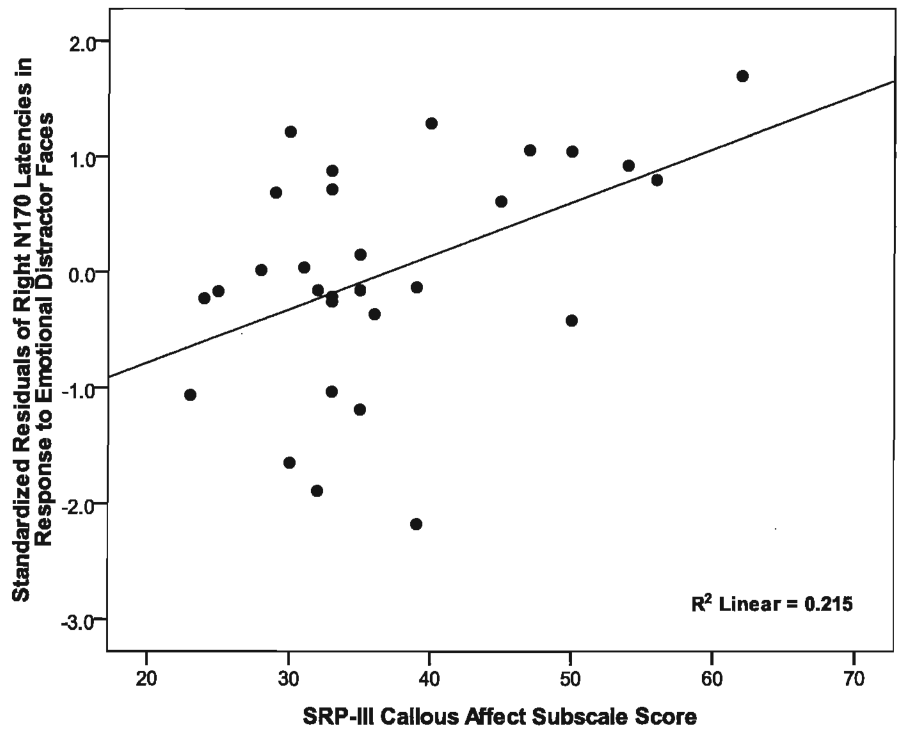

Figure 24. Scatter plot of N170 latencies at right hemisphere sites in response to emotional face distractors correlated with callous affect traits (Task 2).

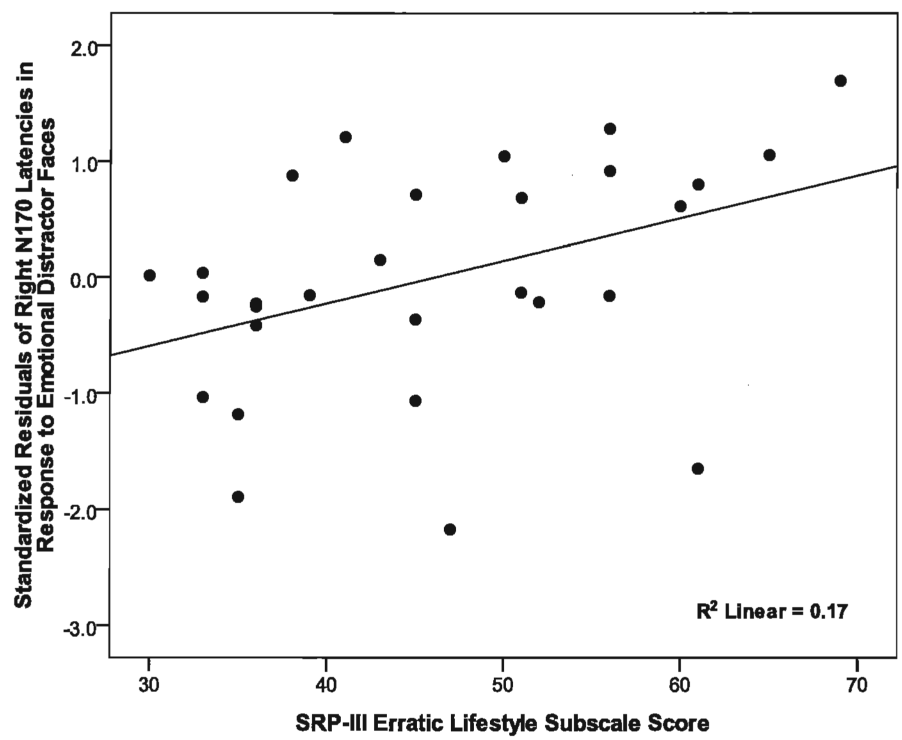

Figure 25. Scatter plot of N170 latencies at right hemisphere sites in response to emotional face distractors correlated with erratic lifestyle traits (Task 2).

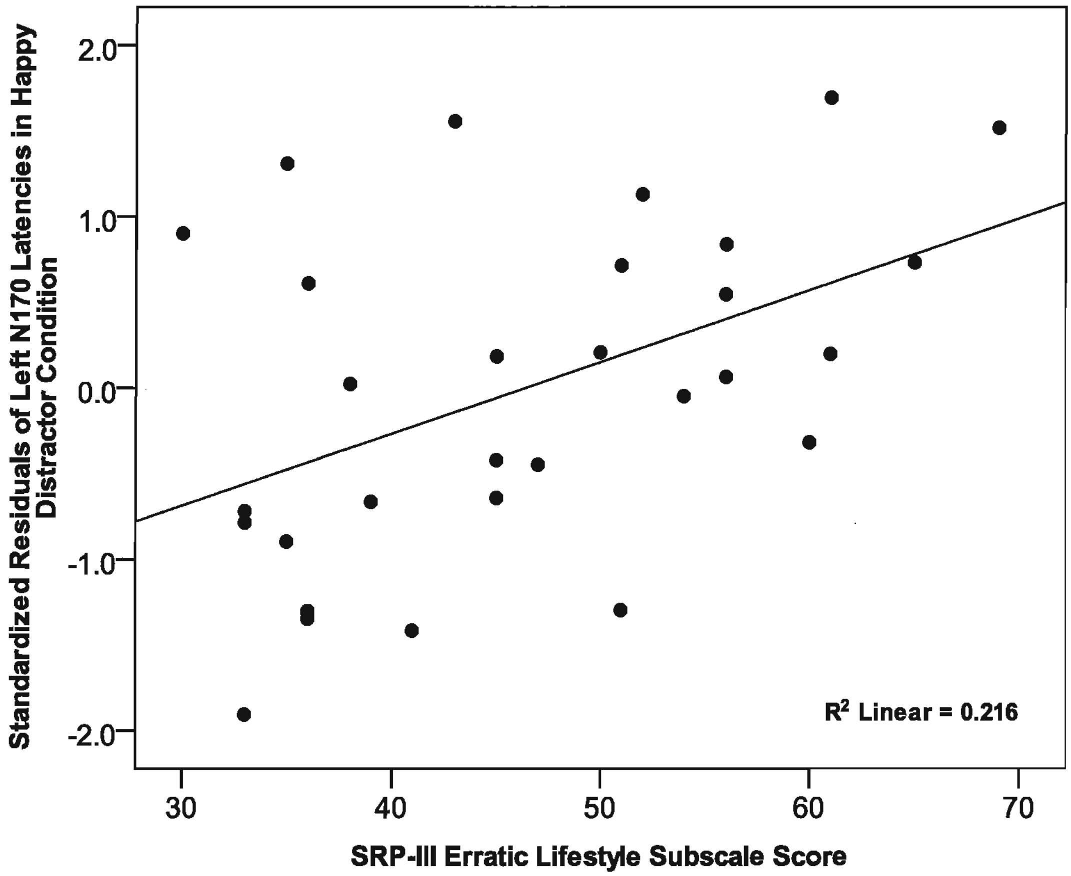

Figure 26. Scatter plot of N170 latencies at left hemisphere sites in the presence of happy distractor faces correlated with erratic lifestyle traits (Task 2).

Finally, it was found that N170 latencies at right hemisphere sites were also positively related to global psychopathy scores for both fearful, $r = .38, p = .039$ (Figure 27), and happy distractor faces, $r = .42, p = .021$ (Figure 28), with a trend towards a similar relationship for angry distractor faces, $r = .33, p = .077$. There were no significant relationships between the latency of the N170 and antisocial behaviour, suggesting that the observed effects may in fact be specific to psychopathic traits.

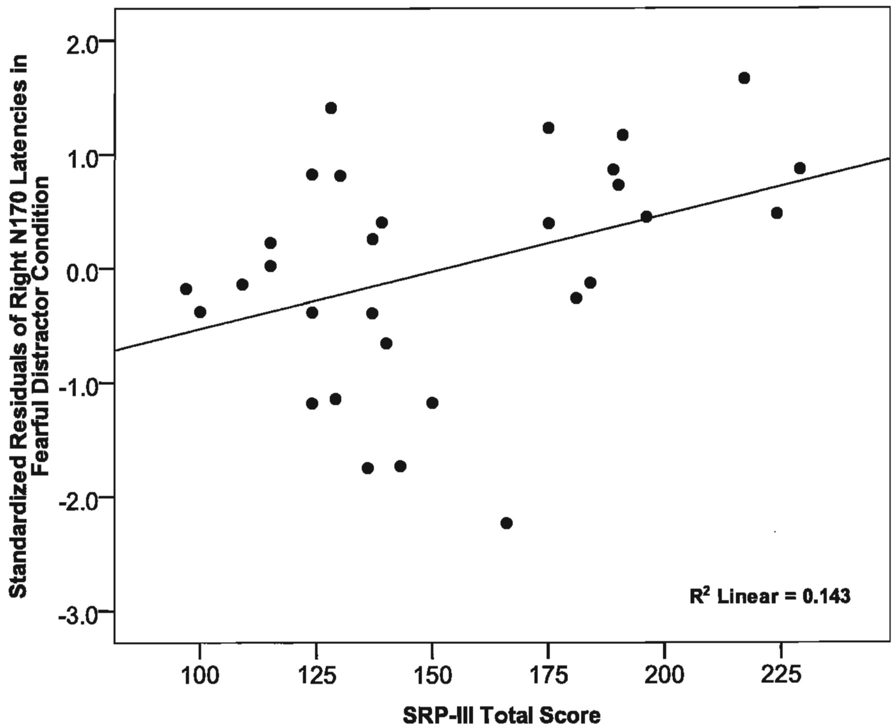

Figure 27. Scatter plot of N170 latencies at right hemisphere sites in response to fearful face distractors correlated with global psychopathic traits (Task 2).

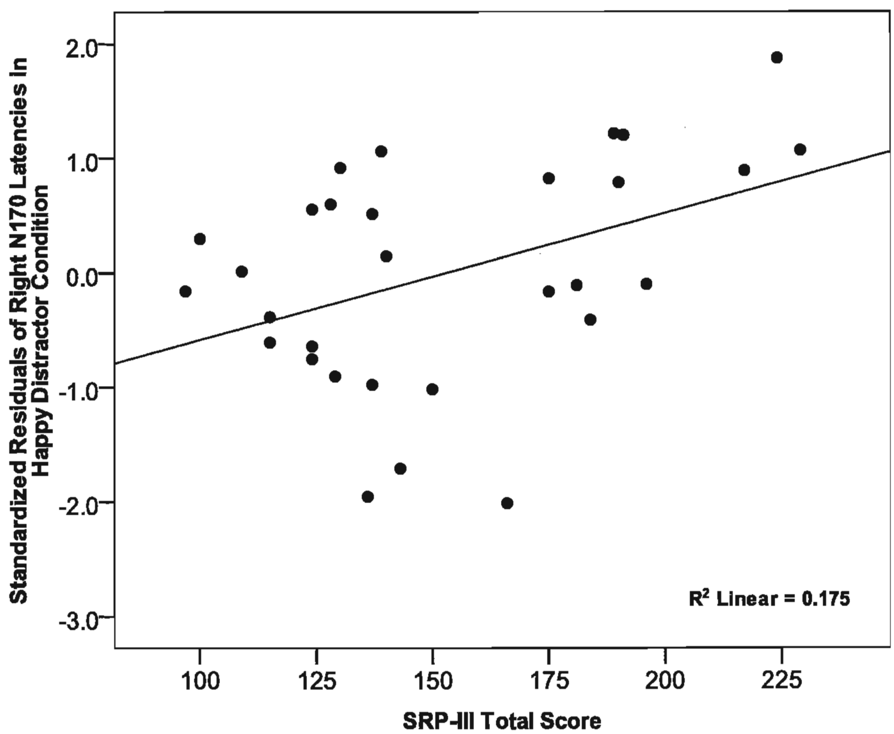

Figure 28. Scatter plot of N170 latencies at right hemisphere sites in response to happy face distractors correlated with global psychopathic traits (Task 2).

Corresponding relationships were observed for VPP latencies, although to a lesser extent. For example, erratic lifestyles traits were positively associated with the latency of the VPP in response to all emotional distractor faces (Figure 29; Table 2), while callous affect was positively associated with VPP latencies in response to both fearful, $r = .39$, $p = .035$ (Figure 30) and happy distractor faces, $r = .50$, $p = .005$ (Figure 31), with an observed trend toward a relationship with angry distractors, $r = .33$, $p = .075$. Finally VPP latencies in response to happy distractors faces, $r = .40$, $p = .028$ (Figure 32), were found to positively correlate with global psychopathy traits, although no trends were observed for the other distractor faces. Once again, no significant relationships were observed between VPP latencies and antisocial behavioural traits, suggesting that the effects observed in the current study are specific to individuals with psychopathic traits, and not more general antisocial tendencies.

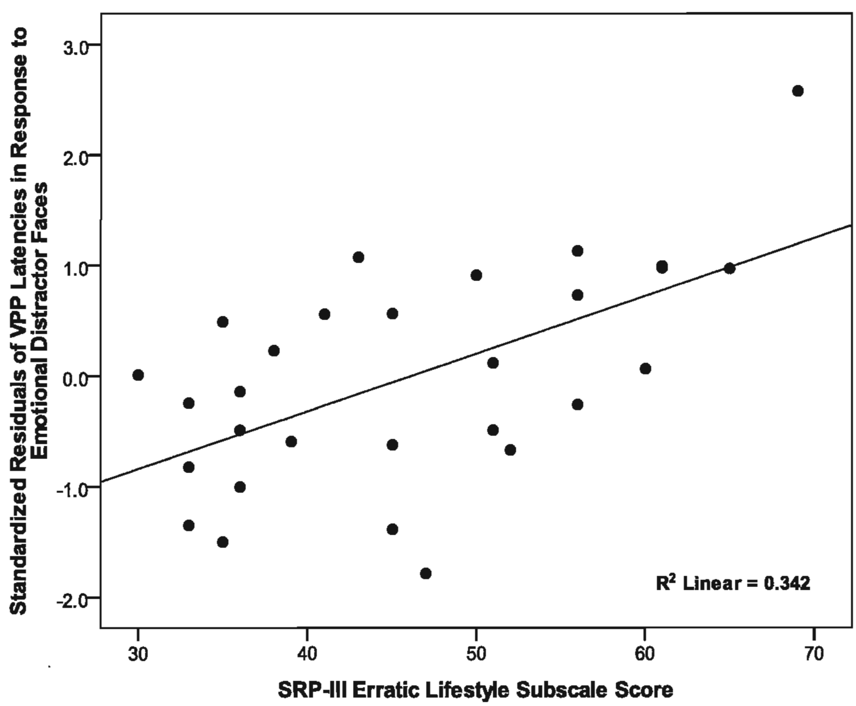

Figure 29. Scatter plot of VPP latencies in response to emotional distractor faces correlated with erratic lifestyle traits (Task 2).

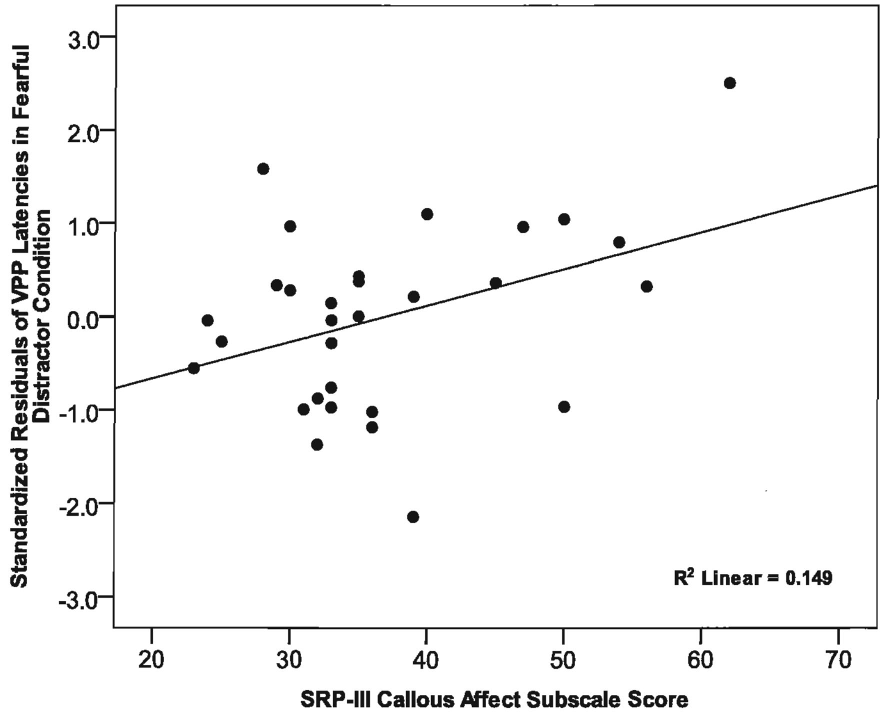

Figure 30. Scatter plot of VPP latencies in response to fearful distractor faces correlated with callous affect traits (Task 2).

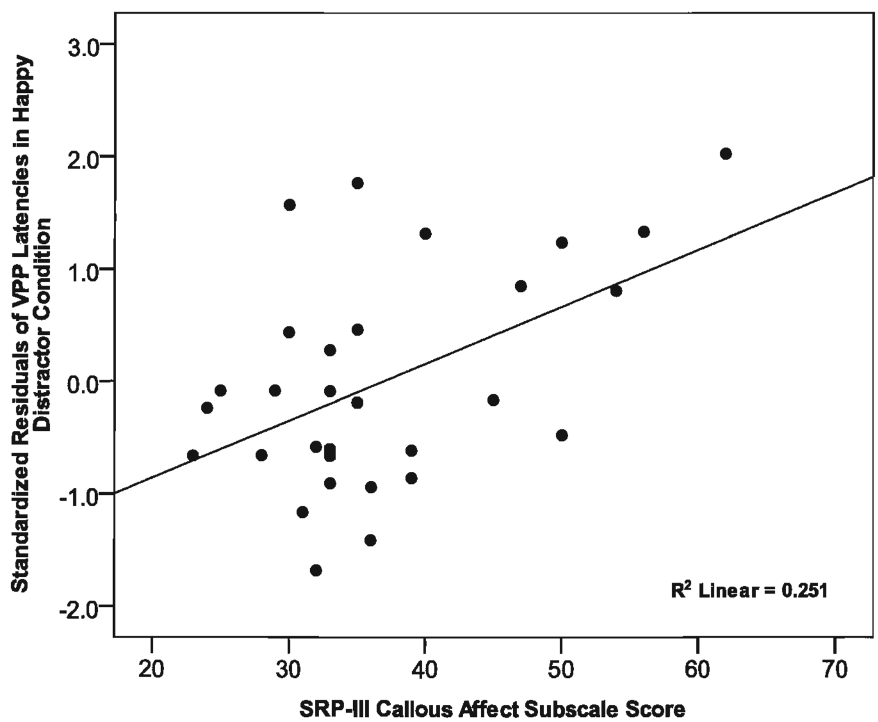

Figure 31. Scatter plot of VPP latencies in response to happy distractor faces correlated with callous affect traits (Task 2).

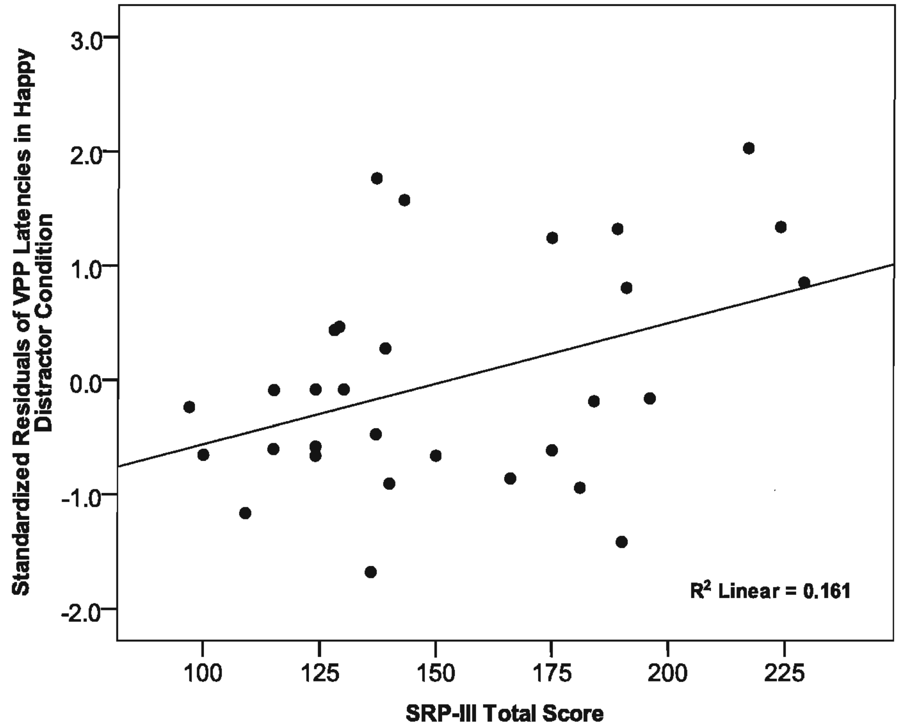

Figure 32. Scatter plot of VPP latencies in response to happy distractor faces correlated with global psychopathy traits (Task 2).

Task 2 Discussion

The Effect of Task-irrelevant Affective Distractors in a Semantic Categorization Task

To further examine the effects of the automatic recruitment of attentional resources to processes affective information, the current thesis included a selective attention/interference task based on a paradigm originally designed by de Fockert et al. (2001) and modified to include affective stimuli by Pecchinenda and Heil (2007). The purpose of this task was to investigate whether affective distractor faces caused greater interference during a word categorization task compared to scrambled face distractors, which would indicate an inability to inhibit processing of these distractors despite task requirements.

Congruent with the findings of Pecchinenda and Heil (2007), participants responded significantly slower to word stimuli presented on top of affective face distractors compared to scrambled face distractors, indicating that emotional face distractors caused greater interference during the categorization of word stimuli than scrambled faces. Unfortunately, we cannot directly conclude that this is a factor of the affective nature of the stimuli specifically, as the task used in the current study did not include a neutral face condition. Fortunately, these findings are still consistent with research suggesting that socially relevant stimuli, such as faces in general, recruit attentional and processing resources automatically (Sergent, Ohta & MacDonald, 1992).

As was expected, distractor type was found to have an effect on the amplitude of the N170 component, such that affective face distractors elicited significantly larger N170 amplitudes compared to scrambled face distractors. Again, such findings are not surprising, and are in line with previous research by Bentin et al. (1996) showing the N170 to be particularly responsive to face stimuli.

An additional effect within emotional distractor type was observed, such that fearful distractor faces produced larger N170 amplitudes than either happy or angry distractor faces. Similarly, angry distractor faces produced significantly larger amplitudes compared to happy distractor faces at left hemisphere (P7) sites only. These findings are once again in line with the previously described research showing that negative, threat-relevant stimuli tend to elicit larger ERP components, a phenomenon thought to indicate the greater evolutionary salience of these stimuli (Schupp, Öhman, Jünghofer, Weike, Stockburger & Hamm, 2004).

The findings of a distractor by site interaction also suggest that with more power (i.e., more trials, larger number of participants), an overall difference in N170 amplitudes between negative and positive emotional stimuli may be observed, although such findings must first be replicated with an equal number of positively and negatively valenced emotional expressions to be certain that the observed effect is not a function of differences in the difficulty of discrimination between emotion categories (Russell, Lewicka & Niit, 1989; Gao, Maurer, & Nishimura, 2010).

Finally, distractor type was found to influence the latency of both the N170 and VPP components, such that emotional distractor stimuli elicited faster component peaks than scrambled face distractors. These findings are in line with previous results indicating that affective face distractors introduce greater interference, as the N170 responses observed in the current task are similar to those elicited in the emotion recognition task, suggesting that task-irrelevant distractor faces are being processed very much the same as target face stimuli. These observations are congruent with the findings of de Fockert et al.'s (2001) original study showing that activity in the FFG elicited by face distractors is a marker of distractor interference. This is also in line with the findings of Pecchinenda and Heil (2007), as well as the general literature on affect facilitation, suggesting that socially relevant affective distractors are in fact being processed, despite instructions to ignore them. Discussion of the results of the individual differences analyses can be found in the General Discussion section, as they are the primary focus of the current thesis.

General Discussion

Manipulating Attention Allocation During Emotion Recognition

The observations of Schyns et al. (2007) have suggested that the information necessary for accurate identification of emotional expressions lies in specific features of the face, depending on which emotion is to be identified (i.e., fear recognition is associated with information extracted from the eye region).To test these findings, we manipulated participants' attention toward specific regions of the face (i.e., eye, nose, or mouth region) while categorizing facial expressions during a masked emotion recognition task.

Effect of emotional expression. Consistent with previous research (Gao & Maurer, 2009; Kirouac & Dore, 1983; Widen & Russell, 2008), happy facial expressions were categorized more quickly and accurately than either fearful or angry facial expressions, although these findings may have been artificially inflated by discrepancies in the current face set. Similarly, happy facial expressions produced smaller N170 and VPP components compared to both fearful and angry expression. These findings are of particular interest, as it has been subject to debate in the N170 literature (Krombholz, Schaefer & Boucsein, 2007) as to whether different emotional expressions elicit components of different amplitudes, as was observed in the current study.

Effect of fixation manipulation. In addition to examining the effects of different emotional expressions on both the behavioural and electrophysiological correlates of emotion recognition, the current study also addressed what effect manipulating the location of participants' attention fixation would have on emotion recognition performance based on Schyns et al.'s (2007) observations of a consistent "eyes-down" attention allocation pattern during the processing of emotional expressions.

As predicted, participants were significantly less accurate when categorizing fearful facial expressions when attention was directed away from the eye region (specifically, toward the mouth region). Similarly, it was found that emotional expressions in general were identified less accurately when attention was directed toward the mouth region. The current findings, when interpreted in the context of the observations of Schyns et al., suggest that the mouth region is unlikely to provide the appropriate diagnostic information with which to accurately categorize an expression. As such, participants may have been more likely to guess when responding to emotional faces presented under the mouth fixation condition.

Fixation of attention was also found to affect the latency of the N170, but not the VPP component, such that the N170 peaked earlier in response to emotional faces presented under a central fixation, compared to faces presented under a mouth fixation. These findings seem to support the functional significance of the "eyes-down" attention allocation pattern observed by Schyns et al., such that having one's attention directed away from the eye region, in turn delays processing and recognition of emotional facial expressions.

Individual Differences in Emotion Recognition in a Masked Emotion Recognition Task

One of the primary goals of this thesis was to examine the relationship between subclinical levels of psychopathic personality traits and behavioural and electrophysiological correlates of emotion recognition. This goal was based on previous research, which has provided evidence of recognition deficits for affective facial expressions in psychopathic individuals (Kosson et al., 2002; Fullam & Dolan, 2006; Dolan & Fullam, 2006; Blair et al., 2004b; Hastings et al., 2008, etc.).

Interestingly, participants' behavioural performance in Task 1 was unrelated to severity of psychopathic traits across all conditions (e.g., emotional expression, fixation location and duration of stimulus presentation). These findings do not support the current hypothesis that psychopathic traits should be negatively associated with participants' behavioural performance (i.e., slower RTs and decreased accuracy), especially for fearful faces, as well as face stimuli presented in the 30 ms duration and central fixation conditions. However, the absence of a relationship between psychopathy and emotion recognition performance is not necessarily inconsistent with the current literature on emotion recognition deficits in psychopathy. Previous research has similarly reported the absence of an association between psychopathic traits and performance on an emotion recognition task, while concurrently observing significant differences in the way these emotional faces are processed in the brain (Gordon, Baird & End, 2004).

Effect of emotional expression. There was no relationship between psychopathic traits and characteristics of the N170 component in response to emotional faces, which does not support our hypotheses of smaller and/or later N170 components in response to fearful, and possibly angry facial expressions. Interestingly, the current study did show trends toward relationships between the latency of the N170 to specific emotional expressions and psychopathic traits. In particular, non-significant, positive relationships between N170 latencies in response to fearful faces and erratic lifestyles traits, and N170 latencies in response to happy faces with both global psychopathy traits and interpersonal manipulation were found. These trends suggest that as the presence of these psychopathic personality traits increase, so does the amount of time it takes for the N170 to peak. This is particularly interesting, as it is in line with our predictions based on the findings of Schyns et al. (2007), suggesting that individuals high in these traits may use abnormal attention allocation patterns when viewing emotional faces, which in turn delays their ability to acquire the relevant information needed to recognize and categorize the emotional expression.

As with the N170 components, no significant relations between psychopathic traits and either the amplitude or latency of the VPP were observed. Unlike the N170, there were no trends found toward any relationship between these factors.

Effect of attention manipulation. There were no observed relationships between either the peak amplitude or the latency of the N170 component. These observations are contrary to the current hypothesis that individuals high in psychopathic traits would show shorter latencies and potentially larger N170 components in response to stimuli presented in the eye fixation condition. As described above, these findings are inconsistent with the observations of Dadds et al. (2008) that directed attention to the eye region improved emotion recognition in a sample of children high in psychopathic traits.

Finally, VPP amplitudes in response to emotional face stimuli presented in the central fixation condition were found to be negatively associated with interpersonal manipulation traits. These findings are consistent with the concept of abnormal neural responses to affective facial expressions in individuals high in psychopathic personality traits. However, these findings must be interpreted cautiously, as the effect was not observed in the N170, and as such may not be very robust. However, it is also possible that the observed effect is present in the amplitude of the N170 and is only failing to reach significance due to the fact that the left and right N170 components represent the activity of two separate neural generators, whereas the VPP component represent the summated activity of these two generators, thereby increasing the likelihood of finding a significant effect.

Despite these limitations, these results are particularly interesting, because it was expected that difference in the amplitude of the VPP and/or N170 related to psychopathic personality traits would be most evident in the central fixation condition. Specifically, we predicted that the recognition of affective expressions would improve for individuals high in psychopathic traits in the eye fixation condition, and decrease in the mouth fixation condition for all participants. Based on these expectations, the most naturalistic observations of neural correlates of emotion recognition are likely to be found in the central fixation condition. There were, however, no observed relationships between the latency of the VPP component and any of the psychopathic personality traits measured in the current study.

Effect of stimulus exposure duration. Contrary to our predictions, no relationship was found between psychopathic personality traits and the peak amplitude of the N170 in response to emotional stimuli presented at variable exposure durations. This is counter to our hypothesis that psychopathic traits would be negatively related to N170 amplitudes in the 30 ms condition, reflecting impaired recognition due to lack of facilitation by the thalamic fast path to the amygdala. The absence of the predicted effect may be a function of the current sample of participants, as a high functioning subclinical population may not possess subcortical abnormalities, or they may be so subtle as to not have an observable impact on emotion recognition processes.

On the other hand, the latency at which the N170 component peaked was found to be related to erratic lifestyle traits, such that the N170 peaked later at right hemisphere sites for individuals higher in erratic lifestyle traits, but only in the 30 ms stimulus exposure condition. When interpreted in the context of the findings of Schyns et al. (2007), the current observations suggest that individuals who are higher in erratic lifestyle traits take longer to acquire key diagnostic information from emotional expressions when they are presented for very brief duration. This explanation is in line with the current hypotheses, although at this time it cannot be directly concluded that these findings are the result of abnormalities in the amygdala, which has been proposed to underlie emotion recognition deficits in psychopathic individuals.

It should also be noted that erratic lifestyle traits are not necessarily unique to psychopathy, but are found in other manifestations of mental illness, such as schizophrenia, and personality disorder, such as antisocial personality disorder, and may more generally reflect patterns of disorganized cognition (Gruzelier & Manchanda, 1982) and, as such, the current findings should be interpreted cautiously.

Similarly, factor analyses on a variety of psychopathy measures (e.g., PCL-R, Harpur, Hakstian & Hare, 1988) have consistently identified a two-factor structure for the individual traits that comprise psychopathy. Specifically, erratic lifestyles traits, as well as antisocial behavioural traits, have been shown to load on the second (high-anxious) factor of psychopathy (Harpur, Hare & Hakstian, 1989), as opposed to the first (low-anxious) factor, which consists of the affective and interpersonal traits that are definitive of psychopathy. This is consistent with the previous caveat, as individuals who are higher in secondary, compared primary psychopathic traits have shown significant similarities with the unstable subtype of antisocial personality disorder (Ullrich & Coid, 2010). In addition, differences in approach and avoidance behaviours have been observed between individuals high in primary versus secondary psychopathic traits (Wallace, Malterer & Newman, 2009). These findings suggest the possibility of more general functional differences between the two subtypes of psychopathic individuals, which may extend to the processes involved in emotion recognition.

The Effect of Task-irrelevant Affective Distractors in a Semantic Categorization Task

In addition to examining the effect of attention manipulation during emotion recognition, another goal of the current thesis was to explore the automatic recruitment of attention by affective stimuli during an affective interference task based on paradigms by de Fockert et al. (2001) and Pecchinenda and Heil (2007). Affective face distractors were found to cause greater interference during an unrelated word categorization task, compared to scrambled face distractors, a finding which is consistent with the work of Pecchinenda and Heil (2007).

As predicted by the face-sensitive nature of the N170, N170 amplitudes were larger in response to affective (intact) face distractors compared to scrambled face distractors. In addition, the amplitude of the N170 was found to further distinguish among emotional expression, such that fearful expressions produced larger N170 components compared to happy and angry expressions. Similarly, the N170 was also larger in response to angry, compared to happy facial expressions at left hemisphere sites specifically. These results are particularly interesting, as the previous analyses for Task 1 also showed that the N170 peak amplitudes were distinguishing between emotional expressions, an effect whose existence has been debated in the N170 literature (Krombholz et al., 2007; Blau, Maurer, Tottenham, McCandliss, 2007).

Distractor type was also found to modulate the latency at which the N170 component peaked, such that the component peaked earlier in response to emotional, compared to scrambled distractor faces. The fact that these results are similar to the findings in Task 1 suggests that distractors are in fact being processed, despite instructions to ignore them. These findings are also is in line with the observations of de Fockert et al. (2001) that activity in the FFG elicited by face distractors can be used a marker of distractor interference.

Individual Differences in Emotion Recognition in an Affective Interference Task

As with the previous task, we were interested in the relationship between psychopathic personality traits, as measured by the SRP-III, and both behavioural performance on a word categorization task in the presence of emotional distractors faces and neural correlates of emotion recognition in response to these affective distractor faces.

Interestingly, word categorization accuracy in the presence of both angry and fearful distractor faces was negatively correlated with callous affect. These observations are contrary to our primary hypothesis that individuals high in psychopathic traits would have higher accuracy rates compared to individuals low in psychopathic traits, due to the decreased saliency of affective distractors as a result of impaired information transmission through the subcortical thalamic path to the amygdala, which should in turn result in less interference by emotional distractor faces.

Similarly, the time taken to categorize word stimuli in the presence of both fearful and angry distractor faces was positively related to interpersonal manipulation traits, with a similar, but non-significant, trend observed between response times and callous affect. The current observations suggest that slower categorization of word stimuli in the presence of negative, threat-relevant affective distractors may be associated with the affective traits of psychopathy, as opposed to the behavioural traits. It should be noted that greater attentional capture by threat-related stimuli is a common observation in the literature (Fox, Russo & Dutton, 2002), and as such it is not surprising that these face stimuli were found to elicit greater interference. What was not expected was that this effect would be strongest in the high psychopathy individuals. One possible explanation for this unexpected finding comes from a body of research that has shown that psychopathic individuals have a particularly acute ability to judge the vulnerability of others to being victimized (Book et al., 2007; Wheeler, Book & Costello, 2009), a trait which could account for the increased attention to expressions of fear and anger, as these expressions may be related to forming judgments of one's vulnerability in individuals high in psychopathic traits (i.e., fearful expressions may indicate greater vulnerability to being a victim, while angry expressions may indicate a less vulnerable target). While this account may seem contradictory to the current proposition that psychopathic individuals show deficits in the recognition of emotional expressions, research on the perception of personality traits from facial information has suggested that the perception of traits such as competence (Todorov, Mandisodza, Goren & Hall, 2005) and trustworthiness

(Vuilleumier & Sander, 2008) reflects distinct processes from those that extract information from emotional facial expressions.

Alternatively, peak amplitudes of both the N170 and VPP components in response to both happy and fearful face distractors were found to be negatively related to antisocial behaviour. These findings suggest that antisocial behaviour, which is not unique to psychopathy, is related to the magnitude of ERP components related to face processing. Specifically, individuals reporting more antisocial behaviours produced more negative N170 components and more positive VPP components. These findings are contrary to the current predictions that individuals high in psychopathic traits, such as antisocial behaviour, would produce face-related components that are smaller, as opposed to larger in amplitude. Again, such findings must interpreted cautiously, as antisocial behaviour is by no means a unique symptom of psychopathy, but has been associated with several manifestations of mental illness (i.e., schizophrenia; Hodgins, Cree, Alderton & Mak, 2007) and personality disorder (i.e. antisocial personality disorder, American Psychiatric Association, 2000).

Similarly, the latency of both the N170 and VPP was found to be positively related to callous affect and erratic lifestyle traits, as well as interpersonal manipulation and global psychopathy traits. What is most interesting about these observation are the implications of decreased recognition accuracy in combination with slower N170 latencies, which suggest both greater interference by emotional distractor faces and delayed acquisition of key diagnostic information required for recognition.

It is proposed that the current effects may in fact be extended to emotional distractors in general, and that the absence of a relationship between angry distractor faces and psychopathic traits may be due to the previously described differences in discriminability between emotions within the current face set.

It must be noted that, although the affective interference task was designed as a selective attention/interference paradigm, the previous observation that emotional face distractors elicited normal N170 components suggests that participants are in fact processing these emotional distractors. These results suggest that, in addition to being a selective attention paradigm, this task may also function as an implicit emotion recognition task in that participants are not actively identifying emotional expressions, but still recognizing and processing the affective distractors as face stimuli.

Another interesting corollary finding of the current analyses was the absence of a relationship between the latency of the N170 and VPP and measures of antisocial behaviour. This finding is particularly informative as strong correlations were observed with all other factors of psychopathy, as well as global psychopathy scores. The fact that the current study failed to show such a relationship suggests that the current findings may genuinely reflect the contribution of psychopathic personality traits, and not broader, more general traits of an antisocial nature.

Limitations

As with any program of research, the current thesis is not without limitations. One limitation that has already been addressed is that of the potentially ambiguous emotional stimuli used. Specifically, post-hoc analyses suggested that both fearful and angry expressions used in the current study were identified as being more ambiguous in the expression of their intended emotions, as compared to happy faces. Although happy facial expressions have consistently been identified as more easily recognizable than other expressions of emotion (Gao & Maurer, 2009; Kirouac & Dore, 1983; Widen & Russell, 2008), the degree incongruence of the discriminability of expressions used in the current study may have exacerbated and inflated this difference, such that more effortful processing may have been required for more ambiguous stimuli, resulting in larger amplitudes.

In addition, the inability of the current study to replicate the findings of Schyns et al. (2007) may have been due to the fact that the current recognition task utilized significantly fewer trials per emotion. It is likely that by increasing the number of trials per emotional expression, future studies will be able to differentiate the effects of different emotional expressions on the latency of the N170 component.

Similarly, the requirements of Task 1 may not have offered the ideal measure of emotion recognition and categorization ability. Specifically, participants were instructed to identify stimuli as being a fearful face or not a fearful face, which may inadvertently direct participants to recruit target detection processes, given that fearful faces are implicitly defined as "targets". This is of concern as research by Mack and Palmeri (2010) has suggested that object (target) detection and basic-level categorization are discrete processes that represent distinct stages of early visual processing.

Finally, our ability to draw concrete conclusions about the presence or absence of the affect facilitation effect in both tasks was limited as the current study failed to include neutral face stimuli, which would offer a true control condition against which to compare the effects of affective face stimuli.

Future Directions

There are several areas of future research that have been suggested by the current study. First and foremost is the continued testing of the current hypotheses within a clinical population of psychopathic individuals. As was previously proposed, it may be that significant abnormalities in subcortical structures that result in abnormal attention allocation patterns and, in turn, emotion recognition difficulties are only present in extreme manifestations of the disorder. In addition, future research should look for differences in emotion recognition between the primary (shallow and callous affect, lack of remorse, etc.) and secondary facets of psychopathy (parasitic lifestyle, revocation of conditional release, etc.), as previous research has shown a distinction between individuals who present as being higher on one of these factors over the other (Anestis, Anestis & Joiner, 2009).

In addition, recent ERP research has identified several components that are thought to be selectively responsive to affective information, for example the N250 and late positive potential (LPP; Holmes, Kragh-Nielsen, Tipper & Green, 2009). Future research should incorporate these components into their analyses, as they may offer new insight into the specific time course of neural processing of affective stimuli, and offer novel means by which to test the hypotheses of impaired transmission of affective information in psychopathic individuals.

In addition, future research should include measures of attention allocation and scanning pattern (i.e., eye tracking) during explicit emotion recognition in order to further test the findings of Schyns et al. (2007) and their implications for the impairment of emotion recognition in individuals high in psychopathic traits. Such methods would directly confirm or refute the current hypothesis of impaired attention allocation to the relevant areas of the face necessary for recognition of emotional expressions, and specifically a lack of attention to the eye region as previously observed in children with psychopathic tendencies (Dadds et al., 2006, 2008).

However, recent research has shown that explicit, directed recognition of emotional expressions may in fact decrease activation in the amygdala in healthy participants in response to these face stimuli, an effect attributed to inhibitory influences from frontal lobe regions (Critchley et al., 2000). In light of these findings, it is recommended that future research into the emotion recognition deficits observed in psychopathy also include some form of implicit emotion recognition task so as to avoid creating an experimental situation which may minimize the differences between individuals low and high in psychopathic personality traits. In other words, an implicit emotion recognition task would, according to Critchley and colleagues, would create an situation in which one might expect maximal activation of the amygdala in response to emotional faces, which would in turn increase one's potential to observe differences between these groups. Similarly, previous research has already shown them to be effective for observing differences between psychopathic and nonpsychopathic samples in neural activation in response to emotional face stimuli (Deeley et al., 2006).

Finally, several modifications to the tasks used in the current study have been proposed, prior to use in future studies. First and foremost, a new set of face stimuli is needed, as post hoc analyses revealed significant differences in the discriminability of expressions across emotion categories. New emotional face stimuli should be equated on this factor to ensure that any future observations of differences across emotion type are in fact the result of the different affective content of the expression and not differences in the discriminability of the emotion being expressed. As well, the range of emotional expressions used in the current tasks should be expanded. For example, neutral face stimuli need to be included in both tasks to allow firm conclusions to be drawn regarding the influence of affective information, versus the social relevance of face stimuli in general. In addition, emotional stimuli with a wider range of valance and arousal ratings (i.e., more positively valenced emotions) should be included in future studies to minimize potential differences in recognition difficulty as a function of inherent differences in these factors (Russell, Lewicka & Niit, 1989; Gao, Maurer, & Nishimura, 2010).

Finally, the inclusion of a "free-gaze" condition in the masked emotion recognition task is suggested, in which no fixation cross would be presented prior to exposure to the face stimuli, allowing participants to follow their own natural patterns of attention allocation when viewing emotional faces. This modification would be of particular interest in clinical populations and in context with the use of eye tracking equipment, as it would allow for observations of attentional scanning and recognition behaviour that would most likely be found in real-world settings.

Conclusions

Although we failed to replicate the original findings of differences in the latency of the N170 in response to specific expression of emotion, the current study offers interesting insight into the function of the eyes-down attention allocation pattern described by Schyns et al. (2007). Specifically, it was observed that, when attention was directed away from the eye region, recognition of emotional expressions was impaired, an effect which was reflected in both behavioural and electrophysiological measures of emotion recognition. These finding suggest that this eyes-down attention allocation pattern is conducive to successful recognition of emotion, and that abnormalities or impairments in this normal pattern of attentional scanning may result in deficits in emotion recognition. This in turn has several implications for research in clinical populations which evidence impaired recognition of emotional expressions, such as psychopathic or autistic individuals.

In addition to examining the advantages of the automatic recruitment of attentional resources by affective stimuli, the current study also examined how this automatic recruitment of attention can be disadvantageous to task performance when affective stimuli are irrelevant to task performance. The results of the current study were consistent with those of previous research (Pecchinenda & Heil, 2007) showing impaired task performance in the presence of irrelevant affective distractors compared to neutral distractors. Similarly, the current study also showed that face-related ERP components reflected the degree of interference by emotional distractor faces, similar to the fMRI findings of de Fockert et al. (2001).

Finally, in the current study we looked at the relationships between self-reported psychopathic personality traits and behavioural and neural responses to emotional facial expressions under different fixation locations and exposure durations. Several associations were observed, the most interesting of which suggests that the acquisition of key information needed to accurately recognize an emotional expression is delayed, reflected in longer N170 and VPP latencies, in individuals high in psychopathic traits.

Another observed relationship between psychopathic traits and face-related ERPs suggests possible delays in emotion processing in individuals high in psychopathic traits under subliminal exposure durations, as well as potential increases in the saliency of emotional stimuli when presented under conditions that draw attention to the eye region.

The contribution of personality characteristics to basic perceptual processes is a phenomenon that has been largely overlooked in the current research literature to date. Existing research has led to the proposal that individual differences in visual processing/attentional mechanisms may be a factor of underlying differences in brain structure that, as a whole, manifest as one's personality traits. These traits, as a function of the structural differences that underlie them, act as a filter for incoming information from the surrounding environment such that certain traits, or clusters of traits (i.e., personality disorders) allocate attention and assign significance to incoming information to different degrees. For example, in the case of psychopathy, it may argued that as a result of abnormalities in the structure and/or function of the amygdala and other related regions of the limbic system, individuals high in psychopathic traits are less attentive to fear signals, and as such find such stimuli to be less salient. This perspective may help to shed light on the construct of psychopathy as a continuous personality trait (or cluster of traits), such that individual differences in structure and function of the brain may contribute to creating a continuum of these traits in the general population, in which true disorder is found only at the extremes.

References

Adolphs, R., Gosselin, F., Buchanan, T. W., Tranel, D., Schyns, P., & Damasio, A. R. (2005). A mechanism for impaired fear recognition after amygdala damage. *Letters to Nature, 433*, 68-72. doi: 10.1038/nature03086

Adolphs, R., Tranel, D., Damasio, H., & Damasio, A. (1994). Impaired emotion recognition in facial expressions following bilateral damage to the human amygdala. *Nature, 372*, 669-672. doi: 10.1038/372669a0

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders: DSM-IV-TR.* Washington, DC : American Psychiatric Association.

Anestis, M. D., Anestis, J. C., & Joiner, T. E. (2009). Affective consideration in antisocial behaviour: An examination of negative urgency in primary and secondary psychopathy. *Personality and Individual Differences*, *47*, 668-670. doi: 10.1016/j.paid.2009.05.013

Aniskiewicz, A. S. (1979). Autonomic components of vicarious conditioning and psychopathy. *Journal of Clinical Psychology*, *35*, 60 -67. doi: 10.1002/1097-4679(197901)35:1<60::AID-JCLP2270350106>3.0.CO;2-R

Arnett, P. A., Howland, E. W., Smith, S. S., & Newman, J. P. (1993). Autonomic responsivity during passive avoidance in incarcerated psychopaths. *Personality and Individual Differences, 14*, 173-184. doi: 10.1016/0191-8869(93)90187-8

Babiak, P. & Hare, R. D. (2007). *Snakes in suits: When psychopaths go to work.* New York, NY: HarperCollins Publishers, Inc.

Balconi, M. & Lucchiari, C. (2005). Event-related potentials related to normal and morphed faces. *The Journal of Psychology, 139*, 176-192. doi: 10.3200/JRLP.139.2.176-192

Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The "Reading the Mind in the Eyes" test revised version: A study with normal adults, and adults with Asperger Syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry, 42*, 241-251. doi: 10.1111/1469-7610.00715

Batty, M. & Taylor, M. J. (2003). Early processing of the six basic facial emotional expressions. *Cognitive Brain Research, 17*, 613-620. doi: 10.1016 /S0926-6410(03)00174-5

Begleiter, H. M., Gross, M., & Kissin, B. (1967). Evoked cortical responses to affective visual stimuli. *Psychophysiology, 3*, 336 –344. doi: 10.1111/j.1469-8986.1967.tb02717.x

Bentin, S., Allison, T., Puce, A., Perez, E., & McCarthy, G. (1996). Electrophysiological studies of face perception in humans. *Journal of Cognitive Neuroscience, 8*, 551-565. doi: 10.1162/jocn.1996.8.6.551

Bird, H., Franklin, S., & Howard, D, (2001). Age of acquisition and imageability ratings for a large set of words, including verbs and function words. *Behavior Research Methods, Instruments, & Computers, 33*, 73-79.

Blair, R. J. R. (2008a). The amygdala and ventromedial prefrontal cortex: Functional contributions and dysfunction in psychopathy. *Philosophical Transactions of the Royal Society of Biological Sciences, 363*, 2557-2565. doi: 10.1098/rstb.2008.0027

Blair, R. J. R. (2008b). The amygdala and ventromedial prefrontal cortex in morality and psychopathy. *Trends in Cognitive Neuroscience, 11*, 387-392. doi: 10.1016/j.tics.2007.07.003

Blair, R. J. R. (2001). Neurocognitive models of aggression, the antisocial personality disorders and psychopathy. *Journal of Neurology, Neurosurgery and Psychiatry, 71*, 727-731. doi: 10.1136/jnnp.71.6.727

Blair, R. J. R. (1999). Responsiveness to distress cues in the child with psychopathic tendencies. *Personality and Individual Differences, 27*, 135-145. doi: 10.1016/S0191-8869(98)00231-1

Blair, R. J. R., Colledge, E., Murray, L., & Mitchell, D. G. V. (2001). A selective impairment in the processing of sad and fearful expressions in children with psychopathic tendencies. *Journal of Abnormal Child Psychology, 29*, 491-498. doi: 10.1023/A:1012225108281

Blair, R. J. R., Mitchell, D., & Blair, K. (2005). *The psychopath: Emotion and the brain.* Malden, MA: Blackwell Publishing.

Blair, R. J. R., Mitchell, D., Leonard, A., Budhani, S., Peschardt, K. S., & Newman, C. (2004a). Passive avoidance learning in individuals with psychopathy: Modulation by reward but not by punishment. *Personality and Individual Differences, 37*, 1179-1192. doi: 10.1016/j.paid.2003.12.001

Blair, R. J. R., Mitchell, D., Peschardt, K., Colledge, E., Leonard, R., Shine, J., . . . Perrett, D. I. (2004b). Reduced sensitivity to others' fearful expressions in psychopathic individuals. *Personality and Individual Differences, 37*, 1111–1122. doi: 10.1016/j.paid.2003.10.008

Blair, R. J. R., Morris, J. S., Frith, C. D., Perrett, D. I. & Dolan, R. J. (1999). Dissociable neural responses to facial expressions of sadness and fear. *Brain, 122*, 883-893.

doi: 10.1093/brain/122.5.883

Blau, V. C., Maurer, U., Tottenham, N., & McCandliss, B. D. (2007). The face specific N170 component is modulated by emotional facial expression. *Behavioural and Brain Functions, 3*. doi: 10.1186/1744-9081-3-7

Blonigen, D. M., Carlson, S. R., Krueger, R. F., & Patrick, C. J. (2003). A twin study of self-reported psychopathic personality traits. *Personality and Individual Differences, 35*, 179-197. doi: 10.1016/S0191-8869(02)00184-8

Book, A. S., Quinsey, V. L., & Langford, D. (2007). Psychopathy and the perception of affect and vulnerability. *Criminal Justice and Behaviour, 34*, 531-544. doi: 10.1177/0093854806293554

Brierly, B., Medford, N., Shaw, P., & David, A. S. (2004). Emotional memory and perception in temporal lobectomy patients with amygdala damage. *Journal of Neurology, Neurosurgery and Psychiatry, 75*, 593-599. doi: 10.1136/jnnp.2002.006403

Broks, P., Young, A. W., Maratos, E. J., Coffey, P. J., Calder, A. J., Isaac, C. L. ... Hadley, D. (1998). Face processing impairments after encephalitis: Amygdala damage and recognition of fear. *Neuropsychologia, 36*, 59-70. doi: 10.1016/S0028-3932(97)00105-X

Caharel, S., Bernard, C., Thibaut, F., Haoouzir, S., Maggio-Clozel, C. D., Allio, G. . . . Rebai, M. (2007). The effects of familiarity and emotional expression on face processing examined by ERPs in patients with schizophrenia. *Schizophrenia Research, 95*, 186-196. doi: 10.1016/j.schres.2007.06.015

Carlson, J. M., & Reinke, K. S. (2010). Spatial attention-related modulation of the N170 by backward masked fearful faces. *Brain and Cognition, 73*, 20-27. doi: 10.1016/j.bandc.2010.01.007

Carlson, J. M., Reinke, K. S., & Habib, R. (2009). A left amygdala mediated network for rapid orienting to masked fearful faces. *Neuropsychologia, 47*, 1386-1389. doi: 10.1016/j.neuropsychologia.2009.01.026

Carlson, N. R. (2007). *Physiology of Behaviour* (9th ed.). Boston, MA: Allyn and Bacon, Pearson Education, Inc.

Christie, R. & Geis, F. L. (1970). *Studies in Machiavellianism*. New York, NY: Academic Press, Inc.

Clark, J. M. & Pavio, A. (2004). Extensions of the Paivio, Yuille, and Madigan (1968) norms. *Behavior Research Methods, Instruments, & Computers, 36*, 371-383.

Coltheart, M. (1981). The MRC Psycholinguistic Database. *Quarterly Journal of Experimental Psychology, 33*, 497-505.

Critchley, H. D., Daly, E., Phillips, M., Brammer, M., Bullmore, E., Williams, S. . . . Murphy, D. (2000). Explicit and Implicit neural mechanisms for processing of social information from facial expressions: a functional magnetic resonance imaging study. *Human Brain Mapping, 9*, 93-105. doi: 10.1002/(SICI)1097-0193(200002)9:2<93::AID-HBM4>3.0.CO;2-Z

Dadds, M. R., El Masry, Y., Wimalaweera, S., & Guastella, A. J. (2008). Reduced eye gaze explains "fear blindness" in childhood psychopathic traits. *Journal of the American Academy of Child & Adolescent Psychiatry, 47*, 455-463. doi: 10.1097/CHI.0b013e31816407f1

Dadds, M. R., Perry, Y., Hawes, D. J., Merz, S., Riddel, A. C., Haines, D. J., . . . Abeygunawardane, A. I. (2006). Attention to the eyes and fear-recognition deficits in child psychopathy. *British Journal of Psychiatry, 189*, 280-281. doi: 10.1192/bjp.bp.105.018150

Day, R., & Wong, S. (1996). Anomalous perceptual asymmetries for negative emotional stimuli in the psychopath. *Journal of Abnormal Psychology, 105*, 648-652. doi: 10.1037/0021-843X.105.4.648

de Fockert, J. W., Rees, G., Frith, C. D., & Lavie, N. (2001). The role of working memory in visual selective attention. *Science, 291*, 1803-1806. doi: 10.1126/science.1056496

Deeley, Q., Daly, E., Surguladze, S., Tunstall, N., Mezey, G., Beer, D. . . . Murphy, D. G. (2006). Facial emotion processing in criminal psychopathy: Preliminary functional magnetic resonance imaging study. *British Journal of Psychiatry, 189*, 533-539. doi: 10.1192/bjp.bp.106.021410

Dolan, M. C. & Fullam, R. S. (2009). Psychopathy and functional magnetic resonance imaging blood oxygenation level-dependent responses to emotional faces in violent patients with schizophrenia. *Biological Psychiatry, 66*, 570-577. doi: 10.1016/j.biopsych.2009.03.019

Dolan, M. C., & Fullam, R. S. (2006). Face affect recognition deficits in personality-disordered offenders: Association with psychopathy. *Psychological Medicine, 36*, 1563-1569. doi: 10.1017/S0033291706008634

Eimer, M. & Holmes, A. (2007). Event-related brain potential correlates of emotional face processing. *Neuropsychologia, 45*, 15-31. doi: 10.1016/j.neuropsychologia.2006.04.022

Eimer, M., Kiss, M., & Holmes, A. (2008). Links between rapid ERP responses to fearful faces and conscious awareness. *Journal of Neuropsychology, 2*, 165-181. doi: 10.1348/174866407X245411

Fox, E., Russo, R., & Dutton, K. (2002). Attentional bias for threat: Evidence for delayed disengagement from emotional faces. *Cognition and Emotion, 16*, 355-379. doi: 10.1080/02699930143000527

Friendly, M., Franklin, P. E., Hoffman, D., & Rubin, D. C. (1982). The Toronto Word Pool: Norms for imagery, concreteness, orthographic variables, and grammatical usage for 1,080 words. *Behavior Research Methods & Instrumentation, 14*, 375-399.

Frühholz, S., Fehr, T. & Herrmann, M. (2009). Early and late temporo-spatial effects of contextual interference during perception of facial affect. *International Journal of Psychophysiology, 74*, 1-13. doi: 10.1016/j.ijpsycho.2009.05.010

Fullam, R., & Dolan, M. (2006). Emotional information processing in violent patients with schizophrenia: Association with psychopathy and symptomatology. *Psychiatry Research, 141*, 29-37. doi: 10.1016/j.psychres.2005.07.013

Gao, X. & Maurer, D. (2009). Influence of intensity on children's sensitivity to happy, sad, and fearful facial expressions. *Journal of Experimental Child Psychology, 102*, 503-521. doi: 10.1016/j.jecp.2008.11.002

Gao, X., Maurer, D., & Nishamura, M. (2010). Similarities and differences in the perceptual structure of facial expressions of children and adults. *Journal of Experimental Child Psychology, 105,* 98-115. doi: 10.1016/j.jecp.2009.09.001

Glass, S. J., & Newman, J. P. (2006). Recognition of facial affect in psychopathic offenders. *Journal of Abnormal Psychology, 115*, 815-820. doi: 10.1037/0021-843X.115.4.815

Gordon, H. L., Baird, A. A., & End, A. (2004). Functional differences among those high and low on a trait measure of psychopathy. *Biological Psychiatry, 56*, 516-521. doi: 10.1016/j.biopsych .2004.06.030.

Gosselin, F., and Schyns, P.G. (2001). Bubbles: A new technique to reveal the use of visual information in recognition tasks. *Vision Research, 41,* 2261–2271. doi: 10.1016/S0042-6989(01)00097-9

Graves, T., Landis, R., & Goodglass, H. (1981). Laterality and sex differences for visual recognition of emotional and non-emotional words. *Neuropsychologia, 19*, 95–102. doi: 10.1016/0028-3932(81)90049-X

Gratton, G., Coles, M. G. & Donchin, E. (1983). A new method for off-line removal of ocular artifact. *Electroencephalography and Clinical Neurophysiology, 55*, 468-484. doi: 10.1016/0013-4694 (83)90135-9.

Greenhouse, S. W. & Geisser, S. (1959). On methods in the analysis of profile data. *Psychometrika,* 24, 95-112. doi: 10.1007/BF02289823

Gruzelier, J. & Manchanda, R. (1982). The syndrome of schizophrenia: relations between electrodermal response lateral asymmetries and clinical ratings. *British Journal of Psychiatry, 141*, 488-495. doi: 10.1192/bjp.141.5.488

Gur R. C., Sara R., Hagendoorn M., Marom O., Hughett P., Macy L., . . . Gur, R. E. (2002). A method for obtaining 3-dimensional facial expressions and its standardization for use in neurocognitive studies. *Journal of Neuroscience Methods, 115*, 137-143. doi: 10.1016/S0165-0270(02)00006-7

Hastings, M. E., Tangney, J. P., & Stuewig, J. (2008). Psychopathy and identification of facial expressions of emotion. *Personality and Individual Differences, 44*, 1474-1483. doi: 10.1016/j.paid.2008.01.004

Hare, R. D. (1991). *The Hare Psychopathy Checklist-Revised.* Toronto, Ontario: Multi-Health Systems.

Hare, R. D. (2003). *The Hare Psychopathy Checklist-Revised* (2nd ed.). Toronto, Ontario: Multi-Health Systems.

Harpur, T. J., Hakstian A. R., & Hare, R. D. (1988). Factor structure of the Psychopathy Checklist. *Journal of Consulting and Clinical Psychology, 56*, 741-747. doi: 10.1037/0022-006X.56.5.741

Harpur, T. J., Hare, R. D., & Hakstian, A. R. (1989). Two-factor conceptualization of psychopathy: Construct validity and assessment implications. *Psychological Assessment: A Journal of Consulting and Clinical Psychology, 1*, 6-17. doi: 10.1037/1040-3590.1.1.6

Hodgins, S., Cree, A., Alderton, J., & Mak, T. (2007). From conduct disorder to severe mental illness: Associations with aggressive behaviour, crime and victimization. *Psychological Medicine, 38*, 975-987. doi: 10.1017/S0033291707002164

Holmes, A., Kragh-Nielsen, M., Tipper, S., & Green, S. (2009). An electrophysiological investigation into the automaticity of emotional face processing in high versus low trait anxious individuals. *Cognitive, Affective & Behavioral Neuroscience, 9*, 323-334. doi: 10.3758/CABN.9.3.323

Itier, R. J., & Taylor, M. J. (2004). Source analysis of the N170 to faces and objects. *Neuroreport, 15*, 1261–1265.

Jasper, H. A. (1958). The ten–twenty system of the International Federation. *Electroencephalography and Clinical Neurophysiology, 10*, 371–375.

Key, A. P. F, Dove, G. O. & Maguire, M. J. (2005). Linking brainwaves to the brain: An ERP primer. *Developmental Neuropsychology, 27*, 183-215. doi: 10.1207/s15326942dn2702_1

Kemmis, I., Hall, J. K., Kingston, R., & Morgan, M. J. (2007). Impaired fear recognition in regular recreational cocaine users. *Psychopharmacology, 194*, 151-159. doi: 10.1007/s00213-007-0829-5

Kiehl, K. A., Hare, R. D., Liddle, P. F., & McDonald, J. J. (1999). Reduced P300 responses in criminal psychopaths during a visual oddball task. *Biological Psychiatry, 45*, 1498-1507. doi: 10.1016/S0006-3223(98)00193-0

Kiehl, K. A., Hare, R. D., McDonald, J. J., & Brink, J. (1999). Semantic and affective processing in psychopaths: An event-related potential (ERP) study. *Psychophysiology, 36*, 765-774. doi: 10.1017/S0048577299971081

Kirouac, G. & Dore, F. Y. (1983). Accuracy and latency of judgment of facial expressions of emotions. *Perceptual and Motor Skills, 57*, 683-686.

Kosson, D. S. & Newman, J. P. (1986). Psychopathy and the allocation of attentional capacity in a divided-attention situation. *Journal of Abnormal Psychology, 95*, 257-263. doi: 10.1037/0021-843X.95.3.257

Kosson, D. S., Suchy, Y., Mayer, A., & Libby, J. (2002). Facial affect recognition in criminal psychopaths. *Emotion, 2*, 398 – 411. doi: 10.1037/1528-3542.2.4.398

Krombholz, A., Schaefer, F., & Boucsein, W. (2007). Modification of N170 by different emotional expression of schematic faces. *Biological Psychology, 76*, 156-162. doi: 10.1016/j.biopsycho.2007.07.004

Kucera, H. & Francis, W. N. (1967). *Computational Analysis of Present-Day American English.* Providence, RI: Brown University Press.

Lawrence, K., Kuntsi, J., Coleman, M., Campbell, R., & Skuse, D. (2003). Face and emotion recognition deficits in Turner Syndrome: A possible role for X-linked genes in amygdala development. *Neuropsychology, 17*, 39-49. doi: 10.1037/0894-4105.17.1.39

Ledoux, J. E. (2000). Emotion circuits in the brain. *Annual Review of Neuroscience, 23*, 155-184. doi: 10.1146/annurev.neuro.23.1.155

Liddell, B. J., Williams, L. M., Rathjen, J., Shevrin, H., & Gordon, E. (2004). A temporal dissociation of subliminal versus supraliminal fear perception: An event-related potential study. *Journal of Cognitive Neuroscience, 16*, 479-486. doi: 10.1162/089892904322926809

Luck, S. J. (2005). *An introduction to the event-related potential technique*. Cambridge, MA: MIT Press.

Mack, M. L. & Palmeri, T. J. (2010). Decoupling object detection and categorization. Journal of Experimental Psychology, 36, 1067-1079. doi: 10.1037/a0020254

Marsh, A. A. & Blair, R. J. R. (2008). Deficits in facial affect recognition among antisocial populations : A meta-analysis. *Neuroscience and Biobehavioural Reviews, 32*, 454-465. doi: 10.1016/j.neubiorev.2007.08.003

Marsh, A. A., Finger, E. C., Mitchell, D. G. V., Reid, M. E., Sims, C., Kosson, D. S., . . . Blair, R. J. R. (2008). Reduced amygdala response to fearful expressions in children and adolescents with callous-unemotional traits and disruptive behavior disorders. *The American Journal of Psychiatry, 165*, 712-720. doi: 10.1176/appi.ajp.2007.07071145

Marsh, A. A., Kozak, M. N., & Ambady, N. (2007). Accurate identification of fear facial expressions predicts prosocial behaviour. *Emotion, 7*, 239-251. doi: 10.1037/1528-3542.7.2.239

McHoskey, J. W., Worzel, W., & Szyarto, C. (1998). Machiavellianism and psychopathy. *Journal of Personality and Social Psychology, 74*, 192-210. doi: 10.1037/0022-3514.74.1.192

McPartland, J., Cheung, C. H. M., Perszyk, D., & Mayes, L. C. (2010). Face-related ERPs are modulated by point of gaze. *Neuropsychologia, 48*, 3657-3660. doi: 10.1016/j.neuropsychologia.2010.07.020

Mercure, E., Dick, F., & Johnson, M. H. (2008). Featural and configural face processing differentially modulate ERP components. *Brain Research, 1239*, 162-170. doi: 10.1016/j.brainres.2008.07.098

Morris, J. S., DeGelder, B., Weiskrantz, L., & Dolan, R. J. (2001). Differential extrageniculostriate and amygdala responses to presentation of emotional faces in a cortically blind field. *Brain, 124*, 1241-1252. doi: 10.1093/brain/124.6.1241

Morris, J. S., Öhman, A., & Dolan, R. J. (1999). Conscious and unconscious emotional learning in the human amygdala. *Nature, 393*, 467-470. doi: 10.1038/30976

Munro, G. E. S., Dywan, J., Harris, G. T., McKee, S., Unsal, A., & Segalowitz, S. J. (2007). ERN varies with degree of psychopathy in an emotion discrimination task. *Biological Psychiatry, 76*, 31-42. doi: 10.1016/j.biopsycho.2007.05.004

Newman, J. P. & Kosson, D. S. (1986). Passive avoidance learning in psychopathic and nonpsychopathic offenders. *Journal of Abnormal Psychology, 95*, 252-256. doi: 10.1037/0021-843X.95.3.252

Newman, J. P., Patterson, C. M., Howland, E. W., & Nichols, S. L. (1990). Passive avoidance in psychopaths: The effects of reward. *Personality and Individual Differences, 11*, 1101-1114. doi: 10.1016/0191-8869(90)90021-I

Nieuwenhuys, R., Voogd, J., & Van Huijzen, C. (2008). *The human central nervous system*. New York, NY: Springer.

Paivio, A., Yuille, J. C., & Madigan, S. (1968). Concreteness, imagery and meaningful values for 925 nouns. *Journal of Experimental Psychology Monograph Supplement, 76*, 1-25. doi: 10.1037/h0025327

Paulhus, D. L., Hemphill, J. D., & Hare, R. D. (in press). *Self-Report Psychopathy scale: Version III*. Toronto: Multi-Health Systems.

Pecchinenda, A., & Heil, M. (2007). Role of working memory load on selective attention to affectively valent information. *European Journal of Cognitive Psychology, 19*, 898-909. doi: 10.1080/09541440601095388

Pessoa, L., Japee, S., & Ungerleider, L. G. (2005). Visual awareness and detection of fearful faces. *Emotion, 5*, 243-247. doi: 10.1037/1528-3542.5.2.243

Raine, A. (2008). From genes to brain to antisocial behaviour. *Current Directions in Psychological Science, 17*, 323-328. doi: 10.1111/j.1467-8721.2008.00599.x

Richell, R. A., Mitchell, D. G. V., Newman, C., Leonard, A., Baron-Cohen, S., & Blair, R. J. R. (2003). Theory of mind and psychopathy: can psychopathic individuals read the 'language of the eyes'?. *Neuropsychologia, 41*, 523-526. doi: 10.1016/S0028-3932(02)00175-6

Rossion, B., Delvenne, J.-F., Debatisse, D., Goffaux, V., Bruyer, R., Crommelinck, M., & Guérit, J.-M. (1999). Spatio-temporal localization of the face inversion effect: An event-related potential study. *Biological Psychology, 50*, 173-189. doi: 10.1016/S0301-0511(99)00013-7

Russell, J. A., Lewicka, M., & Niit, T. (1989). A cross-cultural study of a circumplex model of affect. *Journal of Personality and Social Psychology, 57*, 848-856. doi: 10.1037/0022-3514.57.5.848

Santamaria, B. (2003). *Processing facial expression after traumatic brain injury: A problem of perception or emotional response?* (Unpublished masters thesis). Brock University, St. Catharines, ON.

Schuenke, M., Schulte, E., & Schumacher, U. (2007). *Head and Neuroanatomy: Atlas of Anatomy.* Thieme: New York, NY.

Schupp, H. T., Öhman, A., Jünghofer, M., Weike, A. I., Stockburger, J., & Hamm, A. O. (2004). The facilitated processing of threatening faces: An ERP analysis. *Emotion, 4*, 189-200. doi: 10.1037/1528-3542.4.2.189

Schyns, P. G., Petro, L. S., & Smith, M. L. (2007). Dynamics of visual information integration in the brain for categorizing facial expressions. *Current Biology, 17*, 1580-1585. doi: 10.1016/j.cub.2007.08.048

Segalowitz, S. J. (1999). *ERPScore* [computer software]. St. Catharines, ON, CA.

Sergent, J., Ohta, S., & Macdonald, B. (1992). Functional neuroanatomy of face and object processing: A positron emission tomography study. *Brain, 115*, 15-36. doi: 10.1093/brain/115.1.15

Shibata, T., Nishijo, H., Tamura, R., Miyamoto, K., Eifuku, S., Endo, S., & Ono, T. (2002). Generators of visual evoked potentials for faces and eyes in the human brain as determined by dipole localization. *Brain Topography, 15*, 51-63. doi: 10.1023/A:1019944607316

Sprengelmeyer, R., & Jentzsch, I. (2006). Event related potentials and the perception of intensity in facial expressions. *Neuropsychologia, 44*, 2899-2906. doi: 10.1016/j.neuropsychologia.2006.06.020

Stevens, D., Charman, T., & Blair, R. J. R. (2001). Recognition of emotion in facial expressions and vocal tones in children with psychopathic tendencies. *Journal of Genetic Psychology, 162*, 201–211. doi: 10.1080/00221320109597961

Strauss, E. (1983). Perception of emotional words. *Neuropsychologia, 21*, 99 –103. doi: 10.1016/0028-3932(83)90104-5

Taylor, M. J. (2002). Non-spatial attentional effects on P1. *Clinical Neurophysiology, 113*, 1903-1908. doi: 10.1016/S1388-2457(02)00309-7

Todorov, A., Mandisodza, A. N., Goren, A., & Hall, C., C. (2005). Inference of competence from faces predict election outcomes. *Science, 308*, 1623-1626. doi: 10.1126/science.1110589

Ullrich, S. & Coid, J. (2010). Antisocial personality disorder - Stable and unstable subtypes. *Journal of Personality Disorders, 24*, 171-187. doi: 10.1521/pedi.2010.24.2.171

Utama, N. P., Takemoto, A., Koike, Y., & Nakamura, K. (2009). Phased processing of facial emotion: An ERP study. *Neuroscience Research, 64*, 30-40. doi: 10.1016/j.neures.2009.01.009

Viding, E., Blair, R. J. R., Moffitt, T. E., & Plomin, R. (2005). Evidence for substantial genetic risk for psychopathy in 7-year-olds. *Journal of Child Psychology and Psychiatry, 46*, 592-597. doi: 10.1111/j.1469-7610.2004.00393.x

Vuilleumier, P., & Sander, D. (2008). Trust and valence processing in the amygdala. *Social, Cognitive and Affective Neuroscience, 3*, 299-302. doi: 10.1093/scan/nsn045

Wallace, J. F., Malterer, M. B., & Newman, J. P. (2009). Mapping Gray's BIS and BAS constructs onto Factor 1 and Factor 2 of Hare's Psychopathy Checklist – Revised. *Personality and Individual Differences, 47*, 812-816. doi: 10.1016/j.paid.2009.06.019

Weber, S., Habel, U., Amunts, K., & Schneider, F. (2008). Structural brain abnormalities in psychopaths – A review. *Behavioural Sciences and the Law, 26*, 7-28. doi: 10.1002/bsl.802

Wheeler, S., Book, A., & Costello, K. (2009). Psychopathic traits and perceptions of victim vulnerability. *Criminal Justice and Behaviour, 36*, 635-648. doi: 10.1177/0093854809333958

Widen, S. C. & Russell, J. A. (2008). Young children's understanding of others' emotions. In M., Lewis, J. Haviland-Jones, L. Barrett (Eds.), *Handbook of Emotions* (pp. 348-363). New York, NY: Guilford Press.

Williams, K. M., Paulhus, D. L., & Hare, R. D. (2007). Capturing the four-factor structure of psychopathy in college students via self-report. *Journal of Personality Assessment, 88*, 205-219.

Williamson, S., Harpur, T. J., & Hare, R. D. (1991). Abnormal processing of affective words by psychopaths. *Psychophysiology, 28*, 260-273. doi: 10.1111/j.1469-8986.1991.tb02192.x

Yang, Y., Raine, A., Narr, K. L., Colletti, P., & Toga, A. W. (2009). Localization of deformations within the amygdala in individuals with psychopathy. *Archives of General Psychiatry, 66*, 986-994. doi:10.1001/archgenpsychiatry.2009.110

APPENDICES

Appendix A

Neuropsychological Screening Questionnaire

1. What is your birth date?
2. Do you use non-permanent hair dyes? *(These can run when wet and potentially stain the equipment)*
3. Do you have dreadlocks, braids or hair extensions, or anything else about your hair that might make it difficult for us to place the sensor cap on your head?
4. Do you have any visual impairment that would make it difficult for you to see a standard computer screen?
5. Do you have any condition that might affect the nervous system? *(e.g., epilepsy, multiple sclerosis)*
6. Do you have diabetes, hypoglycemia, lupus, chronic fatigue syndrome?
7. Have you ever had any serious psychiatric difficulties? *(e.g. schizophrenia, clinical depression, etc.)*

   ** *If yes: Have you ever been under treatment for this condition?*
8. Have you ever had a head injury or concussion? If yes, record details.

Appendix B

Health and Medical History Questionnaire

Subject ID code: ________ Age: _____ Gender: ____ Date:__________

Item	*Past*	*Continuing problem/ relevant details*
Special Problems with Reading		
Special Problems with Arithmetic or Number Skills		
Major Surgery (recent, last few years)		
Recent Major Stress (e.g., death in family/health concerns, in last year)		
Problems with appetite/eating (eating more or less than required)		
Problems with attention or concentration (e.g., ADD)		
Problems with activity level (hyperactivity)		
Problems with mood (Depression/Anxiety)		
Other Psychiatric problems		
Problems with sleep (e.g., falling asleep, frequent or early waking)		
Other serious disease/health concerns (e.g., cancer; chronic pain)		

Medications

Are you taking any prescribed or over-the-counter medications?

Medication	*Purpose*

Use of Stimulants/Suppressants

(0 = none; 1= v. light; 2 = light to moderate; 3 = moderate; 4 = moderate to high; 5 = high)

Caffeine (coffee, tea, chocolate, soft drinks)	0	1	2	3	4	5
Alcohol (beer, wine, liquor)	0	1	2	3	4	5
Nicotine	0	1	2	3	4	5
Other	0	1	2	3	4	5

General Health Practices:

Exercise: How strenuous?	0 1 2 3 4 5 6 7 8 9 10 *Very light* *Moderate* *Very strenuous*
Exercise: How often?	0 1 2 3 4 5 6 7 8 9 10 *Never* *Moderately regular* *Very regular*
Diet: Healthy choices?	0 1 2 3 4 5 6 7 8 9 10 *Rarely* *Occasionally* *Consistently*

Self-reported Height = ________ ***Self-reported Weight*** = ________

Appendix C

Example of Emotional Face Stimuli Rating Questionnaire

Rate each face on the degree to which it expresses the indicated emotion.

1 Not at all	2	3 Somewhat	4	5 Very

1. How ______ does ***face 1*** look?

Angry	1	2	3	4	5
Happy	1	2	3	4	5
Neutral	1	2	3	4	5
Scared	1	2	3	4	5

2. How ______ does ***face 2*** look?

Angry	1	2	3	4	5
Happy	1	2	3	4	5
Neutral	1	2	3	4	5
Scared	1	2	3	4	5

3. How ______ does ***face 3*** look?

Angry	1	2	3	4	5
Happy	1	2	3	4	5
Neutral	1	2	3	4	5
Scared	1	2	3	4	5

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21. How ______ does ***face 21*** look?

Angry	1	2	3	4	5
Happy	1	2	3	4	5
Neutral	1	2	3	4	5
Scared	1	2	3	4	5