Interactive Cognitive-Affective Deficits: A Theory of the Psychopathic Personality

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CHAPTER I

INTRODUCTION

Psychopathy is a pervasive and persistent personality disorder formally described for the first time by psychiatrist Dr. Hervey Cleckley (1941, 1976). Cleckley described psychopathy as the unusual co-occurrence in an individual of inclinations toward psychological health on one hand, and poor behavioral adjustment on the other. In much the same way, psychopathy is currently conceptualized as the combination of a broad range of personality traits. These traits include low fear, interpersonal dominance, diminished empathy, manipulation/deception, and superficial charm mixed with impulsivity, aggression, sensation/reward seeking, and increased negative emotionality.

As a disorder psychopathy is associated with increased rates of substance abuse, interpersonal violence, and other criminal behavior, all of which result in significant costs to society. Although psychopaths represent only a minority of incarcerated individuals, approximately 15–30%, they are responsible for a disproportionately large number of crimes, as much as 50% more than non-psychopathic criminals. Psychopaths are also far more likely to commit violent crimes and a greater variety of criminal offences (Hart & Hare, 1997; Moffitt, Caspi, Harrington, & Milne, 2002). Some have also recently begun to consider psychopathic traits as potential contributors in a number of high profile white-collar corporate crimes (e.g. Enron, housing market crash; Smith & Lilienfeld, 2013). It is these potentially huge costs to society that have led to decades of research investigating the etiology of these traits. This research has yielded two broad theories that attempt to account for the personality traits and observed behaviors.

First is the affective, or more specifically, low fear hypothesis (Lykken, 1957). The low fear hypothesis suggests that the primary deficit in the psychopathic personality is an inability to experience fear, which in turn impairs aversive conditioning and recognition of fear in others. Evidence for this hypothesis comes from findings that psychopaths exhibit reduced physiological reactivity to fear stimuli, impaired fear conditioning, and deficits in identifying fearful faces (Benning, Patrick, & Iacono, 2005; Benning & Malone, 2010; Blair, 2011; Blair et al., 2004; Dadds et al., 2006; Kiehl, Hare, McDonald, & Brink, 1999; Stevens, Charman, & Blair, 2001).

Second are the cognitive deficit hypotheses. These hypotheses propose different cognitive deficits such as an impaired ability to shift attention to peripheral stimuli (Howland, Kosson, Patterson, & Newman, 1993) or impaired left hemisphere function (Llanes & Kosson, 2006). These individual hypotheses vary in terms of the exact cognitive processes involved but include an attention bottleneck (Llanes & Kosson, 2006), deficient attention shifting (Bergvall, Wessely, Forsman, & Hansen, 2001), and poor working memory updating (Carlson & Thái, 2010; Carlson, Thái, & McLarnon, 2008; Gao & Raine, 2009).

An important component of these cognitive hypotheses is the idea that deficits in shifting attention and working memory updating are actually due to an over-focusing on potentially rewarded or goal oriented stimuli (Gorenstein & Newman, 1980). However, reward processing is also an affective process, leading to a general positively valenced arousal, if not a specific positive emotion. Despite much research on both affective and cognitive etiologies, as well as on reward processing, there has, until recently, been relatively little discussion of how these different etiologies potentially interact to produce the psychopathic personality. This has led to singular fear or cognitive based theories that are inadequate for explaining the full range of phenomena associated with the psychopathic personality. Those theories that do attempt to include both fear related and cognitive deficits (i.e. two process theory; Patrick & Bernat, 2009) have stopped just short of specifying an interactive relationship between the two.

One theory has very recently taken a large step forward in this direction. The Impaired Integration (II) theory put forth by Hamilton, Hiatt Racer, & Newman, (2015) proposes that the deficit underlying psychopathy is one of information integration. The authors argue that reduced functional connectivity and/or structural differences across brain networks lead to "difficulty rapidly integrating multicomponent perceptual information, which in turn influences the quality of mental representations and shapes the development of associative neural networks" (pp. 771). This deficit in integrating information leads to a focus on what the psychopath considers most relevant (i.e. goal directed information) and subsequent reduced processing of peripheral information. When emotional information is not directly relevant to the task at hand, it is not integrated with other task relevant information and a reduction in affective responding occurs. Following from this prediction, the Impaired Integration theory suggests that when there is limited information to process, when information does not need to be integrated, or when affective information is focal, psychopaths should not show deficits in affective processing. However, there are some crucial limitations to the II theory in regards to how it accounts for the traditional two factor structure of psychopathy, and the differential deficits associated with each, as well as how it accounts for affective deficits when affective processing is the primary goal. Too fully account for these issues a theory is needed that allows for both unitary cognitive and affective deficits, and also accounts for the behavioral, psychophysiological, and neural deficits observed when both cognitive and affective systems are taxed.

Therefore, I aim to propose an interactive theory of psychopathy that is based on the presence of both cognitive and affective deficits that, when elicited together, produce the greatest behavioral and psychophysiological differences. I fully acknowledge that many of the underlying assumptions and predictions put forth by my interactive theory of psychopathy will be the same as those proposed by the II theory. However, I hope to set my theory apart by making predictions about attentional and affective deficits both in isolation and as they interact together, as well as making specific predictions related to each factor of psychopathy. I will also attempt to account for reward processing differences, and fear specific deficits. I will follow my presentation of this theory with a set of studies designed to test the broad hypothesis that cognitive and affective deficits in psychopathy manifest themselves differently as a function of the requirements placed on the other system.

Before discussing the proposed empirical tests of this interactive theoretical framework, I will; 1) review the personality traits that define psychopathy, 2) discuss past research on unitary differences in affect, cognition and reward, and, 3) provide a more detailed overview of recent work suggesting the presence of cognitive affective interactions in psychopathy. Finally I will outline my interactive theory of psychopathy and how the proposed studies are motivated by this theory. These steps make up the primary aims of this dissertation as outlined below.

Specific Aims

Specific Aim 1: Develop a novel framework for understanding the interactive cognitive-affective mechanisms that contribute to the etiology of the psychopathic personality that can; 1) account for past findings of unitary cognitive and affective deficits, 2) make specific predictions about what can be expected behaviorally and psychophysiologically when both cognitive and affective *systems are taxed, and 3) provide specific suggestions for future research towards a better understanding of the exact nature of these interactions.*

This aim has three goals. First is to utilize the existing literature regarding unitary cognitive and affective deficits in the psychopathic personality, along with recent evidence of possible interactive deficits to develop a theoretical framework that could account for the deficits proposed by each of the unitary theories, as well as those differences that one or the other could not account for. Second is to be able to predict in general (i.e. not task specific) terms what can be expected behaviorally and psychophysiologically when both systems are taxed. Third, to articulate specific questions that need to be answered before we can fully understand the nature of these interactive differences in psychopathy.

Specific Aim 2: To test predictions regarding the interaction of cognitive and affective processes involved in reward seeking as a function of psychopathic traits

The goal of this aim is to use the newly developed interactive framework to make and test predictions regarding how individuals with varying levels of psychopathic traits would attend to, and maintain working memory representations of stimuli in conditions of potential reward. The primary motivation for this aim is to test the claim that psychopathic individuals over-attend to potentially rewarded or goal oriented stimuli. Additionally, considerations of the affective response to reward are lacking and therefore the cognitive-affective interactions in this area are not well characterized or understood.

Specific Aim 3: To test predictions regarding the interaction of cognitive and affective processes involved in processing and identifying human affective expressions as a function of psychopathic traits.

The goal of this aim is to make and test predictions about how individuals with varying levels of psychopathic traits attend to, and maintain in working memory, representations of varying emotional facial expressions. The motivation for this aim is the importance of affective expression in interpersonal relationships and the social implications of deficits in this area. Additionally, facial expressions allow for the investigation of general deficits in emotion recognition as well as more specific fear related deficits.

CHAPTER II

THE PSYCHOPATHIC PERSONALITY

Although psychopathy has historically been investigated as a unitary construct, it is now considered to be a cluster of dimensional personality traits that are often organized into two largely orthogonal factors. In non-incarcerated populations these factors can be measured using the Psychopathic Personality Inventory (PPI; Lilienfeld & Andrews, 1996) and have been termed fearless dominance (FD) and impulsive antisociality (IA; Benning, Patrick, Hicks, Blonigen, & Krueger, 2003). FD is closely related to the Interpersonal Affective factor of the Psychopathy Checklist - Revised (PCL-R; Hare et al., 1990), Primary Psychopathy as measured by the Levenson Self-Report Psychopathy Scale (LSRP; Levenson, Kiehl, & Fitzpatrick, 1995; Miller, Gaughan, & Pryor, 2008), and the Boldness factor of the Triarchic Psychopathy Measure (TriPM; Patrick, 2010). IA is closely related to the Impulsive-Antisocial factor of the PCL-R, Secondary Psychopathy on the LSRP, and the Disinhibition factor of the TriPM. Three (Neumann, Malterer, & Newman, 2008; Patrick, Fowles, & Krueger, 2009) and four-factor models (Neumann, Hare, & Newman, 2007; Seibert, Miller, Few, Zeichner, & Lynam, 2011) of psychopathy have also been proposed. These models either further separate the typical two factor structure or add additional factors such as Meanness in the case of the Triarchic model (Patrick et al., 2009). Although there is still some debate regarding the factor structure of various psychopathy measures, and the construct itself (Hare & Neumann, 2010; Skeem & Cooke, 2010a, 2010b), the FD/IA two-factor model of psychopathy has a strong body of research supporting the two factors and the ability of those factors to parse the features of psychopathy into independent components with unique behavioral and psychophysiological correlates

(Benning, Patrick, Blonigen, Hicks, & Iacono, 2005; Edens, Poythress, Lilienfeld, Patrick, & Test, 2008; Marcus, Fulton, & Edens, 2011; Ross, Benning, Patrick, Thompson, & Thurston, 2009). Regardless of the factor structure used there is consensus that psychopathy is a constellation of traits on which individuals can vary in a continuous manner (Edens, Marcus, Lilienfeld, & Poythress, 2006).

Within the two-factor model, fearless dominance is characterized by low anxiety and low fear, social potency, social dominance, egocentricity, and superficial charm. FD is also negatively associated with the co-occurrence of internalizing psychopathology such as anxiety and depression. Behaviorally, FD is related to increased non-violent criminal offending, proactive or instrumental aggression, and increased thrill and adventure seeking behavior (Edens, Poythress, Lilienfeld, Patrick, & Test, 2008; Ross, Benning, Patrick, Thompson, & Thurston, 2009). Physiologically individuals high in FD show reduced processing of affective faces, reduced electrodermal activity to negative emotional stimuli, and reduced startle eye-blink responses while viewing aversive stimuli (Benning, Patrick, & Iacono, 2005; Benning & Malone, 2010; Patrick & Bernat, 2009). It is important to note here that some researchers have questioned the role of FD in psychopathy, citing inconsistent relationships between FD and antisocial behavior (Edens & McDermott, 2010; Lynam & Miller, 2012; Marcus, Fulton, & Edens, 2011; Miller & Lynam, 2012). However, the traits that comprise FD are what sets psychopathy apart from other personality disorders, particularly Antisocial Personality Disorder (Lilienfeld et al., 2012; Patrick, Venables, & Drislane, 2013). It is also these traits that allow some psychopathic individuals to, as Cleckley put it, “mask” their impulsive and antisocial tendencies, making them all the more dangerous (Book et al., 2015).

Impulsive antisociality is characterized by behavioral impulsivity, desire for reward, reactive aggression, negative emotionality, and alienation from others. It is this factor that is most related violent and non-violent criminal behavior and reduced educational and employment sustainment. IA also shows a positive association with other externalizing behaviors such as substance abuse (Anestis, Anestis, & Joiner, 2009; Hare, 2006; Hart & Hare, 1997; Verona, Sprague, & Sadeh, 2012; Walters, 2008). Physiologically, individuals high in these traits show reduced neural processing of non-goal related stimuli, increased dopamine release during anticipation of reward, and reduced overall electrodermal activity in response to affective stimuli (Benning, Patrick, & Iacono, 2005; Buckholtz et al., 2010; Carlson et al., 2008; Gao & Raine, 2009; Patrick, Bradley, & Lang, 1993).

Although individuals can have a range of traits from one or both of these factors, one is considered a "true psychopath" if they possess high levels of traits from both factors. It is this interaction of antisocial and interpersonal/affective traits that differentiates psychopathy from other personality and externalizing disorders, and results in the most significant costs to society. However, understanding the behavioral and physiological correlates of each factor is also helpful for identifying the mechanisms underlying each of these sets of traits.

Affective Deficits in Psychopathy

In Cleckley's original description of the psychopathic personality he describes someone who is void of empathy and remorse, who is fearless, and who displays only superficial emotions (Cleckley, 1941, 1976). It is this description, along with findings that psychopaths showed reduced conditioning to threat stimuli that led to the low fear hypothesis of psychopathy (Lykken, 1957; Lykken, 1995; Patrick & Bernat, 2009). The low fear hypothesis posits that the primary deficit in psychopathy driving all other observed behaviors is an inability to experience fear. This leads to seemingly impulsive, reckless, and maladaptive behavior because these individuals do not think about potential consequences before acting, and they do not fear punishment. These behaviors are continuously repeated because a lack of fear of punishment impairs ones ability to learn from that punishment.

The most replicated finding in the psychopathy literature is the reduced startle eye-blink responses of psychopaths to noise probes presented during aversive images (See Figure 1; Patrick, Bradley, & Lang, 1993). Reduced potentiation of the startle-response in psychopaths indicates that they view images most people find aversive as neutral or even slightly pleasant. This is particularly evident for personal threat related images such as a picture of a gun pointed directly at the viewer. Importantly, psychopaths show normal attenuation of the startle reflex while viewing pleasant images indicating that this is not a global emotion deficit but one that is specific to fear, or at least negative affect (Anderson & Stanford, 2012; Anderson, Stanford, Wan, & Young, 2011; Benning, Patrick, Salekin, et al., 2005; Miller, Patrick, & Levenston, 2002; Patrick et al., 1993; Vaidyanathan, Hall, Patrick, & Bernat, 2011). Moreover, this difference is typically specific to the FD factor. Individuals high in only the IA factor of psychopathy show overall decreased electrodermal activity to affective stimuli but do not show the same specific fear related deficit in startle modulation as their high FD counterparts (Benning, Patrick, & Iacono, 2005; Vanman, Mejia, Dawson, Schell, & Raine, 2003).

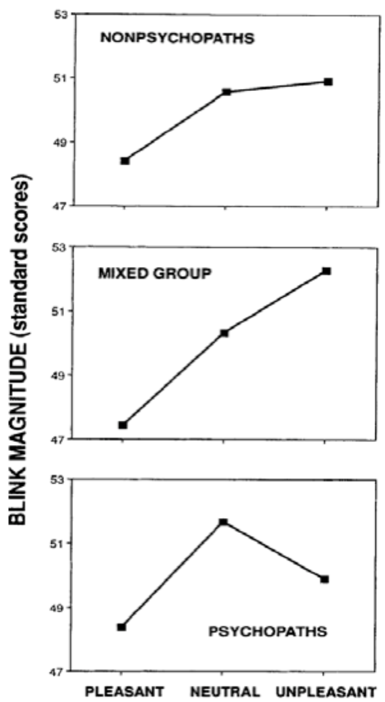

Figure 1. Reduced startle eye-blink modulation in psychopaths during aversive images.

Psychopaths have also shown reductions in other psychophysiological responses to affective stimuli including reduce skin-conductance response to potential and conditioned threat (Baskin-Sommers, Curtin, & Newman, 2011; Benning, Patrick, & Iacono, 2005). Event-Related Potential (ERP) responses to affective stimuli have also shown differences between psychopaths and non-psychopaths, particularly the early posterior negativity (EPN) and the late positive potential (LPP). In these studies psychopaths have shown reduced differentiation between neutral and affective pictures, words, and faces, compared to non-psychopathic individuals (Anderson & Stanford, 2012; Kiehl, Hare, McDonald, & Brink, 1999; Venables, Hall, Yancey, & Patrick, 2015; Williamson, Harpur, & Hare, 1991).

Deficits in processing of affective faces are thought to be particularly important because they directly impact social communication and are related to psychopaths' propensity to manipulate, victimize, and generally harm others without remorse (Blair, 2003). Specifically, Blair (2003) argues that because psychopaths do not fully process the emotions of others, they are less emotionally aware of the harm they are inflicting, and feel less empathy for their victims. They are therefore more likely to continue manipulating or otherwise victimizing others. Blair also characterizes this deficit as a developmental one, with links to reduced amygdala volume. He also states that deficits in facial affect recognition are often more apparent in children with callous unemotional traits than in adult psychopaths because adult psychopaths have learned to identify emotional expressions. However, even if adult psychopaths have learned to more accurately identify the emotion being expressed, they still may not experience the same physiological or neurological reaction as non-psychopaths. Support for this idea has come from a number of studies in recent years investigating facial processing in psychopaths using ERP (Eisenbarth, 2008, 2013) and neuroimaging (Deeley, 2006; Malterer, 2010; Decety et. al., 2013, 2014; Corre, 2013 & Mier, 2014) techniques. These differences are almost always specific to negative affect or fear faces only (see Seara-Cardoso & Viding, 2014 for a review). Importantly, in a 2008 meta-analysis, Marsh and Blair concluded that deficits in fear recognition specifically appear to be consistent across studies employing different types of facial stimuli (i.e. static and dynamic) and different task demands (i.e. passive viewing and emotion identification).

With evidence from studies of startle responses and processing of facial affect, the low fear hypothesis provides an explanation for psychopaths manipulation of others, low empathy, and poor aversive conditioning. The low fear hypothesis also attempts to explain psychopaths' reckless behavior, and to some extent even criminal behavior. However, there are deficits it does not explain, such as deficits in shifting attention or target identification when affect is not involved. The cognitive hypotheses of psychopathy described in the next section attempt to explain these deficits.

Cognitive Deficits in Psychopathy

One of the most obvious behavioral features of psychopathy is a propensity for behavioral disinhibition similar to that seen in other externalizing disorders. The primary theories regarding the etiology of externalizing disorders more generally suggest that a cognitive deficit, or combination of deficits, is responsible for this observed impulsive behavior. For example, the ability to inhibit a planned or dominant response is a key executive function that allows us to avoid mistakes and adapt to changing environmental demands. Psychopaths have repeatedly shown poor performance on stop signal and Go/No-go tasks that index this inhibitory control as well as reduced ERP responses indexing important inhibitory mechanisms (Heritage & Benning, 2013; Iacono, 2002; Munro et al., 2007; Vitale et al., 2005).

Psychophysiological differences in the processing of neutral target stimuli are also present in psychopathy including reduced P3 amplitude in oddball tasks (Carlson, Iacono, & McGue, 2002; Finn, Mazas, Justus, & Steinmetz, 2002; Raine & Venables, 1987). This reduction in P3 amplitude is another of the most consistent and often replicated effects in the psychopathy literature (see Figure 2; Carlson et al., 2008) and is almost exclusively related to the IA factor (Carlson, Thái, & McLarnon, 2008; Gao & Raine, 2009; Raine & Venables, 1987; Venables & Patrick, 2014). The majority of these studies have used a visual oddball paradigm with others using variations such as auditory oddball paradigms (see Gao & Raine, 2009 or Venables & Patrick, 2014 for a review). Because the P3 is thought to index a complex set of cognitive mechanisms including attention and working memory or context updating (Polich, 2007). Therefore, this reduction in P3 amplitude supports the hypothesis that a deficit in working memory updating may play a role in externalizing psychopathology and psychopathy. However, some studies have found no differences (Jutai, Hare, & Connolly, 1987) or even enhanced P3 responses in psychopathy (Raine & Venables, 1987). Venables & Patrick (2014) discuss in detail these discrepant findings concluding that they are likely due to the use of psychopathy total scores instead of factor scores. Specifically it is the IA factor that is related to reduced P3 amplitude (Carlson et al., 2008). This should not be surprising given the strong similarities between the IA factor of psychopathy and other externalizing disorders such as APD and substance abuse that

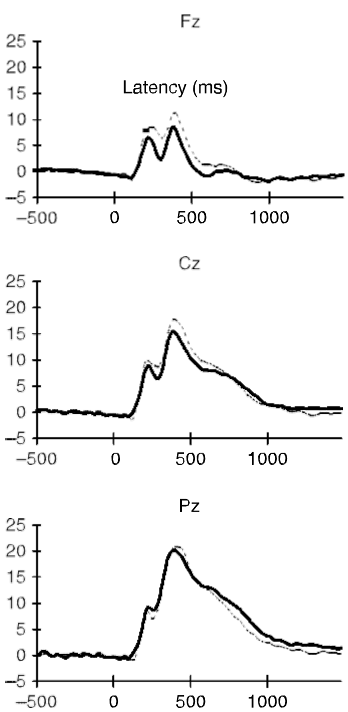

Figure 2. Reduced P3 response to target stimuli in psychopaths (Carlson et al., 2008).

have consistently shown reduced P3 responses (Carlson, Iacono, & McGue, 2002; Carlson, Katsanis, Iacono, & Mertz, 1999; Iacono, 2002). However, as Venables & Patrick (2014) discuss, no study measuring P3 amplitude in psychopathy using an oddball paradigm had included an affective component prior to their study. In their study, Venables & Patrick inserted affective IAPS images into a traditional oddball paradigm as task irrelevant novel stimuli. However, they do not report results regarding P3 amplitudes to the images or how the images impacted detection of task relevant targets, leaving many unanswered questions regarding how affective demands impact performance and ERP responses.

Together these behavioral and psychophysiological deficits have led to the development of cognitive theories of psychopathy such as the Left Hemisphere Activation hypothesis (Kosson, 1998; Llanes & Kosson, 2006) and the Response Modulation hypothesis (Howland et al., 1993; Patterson & Newman, 1993). The Left Hemisphere Activation hypothesis proposes that although psychopaths do not show selective deficits in left hemisphere processes, they do show state specific deficits when the left hemisphere is substantially and differentially activated. The Left Hemisphere Activation hypothesis grew out of evidence from dual task studies showing that psychopaths allocated less attention to secondary task or irrelevant stimuli, particularly when the stimuli were presented in the right visual field or when responses were made with the left hand (i.e. activating the left hemisphere; Kosson, 1996). There is also evidence that psychopaths do not process linguistic information as efficiently as non-psychopaths, again, especially when presented to the right ear or in the right visual field (Howland et al., 1993; Jutai, Hare, & Connolly, 1987; Raine, Venables, & Williams, 1990). These deficits are seen even when the processing demands activating the left hemisphere (e.g. responding with the right hand) are unrelated to the goal of the task (Suchy & Kosson, 2005, 2006). Llanes &

Kosson, (2006) furthered this work by demonstrating that psychopaths perform equally well as non-psychopaths in right-hemisphere activation conditions (more targets in the left visual field), and under increased cognitive loads (having to identify a central target as well as a peripheral target). They also used a color identification task to rule out language specific deficits.

The Response Modulation hypothesis proposes a similar deficit to the Left Hemisphere Activation hypothesis, but does not predict a hemisphere specific effect. The Response Modulation hypothesis predicts reduced processing of stimuli that are relevant, but not directly related to the immediate goal of the task, regardless of the hemisphere activated. The Response Modulation hypothesis is also more specific in that it defines response modulation as "a brief and relatively automatic shift of attention from the effortful organization and implementation of goal-directed behavior to its evaluation (i.e., processing peripheral cues)" (Bernstein, Newman, Wallace, & Luh, 2000, p. 414). This information-processing deficit leads to difficulty using contextual cues to modulate ongoing behavior and even to recognize errors when behavior does not change with new demands. For example, in the context of a stop-signal task where the primary goal of the task is to respond to go stimuli, individuals with high levels of IA traits have shown a failure to fully process auditory stop signals and to subsequently show reduced recognition of errors when they fail to stop (Heritage & Benning, 2013). It is important to make a distinction here between reduced processing of peripheral stimuli in general (i.e. reduced processing of stimuli outside the focus of attention) and the selective deficit in shifting attention seen in psychopaths. The former is essentially a description of how attention functions (i.e. attended stimuli are processed more than unattended or peripheral stimuli; Cowan, 2011). The later suggests a deficit wherein psychopaths do not appropriately shift attention from goal related stimuli to relevant peripheral information as efficiently as non-psychopaths do, such as in the stop signal example discussed above. In similar everyday situations these individuals fail to respond to contextual cues to adapt their behavior accordingly.

In general, cognitive hypotheses explain many of the behavioral and psychophysiological differences seen in relation to the psychopathic personality. This is particularly true for differences related to behavioral disinhibition, linguistic processing and general stimulus processing. The Response Modulation hypothesis has also been used to explain reduced startle eye-blink potentiation based on the idea that individuals with psychopathic traits are less able to shift attention to the startle probe because it is a peripheral stimulus. However, the Response Modulation hypothesis cannot explain the affect specific deficit in startle responses during aversive images and not pleasant images. Unique fear specific deficits in facial affect recognition, even when affect identification is the primary goal of the task, can also not be explained well by the Response Modulation or Left Hemisphere Activation hypotheses.

Reward Processing in Psychopathy

Findings of reward processing differences in psychopathy do not fit cleanly under either the cognitive or affective hypotheses already discussed, and may be initial evidence of abnormal cognitive-affective interactions in psychopathy. Prior to 1965 the only significant theory of psychopathy was the low fear hypothesis based on Lykken's (1957) finding that low anxious psychopaths did not learn to avoid button presses that resulted in shock. However, in 1965 Quay proposed that the poor fear conditioning, and poor avoidance of negative stimuli more broadly, was due instead to pathological sensation seeking. Quay's hypothesis was that psychopaths existed in an aversive state of under arousal, which they tried to remedy through reward seeking behavior as a means of increasing arousal. Other studies of fear conditioning (Hare, 1970), delay of gratification (Widom, 1977), and response perseveration (Newman, Patterson, & Kosson,

1987) supported the theory that psychopaths will seek rewards despite potentially negative future consequences. Gorenstein & Newman (1980) provide a review of this early work and suggest that psychopathy can be characterized by a need for increased arousal met through sensation or reward seeking. However, little was found in the way of actual increased arousal to the receipt of reward (Newman, Patterson, Howland, & Nichols, 1990). Therefore, Newman and collogues (1990) proposed that instead of reward leading to increased arousal in psychopaths, the potential for reward led to an increased focus of attention on goal directed behavior. This focus on goal directed behavior, or the possibility of a reward, is to such an extreme that any other stimuli that are not directly goal related fail to be attended to and processed. This includes aversive stimuli and stimuli associated with punishment.

Recent work has supported this view and shown that psychopathic traits are associated specifically with an increased desire for reward, rather than increased pleasure from the receipt of rewards. Multiple studies have found that psychopathy is associated with increased reward related activity in the ventral striatum while anticipating rewards, but not when receiving rewards (Bjork, Chen, & Hommer, 2012; Buckholtz et al., 2010). Further evidence indicates that increased processing of potentially rewarded stimuli leads to a reduced ability to inhibit a response, when making the response is rewarded more often than inhibiting the response (Marini & Stickle, 2010; Masui & Nomura, 2011). This theory of increased reward seeking, or anticipation of reward, has since been incorporated into the Response Modulation hypothesis as a possible explanation for why psychopaths display deficits in shifting attention. In this case psychopaths become over-focused on their goal more broadly (not just obvious rewards), and perseverate on that dominant response set, therefore failing to shift attention to process non-goal related stimuli. From this perspective, it is suggested that the reduced fear response seen in psychopaths is actually the result of a process whereby they fail to fully shift attention away from goal oriented stimuli and towards the fear related stimuli. However, based on increased reward seeking or focus on goal directed behavior alone, it is unclear why this deficit in shifting attention would apply selectively to aversive or fearful stimuli. Additionally, because deficits in fear processing (such as identifying fear faces) are seen even when identifying the affect is the goal of the task, this hypothesis alone still does not fully explain the observed behaviors or underlying etiology of the psychopathic personality. Finally, evidence of psychopaths' inability to shift attention away from goal-oriented stimuli does not necessarily mean there is an over-focus on rewarding or goal-oriented stimuli. It is possible that a deficit in shifting attention is the result of some other impaired process such as deficits in processing of broader contextual information or control of top-down attentional processes (Hoppenbrouwers, Van der Stigchel, Slotboom, Dalmaijer, & Theeuwes, 2015; Krakowski et al., 2015).

Evidence of Cognitive-Affective Interactions in Psychopathy

It is clear that psychopaths display both affective and cognitive deficits, as well as some abnormalities that may reflect differences in both affective and cognitive processes (i.e. increased reward anticipation). However, it is unclear whether these cognitive and affective deficits are two distinct processes impacting behavior in separate ways (as suggested by the two process theory; Patrick & Bernat, 2009; Venables, Hall, Yancey, & Patrick, 2015), if they reflect a deficit in integrating multiple types of information (Hamilton, Hiatt Racer, & Newman, 2015), or if these two deficits with separate underlying mechanisms interact, as proposed here, to produce the observed behavioral and psychophysiological differences. Past research on processing of affective faces may provide an example of such an interaction. Psychopathy has been associated in many studies with reduced recognition and processing of affective faces. This deficit has also been seen in children with callous-unemotional personality traits, which are thought to be a precursor to psychopathy. These studies fit with the low fear hypothesis of psychopathy such that the deficits in recognition are greatest for fear faces. However, with the use of eye tracking experiments, Dadds and collogues (Dadds et al., 2006; Dadds, Jambrak, Pasalich, Hawes, & Brennan, 2011) have demonstrated that children with high levels of callous–unemotional or psychopathic traits attend to different parts of the face than do individuals without these traits. Dadds and colleagues (2006) also found that by training children with callous-unemotional traits to attend to the eyes, they could perform equally to children without these traits. Richell et.al., (2003) showed a similar finding in a sample of incarcerated adult males when they demonstrated that psychopathic criminals did just as well as non-psychopathic criminals on a task where they had to identify a person's emotional state from a picture of only the eyes (i.e. The Reading of the Mind in the Eyes task, Barron-Cohen, 1997). Together these findings suggest that deficits in fear recognition may not be purely affective but instead that there may be an interaction between cognition, in this case attention, and affect. While the effect of attention suggests a cognitive deficit, the finding that the deficit is specific to fear, and not for all emotions, suggests that a deficient affective process is also involved, and that this affective process interacts with attention to produce the observed deficit in recognizing fear faces.

Another of the major findings in the psychopathy literature, the reduced aversive modulation of the startle reflex may also be an interaction between attentional and affective processes (Levenston, Patrick, Bradley, & Lang, 2000). Levenston and colleagues demonstrated that reduced aversive startle modulation in psychopathy might not be as straightforward as initially observed by showing different patterns of startle responses at different delays post stimulus (see Figure 3). In this case psychopaths actually showed increased early aversive modulation of the startle reflex (i.e. within 300ms of picture onset) but reduced aversive modulation at 800ms post picture onset and later. One possible explanation put forth for these results is a different pattern of attentional deployment to the affective significance of the pictures versus other neutral features. If this is the case, psychopaths may display increased early attention to aversive stimuli but reduced sustained attention.

Recent work from the laboratory of Joseph Newman and others (Baskin–Sommers, Curtin, Li, & Newman, 2012; Baskin-Sommers et al., 2010, 2011; Sadeh & Verona, 2008; Verona, Sprague, & Sadeh, 2012; Verona et al., 2012; Wolf et al., 2012) has also begun to suggest that previously held theories of psychopathy proposing a unitary deficit may be in need of revision. This work has focused primarily on attempting to manipulate affective deficits in psychopaths by altering the cognitive demands of a task (e.g. measuring startle eye-blink responses when attending to threat or neutral stimuli). Using an instructed fear paradigm (see Figure 4), Baskin-Sommers et al., had participants attend to either a threat cue (red or green square), which predicted the likelihood of an electric shock, or an alternative cue (upper or lower case letter), which did not predict the shock. Both types of information were presented on each trial but the order of presentation was alternated such that the relevant information to be focused on could come either before or after

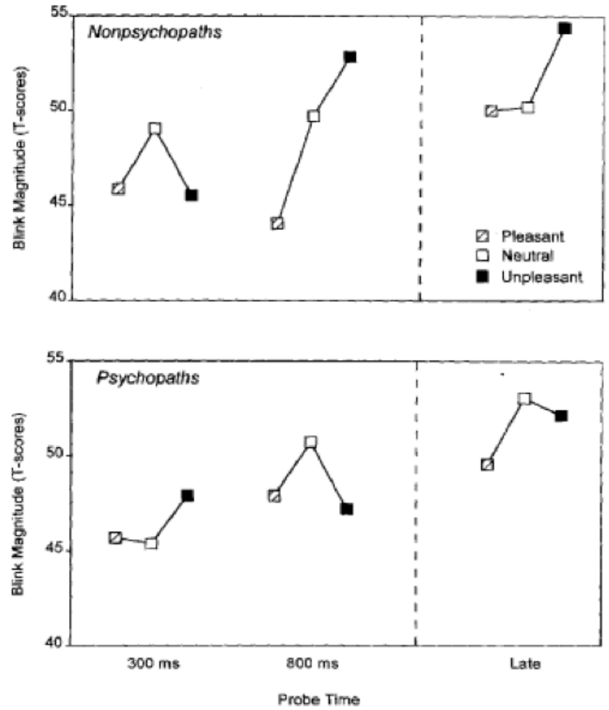

Figure 3. Results from Levenston et al., (2000) demonstrating varying aversive startle modulation as a function of time post picture onset.

the unattended stimulus. Using this paradigm they found fear potentiated startle differences in individuals with high levels of externalizing behaviors as a function of focus of attention. Individuals high in externalizing traits showed no fear-potentiated startle differences when asked to focus on the case of the letter instead of the threat cue. However, in the threat focus condition high externalizing individuals showed increased fear-potentiated startle when the threat stimulus appeared first but reduced fear potentiated startle when the threat cue appeared second. The authors concluded that these results indicate that these individuals attended strongly to the first stimulus and were unable to switch attention when the second stimulus appeared, even if it was the task relevant threat cue.

On the contrary, using the same task, Anton, Baskin-Sommers, Vitale, Curtin, & Newman (2012) found that individuals high in overall psychopathic traits showed reduced fear-potentiated startle when asked to attend to the letter, and the letter appeared first. They showed no differences in the threat focus condition, regardless of the order of presentation for the threat cue. When psychopathy scores were analyzed at the factor level, the relationship between Factor 2 (the IA factor) and reduced fear-potentiated startle in the early alternative focus condition remained significant (p = .05) but the effect was much stronger for Factor 1 (the FD factor; p =.009). Furthermore, working memory capacity moderated reduced fear-potentiated startle in psychopaths. This was the case for total scores and

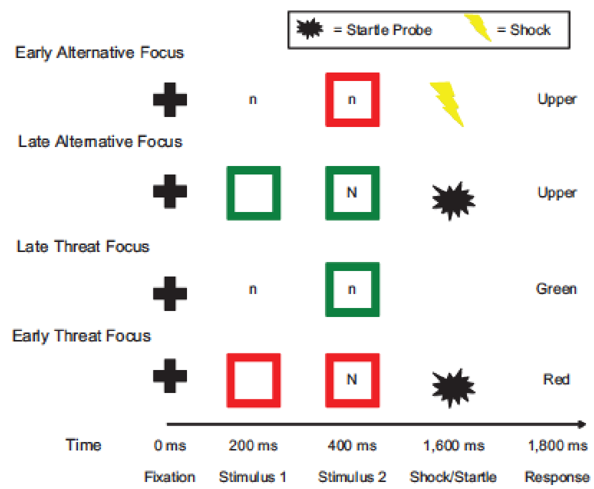

Figure 4. Instructed fear paradigm used by Baskin-Sommers et al., 2012 to test interactions between attentional selection and startle responses to threat.

both factors, although the moderation was stronger for Factor 2. The impact of working memory capacity was such that psychopaths, particularly those high in IA traits, with higher working memory capacities were better able to switch attention away from the threat cue in the late alternative focus condition. This resulted in greater fear-potentiated startle in the late alternative focus condition for psychopaths with low working memory capacities but reduced fear potentiated startle for psychopaths with high working memory capacities.

Furthermore Verona et al., (2012) demonstrated that the need for inhibitory control on a go/no-go task differentially impacted the processing of affective words, as measured by P3 amplitude, based on psychopathy factor score. In those with overall high PCL-R psychopathy scores, the need for inhibitory control did not significantly impact affective processing. When separated into two factors, the relationships with affective processing differed as a function of inhibitory control. The interpersonal/affective factor (i.e. FD) was related to reduced P3 amplitude following negative words, regardless of the need for inhibitory control. The impulsive-antisocial factor was related to increased P3 amplitude following negative words, but only on no-go trials. This suggests that inhibitory demands led to a reduced ability to regulate an emotional response to the word.

Each of these studies suggests different interactions between cognitive and affective processes in the FD and IA factors. In IA, the initial propensity is to over focus attention on task relevant stimuli leading to increased fear potentiated startle in the early threat focus condition but decreased startle response in the late threat focus condition. They also show increased P3 responses following negative words when inhibitory control is required suggesting more cognitive effort is required when negative affective information is also being processed. However, those with high working memory capacity are better able to shift attention from initial irrelevant stimuli to new task relevant stimuli. For those high in FD traits, the initial propensity is to attend less to affective stimuli and therefore show reduced affective responding. However, when forced to attend to the affect, they show normal psychophysiological responses.

These results suggest two possibilities. First, they suggest that individuals with high overall levels of psychopathic traits and greater working memory capacity, may be able overcome their initial affective deficit (in this case fear processing) due to improved attention shifting, at least when instructed to do so. Second, they also suggest, that the affective deficit may only be present, or at least observable, when attention is focused on irrelevant or neutral stimuli or when working memory is impaired. However, the available data do not differentially support one possibility over the other. Additionally, it is still unclear if attentional deficits exist when attention is directed to the affective stimulus, or the deficit is specific to shifting of attention to or from affective stimuli when already focused. The specificity of the attentional deficit also remains to be seen with regard to attending to reward cues or rewarded stimuli, as well as pleasant stimuli more broadly. However, despite these limitations, Joe Newman and colleagues have used the work discussed above to develop the most comprehensive theory yet regarding the cognitive and affective deficits associated with psychopathy (Hamilton et al., 2015).

The Impaired Integration (II) theory of psychopathy put forth by Hamilton et al. (2015) is the first to directly address the simultaneous deficits in cognitive and affective processing. Importantly, this theory differs from Newman's earlier response modulation hypothesis (Howland, Kosson, Patterson, & Newman, 1993; Newman, Schmitt, & Voss, 1997) in that, instead of a deficit in shifting attention, the II proposes a failure to rapidly bind complex perceptual information. This failure leads to a "perceptual bottleneck" which then hinders downstream processing of information and results in observed deficits such as poor facial affect identification and poor inhibitory control. The authors also provide a valuable in-depth discussion of possible underlying neural networks and how differences in connectivity between these networks impair reciprocal attentional and emotional processes in psychopathy, accounting for many of the findings discussed above. The difficulty integrating multicomponent perceptual information proposed by the II hypothesis can account for deficits in fear potentiated startle, and the differential pattern of startle over time demonstrated by Levenston et al., (2000), as well as the impaired behavioral inhibition following aversive words demonstrated by Verona et al., (2012). However, despite the huge step forward that the II theory takes, it does not fully address some of the key deficits that have long been associated with psychopathy. Primarily, the II hypothesis accounts only for a general deficit in integrating emotional and attentional processes. It does not discuss or account for specific fear (or even negative affect) related deficits. It does not address situations in which positive emotions appear to be adequately integrated, and relatedly it does not specifically address differences in reward processing. Furthermore, the authors provide only a very brief and limited description of how this theory accounts for the repeatedly replicated two-factor structure of psychopathy (i.e. fearless dominance and impulsive antisociality). Finally, despite the goal of developing an integrative theory, one could argue that the primary deficit leading to impaired integration is one of attention whereby selective attention to certain stimulus properties and not others is at the core of any observed differences in affective processing. For example, the II hypothesis predicts that when affective information is central to the task at hand, psychopaths should not show deficits in affective processing, which implies attention as the core mechanism.

From the evidence presented above, it is clear that unitary deficits in either affective or cognitive processes cannot explain all of the trait level, behavioral, psychophysiological, and neural differences observed in the psychopathic personality. Based on the available data, IA traits generally appear to be associated with over-attention to affective stimuli when the stimuli are related to a goal or the individual is explicitly instructed to attend to the affect. However, if individuals with these traits are directed to attend to a neutral stimulus, or if a neutral stimulus appears when an affective stimulus is expected, they are unable to switch their attention to the affective information and therefore show a reduced affective response. Individuals with high FD traits allocate more sustained attentional resources to processing the physical characteristics of negative emotional stimuli rather than the affective characteristics, possibly because they have greater difficulty processing the affective information. This greater allocation of sustained attentional resources to the physical characteristics of the stimulus leads to fewer resources available for affective processing. Thus, an interactive theory of psychopathy is needed to provide a comprehensive means of understanding these varying differences. Although there are still many unanswered questions as to the exact nature of these interactions, evidence of similar interactions in healthy populations, recent evidence of deficient attention-emotion interactions in psychopathy, and the re-interpretation of past findings of unitary deficits, provides an initial understanding of how these interactions may underlie the psychopathic personality.

CHAPTER III

AN INTERACTIVE THEORY

The cognitive-affective interaction hypothesis proposed here is based on evidence that cognitive (e.g. shifting of attention) and affective (e.g. fear processing) deficits underlie the psychopathic personality, and the premise that increasing demands on one system reduces the resources available to the other and therefore decrease performance of that system. Support for the underlying assumptions of this theory, namely interactive cognitive and affective processes, comes not only from the psychopathy literature discussed above but also from data showing overlapping brain structures involved in these affective and cognitive processes (Dougherty, 2004; Müller et al., 2008; Sabatinelli, Bradley, Fitzsimmons, & Lang, 2005), as well as behavioral and psychophysiological evidence of cognitive-affective interactions in healthy populations (Blair et al., 2007; Briggs & Martin, 2009; Lang, Bradley, & Cuthbert, 1990; Pessoa, 2005; Pessoa, Japee, & Ungerleider, 2005; Verbruggen & De Houwer, 2007).

The Underlying Neural Structures

The neural structures implicated by the cognitive-affective interaction hypotheses of psychopathy have some distinct functions but are largely interconnected. These structures include the amygdala, anterior-cingulate cortex (ACC), and orbital-frontal cortex (OFC), as well as the ventral striatum. Each of these structures contribute in unique ways to the affective and cognitive deficits in psychopathy but are also largely interconnected through bi-directional influences on other structures or processes in the system. Fear-potentiated startle, electrodermal reactivity to stress or negative affect, ERP differentiation between negative and neutral stimuli, and identification of emotional faces rely heavily on activation of the amygdala for affect processing whereas the ventral striatum is implicated in processing both rewards and aversive stimuli. Important in each of these processes are the OFC and ACC for attentional control, decision-making, behavioral responses, and response monitoring.

The amygdala is the primary subcortical structure implicated by the low fear hypothesis of psychopathy. It has consistently been identified as a physiological indicator of trait fear and an index of reactivity to fear cues (Kramer, 2008; Vaidyanathan, 2008). It is also the central structure related to startle reactivity in both humans and animals (Davis, Falls, Campeau, & Kim, 1993; Davis et al., 1993). In addition to reduced startle potentiation, psychopathy has been linked structurally to reduced amygdala volume (Tiihonen et al., 2000) and functionally to reduced amygdala response during processing of affective words (Kiehl et al., 2001). Functional connectivity is also found between the amygdala and visual cortex such that the activation in these two structures covary closely when an individual is viewing aversive stimuli (Sabatinelli et al., 2005). Sabatinelli et al., (2005) also demonstrated that this co-activation of visual cortex and amygdala is sensitive to individual differences in trait fear such that individuals high in trait fear show greater parallel activation in both areas compared to control participants.

Although the exact cause of this reduced amygdala volume and function in psychopathy is not fully known, one possibility is an early hormonal imbalance, particularly in hormones regulated by the HPA axis. Beginning very early in life, possibly even in-utero, an imbalance between cortisol and testosterone can reduce cortical-subcortical communication and disrupt amygdala development (Glenn & Raine, 2008; see Patrick & Bernat, 2009 for a review). Imbalances in cortisol and testosterone have been shown in individuals with psychopathic traits (Cima, Smeets, & Jelicic, 2008; Glenn, Raine, Schug, Gao, & Granger, 2011; O’Leary, Loney,

& Eckel, 2007) and differences in cortical-subcortical communication have been observed in children who express callous-unemotional traits as early as three years old (Glenn & Raine, 2008). Reduced communication between cortical and subcortical structures also has implications for instrumental learning and fear conditioning, both of which are deficient in psychopathy (Blair, 2003; 2005).

Particularly important to this learning, as well as other cognitive functions including affective decision making, responding to uncertainty, and behavioral inhibition is the OFC (Elliott, Dolan, & Frith, 2000; Happaney, Zelazo, & Stuss, 2004). Aside from behavioral differences in task switching and inhibition, evidence for OFC dysfunction in psychopathy comes primarily from studies of P3 amplitude and morphology. Specifically, the association between psychopathic traits and reduced P3 amplitude is stronger for novel stimuli than target stimuli (Venables et al., 2005). The novelty P3 (or P3a) has a more fronto-central distribution than the traditional target P3 (Courchesne, Hillyard, & Galambos, 1975; Friedman, Cycowicz, & Gaeta, 2001; Squires, Squires, & Hillyard, 1975) and recent source localization of the P3 has shown involvement of the OFC (Nieuwenhuis, Aston-Jones, & Cohen, 2005) and ACC (Dien, Spencer, & Donchin, 2003). The ACC has also been implicated as the source of the error-related negativity (ERN; Gehring & Fencsik, 2001; Gehring & Willoughby, 2002; Herrmann, Römmler, Ehlis, Heidrich, & Fallgatter, 2004) which has been consistently shown to be reduced in psychopathy (Hall, Bernat, & Patrick, 2007) and to be related to deficits in response modulation (Heritage & Benning, 2013). Reduced recognition of novel stimuli and the recognition of errors both impact adaptation to changing circumstances or goals as well as behavioral impulsivity and the ability to learn from past errors.

Individual differences in P3 amplitude and externalizing vulnerability have shown substantial overlap in heritability (Carlson et al., 2002; Hicks et al., 2007; Patrick et al., 2006) suggesting that P3 reductions, and the associated OFC dysfunction may serve as a biomarker for externalizing traits in psychopathy. Psychopaths have also shown reduced pre-frontal and limbic system gray matter volume (Raine & Yang, 2006; Yang et al., 2005) suggesting reduced functioning in these areas and repeated transcranial magnetic stimulation (rTMS) to the OFC has been shown to reduce physiological responses to affective stimuli, similar to the reductions seen in psychopathy (van Honk et al., 2001).

Although it has been the focus of less research in relationship to psychopathy, differential patterns of activation (Glenn & Yang, 2012), as well as structural differences (Glenn, Raine, Yaralian, & Yang, 2010), in the ventral striatum have been implicated in psychopathy. The ventral striatum plays a key role in psychopaths increased anticipation of reward (Bjork et al., 2012; Buckholtz et al., 2010), general increased sensation seeking and propensity for addictive behaviors (Carlson, Foti, Mujica-Parodi, Harmon-Jones, & Hajcak, 2011; Glenn & Yang, 2012), and abnormal responses to negative affective information (Carré, Hyde, Neumann, Viding, & Hariri, 2013). Abnormal relationships between activity in the ventral striatum and frontal cortices may also be implicated in reward seeking behaviors (Bjork et al., 2012).

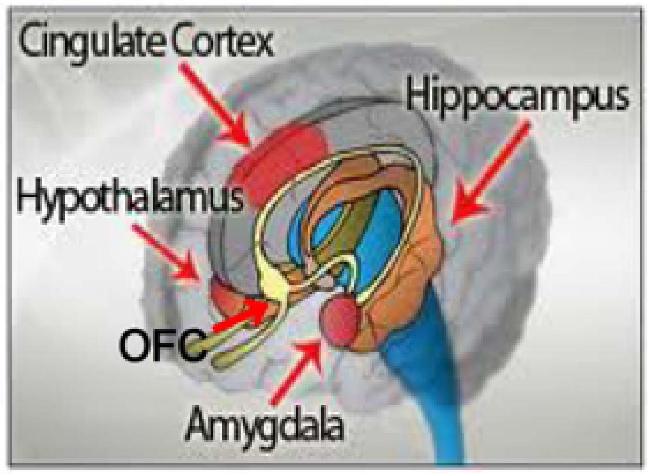

Figure 5. Limbic structures and systems underlying affective and cognitive deficits in psychopathy: OFC, ACC, Amygdala. Hypothalamus, Hippocampus, and HPA Axis are also impacted.

Together, these differences in brain structure and electrophysiology suggest deficits within and between limbic system structures (see Figure 5). Because of the bidirectional transfer of activity between the OFC, amygdala, ACC, and striatum, aberrant functioning in one area can create a cascade of effects throughout the system. Although it is still largely unclear how these deficits develop, or which comes first, one possible pattern of development suggests the early imbalance of cortisol and testosterone previously discussed. This imbalance leads to reduced development of the amygdala and reduced connectivity between the pre-frontal cortex and the amygdala. This consequently results in smaller amygdala volumes and reduced activity in response to fear, thus giving rise to fear related deficits. Subsequently, the reduced amygdala-pre-frontal communication results in reduced pre-frontal function, and possibly reduced grey matter volume, particularly in the OFC. This OFC impairment may then transfer to the ACC through reduced monitoring of changing goal demands and processing of response conflict. Finally, hormonal imbalance as well as reduced amygdala and OFC function may all impact functioning of the hippocampus and HPA axis resulting in reduced emotion regulation, impaired instrumental learning and poor fear conditioning. It is the hypothesized interaction of these structures, not their involvement in isolation, which gives rise to the differences that characterize the psychopathic personality.

The Interactive Hypothesis of Psychopathy

Based on the above evidence, the cognitive-affective interaction hypothesis proposes that interactions between cognitive (e.g. shifting of attention) and affective (e.g fear processing) deficits are present in psychopathy such that increasing demands on one system reduce the resources available to the other and therefore decrease performance of that system. For example if attention is taxed (e.g. by increasing the number of stimuli in the visual field), facial affect processing deficits will be more pronounced. On the other hand, if affective information is present (e.g. negative emotional faces), the availability of attentional resources for processing other stimuli is decreased. This hypothesis is distinct from the II theory put forth by Hamilton et. al., (2015) in that it proposes deficient processing of affective information even when that affective information is central to the task at hand and does not have to be integrated with other types of information. This hypothesis is also distinct from the two-process theory of psychopathy put forth by Patrick & Bernat, (2009) in that it proposes that deficits in one system will increase as the requirements placed on the other increase. Furthermore, it is important to note that this interactive theory is not proposing that "psychopathy" is unitary construct characterized by one distinct set of traits or sharing one common etiology. Instead, it proposes that the unique interaction of distinct biological deficits and two largely orthogonal clusters of traits produces the affective, cognitive, behavioral, and physiological differences that characterize the psychopathic personality.

Testing the Interactive Hypothesis

Previous research on cognitive-affective interactions in psychopathy has focused almost exclusively on directing attention to or from affective stimuli, particularly threat cues, and assessing the change in affective response. However, this addresses only a subset of the possible manifestations of interactive deficits. A truly interactive deficit must go both ways (i.e. affect ➔ cognition and cognition ➔ affect). The two complimentary studies that make up this dissertation were intended to be a first step in this direction by examining how changing different types of affective demands influences the functioning of cognitive mechanisms. First, in an attempt to address the influence of positively valenced affect on cognition, study one investigated the influence of potential rewards on working memory maintenance and deployment of attention as a function of psychopathic traits. A reward manipulation was chosen not only for being a form of positively valenced affect, but also because of previously demonstrated relationships between psychopathy and reward anticipation. Study two investigated the influence of inherently affective information, in the form of emotional faces, on these same mechanisms and how that influence differed with varying levels of psychopathic traits. Emotional faces provide the opportunity to manipulate affect across positive (i.e. happy) and negative valence, as well as different negative emotions (i.e. sad, anger, fear). Faces were chosen for study two because of their naturally emotional properties, previously shown deficits in facial affect recognition in psychopathy, and the importance of affect recognition for social communication.

To allow for comparisons to be made across studies, the primary task used in both studies was a memory guided visual search task designed to investigate specific cognitive mechanisms, and adapted to include an affective manipulation. Memory guided visual search tasks are ideal for this purpose for multiple reasons. First, they are behaviorally simple. In both studies participants were required to remember one target stimulus over a short delay and then provide a response regarding the presence of that target within the search array (i.e. present vs. absent or location). Second, these tasks are designed in such a way as to involve multiple cognitive mechanisms, but at distinct points in the task. For example, participants must first deploy attention to the initial target stimulus, then maintain a representation of the target stimulus in working memory over a short delay, and then again deploy attention again to find the potential target in an array of distractor stimuli before making a behavioral response.

There are also well-established ways of measuring the cognitive processes involved in these tasks, primarily through the use of event-related potentials (ERPs). ERPs are ideal for investigating cognitive and affective processes during task performance because of their millisecond-by-millisecond temporal resolution. There are also specific ERP components that have been identified as indexing distinct cognitive processes (e.g. deployment of attention, working memory maintenance) during visual search tasks, as well as components that have been identified as indexing affective processing across tasks. Having high temporal resolution and distinct ERP components allows for the measurement of unique processes at each part of a task. In turn, the relationship between psychopathic traits and each of these processes can then be investigated.

CHAPTER IV

STUDY ONE: ATTENTION AND WORKING MEMORY IN CONDITIONS OF POTENTIAL REWARD

One of the primary propositions of the response modulation hypothesis, and an assumption of the II hypothesis, is that psychopaths over-attend to rewarding or goal relevant information, which results in a reduced ability to shift attention to contextual information (Hamilton, Hiatt Racer, & Newman, 2015; Newman, Patterson, Howland, & Nichols, 1990; Newman, Patterson, & Kosson, 1987). Additionally, individuals with psychopathic traits have shown increased dopamine release during reward anticipation, suggesting an increased desire for rewards (Bjork, Chen, & Hommer, 2012; Buckholtz et al., 2010). However, the deployment of attention directly to potentially rewarded stimuli, and the maintenance of those stimuli in working memory, as a function of psychopathic traits has yet to be adequately characterized. Study One was designed to investigate this process by assessing how individuals with varying levels of psychopathic traits would deploy attention to stimuli, and maintain representations of stimuli in working memory, when those stimuli were important for earning potential rewards. The memory guided visual search task in Study One used stimuli that were by themselves neutral, but attempted to induce an affective process by providing the chance to earn a reward on some trials. Reward magnitude was manipulated such that participants could earn no reward, a low reward, or a high reward, for correct responses on different trials. Reward magnitude was manipulated in this way because rewards of different magnitudes have been shown to differentially impact behavior in non-clinical psychopathy (Masui & Nomura, 2011). Additionally, the design of the task (detailed below) allowed for a novel investigation of reward modulated long-term memory processes as a function of psychopathic traits. This study attempted to address gaps in the literature regarding the specific deployment of attention to potentially rewarding stimuli in psychopathy, as well as begin to address the influence of reward processing on working memory differences in psychopathy, which has been largely ignored in the literature relative to investigations of attention.

Hypotheses for Basic Effects

In general, it was expected that participants would attend to potentially rewarded stimuli, and maintain those stimuli in working memory, to a greater extent than they would non-rewarded stimuli. Specifically, high-reward cues and potentially high reward targets were expected to be initially more salient, as well as more strongly attended to and maintained in working memory than both low reward and no reward cues and targets. Behavioral performance was also expected to improve on reward trials relative to no-reward as evidenced by faster reaction times and improved response accuracy. A linear effect of reward magnitude was expected such that no-reward < low-reward < high-reward in terms of salience, attention, working memory maintenance and behavioral effect.

Competing Hypotheses for Psychopathic Traits

Cognitive-affective interactions in the form of reward anticipation, attention, and working memory were investigated in relationship to both factors of psychopathy. However, because reward processes are most strongly related to the IA factor of psychopathy, predictions are presented for IA only.

H1. Differences in interactive cognitive-affective processes underlie psychopathic personality traits and therefore when one system is activated the observed differences in the other system are altered. Thus:

a. IA will be negatively related to processing of no-reward cues as evidence of a weakness in working memory updating but this weakness will be reduced or eliminated in conditions of reward.

b. IA will be negatively related to deployment of attention to target stimuli, as expected from the response modulation hypothesis, and negatively related to maintenance of those stimuli in working memory in no-reward conditions. These weaknesses in shifting of attention and working memory maintenance will be reduced or eliminated in conditions of reward.

H2. Separate cognitive and affective processes underlie psychopathic personality traits and therefore the affective response to reward will have no effect on weaknesses in deployment of attention and working memory maintenance related to psychopathic traits.

a. IA will be negatively related to processing of initial cues at all reward levels.

b. IA will be negatively related to shifting of attention and working memory maintenance at all reward levels.

Methods

Participants and Procedure

Undergraduate and community participants (N = 80) were recruited using the Vanderbilt psychology online research sign up system. Participants were screened for normal color vision and either normal or corrected to normal visual acuity, as well as history of head injury or neurological disorders. Upon arriving in the laboratory all participants provided informed consent as approved by the Vanderbilt University Institutional Review Board. Participants then underwent a four-hour experimental session including the rewarded visual search task, ERP recording, and self-report measures. Participants also completed a short behavioral change detection paradigm to measure working memory capacity (Fukuda, Awh, & Vogel, 2010) prior to the visual search task. ERPs were not recorded during this task. Healthy adults typically have a working memory capacity of around three items on this and similar tasks (Fukuda et al., 2010). One participant did not complete that task due to excessive eye movements/blinks and EEG recording difficulties. Fourteen additional participants were excluded because of contaminated ERP data (i.e. more than 30% of trials with eye movements, blinks, or recording errors rejected at processing). The final sample consisted of 65 participants, 47% women, with a mean (sd) age of 23.5 (0.58).

Rewarded Visual Search Task

The rewarded, memory-guided visual search task (Figure 6) included multiple stages that were designed to involve specific cognitive mechanisms including attention, working memory, and long-term memory, as well as context updating following the reward cue. The potential for reward, as well as reward magnitude (no, low, or high) was manipulated across trials and cued at the start of each trial. Successful low reward trials resulted in $1 earned and successful high reward trials resulted in $5 earned. Participants completed a total of 840 trials (120 rewarded). To increase the salience of the reward, participants received the money earned on four randomly selected trials (two low reward trials and two high reward trials). Participants were told about this bonus prior to performing the task.

Each trial began with a randomly jittered fixation cross (1200ms -1600ms), followed by a reward cue (300ms). The cue was either the null symbol (Ø) for no reward, a dollar sign ($) for low reward, or a dollar sign with a plus sign (+$) for high reward. The reward cue was followed by a second fixation cross (100ms) before the presentation of the target. Targets

(300ms) were red or green Landolt-Cs in one of eight possible orientations. Target color was determined prior to the task, remained the same on all trials, and was counterbalanced across participants. The key stimulus feature participants had to remember was the orientation of the target stimuli (i.e. which direction the opening of the Landolt-C was facing). A shape in the non-target color was presented contralateral to the target shape on each trial to minimize physical stimulus confounds in the ERP recordings. The orientation of the target remained the same for runs of seven trials. After a run of seven trials, a new run of seven trials started with the target in a new orientation. During 95% of trial runs, trials one through four were no reward, trial five was rewarded (equal numbers of low and high reward trials), and trials six and seven were, again, no reward. A memory delay period (1000ms) followed the target during which only a fixation cross was presented. The search array (2000ms) included 10 black shapes, one red shape, and one green shape arranged in a circular pattern. The position of the target shape within the array was randomly determined prior to the start of each trial. Participants were required to indicate if the orientation of the shape in the target color was a match or non-match to the previously presented target as quickly and accurately as possible by pressing one of two buttons on a gamepad. Responses had to occur within 2000ms to be correct. Each trial ended with a feedback display that conveyed the accuracy of the response, the amount earned on that trial, and the total amount earned.

One unique feature of this task is that searching for the same target (i.e. a shape in the same orientation) for a series of trials allows for the transfer of target representations from working memory to long-term memory and allows for the use of ERP components that track this transfer of information (Reinhart & Woodman, 2013). Additionally, having the rewarded trial occur in the middle of each run of seven trials results in reward-modulated re-instantiations of target representations from long-term memory into working memory (Reinhart & Woodman, 2013). Therefore, I was able to investigate the relationship between psychopathic traits and the transfer of information to long-term memory under conditions of reward, as well as the relationship between psychopathic traits reward modulated re-instantiations of target representations into working memory.

Event-Related Potentials

Participants' raw electroencephalograms (EEG) were recorded from 21 standard electrode sites across the scalp using an electrode cap (Electro-cap International) according to standard EEG recording methods (Carlisle, Arita, Pardo & Woodman, 2001). Mastoid electrodes were used as the reference, and peri-orbital electrodes were used to detect eye movement and shifts from fixation for the rejection of artifacts before analysis. Raw EEG signal was amplified (bandpass of 0.01 – 100 Hz) and digitized at 250 Hz. Data preprocessing, artifact rejection, and ERP averaging were completed in ERPSS and EEGLAB toolbox for MATLAB. All data were filtered after artifact rejection using a .1Hz highpass filter and a 30Hz lowpass filter. Four event-related potentials (ERPs) were derived from the raw EEG to index specific cognitive processes as they unfolded on a millisecond-by-millisecond time scale.

I examined four ERP components to index specific cognitive mechanisms at different points in the task. The P3 component following the reward cue was used to index stimulus evaluation and context updating (Cohen & Polich, 1997; Kok, 2001). The P3 is sensitive to relevant individual differences in personality correlates of impulsivity and reward seeking, as well as overall risk for externalizing psychopathology (Baskin-Sommers et al., 2014; Carlson & Thái, 2010; Iacono, Carlson, Malone, & McGue, 2002). The P3 was measured as the mean ERP amplitude at electrode site Pz between 400ms - 900ms post reward cue onset. The N2 posterior-contralateral (N2pc) component, was used as an index of selective attention (Eimer, 1996; Woodman & Arita, 2011; Woodman & Luck, 1999), following the presentation of the initial target and the search array. The N2pc has also shown relevant associations with trait level individual differences as well as sensitivity to stimulus salience (Della Libera & Chelazzi, 2006; Eimer & Kiss, 2007). The N2pc was measured as the difference in mean amplitude between activity contralateral and ipsilateral to the target at electrode sites OL/OR between 200ms – 300ms post target/array onset. Finally, the contralateral delay activity (CDA), which has been linked to maintenance and manipulation of information in working memory (Vogel, McCollough, & Machizawa, 2005), and the P170, which is associated with the transfer of information into long-term memory (Voss, Schendan, & Paller, 2010), were measured during the memory retention stage of the task. The CDA was measured as the difference in mean amplitude between activity contralateral and ipsilateral to the target at electrode sites OL/OR between 300-1000ms following the presentation of the target. The P170 was measured as the mean amplitude at electrode site Fz between 180ms – 320ms post target onset.

Working Memory Capacity Task

Participants also completed a change detection task to estimate visual working memory capacity. This task began with a fixation cross, followed by the presentation of a set of colored squares. The number of colored squares presented on the screen (set size) varied from 2 – 8. Participants were required to remember both the location and color of each square over a delay period, during which only a fixation cross was on the screen. Following the delay period a single square was presented at one a location where a square was presented in the memory array. Participant had to then indicate whether that single square was the same color as the one that was in that location before. Therefore, this task required participants to remember both the color and spatial location of the squares. Varying the set size systematically allows for an estimate of participants' visual working memory capacity, which averages between three and four items.

Psychopathy Measure

The Multidimensional Personality Questionnaire – Brief Form (MPQ-BF; Patrick, Curtin, & Tellegen, 2002) is a broadband personality measure consisting of 155 items and providing scores on 11 primary trait scales. These scales aggregate into three higher-order factors including Positive Emotionality, Negative Emotionality, and Constraint. The MPQ-BF has shown good internal consistency, expected relationships with other personality measures, and good test-retest reliability (Patrick et al., 2002). The MPQ was used to estimate scores for the two main factors of psychopathy; fearless dominance (FD) and impulsive antisociality (IA) using established regression equations (Benning et al., 2003, 2005). These equations produce z-scores for FD and IA that are scaled relative to the MPQ normative sample. Therefore, z-scores greater than zero for either factor indicate higher levels of those traits than are found in the MPQ normative sample.

Analysis

To obtain a single no-reward value, I computed the average of no reward trials 4 and 6 from each run of seven trials for each of the dependent variables. This was done to minimize serial position effects and the effect of reward anticipation or post reward differences. I also computed the averages of trials 2-3, 3-4, and 6-7 to assess for serial position effects within the no reward condition. These averages, as well as values for low and high reward, can be seen in Figure 5. The average of trials 4 and 6 did not significantly differ from the averages of the other serial positions for any dependent variables except reaction time. For reaction time, the average of trials 3-4 was significantly faster than the average of 4 and 6. However, nearly identical results were obtained for subsequent reaction time analyses using the average of 3-4 instead of the average of 4 and 6 as the no-reward value. Because the results for reaction time did not differ when the 3-4 average or the 4 and 6 average was used, the average of 4 and 6 was used in the analyses reported below for consistency with the average of 4 and 6 used for all other dependent measures.

I then ran separate paired samples *t*-tests to test the difference between both low and high reward from no reward, and between low and high reward conditions for accuracy, reaction time, and for each of the ERP components described above. Difference scores were then computed for each measure to isolate the reward-induced change and control for individual differences in baseline responses. For example, high reward related change in reaction time (RT) was computed as ΔRT = High-Reward RT – No-Reward RT. Correlations were then computed between these difference scores and FD/IA scores to assess the relationship between psychopathic traits and reward induced change in behavioral and EPR responses. Only correct trials were included in all analyses. Additionally, trials with reaction times faster than 250ms or more than 3*sd* from the mean were excluded. Using an average effect size of .40 and an alpha of .05, 65 participants resulted in an achieved power of .89 across t-tests. Using the pre-determined average correlation value of .3, achieved power for all correlational analyses was .69. (G*Power; Goldman, Greenbaum, & Darkes, 1997).

Results

Psychopathy Scores

The mean (sd) scores for FD and IA were 0.39 (0.72) and 0.36 (0.63) respectively indicating similar levels of both FD and IA as in the MPQ normative sample. The distribution of these scores was such that for FD no participants fell more than 2sd from the mean. Only nine participants fell outside 1sd for IA, three of whom were outside 2sd. FD and IA were not significantly correlated with each other (r = .02, p = .89). The average working memory capacity calculated from the change detection task in the current sample was 3.26 (1.00) items. Neither FD nor IA scores were correlated with working memory capacity as measured by this task.

Basic Effects of Reward

Table 1 shows means and significant differences by reward level for reaction time, accuracy, and each of the ERP measures of interest. Behaviorally, there were significant effects of reward on reaction time, and on accuracy. Participants responded faster on both low and high reward trials compared to no reward, but there was no reaction time difference between low and high reward trials. Participants were also more accurate on high reward trials than both no and low reward trials despite accuracy being near ceiling across all reward levels.

The recruitment of cognitive mechanisms also differed by reward level. Potential rewards influenced the extent to which participants engaged in context updating following the reward cue in the expected way, with a significant effect for both overall reward and reward magnitude. Larger P3 amplitudes were observed following high reward cues than low reward cues and following both high and low reward cues compared to no reward cues. Potential rewards also influenced the deployment of attention to the initial target (N2pc) and the maintenance of the target in working memory (CDA). However, the pattern of these effects was in the opposite direction as expected. Both the N2pc to the target and the CDA during the memory delay showed significantly larger (i.e. more negative) amplitudes on low reward, but not high reward, trials compared to no reward trials. CDA amplitude was also significantly more negative on low reward trials than high reward trials. N2pc amplitude on low reward trials was more negative than on high reward trials at a trend level (t = -1.79, p = .08). The amplitude of the P170 indexing the recruitment of long-term memory and the N2pc indexing deployment of attention to the search array did not change as a function of reward level. Grand-average ERP waveforms by reward level can be seen in Figure 8.

Correlations with Psychopathy Scores

Neither FD nor IA was significantly correlated with reward related change in reaction time (|rs| < .14, ps > .27), although FD was related to faster reaction time on both no reward and high reward (rs < -.24, ps < .05) trials, and at a trend level on low reward trials (r = -.23, p = .07). FD was also correlated with high reward related change in accuracy (r = -.31, p = .01) whereas IA was correlated at trend levels with low reward related change in accuracy (r = -.24, p = .06) as well as reward magnitude related change in accuracy (r = -.22, p = .08). The direction of each of these correlations indicates less accuracy improvement for participants high in FD on high reward trials and for participants high in IA on low reward trials. Contrary to predictions, IA was not correlated with reward related change in the amplitude of any ERP measures. FD was not significantly correlated with reward related change in the P3 ERP component indexing context updating following the reward cue or the N2pc indexing deployment of attention to the search array (|rs| < .15, ps > .24). FD was however correlated with low reward (r = -.29, p = .02) and reward magnitude (r = .27, p = .03) induced change in the N2pc to the target as well as at a trend level with reward magnitude related change in the CDA (r = .24, p = .06). The direction of these correlations indicates greater differentiation between low reward and no reward N2pc for those high in FD, as well as a larger low reward N2pc and CDA compared to high reward.

Consistent with past studies (Hicks et al., 2012), IA scores were also correlated with gender (Spearman's ρ = .24, p = .06) such that men had higher levels of IA. Therefore, partial correlations were computed between both FD and IA and behavioral and ERP measures, controlling for gender. One additional participant was excluded from the partial correlations because they reported their gender as transgender leaving 64 participants for the partial correlations. The overall pattern of results for partial correlations was the same as for the zero order correlations, but the magnitude of some relationships changed. Again, neither FD nor IA was significantly correlated with reward related change in reaction time ($|rs| < .14$, $ps > .29$), although FD remained correlated with reaction time across reward levels. FD also remained correlated with high reward related change in accuracy ($r = -.30$, $p = .02$) and IA became significantly correlated with both low reward ($r = -.25$, $p < .05$) and reward magnitude related change in accuracy ($r = -.26$, $p = .04$). IA was again not significantly correlated with reward-induced change in any ERP measures, and FD was again not significantly correlated with reward related change in P3 amplitude or the amplitude of the N2pc to the search array ($|rs| < .17$, $ps > .18$). FD remained correlated with low reward ($r = -.29$, $p = .02$) and reward magnitude ($r = .26$, $p = .04$) related change in the N2pc to the target as well as at a trend level with reward magnitude related change in the CDA ($r = .23$, $p = .07$).

Exploration of potential inter-hemispheric differences

Potential inter-hemispheric differences related to psychopathic traits, as well as potentially reduced communication between hemispheres (Bernstein, Newman, Wallace, & Luh, 2000; Hamilton et al., 2015; Llanes & Kosson, 2006) prompted an exploratory analysis of the relationship between FD and IA with reward modulated ERP amplitude change in the time window of the N2pc and CDA separately for the activity contralateral and ipsilateral to the reward cue. In this case partial correlations (again controlling for gender) showed that FD was significantly correlated with high reward modulated amplitude change contralateral ($r = .26$, $p <$

.05) to the target, and at a trend level for activity ipsilateral ($r = .24$, $p < .07$) to the target in the CDA time window. Similarly, IA was significantly correlated with reward modulated amplitude change contralateral ($r = .29$, $p = .02$) and, at a trend level, ipsilateral ($r = .21$, $p = .10$) activity to the remembered stimulus in the CDA time window. IA was also significantly correlated with reward magnitude modulated change (i.e. greater high reward activity compared to low reward) both contralateral ($r = .26$, $p = .04$) and ipsilateral ($r = .27$, $p =. 03$) to the remembered stimulus in the CDA time window. Neither FD nor IA was correlated with separate contralateral or ipsilateral activity in the N2pc time window following the target or search array. The direction of these correlations indicates greater activity for those high in FD and IA both contralateral and ipsilateral to high reward targets in the time window for the CDA. ERP waveforms for the N2pc to the target and the CDA as a function of FD and IA scores can be seen in Figure 3. Scatterplots of the significant correlations between FD and the N2pc and CDA to the target, as well as IA to high reward targets during the CDA time window, can be seen in Figure 9.

Interim Discussion

Study 1 tested the competing hypotheses that either 1) cognitive-affective processes would interact in relation to psychopathic traits such that reward processing would alter the observed differences in attention and working memory or 2) separate cognitive and affective processes would be related to psychopathic traits such that the affective response to reward would have no effect on attention and working memory processes. The interactive hypothesis outlined above predicts that individuals with high levels of IA traits would engage in more context updating following reward cues but less following no-reward cues and that they would show reductions in attention and working memory on no-reward trials but not on reward trials. The separate process hypothesis predicts that individuals with high levels of IA traits would engage in less context updating following reward and no reward cues and that they would show reductions in attention and working memory maintenance across all reward levels.

Contrary to predictions, IA was not correlated with reward related amplitude change in any ERP measures. The overall pattern of results shows consistent relationships between FD and ERP measures of attention to the initial target (N2pc) and maintenance of that target in working memory (CDA). These correlations are such that participants high in FD showed larger increases in N2pc amplitude on low reward trials compared to no reward, as well as larger N2pc and CDA amplitude on low reward trials compared to high reward trials. FD and IA were also correlated with an overall increase in ERP amplitude both contralateral and ipsilateral to potentially high reward targets in the time window associated with the CDA. Because the CDA is computed as a subtraction between contralateral and ipsilateral, this relationship is lost when the CDA component is computed. This relationship suggests a possible increase in working memory maintenance for high FD and IA individuals on high reward trials, but this conclusion cannot be definitively drawn because the evidence linking the CDA with working memory maintenance is for the difference between contralateral and ipsilateral activity. Overall the results do not fully support either of the competing hypotheses for Study One. Although there were relationships found between some psychopathic traits and cognitive mechanisms in conditions of reward, these relationships were not such that they showed an interactive effect compared to no-reward conditions. In fact, both hypotheses would have predicted reduced attentional deployment on no reward trials, which was not observed. Additionally, the increased attention to and working memory maintenance of low reward, but not high reward targets for individuals high in FD was surprising. It was expected that more attention would be deployed to high reward targets, and that those high reward targets would be better maintained in working memory compared to low reward targets.

Limitations

There are several limitations to the current study that warrant discussion. First is the lack of explicit loss trials in the task. One key feature of the low fear hypothesis of psychopathy is that psychopaths fail to learn from punishment and loss (Blair et al., 2004; Newman et al., 1990; Pujara, Motzkin, Newman, Kiehl, & Koenigs, 2013). Although the current study was explicitly designed to investigate the effects of reward, it is possible that potential losses could have had an effect on the cognitive mechanisms measured here, or made the rewards more salient. Furthermore, the limited number of incorrect trials, which would have constituted a failure to earn a reward and could have served as a proxy for losses, meant that I was unable to examine differences in processing of reward versus failure feedback. Relatedly, the lack of error trials suggests that participants' attention and working memory may not have been taxed to the extent needed to reveal interactive differences related to psychopathic traits.

Second is ERP component overlap between the P3 to the reward cue and the N2pc and CDA to the target. Residual P3 activity following the reward cue may be at least partially responsible for the finding that high reward trials had smaller N2pc and CDA amplitudes than low reward trials, as well as the finding that FD was related to CDA and N2pc amplitude on low reward, but not high reward, trials. The time window for the P3 ERP component overlapped fully with the N2pc time window and by 200ms with the CDA time window following the target. The overlapping, large, and positive going P3 response to high reward cues may have reduced (i.e. made less negative) the amplitude of the N2pc and CDA on high reward trials. To reduce this component overlap future work should increase the time between the reward cue presentation and the target as well as possibly jittering this time window to ensure that any remaining component overlap would be removed during the averaging process. Although the time between trials was jittered in the current study, the time between the reward cue and target was not.

The target stimuli used in this study, although potentially affect inducing because of the opportunity for reward, were not inherently affective. The study was also not designed to elicit any negative affect. More traditional affective stimuli such as emotional faces or threatening images may be better for eliciting cognitive-affective interactions in psychopathy. Finally, the participant sample used in Study One was somewhat restricted in its range of psychopathic traits. A sample with a greater range of psychopathic traits may also yield more informative results. Study Two attempted to address both of these weaknesses.

Conclusions

The results of Study One do not conclusively support the cognitive-affective interaction hypothesis or the alternative, and were largely contrary to expectations. IA was expected to show the strongest relationships with differential functioning of cognitive mechanisms as a function of reward. This prediction was based on past work demonstrating attention, working memory, and reward related differences in IA. However, the current results showed a relationship between FD and increased attention and working memory for low rewards, but not high rewards. It is possible that traits related to sensation seeking found in FD were responsible for this effect. However, the lack of effect for high reward makes that difficult to confirm. Overall, the results of this study leave many remaining questions regarding the nature of cognitive-affective interactions in psychopathy, and what role, if any, reward processing plays in those interactions.

CHAPTER V

STUDY TWO: ATTENTION AND WORKING MEMORY FOR EMOTIONAL FACES

Study Two was designed to investigate the influence of inherently affective stimuli, specifically emotional faces, on attention and working memory in relationship to psychopathic traits. The visual search task used in this study was similar to the task used in Study One, but with emotional faces as the stimuli instead of the Landolt-Cs, and without the reward manipulation. This task allowed me to investigate whether emotional faces would be attended to or maintained in working memory differently than neutral faces as a function of psychopathic traits. Furthermore, the use of different facial expressions across both positive (i.e. happy) and negative (fear, anger, and sadness) valence allowed me to investigate emotion specific deficits in relationship to psychopathic traits. As with Study One, a key feature of the visual search task used in Study Two is that the primary manipulation involves the emotional content of the stimuli. This allowed me to investigate the influence of this manipulation on cognitive processes. As discussed above this manipulation has traditionally been neglected in the literature, which has focused much more on manipulating attention and measuring changes in affective response. As outlined by the cognitive-affective interaction hypothesis, if interactive deficits exist, the functioning of cognitive mechanisms such as attention and working memory should be altered in those with psychopathic traits when the to-be attended or remembered stimuli contain emotional information.

Hypotheses for Basic Effects

In general, it is expected that affective faces will be more strongly attended to and maintained in working memory than neutral faces. Specifically, it is expected that potentially threatening faces (i.e. fear, anger) will be attended to and remembered better than non-threatening faces (i.e. sad, happy). Behaviorally, happy faces are expected to speed reaction time whereas negative emotional faces are expected to slow reaction time due to approach versus withdrawal motivation. Search accuracy is expected to be greater for all affective faces compared to neutral faces.

Competing Hypotheses for Psychopathic Traits

Deficits in identifying affective faces have been most strongly related to FD traits. Therefore, it is expected that FD traits, as well as the boldness factor of the TriPM, will be most strongly related to differences in processing the affective content of faces. IA has been most strongly related to deficits in working memory and attention, and, along with the disinhibition factor of the TriPM, is expected to be related to overall reduced attentional deployment and working memory maintenance. However, it is expected that both factors will show differences in attention and working memory processes as a function of affective condition.

H1. Interactive cognitive-affective deficits underlie the psychopathic personality and therefore when one system is stressed the observed differences in the other system increase. Thus:

a. IA traits will be related to overall reduced deployment of attention to and working memory maintenance of target faces. This reduction will be larger for negative affective faces as compared to neutral faces, and most strongly observed for fear faces.

b. FD traits will be related to reduced differentiation between emotional, particularly fear, and neutral faces. This reduced differentiation between emotional and neutral faces will lead to reduced attentional deployment and working memory maintenance for emotional faces compared to neutral.

c. Both factors will show a negative relationship with emotion identification, and this impaired identification will be related to both the cognitive (working memory and attention) and affective processing of target faces.

H2. Separate cognitive and affective deficits underlie the psychopathic personality and therefore the affective content of faces will have no effect on attention or working memory for those faces compared to neutral. Thus:

a. IA will be related to overall reduced deployment of attention and working memory maintenance of target stimuli, regardless of the affect of the stimuli.

b. FD will be related to reduced differentiation between affective, particularly fear, and neutral faces. However, the amount of this differentiation will be un-related to deployment of attention and working memory maintenance.

c. Both factors will show a negative relationship with affect identification, but this reduced identification will be related to cognitive processes in IA and affective processes in FD.

Methods

Participants

Participants for Study Two were recruited from the broader Nashville community using flyers (see Appendix A) asking for specific personality traits. For example, questions such as "Are you aggressive, rebellious, or impulsive?" and "Are you careful and always plan ahead?" were designed to invite individuals at the high and low ends of the IA continuum respectively. Questions such as "Ever been called 'fearless'?" and "Are you the sensitive type?" were designed to invite individuals at the high and low ends of the FD continuum respectively. These questions were taken from questions previously used to recruit participants with psychopathic traits as well as adapted from questions on the Psychopathic Personality Inventory's FD and IA scales (DeMatteo, Heilbrun, & Marczyk, 2006; Lilienfeld & Andrews, 1996). Flyers were placed in locations selected to provide a broad sample of the population as well as those previously shown to produce a sample with significant psychopathic traits (e.g. emergency rooms, unemployment centers; Dowgwillo & Benning, unpublished data; DeMateo et al., 2006). The same flyers were also posted on craigslist to broaden the participant population and increase recruitment rates.

A total of 46 participants were recruited to participate in Study Two. Seven participants were unable to successfully complete the primary visual search task either due to poor behavioral performance or an inability to sufficiently control their eye movements. An additional four participants chose to discontinue the study due to "boredom". Five participants were excluded because of poor ERP data (i.e. more than 30% or trials excluded during processing due to eye movements or blinks). This left a final sample of 30 participants with usable data on the visual search task and psychopathy scores from the PPI. Scores on the TriPM were only available for 26 of these participants. One participant's TriPM factor scores were excluded because they were more than 3 standard deviations from the mean, leaving 25 participants with usable TriPM scores. Demographic information was not available for one participant. The final sample had a mean (sd) age of 29.69 (10.83) and was 63% female.

Procedure

Individuals who expressed interest in the study were screened for normal, or corrected to normal, visual acuity as well as history of head injury or neurological disorders. Participants in

Study Two were not required to have normal color vision as all stimuli were black and white. Upon entering the laboratory, participants first provided informed consent as approved by the Vanderbilt University Institutional Review Board. Following consent, participants were prepped for the electroencephalogram (EEG) recording to take place during the visual search task. Participants then completed the visual search task followed by a set of computerized self-report questionnaires including demographics and two measures of psychopathic traits described below. Participants were given sufficient practice time on the visual search task to achieve response accuracies at all stages that were significantly above chance levels. This time was also used to ensure participants were able to adequately control their eye movements and minimize blinks. The total study time for participants was approximately five and a half hours. Participants were compensated at a rate of $10.00/hour.

Visual Search for Emotional Faces

The visual search task (see Figure 10) required participants to remember a target face over a delay period before indicating which face in an array of four faces matched the remembered target. Following their response to the search array, participants were required to either label the emotion of the target face or identify which face in a set of new faces matched the emotion of the target face. A gender identification condition with only neutral faces was also included to control for baseline working memory and attention differences for facial stimuli as well as the pop-out feature of an emotional face within a set of neutral faces. The task consisted of 10 blocks (8 emotion, 2 gender) with 120 trials in each block. The order of the emotion and gender blocks was randomly determined prior to the start of the task.

Each trial began with a fixation cross for 1500ms to 2500ms followed by an arrow

(500ms) indicating in which visual field (right or left) the target face would appear. This arrow was followed by another fixation cross (500ms), and then the target display (800ms). In the emotion condition the emotional target was always paired with a neutral distractor of the same gender. In the gender condition, the distractor was of the opposite gender, and all faces were neutral. Following the target display was another fixation cross (800ms), followed by the search array (3000ms). The search array consisted of the remembered target and three different distractor faces. In the emotion condition the three distractors were neutral faces of the same gender. In the gender condition the three distractors were neutral faces of the opposite gender. The four faces were presented in a 2x2 matrix, which was centered on the screen to minimize eye movements. Participants were required to indicate which face was the previously presented target (i.e. top left, bottom left, top right, bottom right) using the corresponding buttons on a game pad. Following their search response, another fixation-cross appeared (500ms) followed by either a match or label choice (6000ms in the emotion condition, 5000ms in the gender condition). On match trials in the emotion condition, participants were presented with five new faces (1 for each emotion and one neutral) and were required to indicate which of the faces matched the emotion of the remembered target. These faces were presented without labels indicating which emotion they were displaying. For label trials in the emotion condition participants were presented with the words ‘happy’, ‘sad’, ‘angry’, fear’, and ‘neutral’ and asked to indicate which correctly labeled the emotion of the remembered target. These labels were not accompanied by images of the corresponding emotional faces. For match and label trials in the gender condition, participants were given two new faces, one male one female or the words ‘Male’ and ‘Female’ respectively. The location, gender, and emotion of the target, as well as the order of presentation for the match and label choices were randomly determined prior to the start of each trial. The only constraint on this randomization was that the same target, distractor, and match faces could not be used on consecutive trials.

Face Stimuli.

Stimuli for the visual search task were from the Karolinska Directed Emotional Faces (KDEF) set (Lundqvist, Flykt, & Öhman, 1998). The KDEF set has been shown to reliably evoke specific emotions (Goeleven, De Raedt, Leyman, & Verschuere, 2008) and consists of relatively naturalistic emotional expressions (Adolph & Georg, 2010). The KDEF set has also been previously used to study processing of affective faces in psychopathy (Eisenbarth, Alpers, Segrè, Calogero, & Angrilli, 2008). The KDEF set includes 70 individuals (35 men, 35 women) each displaying seven different emotions (including neutral). Only five emotions (happy, sad, angry, fear, and neutral) are used in this task. These five were chosen for two reasons. First, the other two emotions, surprise and disgust, are less reliably identifiable, potentially introducing an additional source of error. Second, the number of emotions was limited to ensure a sufficient number of trials per emotion without making the task too long for most participants to complete without excessive fatigue.

All images came from the ‘A’ set of the KDEF unless there was an obvious visual difference in the brightness of the image. In that case, an image of the same individual was selected from the ‘B’ set. Only images of direct frontal views of faces were used (i.e. no profiles), again to minimize the number of different conditions. After selecting the images from the KDEF set, the images were converted to black and white, and equated for low-level visual features including spatial frequency, histogram, luminance, and Fourier amplitude spectra using the SHINE toolbox in Matlab (Willenbockel et al., 2010). All images were also converted to 120x120 pixels to ensure a visually balanced search array and to help minimize eye movement.

Event Related Potentials

Participants raw EEG was recorded during the visual search task using the same recording procedures used in Study One. The N2pc and CDA were used in the same way as Study One to measure deployment of attention (N2pc) and working memory maintenance (CDA). In Study Two the N2pc and CDA were measured as the difference between activity contralateral versus ipsilateral to the stimulus, averaged across occipital sites OL/OR, O1/O2, and PO3/PO4, instead of only OL/OR as in Study One. This was done to ensure more stable waveforms because Study Two included fewer participants, and fewer trials per condition. The CDA was measured between 320 – 700ms post target onset. The N2pc was measured between 220 – 280ms post target and search array onset. The affect sensitive components used in Study Two were the early posterior negativity (EPN), and the late positive potential (LPP). Both of these components have been shown to be sensitive to the processing of faces, and the emotional content of those faces (Lui et. al., 2012; Feldman et al., 2010; Eimer & Holmes, 2001; see Eimer and Holmes 2007 for a review of ERPs elicited by emotional faces). The EPN and LPP were both recorded from central-parietal electrode sites (P3, P4, C3, C4, Pz, Cz; Schupp, Junghöfer, Weike, & Hamm, 2004). At these central-parietal sites the polarity of the EPN is such that the amplitude is more positive for affective stimuli than for neutral. The EPN was measured as the mean amplitude at between 160ms – 320ms post target and search array onset. The LPP was measured as the mean amplitude between 320ms – 700ms post target onset and between 400 – 800ms post search array onset. The later time window for the LPP at the search array was used because of the longer presentation time of the search array versus the target. The LPP has been previously shown to sustain differences throughout the duration of an emotional stimulus (Lui et. al., 2012).

Psychopathy Measures

Psychopathic Personality Inventory.

The Psychopathic Personality Inventory (PPI; Lilienfeld & Andrews 1996; Poythress, Edens, & Lilienfeld, 1998) is a self-report measure designed for use in a non-incarcerated sample. The PPI is also designed to measure the personality traits related to psychopathy without focusing on specific behavioral manifestations of those traits. The PPI yields scores on two primary factors, Fearless Dominance and Impulsive Antisociality, as discussed above.

Triarchic Psychopathy Measure.

The Triarchic Psychopathy Measure (TriPM; Patrick 2010) is a 58 item self-report measure designed to assess psychopathy based on a three-factor model of Boldness, Meanness, and Disinhibition. The TriPM yields scores on each of these individual factors, and is intended for use in non-incarcerated samples. The TriPM scales of disinhibition and meanness together represent a similar construct to that operationalized by the IA scale of the PPI. However, the distinction between disinhibition and meanness made by the TriPM may be important because the constructs that these factors operationalize may differentially relate to the cognitive and affective aspects of the task. The boldness scale represents an operationalization of a similar construct to that of PPI FD and is expected to relate to the task in the same way.

Analyses

Basic task effects of emotion on each dependent variable were analyzed using repeated measures ANOVAs with each emotion, including neutral, being entered as a level of the within subjects factor. The gender condition was also included as an additional level in the analyses for two reasons. First, in the emotion condition, each emotional face was always paired with a neutral face at the presentation of the target, and three neutral faces at the search array. This means that not only was the target face different from the distractors in the sense of having an affective expression, it was also different in the sense that, especially at the search array, it was the one face with a distinctly different property. In contrast, neutral faces in the emotion condition were in the search array with three other neutral faces and therefore had no explicit distinguishing feature that would make them more readily apparent. Therefore, the gender condition, in which the target face had a neutral expression but still had a characteristic to distinguish it from the other neutral distractors (i.e. being a different gender), may be a better comparison to isolate the effect of emotion on behavior and ERPs.

Separate ANOVAs were conducted for behavioral measures including search reaction time (RT), search accuracy, label RT, label accuracy, match RT, and match accuracy. Separate ANOVAs were also conducted for ERPs to the target (EPN, LPP, N2pc, and CDA) and to the search array (EPN, LPP, N2pc). Main effects of face type were Huynh-Feldt corrected for sphericity where appropriate. All comparisons between emotion and neutral or emotion and gender were conducted at a Bonferroni corrected family-wise type-I error rate of $\alpha = .05$. 95% confidence intervals for differences between means were also appropriately adjusted. This resulted in criterion equivalent to an uncorrected $\alpha = .01$ and 99% confidence intervals. Only correct trials were used for all RT and ERP measures. Trials with RTs less than 250ms or more than 3 standard deviations from the mean were also excluded.

Difference scores were computed between each emotion and neutral faces from the emotion condition, as well as each emotion and target faces from the gender condition, for each dependent variable. For example, to examine deployment of attention to the target, difference scores were computed for the mean N2pc amplitude following each emotion (happy, angry, sad, fear) minus neutral and each emotion minus gender. These difference scores were computed to control for baseline individual differences in ERP amplitude and to isolate the effect of emotion for each individual. The difference scores were then correlated with each of the PPI and TriPM factor scores to test the relationship between psychopathic traits, and changes in behavioral performance, cognitive processes, and emotion processing. As is Study One, gender was controlled for in all analyses of psychopathic traits as men typically have higher levels of psychopathic traits, particularly IA traits, than do women (Anton, Baskin-Sommers, Vitale, Curtin, & Newman, 2012; Forouzan & Cooke, 2005). Only partial correlations are reported here. As in Study One, the overall pattern of results was similar for partial and zero-order correlations.

Results

Psychopathy Scores

Mean scores on the FD and IA scales of the PPI were 135.23 (25.55) and 184.46 (32.37) respectively. Scores on the TriPM scales of boldness, meanness, and disinhibition were 52.34 (12.07), 28.48 (8.58), and 40.04 (10.53) respectively. As expected FD and IA scores were not significantly correlated with each other ($r = .21$, $p = .28$). Similarly, boldness was not correlated with meanness or disinhibition (rs < .04, ps > .85). Meanness and disinhibition were significantly correlated with each other ($r = .52$, $p < .01$). FD was significantly correlated with boldness ($r = .83$, $p < .001$), and IA was significantly correlated with meanness ($r = .63$, $p < .001$) and disinhibition ($r = .87$, $p < .001$). Also as expected, IA was correlated with gender such that men had tended to have higher IA scores ($r = .39$, $p = .04$). No other psychopathy scores correlated with gender ($|r\text{s}| < .27$, ps > .18) although the direction of all correlations with gender suggested higher scores for men.

Basic task effects

Behavior

There was a significant effect of target face type on reaction time ($F_{(2.23,62.40)} = 3.06$, $p = .049$) and on search accuracy ($F_{(1.48,41.41)} = 5.77$, $p = .01$). For RT, Bonferroni corrected comparisons showed that participants responded faster to happy faces than neutral faces, but there was no significant difference between RTs for any other emotional faces and neutral faces or any emotional faces and gender faces (see Table 2). For search accuracy, all emotional faces were identified more accurately than neutral faces, with sad faces at a trend level following Bonferroni correction. Emotional faces were not more accurately identified than gender faces. Gender faces were also identified more accurately than neutral faces at a trend level.

For the label condition, there was a significant effect of face type on reaction time ($F_{(2.68,75.03)} = 61.38$, $p < .001$) and label accuracy ($F_{(1.97,53.39)} = 5.94$, $p < .01$). The size of the main effect for RT was largely driven by the gender faces which were labeled more quickly than any other faces, likely due to having only two response options in the gender condition compared to five in the emotion condition. However, gender faces were not labeled more accurately than emotion, and were only labeled more accurately than neutral faces at a trend level. Happy faces were labeled more quickly than neutral faces and fear faces took longer to label than neutral faces. Happy faces and angry faces were also labeled more accurately than neutral faces.

In the match condition there was again a significant effect of face type on RT ($F_{(1.47,41.04)} = 58.76$, $p < .001$) and accuracy ($F_{(2.54,64.95)} = 3.84$, $p = .02$). As in the label condition, gender faces were matched more quickly than all other face types, including neutral. Gender faces were not matched more accurately than emotion faces and were only matched more accurately than neutral faces at a trend level. Fear faces were matched more slowly than neutral faces, and happy faces were matched more quickly than neutral faces. Both fear and happy faces were matched more accurately than neutral faces. Additionally, all faces were labeled more quickly than they were matched (all *t*s(29) > 5.79, all *p*s < .001) but not all were labeled more accurately than they were matched. Anger faces were more accurately labeled than matched ($t(29) = 3.14$, $p < .01$; uncorrected) whereas fear faces were more accurately matched than labeled ($t(29) = 2.44$, $p = .02$; uncorrected). No other faces differed significantly for accuracy on label versus match trials.

Event-related potentials

There was a main significant effect of face type on the EPN ($F_{(3.11,84.06)} = 7.26$, $p < .001$), LPP ($F_{(3.26,88.04)} = 3.12$, $p = .03$), N2pc ($F_{(3.08, 83.05)} = 4.28$, $p < .01$), and CDA ($F_{(2.76,74.60)} = 4.27$, $p < .01$) to the initial target, as well as a significant main effect of face type on the EPN ($F_{(3.12, 84.17)} = 7.97$, $p < .001$), and LPP ($F_{(3.36,90.83)} = 3.29$, $p = .02$) to the search array. There was not a significant main effect of face type on the N2pc to the search array ($F_{(5,135)} = 1.34$, $p = .25$).

EPN amplitude to the target was significantly greater (i.e. more positive) for all emotional faces compared to neutral, but not gender faces (see Table 3). EPN amplitude was also greater for gender faces compared to neutral. LPP amplitude to the target was significantly greater for angry faces compared to neutral. LPP amplitude to the target did not differ for any other faces compared to neutral, or between any emotional faces and gender faces. N2pc amplitude to the target was significantly greater (i.e. more negative) for happy faces compared to neutral. N2pc amplitude did not differ between any other faces and neutral, or between any emotional faces and gender. CDA amplitude to the target was significantly more negative for happy and sad faces, and more negative at a trend level for angry and fear faces compared to neutral faces. CDA amplitude was also significantly more negative for happy and sad faces compared to gender faces, and more negative for angry and fear faces compared to gender at a trend level. CDA amplitude did not differ between neutral and gender faces.

EPN to the search array was again significantly greater for all emotional faces than for neutral faces, as well as for gender faces compared to neutral. EPN amplitude to the search array was also significantly more positive for gender faces than for angry faces, and for fear faces at a trend level. EPN amplitude to the search array did not differ for happy and sad faces compared to gender faces. LPP amplitude to the search array was significantly greater for happy faces compared to neutral. LPP amplitude to the search array did not differ for any other faces, including gender faces, compared to neutral. LPP amplitude did not significantly differ for any emotional faces compared to gender faces. N2pc amplitude to the search array did not differ for any emotional faces compared to neutral or gender faces. Neutral and gender faces also did not differ in N2pc amplitude. Grand average ERP waveforms to the target and search array can be seen in figure 11.

Psychopathy score correlations with behavior

In general there were few significant correlations between psychopathy scores and emotion related differences in behavioral performance. However, the general pattern of these correlations showed stronger relationships between IA scores (as well as meanness and disinhibition), and emotion related behavior change than between FD and boldness scores and emotion related behavior change (see Table 4). Additionally, IA was more strongly related to accuracy differences whereas meanness and disinhibition were more strongly related to RT differences.

Fearless Dominance and Impulsive Antisociality

Fearless dominance was not significantly correlated with emotion related change in RT or accuracy at the search array, label, or match stage. IA was significantly and positively correlated with search accuracy differences for angry faces compared to gender, as well as at a trend level for fear, sad, and neutral faces compared to gender faces. The direction of these correlations indicates less differentiation in accuracy from gender faces. However, this relationship appears to be driven by reduced accuracy improvement for gender faces, not a reduction in accuracy for finding emotional or neutral faces in the search array. IA showed the same pattern of correlations in the label condition and was significantly and positively correlated with label accuracy differences for angry faces compared to gender, as well as at a trend level for fear, sad, and neutral faces compared to gender faces. IA was not significantly correlated with accuracy differences in the match condition, and was not correlated with RT differences at search, label or match.

Boldness, meanness, disinhibition

Boldness, meanness, and disinhibition were not significantly correlated with search, label, or match accuracy. Boldness was significantly and negatively correlated with emotion related reaction time change for labeling angry faces compared to neutral and for matching fear faces compared to neutral, but not for any faces compared to gender, or any RT change at the search array. The direction of these correlations suggests that participants high in boldness were slower to label angry faces, and match fear faces compared to neutral faces. Meanness was significantly and positively correlated with search RT change for fear and happy faces compared to neutral, as well as at a trend level with sad and gender faces compared to neutral. Disinhibition was also correlated at a trend level with search RT for angry and fear faces compared to neutral. The direction of these correlations indicates that participants high in meanness or disinhibition showed less RT speeding for the emotional faces compared to neutral, and less RT speeding for gender faces compared to neutral at search. Meanness and disinhibition were not correlated with RT change at the label or match stage.

Psychopathy score correlations with ERPs

The correlations between psychopathy scores and emotion related differences in ERP amplitude were more widespread than for behavior, with each psychopathy factor score being correlated with at least two different ERP measures (see Table 5). The general pattern of these correlations indicates that FD and boldness were more strongly and consistently correlated with ERP components indexing affective processes (i.e. EPN and LPP) whereas IA and disinhibition were more strongly and consistently correlated with ERP components indexing cognitive processes (i.e. N2pc and CDA). Meanness was unique in that scores were correlated with emotion related change in ERP components indexing both cognitive and affective processes.

Correlations with Affective ERP Components to the target

FD and boldness were both significantly and negatively correlated with EPN amplitude change for happy faces compared to both neutral and gender faces. Meanness was also negatively correlated with the difference in EPN amplitude between sad and gender faces at a trend level. For the LPP to the target, psychopathy scores were only correlated with emotion related amplitude differences at trend levels but the pattern was similar to the EPN. FD was negatively correlated with the difference in LPP amplitude to the target for happy and sad faces compared to neutral. Boldness was negatively correlated with the difference in LPP amplitude to the target for happy and angry faces compared to neutral, and meanness was negatively correlated with the difference in LPP amplitude to the target for fear faces compared to neutral. The direction of each of these correlations indicates less differentiation between emotional and neutral/gender faces for participants high in FD, boldness, and to a lesser extent, meanness. IA and disinhibition were not correlated with any emotion related amplitude differences in the EPN or LPP. No psychopathy scores were correlated with any LPP amplitude change for emotional faces versus gender.

Correlations with Affective ERP Components to the search array

FD was significantly and negatively correlated with emotion related change in EPN amplitude for angry and happy faces compared to neutral, as well as with emotion related change in LPP amplitude for angry, fear (at trend), and happy (at trend) faces compared to neutral. Boldness was not correlated with emotion related amplitude differences in the EPN compared to gender or neutral faces, but boldness was negatively correlated with LPP amplitude change for angry and fear (at trend) faces compared to neutral. Boldness was not correlated with any emotion related differences in LPP amplitude compared to gender faces. Finally, meanness was negatively correlated with emotion related change in EPN amplitude for angry and happy faces compared to gender faces, as well as LPP amplitude for sad faces compared to gender. Meanness was not correlated with any emotion related EPN or LPP amplitude differences compared to neutral faces. Again, IA and disinhibition were not significantly correlated with emotion related amplitude change in either the EPN or LPP.

Correlations with Cognitive ERP Components to the target

FD and boldness were not correlated with any emotion related amplitude differences in either the N2pc or CDA to the target. IA was positively correlated with emotion related change in CDA and N2pc amplitude to the target for angry (at trend), fear (trend for N2pc), and happy faces compared to neutral, as well as happy faces compared to gender faces (trend for CDA). IA was also positively correlated with emotion related change in CDA amplitude to the target for fear faces compared to gender at a trend level and in N2pc amplitude to the target for angry versus gender faces at a trend level. Disinhibition showed a similar pattern of significant positive correlations with emotion related change in CDA and N2pc amplitude to the target for happy faces compared to both gender and neutral. Disinhibition was also positively correlated with emotion related change in CDA amplitude to the target for sad faces compared to gender at a trend level. Finally, meanness was correlated at a trend level with emotion related change in N2pc amplitude to the target for happy faces compared to gender and neutral. Meanness was not correlated with emotion related differences in N2pc amplitude.

Correlations with Cognitive ERP Components to the Search Array

Only meanness and disinhibition showed significant correlations with emotion related change in N2pc amplitude to the search array. Notably, these correlations are in the opposite direction as the correlations between these same scales and N2pc amplitude to the target. meanness was significantly and negatively correlated with N2pc amplitude to the search array for angry, and sad faces compared to neutral as well as angry faces compared to gender faces. Disinhibition was negatively correlated with differences in N2pc amplitude for both fear and sad faces compared to gender faces, at a trend level. Disinhibition was not correlated with any emotion related differences in N2pc amplitude compared to neutral.

Exploratory Analysis of PPI Coldheartedness Facet Scores

Although not part of the original planned analyses, partial correlations (controlling for gender) between PPI coldheartedness facet scores and emotion related differences in behavior and ERPs were examined after observing the way the meanness factor of the TriPM was correlated with both affective and cognitive ERP components. Coldheartedness was not correlated with any emotion related differences in behavioral performance compared to gender or neutral but was correlated with affective ERP components to the target, and cognitive ERP components to the search array. Specifically, coldheartedness scores were correlated with emotion related change in EPN amplitude to the target for angry ($r = .45$, $p = .02$), fear ($r = .40$, $p = .04$), and happy ($r = .46$, $p = .02$) faces compared to gender faces and with emotion related change in LPP amplitude to the target for angry ($r = .42$, $p = .03$), fear ($r = .50$, $p = .01$), and sad faces ($r = .52$, $p = .01$) compared to gender faces. Coldheartedness was correlated with emotion related change in N2pc amplitude to the search array for angry ($r = -.36$, $p = .05$), and happy ($r = -.49$, $p < .01$) faces compared to neutral. Because coldheartednes is a reverse scored scale, the direction of these correlations indicates less EPN and LPP amplitude differentiation between emotional and gender faces at the target, but greater N2pc amplitude differentiation for happy and angry faces compared to neutral at the search array.

Interim Discussion

Study Two tested the competing hypotheses that differences in attention and working memory, related to psychopathic traits, would either increase when the information attended to and maintained in working memory was affective in nature (i.e. the interactive hypothesis), or that differences in attention and working memory related to psychopathic traits would not vary with the emotional nature of the stimuli attended to and maintained in memory (i.e. the separate hypothesis). The results of this study generally support the interactive hypothesis that differences in attention and working memory vary with the affective content of the stimuli in relationship to psychopathic traits. These results provide novel evidence of altered attention to, and working memory maintenance of, emotional faces related to psychopathic traits. The results of the current study further suggest that some individual factors of psychopathy are related more strongly to reductions in affective (e.g. FD, boldness) or cognitive (e.g. IA, disinhibition) processing, whereas other factors (e.g. meanness) or facets (e.g. coldheartedness) of psychopathy may be related to both cognitive and affective processes. Although there was no evidence of fear-, or even negative affect-, specific differences, there was some evidence that, when the visual stimulus was more complex (i.e. at the search array) the strongest relationships were for anger and fear faces. This may suggest that when cognitive load is increased, individuals with higher levels of psychopathic traits show the greatest differences in processing of these negative affective faces.

Basic effects

Facial emotion had a significant main effect on nearly every behavioral and ERP measure of interest, aside from the N2pc to the search array. Differences between specific emotions and neutral or gender faces were less widespread but were generally in line with predictions. Behaviorally, participants responded faster to happy faces and all emotions were identified more accurately than neutral faces in the search array. In regards to labeling and matching faces, happy faces were labeled and matched more quickly, and more accurately whereas fear faces were labeled and matched more slowly, but also more accurately than neutral faces Angry faces were also labeled more accurately that neutral faces. Regarding the ERP measures of interest, EPN amplitude to the target was more positive for all emotional faces, and gender faces, compared to neutral. This suggests that the target EPN may have reflected general salience rather than something emotion specific in the current task. EPN amplitude differences to the search array were more nuanced with amplitudes for happy, fear, and gender faces being more positive than neutral, but amplitude for anger faces being more negative than for gender faces. The LPP and N2pc components showed few significant amplitude differences for specific emotional faces compared to neutral or gender faces. Only angry faces at the target showed larger LPP amplitudes than neutral faces, and only happy faces at the target showed larger N2pc amplitudes than neutral faces. No emotion specific LPP or N2pc differences were observed to the search array. However, the amplitude of the CDA was more negative for all emotions compared to both gender and neutral target faces. This suggests greater working memory maintenance of emotional faces, despite essentially no differences in deployment of attention.

Factor level relationships

IA and disinhibition were almost exclusively related to differences in attention and working memory processes, as was expected based on past research regarding cognitive deficits in psychopathy. Specifically, IA was correlated exclusively with reduced N2pc and CDA amplitude differentiation to the target for angry, fear, and happy faces compared to neutral faces, as well as for angry and happy faces compared to gender faces. This suggests reduced attention to and maintenance of these emotional faces in working memory. Similarly, disinhibition showed almost exclusive correlation with N2pc and CDA amplitudes, including reduced differentiation for angry and happy faces compared to both neutral and gender faces, and sad compared to neutral faces for the CDA only. Unlike IA, disinhibition was also related to differences in N2pc amplitude to the search array for fear and sad faces compared to gender faces and LPP amplitude to the target for fear faces compared to neutral faces. These relationships suggest overall reduced attention to and working memory maintenance for these emotional faces at the presentation of the target. However, at the search array the direction of this relationship suggests that participants high in disinhibition deployed more attention to fear and sad faces compared to neutral faces. One possibility for this switch is that initially reduced attention to emotional targets and poorer working memory representations of those targets meant that greater attention had to be paid to the search array for these individuals to identify the target and make the correct response.

These results provide support for the cognitive-affective interaction hypothesis in two ways. First, the cognitive-affective interaction hypothesis specifies that there are specific deficits associated with the different factors of psychopathy and these results demonstrate a specific relationship between IA/disinhibition and cognitive processes of attention and working memory. Secondly, the relationship between IA/disinhibition and these cognitive processes differed as a function of processing emotional versus neutral faces suggesting an interactive effect. The lack of relationship between IA/disinhibition and ERP differentiation of neutral and gender faces also suggests the involvement of an affective process.

Similar specificity was seen for FD and boldness, with both being almost exclusively related to amplitude differences in the EPN and LPP. FD was related to reduced EPN and LPP differentiation to the target for happy faces compared to neutral as well as EPN amplitude for happy faces compared to gender faces and LPP amplitude for sad faces compared to neutral faces. Boldness was also related to reduced EPN and LPP differentiation between happy and neutral faces at the target. Boldness was additionally related to reduced angry versus neutral differentiation in LPP amplitude at the target, as well as reduced LPP differentiation for angry and fear faces compared to neutral at the search array. FD and boldness showed no relationship with N2pc or CDA amplitude differentiation for emotional faces suggesting a specific relationship with affective processes. However, as discussed above, the increased cognitive load of the search array compared to the target presentation may have influenced specific processing differences for negative affect.

The results for FD and boldness support the cognitive-affective interaction hypothesis in a very similar way to the results for IA and disinhibition. First, there is again specificity in the relationship between these factors and affective ERP components, but not cognitive ERP components. Second, only for the LPP to the target was either factor, in this case boldness, related to ERP differentiation between gender and neutral suggesting that overall these factors are related to differences in an affect specific process. Lastly, there is the finding that both FD and boldness show relationships exclusively with differentiation between negative faces and neutral at the presentation of the search array, and not happy faces like they did at the initial target. This suggests the possibility that the increased attentional load of three additional faces in the search array exacerbated a weakness that is most strongly related to negative affect.

In contrast to the FD/IA or boldness/disinhibition factors, the meanness factor of the TriPM and the coldheartedness facet of the PPI showed relationships with both cognitive and affective ERP components. These two constructs are somewhat unique in that they both capture some of the more interpersonal-affective psychopathic traits (e.g. empathy) and some of the more antisocial traits (e.g. relational aggression). Although meanness covers a somewhat broader set of topics, meanness and coldheartedness share many similarities and both have questions relevant to caring for others, or considering the impact of ones actions on others. On the revised version of the PPI (i.e. PPI-R; Lilienfeld & Widows, 2005) coldheartedness does not load onto either the FD or IA equivalent factors and therefore has received little attention in the literature. Additionally, all of the items on the coldheartedness scale are reverse scored except one, prompting some concerns about its validity. However, it has been shown to contribute meaningful variance to relationships between psychopathy and other personality measures as well as some criminal behavior (Benning, Heritage, Molina, Adams, & Ross, 2016; Berg, Hecht, Latzman, & Lilienfeld, 2015). Additionally, meanness and coldheartedness both show some evidence of a more specific relationship with differences in processing negative affect. These two scores showed fewer, and generally weaker, relationships with differentiation for happy faces than did other factors, and generally stronger relationships with fear, anger, and sadness. Therefore, while they do not capture the full range of psychopathic traits, meanness and coldheartedness may capture some of the essential traits related to cognitive-affective interactions.

When added to the relationships found for IA/disinhibition, and FD/boldness, the finding that meanness and coldheartedness are related to differential emotion related ERP responses across both cognitive and affective components furthers the support for the cognitive-affective interaction hypothesis by demonstrating that some aspects of psychopathy are related to simultaneous weaknesses in cognitive and affective processes.

Limitations

The biggest limitation to the current study is low power due to a small sample size. Main effects for emotion on behavior and ERPs were clearly observable, as were some differences between specific emotions and neutral or gender faces and correlations with psychopathy scores. However, there were a number of trend level differences and correlations that may have been significant if greater power was obtained by having a larger sample size. The confidence intervals around the significant effects are also quite large, which reduces confidence in the stability of the results and makes it difficult to determine the true magnitude of these effects. Therefore, these results should be interpreted with some caution. However, because these findings were generally in line with theoretically supported predictions they still provide a valuable first step towards understanding the exact nature of cognitive-affective interactions in psychopathy.

Secondly, the current study examined only attentional deployment to the cued target location, and did not include any shift of attention from goal directed stimuli. Relatedly, the current study did not include affective stimuli as distractors. This was done by choice to specifically examine the influence of affective stimuli on attention and working memory when the affect was related to the primary goal of the task. Additionally, including emotional distractors would have resulted in a task that was either too long, or had too few trials per condition. However, it will be important for future studies to include elements of shifting attention, and having to ignore emotional distractors as these processes may be related to key differences underlying the psychopathic personality (Baskin-Sommers, Curtin, & Newman, 2011; Larson et al., 2013). Lastly, the current study did not include any threat specific stimuli, which psychopaths have consistently been shown to under process, which may be another key deficit underlying this disorder (Baskin-Sommers, Curtin, & Newman, 2013; Patrick, Bradley, & Lang, 1993). Furthermore, despite showing relationships between psychopathy scores and ERP components previously shown to be sensitive to affective differences in stimuli, the current study did not have a specific measure of participants' actual affective experience, which is a key feature of the low fear hypothesis of psychopathy. Applying measures of affective experience such as the startle eye-blink and post-auricular reflexes, in conjunction with affective and cognitive ERPs could help to link differences in emotional experience, with differences in cognitive and affective processing.

Conclusions

Despite these limitations the results of the current study provide new evidence for interactive cognitive-affective differences related to psychopathic traits. Moreover, these results support the predictions of the cognitive-affective interaction hypothesis that both cognitive and affective differences exist, with specific relationships to each factor, even when the affect if central to the task at hand. The finding the FD and boldness were related to reduced ERP differentiation between emotional and neutral/gender stimuli even when the emotion was central to the task is contrary to predictions of the II hypothesis which proposes that these differences occur only when the emotional information is not central to the task or must be integrated with some other non-affective information. Finally, the finding that meanness and coldheartedness were related to differences in both cognitive and affective processes suggests that these constructs may deserve increased attention from future research attempting to understand cognitive affective interactions in psychopathy.

CHAPTER VI

GENERAL DISCUSSION AND CONCLUSIONS

Until very recently the underlying deficits in psychopathy have been conceptualized as either affective or cognitive. The affective hypotheses have proposed that the primary deficit in psychopathy is an inability to experience fear, and by extension to learn from punishment, and to recognize fear in others (Lykken, 1957; Lykken, 1995; Patrick, Bradley, & Lang, 1993). The cognitive hypotheses have specified deficits primarily in attention, and more specifically in shifting attention from goal relevant or rewarding information to contextual cues (Bernstein, Newman, Wallace, & Luh, 2000; Howland, Kosson, Patterson, & Newman, 1993; Newman, Schmitt, & Voss, 1997). The two-process theory of psychopathy (Patrick & Bernat, 2009) attempted to account for both cognitive and affective deficits but continued to conceptualize them as separate processes. Finally, as a result of increasing evidence that these processes are not separate, and that deficits in one process do in fact influence the other, the Impaired Integration (II) hypothesis (Hamilton, Hiatt Racer, & Newman, 2015) was put forth to explain the influence of these processes on each other. The II hypothesis proposed that deficient or altered connections between brain areas is the underlying neural mechanism leading to impaired integration of affective and neutral information. As discussed above, the II hypothesis makes a significant contribution to the literature and takes a huge step forward toward better understanding the relationships between cognitive and affective deficits in psychopathy, particularly in regards to the underlying neural structures and connections. However, the II hypothesis is still one primarily based in attentional differences and does not explicitly specify a bi-directional interactive relationship between deficits in affective and cognitive processes. Furthermore, the II hypothesis does not provide an adequate explanation for the unique behavioral and psychophysiological correlates associated with different psychopathy factors (Benning, Patrick, Hicks, Blonigen, & Krueger, 2003; Benning, Patrick, Salekin, & Leistico, 2005). Therefore, I have put forth an interactive theory of psychopathy that proposes a truly bi-directional interactive relationship between cognitive and affective deficits in psychopathy where requirements placed on either system can also influence the functioning of the other. The interactive hypothesis proposed here also accounts for differences between psychopathy factors by allowing for specific unitary deficits to be related to each factor, while interactive deficits are related to other factors, or the psychopathic personality as a whole.

This theory drove the two studies that make up this dissertation as first attempts to demonstrate the bi-directional nature of these cognitive-affective interactions, as well as the differences in their expression between factors. Study One tested this theory by investigating the influence of potential rewards on attention and working memory as a function of psychopathic traits. Study Two tested this theory by investigating the influence of processing emotional faces on attention and working memory as a function of psychopathic traits. These two studies differed in the type of affective process involved, but the cognitive mechanisms investigated, and the behavioral responses required by the tasks were similar, allowing for a comparison between potential rewards and facial emotion in regards to how they influence attention and working memory in relationship to psychopathic traits. Finally, both studies assessed psychopathy as a constellation of personality traits organized into the two largely orthogonal factors of FD and IA allowing me to assess differential processes related to each factor. Study Two included a measure of additional psychopathy factors that may be unique in their inclusion of traits that have both affective and cognitive bases.

The results of Study One did not conclusively support the interactive hypothesis, or the alternative hypothesis of separate cognitive and affective processes. FD scores were related to changes in ERP amplitude that suggest increased attentional deployment to, and increased working memory maintenance of low-reward targets compared to no reward, but no differentiation for high reward. IA showed some tentative evidence of greater working memory maintenance for high reward stimuli through greater ERP amplitude both contralateral and ipsilateral to the remembered target during the memory delay interval. However, it is unclear if this truly reflects a working memory process or not because evidence linking the CDA to working memory is for the difference between contralateral and ipsilateral activity. Additionally, there was no evidence of reduced attentional deployment or working memory maintenance for no-reward targets associated with either factor, and no reward related differences in behavioral performance. Therefore, it appears that in this context, either potential monetary rewards were not salient enough to produce the affective response needed to elicit interactive differences, or, that the positive affect associated with potential rewards is not the type of affective response that interacts with cognitive processes in psychopathy.

In contrast to Study One, the results of Study Two do provide initial support for the interactive theory proposed here by demonstrating not only cognitive and affective related ERP differences associated with the IA and FD factors respectively, but also that coldheartedness and meanness were related to reductions in emotion related ERP amplitude differentiation associated with both cognitive and affective processes. Participants high in IA or disinhibition showed generally reduced ERP differentiation between emotional and neutral faces for components indexing attention to the initial target, and working memory maintenance of that target. These participants also showed less behavioral performance improvements for emotional faces (i.e. less RT speeding and less accuracy improvement), although the behavioral differences were less robust than the ERP differences. On the other hand, FD and boldness generally showed reduced ERP differentiation between emotional faces and neutral faces for components indexing affective processes, suggesting overall reduced processing of emotional information, but with no impact on behavior. Coldheartedness and meanness, two factors that have received less attention in the literature but that measure some of the key interpersonal deficits in psychopathy (i.e. empathy) were uniquely related to reduced cognitive and affective differentiation between emotional and neutral faces, as well as some of the strongest individual correlations with behavioral performance suggesting that when both cognitive and affective processing of emotional faces is reduced, the greatest behavioral differences may be produced. Finally, both meanness and coldheartedness were also correlated with increased attention (as indexed by the N2pc) to negative emotional faces at the search array. It is possible that this reflects an increase in attentional resources needed at the search array because of reduced processing of these faces at the initial presentation of the target. It may also reflect the need for these individuals to deploy more attention to find negative emotional faces within the larger search array, which is more visually complex than the initial target. Either way, this increased attentional deployment, without an accompanying improvement in search accuracy or reaction time speeding for these negative affective faces suggests some type of compensatory mechanism that, unlike the other differences previously discussed, may be specific to negative affect.

Together, the results of these two studies lend support to the interactive hypothesis of psychopathy and may begin to help define the boundaries of the suggested deficient cognitive-affective interactions. The results of Study Two generally replicate the distinction in the literature where antisocial psychopathic traits are associated with cognitive mechanisms (Anton, Baskin-Sommers, Vitale, Curtin, & Newman, 2012; Carlson, Thái, & McLarnon, 2008; Vaidyanathan, Hall, Patrick, & Bernat, 2011) and interpersonal-affective traits are associated with affective processes (Anderson & Stanford, 2012; Dawel, O'Kearney, McKone, & Palermo, 2012; Patrick et al., 1993), but also extend these results to show that the more callous/lack of empathy traits may be associated with both cognitive and affective processes. Furthermore, these results suggest that the deficient cognitive-affective interactions related to the psychopathic personality may not be specific to fear, or even negative affect, but that they also may not include reward related positive affect. Instead, these differences in processing may be specific to human emotion, or at least more socially relevant affect.

Limitations

In addition to the limitations discussed for each individual study, there are some overall limitations to the studies reported here. First is the samples used. Both studies used samples comprised of presumably healthy individuals who would be unlikely to be diagnosed as psychopaths if measured categorically. Although Study Two used a broader population in comparison to Study One, and therefore had a greater range of psychopathic traits, the range of these traits was still relatively limited. Furthermore, the number of people with higher levels of traits on both factors (i.e. in the top third on both the FD and IA factors), who may be the closest to psychopaths as traditionally conceptualized was limited to six in each of Studies One and Two, ruling out the possibility of a group level comparison of these individuals.

Secondly, despite still producing many expected effects, the affective modulations used across studies were relatively mild. In Study One the potential rewards were small (i.e. $1 and

$5) on each trial, and the total bonus participants could earn was only $12. While this is well within the range of incentives typically used in the laboratory, it may pale in comparison to the real- world rewards these individuals find motivating. In Study Two the faces used elicited the expected affective processing differences related to psychopathic traits but likely did not elicit an emotional response in participants themselves. This is problematic only in the sense that a deficit in the internal experience of emotion is thought to be central to the psychopathic personality but could not be evaluated here. Furthermore, the faces used were static, black and white faces, which may not elicit the same intensity of responses as real world emotional expressions. Although the use of dynamic facial expressions or more intense affective stimuli introduces other limitations, the use of these stimuli may help to characterize the full range of cognitive-affective interactions in psychopathy.

Finally, as is true with all ERP studies, the interpretation of ERP components depends upon the reverse inference that the waveforms measured reflect a specific cognitive or affective process. Although we have much reliable evidence that each of these components is related to the cognitive or affective process it was used to measure, the ERP component and the cognitive process itself should not be conflated. ERP components are sensitive to a number of variables including specific task demands, general individual differences, and recording conditions, among others. The processes these components attempt to measure (e.g. attention and working memory) are also not completely separable and may be active concurrently during the performance of the task (Woodman, Carlisle, & Reinhart, 2013). While every attempt was made to control, or account for these potential influences, they must still be considered when attempting to relate differences in ERP components to differences in specific cognitive or affective processes.

Suggestions for future research

The finding that IA traits were related to reduced working memory differentiation (as measured by the CDA) between affective and neutral faces suggests that in addition to attention, working memory may be an essential cognitive mechanism that is part of the interactive cognitive-affective deficits in psychopathy. Working memory and attention are also closely linked and, as was the case in the tasks used here, working memory often guides attention (Carlisle, Arita, Pardo, & Woodman, 2011; Woodman et al., 2013). Future work should directly examine the impact of working memory load on the processing of affective information as a function of psychopathic traits. Additionally, to address the bi-directional nature of this relationship, future work should examine the influence of affective demands on working memory capacity in psychopathy. As was done in the two studies reported here, adapting tasks known to tap specific cognitive mechanisms to include an affective manipulation provides a way to investigate the impact of affective stimuli across known cognitive effects. For example, change detection tasks have been reliably used to measure working memory capacity and elicit the CDA as an ERP measure of that capacity (Fukuda, Awh, & Vogel, 2010; Vogel, McCollough, & Machizawa, 2005). Using such a task with affective stimuli would allow for the testing of the impact of affect on working memory capacity. Whereas affective faces have been shown to impair working memory performance in healthy individuals (Kensinger & Corkin, 2003), presumably because the affective information takes up more capacity, individuals with high levels of psychopathic traits could be expected to show less impairment in working memory capacity for affective stimuli compared to neutral because they do not maintain the emotional content to the same extent. Alternatively, a similar change detection task with neutral stimuli and an affective image presented during the delay period could be used to test the impact of working memory load on affective processing. Presenting startle probes during the delay could also be used to measure state level affect and allow for the comparison of such results with past research on startle potentiation in psychopathy. If startle potentiation were reduced as set size increased it would suggest that increased cognitive demands reduce the remaining resources available for affective processing. Here it could be expected that reductions in potentiation as a function of set size would be greater in those with high levels of psychopathic traits.

Finally, the extent of reward related differences in attention and working memory remains to be seen, as does the influences of losses. Future research may be better able to characterize these reward related cognitive processes by using tasks that include both rewards and losses, along with tasks with greater difficulty than the rewarded visual search task used here. It may also be important to examine not only monetary rewards but also other potential motivating stimuli such as social rewards or the removal of an aversive stimulus. By understanding not only what individuals with psychopathic traits fail to fully process, but also what they process more, or what motivates them more, and how that motivation influences cognitive processes, we may be better able to understand the mechanisms behind some of the more harmful impulsive or antisocial behaviors associated with these traits.

Conclusions

The evidence provided by the two studies reported here preliminarily supports the hypothesis that deficient cognitive-affective interactions underlie the psychopathic personality. Moreover, the evidence presented here suggests specific relationship between cognitive processes and the impulsive antisocial factors of psychopathy as well as between affective processes and the more interpersonal affective factors of psychopathy, with factors that measure callousness and lack of empathy being related to both cognitive and affective processes. Across factors, and across both cognitive and affective processing, these results suggest a broader association with both positive and negative affect, and not one that is fear specific. However, the affective differences, and associated interactive effects related to psychopathic traits may be limited to, or at least most pronounced for human emotions, and may not extend to other forms of positive affect such as that created by potential rewards. Finally, as we continue to explore the interactive cognitive-affective processes underlying psychopathic personality traits, it may be those factors related most strongly to problematic interpersonal relationships such as meanness and coldheartedness that hold the key to truly understanding the etiology of the psychopathic personality. Perhaps Hervey Cleckley had it right from the start when he said about the psychopath, “only when we observe him not through his speech but as he seeks his aims in behavior and demonstrates his disability in interaction with the social group can we begin to feel how genuine is his disorder” (Cleckley, 1976, pp. 22).

Table 1.
Behavioral and ERP Measures by Reward Level

	Means (sd)		
	No Reward	Low Reward	High Reward
Behavior			
Reaction Time (ms)	665 (88)[a]	647 (85)[b]	650 (98)[b]
Accuracy (%)	97.78 (2.41)[a]	97.95 (3.32)[a]	98.50 (2.55)[b]
ERPs (μV)			
Cue P3	0.16 (2.10)[a]	5.67 (4.10)[b]	8.93 (5.45)[c]
Target N2pc	-0.62 (0.72)[a]	-0.95 (1.16)[b]	-0.62 (1.19)[a, b]
Target CDA	-0.64 (0.63)[a]	-0.96 (1.13)[b]	-0.60 (1.12)[a]
Target P170	3.06 (3.21)[a]	3.07 (4.38)[a]	2.99 (3.43)[a]
Array N2pc	-0.89 (1.07)[a]	-1.14 (1.42)[a]	-1.07 (1.41)[a]

Note: Mean values within each reward level. Means for the no reward level are the average of serial positions 4 & 6. Means with different superscripts are significantly different at $p < .05$ (e.g. all reward levels are significantly different from each other for the Cue P3 ERP component).

Table 2.

Visual Search Behavioral Performance Differences for Emotional Faces Compared to Neutral and Gender

	Mean Difference (ms)	**Standard Error**	**95% CI. Lower Limit**	**95% CI. Upper Limit**	**Mean Difference (%)**	**Standard Error**	**95% CI. Lower Limit**	**95% CI. Upper Limit**
Reaction Time					Accuracy			
Search								
Angry v Neutral	-21.79	9.95	-53.71	10.13	**3.41 ****	**0.80**	**0.80**	**5.91**
Fear v Neutral	-11.12	10.19	-43.81	21.56	**3.30 ****	**0.86**	**0.56**	**6.06**
Happy v Neutral	**-47.87 ***	**14.05**	**-94.48**	**-4.29**	**4.71 ****	**1.01**	**1.30**	**7.79**
Sad v Neutral	-10.77	10.26	-43.69	22.16	**2.54 ***	**0.80**	**0.03**	**5.11**
Angry v Gender	14.94	20.16	-49.74	79.63	-5.47	2.88	-14.71	3.78
Fear v Gender	25.61	22.41	-46.28	97.50	-5.51	2.74	-14.32	3.29
Happy v Gender	-12.65	20.37	-78.01	52.71	-4.27	2.57	-12.50	3.96
Sad v Gender	25.96	22.50	-46.23	98.16	-6.28	2.69	-14.90	2.34
Gender v Neutral	36.73	22.95	-36.89	110.36	**8.82 ***	**2.78**	**0.10**	**17.74**
Label								
Angry v Neutral	69.97	52.44	-98.27	238.21	**5.16 ****	**1.19**	**1.41**	**9.02**
Fear v Neutral	**215.33 ****	**46.49**	**66.29**	**364.60**	2.36	1.08	-1.10	5.82
Happy v Neutral	**-171.69 ****	**35.05**	**-283.79**	**-58.91**	**5.46 ****	**1.40**	**0.87**	**9.86**
Sad v Neutral	-14.07	41.84	-148.32	120.16	1.89	0.80	-0.67	4.44
Angry v Gender	**784.90 ****	**68.29**	**-934.04**	**-495.81**	-2.80	2.57	-11.03	5.44
Fear v Gender	**930.37 ****	**90.33**	**640.56**	**1220.18**	-5.65	2.64	-14.12	2.83
Happy v Gender	**543.57 ****	**56.45**	**362.46**	**724.69**	-2.65	2.26	-9.90	4.61
Sad v Gender	**700.85 ****	**78.12**	**450.20**	**951.50**	-6.12	2.63	-14.57	2.32
Gender v Neutral	**-714.92 ****	**68.29**	**-934.04**	**-495.81**	-8.01	2.56	-16.22	0.21
Match								
Angry v Neutral	45.07	26.59	-40.24	130.37	1.76	0.89	-1.09	4.60
Fear v Neutral	**132.00 ***	**38.66**	**7.57**	**[illegible]55.64**	**3.98 ***	**1.20**	**0.09**	**7.76**
Happy v Neutral	**-447.42 ****	**83.76**	**-715.67**	**-178.19**	**3.94 ***	**1.10**	**0.34**	**7.38**
Sad v Neutral	37.35	38.14	-85.02	159.73	3.29	1.77	-2.38	8.97
Angry v Gender	**1142.92 ****	**138.71**	**697.90**	**1587.95**	-5.75	2.64	-14.24	2.73
Fear v Gender	**1229.46 ****	**132.91**	**803.04**	**1655.88**	-3.58	2.54	-11.73	4.57
Happy v Gender	**650.93 ****	**80.47**	**392.74**	**909.11**	-3.64	2.35	-11.20	3.91
Sad v Gender	**1135.21 ****	**136.91**	**695.95**	**1574.47**	-4.21	2.54	-12.36	3.93
Gender v Neutral	**-1097.86 ****	**136.28**	**-1535.10**	**-660.61**	*7.50 +*	*2.55*	*-0.68*	*15.69*

Note: Mean differences in reaction time (ms) and response accuracy (%) between emotional and neutral, as well as emotional and gender faces (i.e. neutral faces from the gender identification condition) for responses to the search array, as well as the target label and target match. 95% confidence interval (C.I.) has been adjusted for multiple comparisons and is equivalent to an uncorrected 99% C.I. Mean differences in bold have confidence intervals that do not include zero. + $p < .1$, *$p < .05$, **$p < .01$, corrected.

Table 3.
ERP Amplitude Differences for Emotional Faces Compared to Neutral and Gender at the Target and Search Array

	Mean Difference (µV)	**Standard Error**	**95% CI. Lower Limit**	**95% CI. Upper Limit**	**Mean Difference (µV)**	**Standard Error**	**95% CI. Lower Limit**	**95% CI. Upper Limit**
Target					Search			
EPN								
Angry v Neutral	**1.54 ***	**0.40**	**0.25**	**2.82**	1.15	0.43	-0.23	2.53
Fear v Neutral	***1.30 +***	***0.42***	***-0.05***	***2.66***	*1.43 +*	*0.46*	*-0.06*	*2.92*
Happy v Neutral	**1.43 ***	**0.42**	**0.08**	**2.77**	**1.59 ***	**0.46**	**0.10**	**3.07**
Sad v Neutral	***1.37 +***	***0.46***	***-0.11***	***2.85***	1.36	0.52	-0.30	3.03
Angry v Gender	-0.10	0.24	-0.88	0.68	**-1.09 ***	**0.33**	**-2.16**	**-0.01**
Fear v Gender	-0.33	0.25	-1.15	0.49	-0.81	0.31	-1.79	0.18
Happy v Gender	-0.21	0.19	-0.83	0.41	-0.65	0.33	-1.72	0.42
Sad v Gender	-0.27	0.26	-1.11	0.58	-0.87	0.37	-2.05	0.31
Gender v Neutral	**-1.64 ***	**0.45**	**-3.09**	**-0.18**	**-2.24 ****	**0.56**	**-4.05**	**-0.42**
LPP								
Angry v Neutral	*1.07 +*	*0.34*	*-0.02*	*2.16*	0.08	0.38	-1.15	1.30
Fear v Neutral	-0.84	0.38	-0.39	2.07	0.39	0.46	-1.10	1.87
Happy v Neutral	1.03	0.47	-0.49	2.55	1.21	0.43	-0.18	2.61
Sad v Neutral	0.94	0.39	-0.32	2.20	0.14	0.42	-1.22	1.50
Angry v Gender	0.37	0.32	-0.66	1.39	-0.52	0.39	-1.80	0.75
Fear v Gender	0.14	0.26	-0.70	0.97	-0.22	0.28	-1.11	0.68
Happy v Gender	0.32	0.22	-0.38	1.03	0.61	0.29	-0.32	1.54
Sad v Gender	0.24	0.26	-0.61	1.08	-0.46	0.36	-1.61	0.68
Gender v Neutral	-0.70	0.44	-2.11	0.70	-0.60	0.53	-2.31	1.11
N2pc								
Angry v Neutral	-0.70	0.26	-1.53	0.14	-0.08	0.14	-0.52	0.36
Fear v Neutral	-0.55	0.21	-1.21	0.11	-0.29	0.14	-0.74	0.15
Happy v Neutral	**-0.61 ***	**0.16**	**-1.13**	**-0.09**	-0.24	0.11	-0.61	0.12
Sad v Neutral	-0.35	0.12	-0.75	0.04	-0.25	0.17	-0.80	0.29
Angry v Gender	-0.35	0.21	-1.03	0.33	0.09	0.10	-0.25	0.42
Fear v Gender	-0.21	0.15	-0.70	0.28	-0.12	0.11	-0.47	0.23
Happy v Gender	-0.27	0.13	-0.69	0.16	-0.07	0.11	-0.42	0.27
Sad v Gender	-0.01	0.12	-0.40	0.38	-0.08	0.16	-0.58	0.42
Gender v Neutral	0.34	0.14	-0.09	0.78	0.17	0.13	-0.24	0.58
CDA								
Angry v Neutral	***-0.47 +***	***0.20***	***-1.13***	***0.19***				
Fear v Neutral	***-0.41 +***	***0.19***	***-1.03***	***0.20***				
Happy v Neutral	**-0.42 ***	**0.13**	**-0.86**	**0.01**				
Sad v Neutral	**-0.33 ***	**0.10**	**-0.65**	**-0.01**				
Angry v Gender	***-0.49 +***	***0.19***	***-1.10***	***0.11***				
Fear v Gender	***-0.44 +***	***0.17***	***-0.98***	***0.10***				
Happy v Gender	**-0.45 ****	0.11	-0.80	-0.10				
Sad v Gender	**-0.35 ***	0.11	-0.69	-0.01				
Gender v Neutral	-0.02	0.12	-0.41	0.36				

Note: Mean differences in ERP amplitudes between emotional and neutral, as well as emotional and gender faces (i.e. neutral faces from the gender identification condition) time-locked to the initial target and to the search array. 95% confidence interval (C.I.) has been adjusted for multiple comparisons and is equivalent to an uncorrected 99% C.I. Mean differences in bold have confidence intervals that do not include zero. + $p < .1$, *$p < .05$, **$p < .01$, corrected.

Table 4.

Correlations Among Psychopathy Factor Scores and Emotion Related Differences in Behavioral Performance

	FD	**IA**	**Boldness**	**Meanness**	**Disinhibition**	**FD**	**IA**	**Boldness**	**Meanness**	**Disinhibition**
Reaction Time						Accuracy				
Search										
Angry v Neutral	.12	.31	-.09	.28	***.39***	.00	.10	.20	.10	-.08
Fear v Neutral	.25	.26	.09	**.45**	***.36***	.02	-.06	.00	.20	-.11
Happy v Neutral	.24	.30	.12	**.48**	.33	-.20	-.21	-.17	-.08	-.29
Sad v Neutral	.01	.13	-.11	***.37***	.21	.06	-.05	.17	.06	-.14
Angry v Gender	.03	-.11	.13	-.31	-.21	-.13	**.38**	-.21	.19	.18
Fear v Gender	.08	-.13	.19	-.22	-.21	-.12	***.35***	-.27	.24	.17
Happy v Gender	.12	-.07	.23	-.15	-.18	-.22	.32	-.36	.16	.11
Sad v Gender	-.02	-.18	.12	-.25	-.28	-.11	***.36***	-.22	.19	.17
Gender v Neutral	.04	.25	-.20	***.37***	.29	.13	***-.36***	.20	-.18	-.23
Label										
Angry v Neutral	-.22	-.11	**-.37**	-.04	-.13	.14	.02	.28	.21	-.07
Fear v Neutral	.17	.19	.04	.12	.12	-.14	-.08	-.11	.17	-.11
Happy v Neutral	-.02	-.07	-.02	-.05	.05	-.07	-.36	.02	-.14	-.34
Sad v Neutral	-.19	.00	-.19	.16	-.02	-.01	-.07	.02	.11	-.06
Angry v Gender	-.19	.05	-.25	-.09	-.18	-.04	***.38***	-.10	.23	.14
Fear v Gender	.03	.21	.00	-.01	-.02	-.16	***.33***	-.26	.20	.12
Happy v Gender	-.07	.14	-.01	-.12	-.09	-.16	.19	-.23	.07	-.03
Sad v Gender	-.16	.14	-.14	.00	-.10	-.11	***.33***	-.23	.15	.15
Gender v Neutral	.06	-.15	.02	.08	.10	.11	***-.37***	.23	-.13	-.16
Match										
Angry v Neutral	-.23	.24	-.33	.22	.24	-.12	.01	.16	-.22	-.26
Fear v Neutral	-.35	.00	**-.45**	.11	.05	.14	-.12	.22	.03	-.18
Happy v Neutral	.05	.10	.03	-.02	.30	-.20	-.03	-.12	-.05	-.25
Sad v Neutral	-.26	.05	-.25	.32	.07	.18	-.07	.34	-.03	-.15
Angry v Gender	-.11	.08	-.20	.04	-.23	-.12	.29	-.18	.10	.06
Fear v Gender	-.18	.03	-.27	.03	-.28	.02	.24	-.13	.18	.05
Happy v Gender	-.04	.15	-.13	-.01	-.19	-.19	.31	-.32	.16	.04
Sad v Gender	-.14	.05	-.18	.09	-.27	.05	.25	.03	.15	.03
Gender v Neutral	.06	-.03	.11	.00	.29	.08	-.30	.24	-.17	-.14

Note: Correlations among self-report psychopathy factor scores and emotion related behavioral performance change for reaction time and response accuracy to the search array, label, and match. Correlations in bold are significant at $p < .05$. Fearless dominance (FD) and Impulsive Antisociality (IA) from the PPI. Boldness Meanness, Disinhibition from the TriPM.

Table 5.

Correlations Among Psychopathy Factor Scores and Emotion Related Differences in ERP Amplitude

	FD	IA	Boldness	Meanness	Disinhibition	FD	IA	Boldness	Meanness	Disinhibition
Target						Search				
EPN										
Angry v Neutral	-.17	.03	-.28	.12	-.04	**-.38**	-.07	-.25	.05	-.18
Fear v Neutral	-.20	-.17	-.25	-.06	-.24	-.29	.08	-.26	.24	-.09
Happy v Neutral	**-.38**	-.11	**-.46**	.13	-.17	**-.41**	.02	-.30	.03	-.15
Sad v Neutral	-.26	-.15	-.23	-.15	-.19	-.23	.05	-.16	.22	-.04
Angry v Gender	-.06	.22	-.05	.03	.09	-.05	-.20	.11	***-.40***	-.02
Fear v Gender	-.13	-.12	-.03	-.27	-.29	.07	.01	.10	-.11	.10
Happy v Gender	**-.55**	-.01	**-.51**	.07	-.17	-.19	-.09	-.04	***-.38***	-.07
Sad v Gender	-.29	-.10	-.05	***-.42***	-.23	.07	-.03	.15	-.08	.10
Gender v Neutral	.13	.10	.24	-.10	.10	.26	-.07	.23	-.27	.12
LPP										
Angry v Neutral	-.26	.03	***-.40***	.17	-.12	**-.41**	.14	**-.41**	.14	.09
Fear v Neutral	-.22	-.21	-.25	-.04	***-.39***	***-.32***	.23	***-.38***	.25	.08
Happy v Neutral	***-.33***	-.13	***-.38***	.01	-.27	-.27	.27	-.30	.27	.17
Sad v Neutral	***-.33***	-.16	-.28	-.13	-.29	***-.34***	.10	-.29	.10	-.01
Angry v Gender	.02	.28	.03	.35	.10	-.05	-.14	.02	-.30	.07
Fear v Gender	.01	-.01	.12	.13	-.35	-.05	-.02	-.06	-.20	.07
Happy v Gender	-.31	.08	-.25	.25	-.28	.00	.04	.04	-.12	.18
Sad v Gender	-.19	.05	.06	-.03	-.18	-.04	-.19	.05	***-.37***	-.05
Gender v Neutral	.22	.19	***.36***	.14	.14	.26	-.21	.28	-.33	-.01
N2pc										
Angry v Neutral	-.12	***.36***	-.17	.16	.29	.08	-.13	.07	**-.54**	.05
Fear v Neutral	-.02	***.31***	-.12	.12	.28	.01	-.17	.02	-.29	-.15
Happy v Neutral	.07	**.58**	-.05	***.38***	**.61**	.13	.11	.10	-.09	.09
Sad v Neutral	-.18	.12	-.32	.15	.21	-.17	-.22	-.24	**-.44**	-.24
Angry v Gender	-.10	***.36***	-.14	.10	.27	.13	-.20	.29	**-.46**	-.15
Fear v Gender	.03	.30	-.07	.05	.24	.03	-.30	.17	-.17	***-.40***
Happy v Gender	.16	**.62**	.10	***.38***	**.55**	.15	.09	.20	.13	-.05
Sad v Gender	-.07	.01	-.18	-.01	.08	-.18	-.26	-.20	-.32	***-.39***
Gender v Neutral	.07	-.13	.11	-.13	-.17	-.01	-.02	.03	.18	-.13
CDA										
Angry v Neutral	-.03	***.37***	-.17	.21	.27					
Fear v Neutral	-.10	**.41**	-.20	.17	.28					
Happy v Neutral	.00	**.45**	-.20	.26	**.45**					
Sad v Neutral	-.06	.30	-.19	.17	***.37***					
Angry v Gender	-.10	.30	-.15	.09	.22					
Fear v Gender	-.17	***.35***	-.17	.04	.24					
Happy v Gender	-.11	***.37***	-.16	.11	**.42**					
Sad v Gender	-.11	.13	-.05	-.08	.30					
Gender v Neutral	-.09	-.17	.10	-.21	-.15					

Note: Correlations among self-report psychopathy factor scores and emotion related change in ERP amplitude to the target and search array. Correlations in bold are significant at $p < .05$. Fearless dominance (FD) and Impulsive Antisociality (IA) from the PPI. Boldness Meanness, Disinhibition from the TriPM.

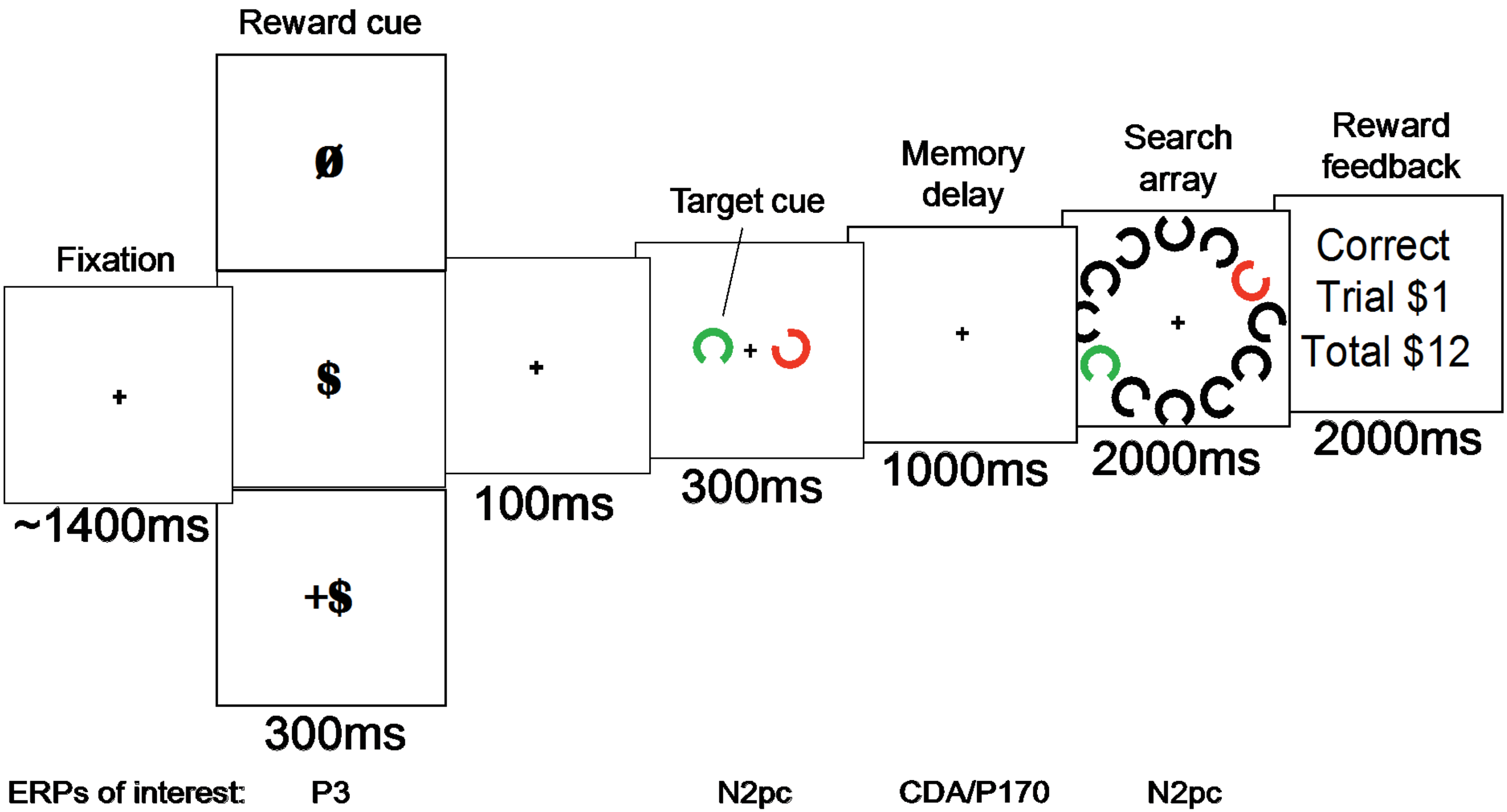

Figure 6. *Rewarded visual search task.* A single trial of the rewarded visual search task is shown. The target to be remembered is a match to the search array and feedback is for a correct response on a low reward trial.

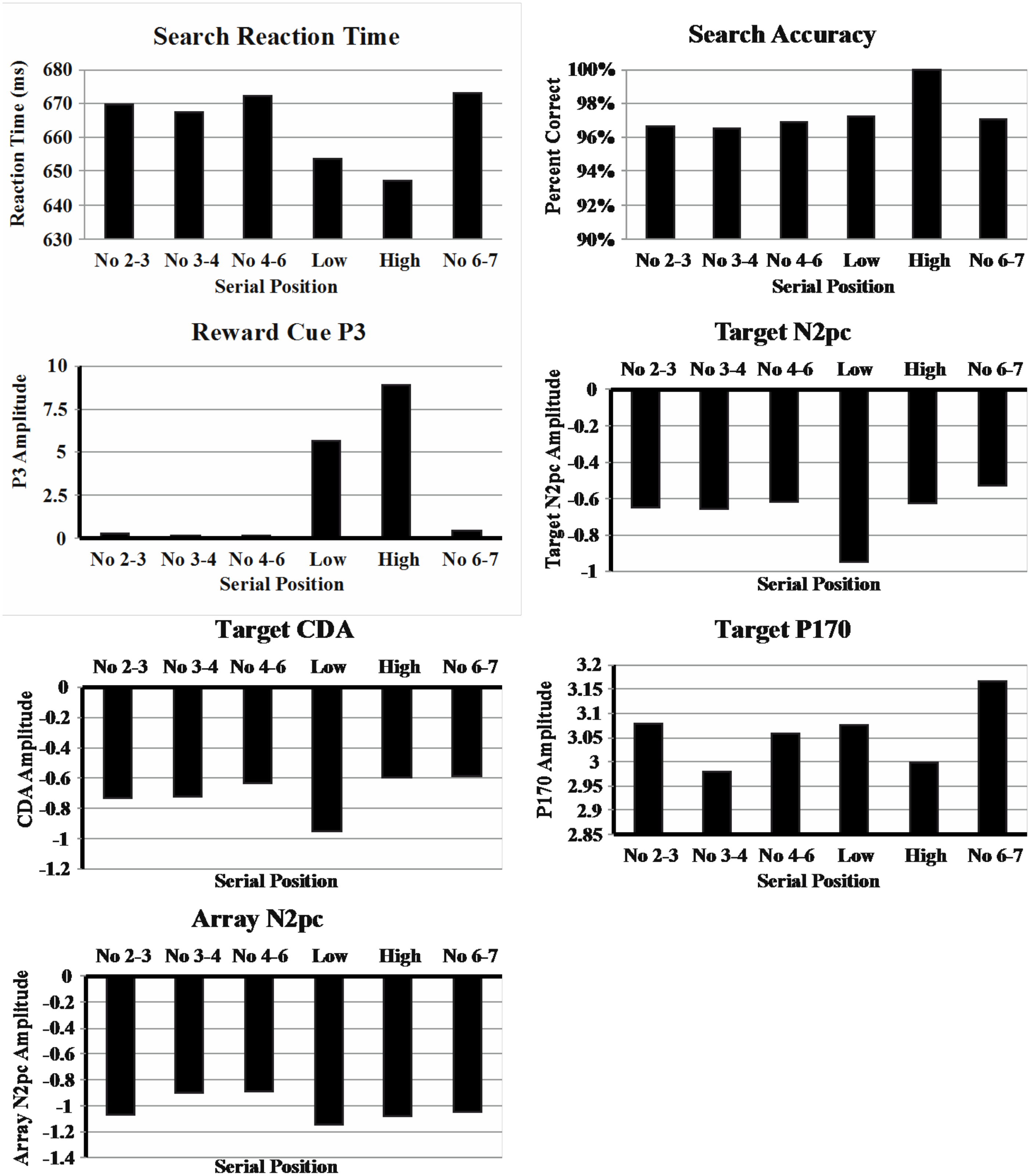

Figure 7. *Serial Position Averages for No-Reward Trials Across Dependent Measures.* Values are means for the specified serial positions, with low and high reward at serial position five. ERP amplitude values are in µV.

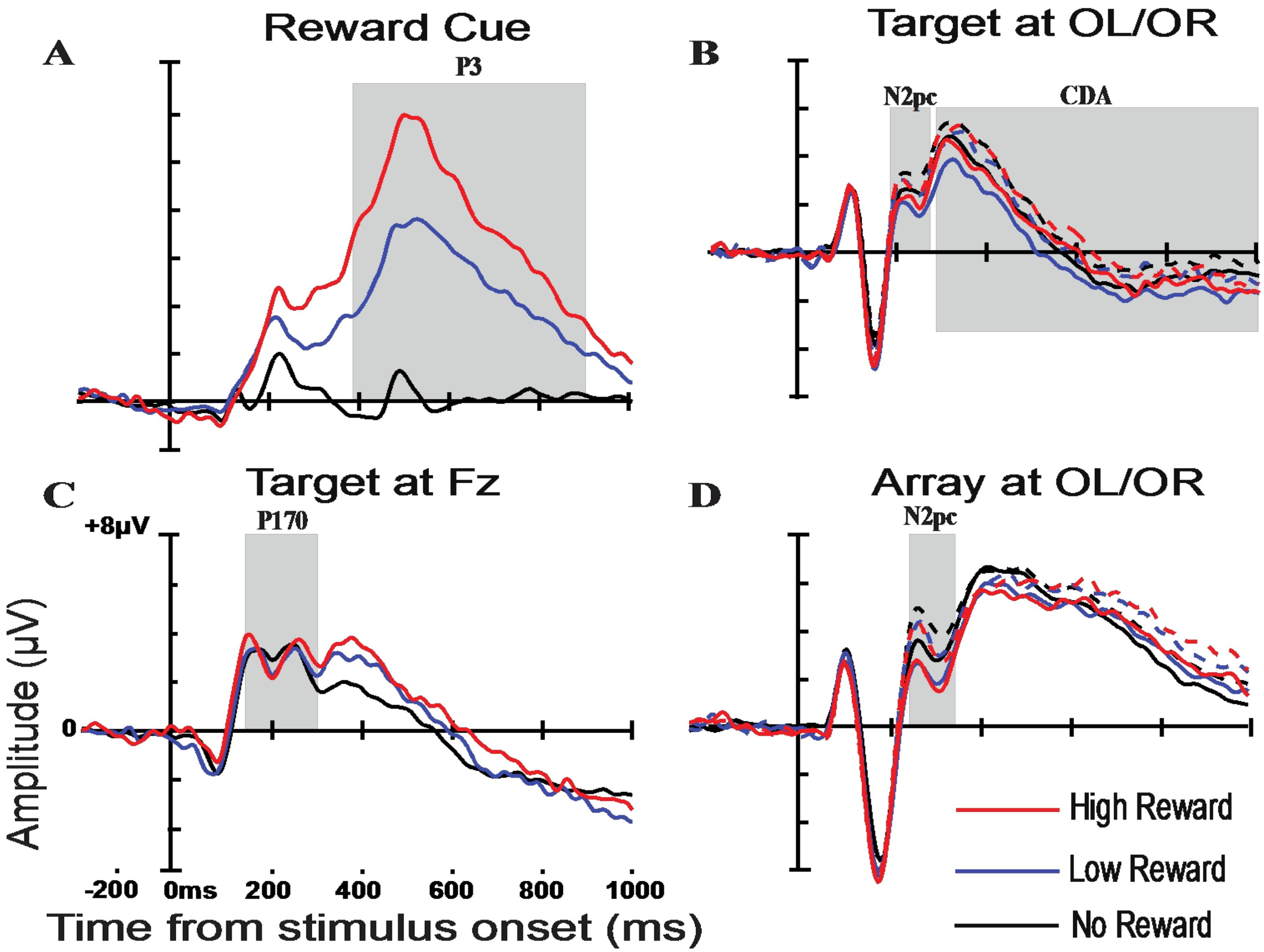

Figure 8. *ERP indices of cognitive mechanisms by reward level.* A) P3 following the reward cue. B) N2pc & CDA following target onset. C) P170 following target onset. D) N2pc following search array onset. No reward trials (average of serial positions 4 & 6) shown in black, low reward trials in blue, and high reward trials in red. For the N2pc and CDA dashed lines are ipsilateral to the target, solid lines are contralateral. Positive amplitude plotted up.

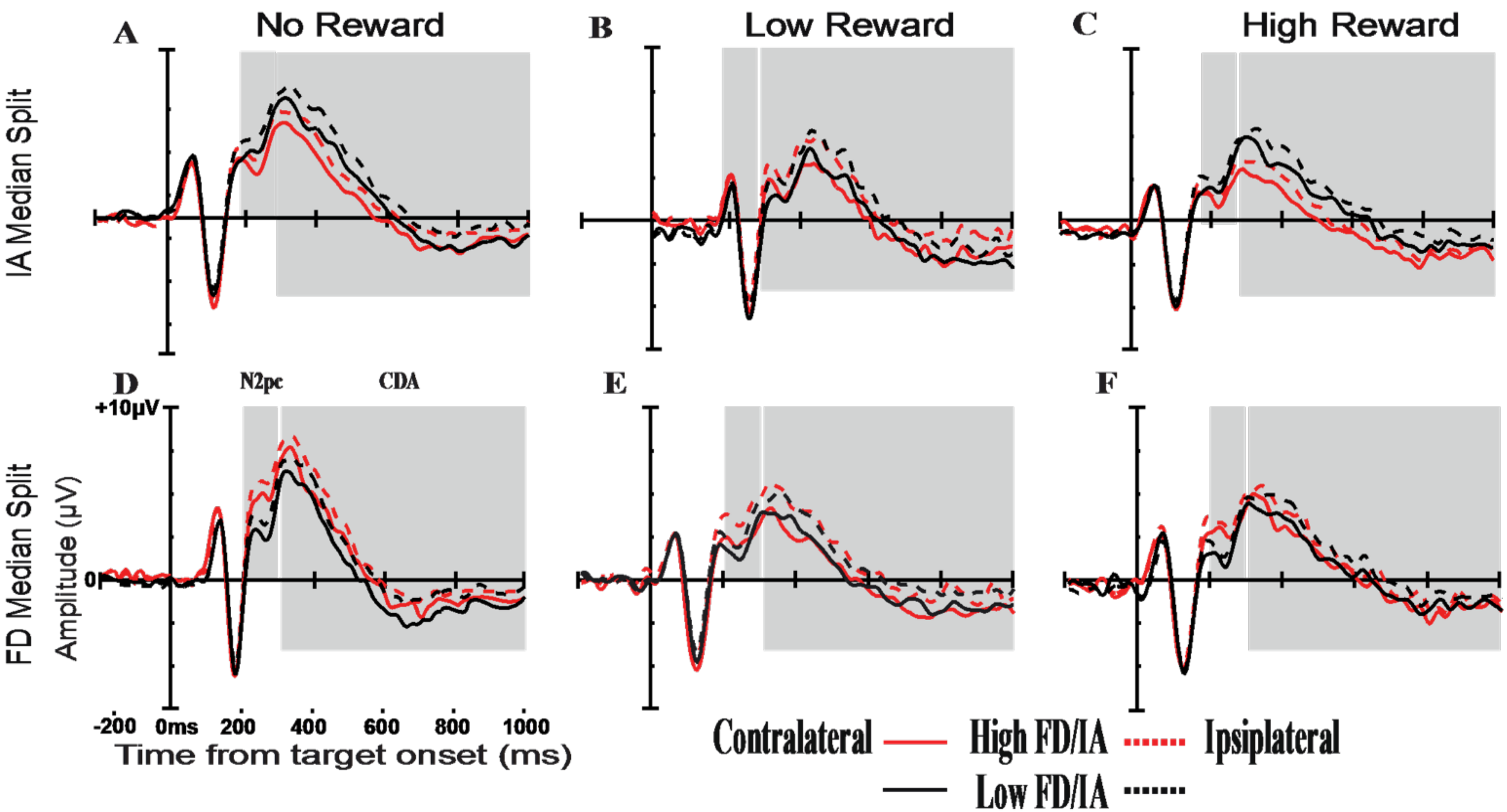

Figure 9. *ERP indices of cognitive mechanisms by reward level and psychopathy factor scores.* A-C) N2pc & CDA following target onset, median split by IA score, at no (average of serial positions 4 & 6), low, and high reward. D-E) N2pc & CDA following target onset, median split by FD score, at no (average of serial positions 4 & 6), low, and high reward. Participants with scores above the median in red, below the median in black. Dashed lines are ipsilateral to the target, solid lines are contralateral. Positive amplitude plotted up.

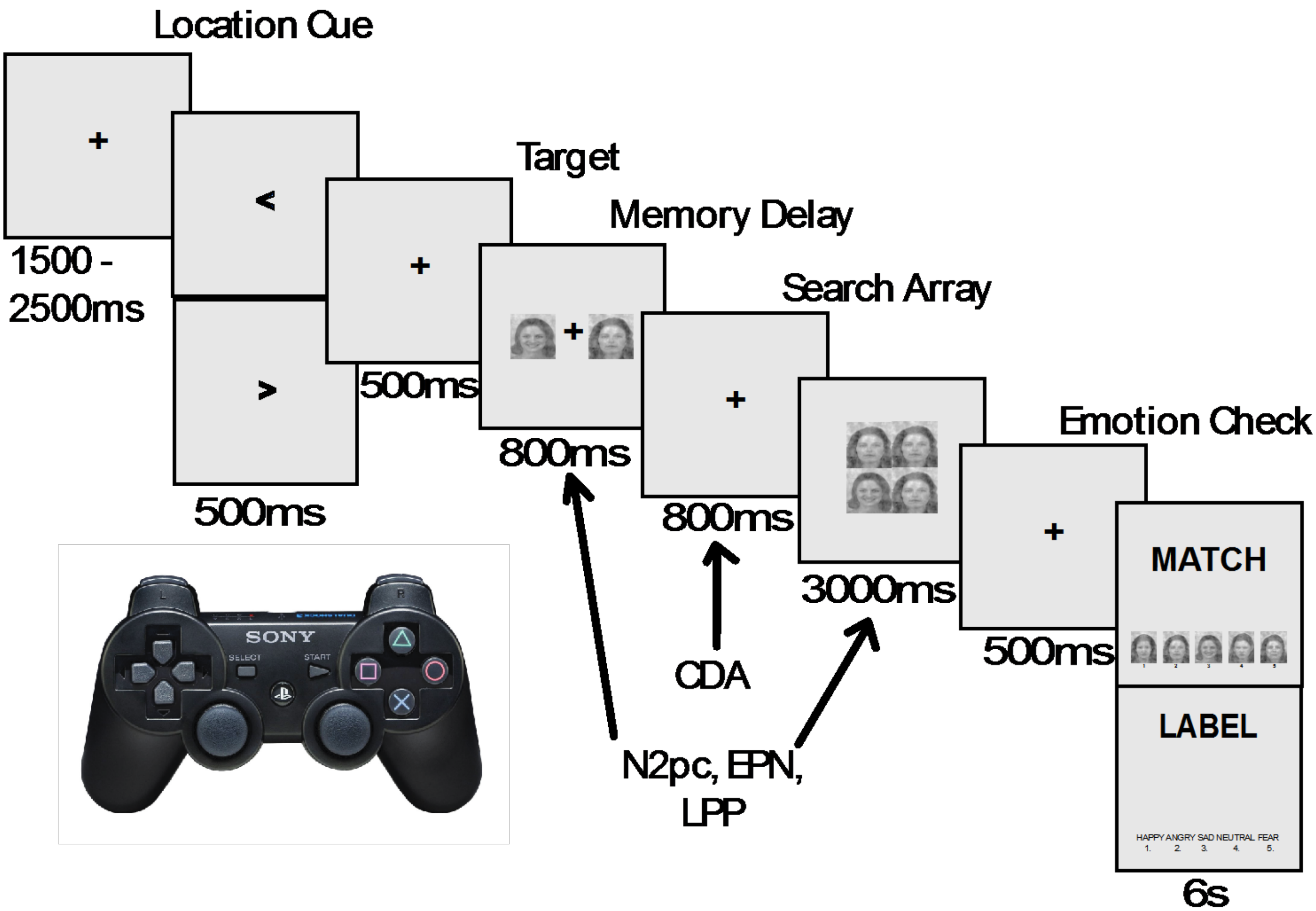

Figure 10. *Visual search for faces task.* Temporal position of the ERP components of interest indicated with arrows. The target cue, search array, and emotion match depicted here represent a trial in the emotion identification condition with female faces.

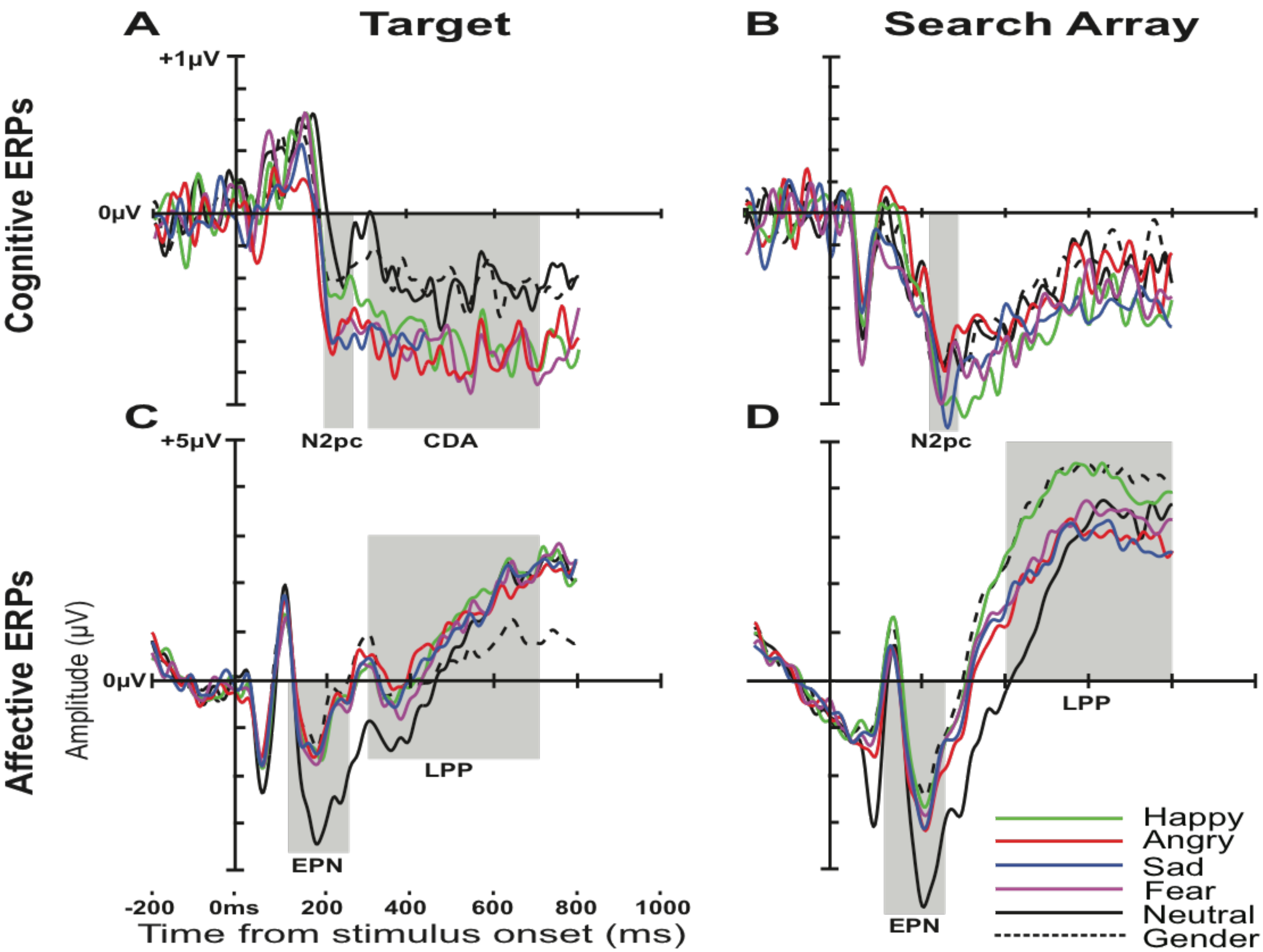

Figure 11. *ERP indices of cognitive and affective processes by emotion.* A) Contralateral minus ipsilateral activity for N2pc & CDA following target onset. B) Contralateral minus ipsilateral activity for N2pc following search array onset. C) EPN and LPP following target onset. D) EPN and LPP following search array onset. Positive amplitude plotted up.

APPENDIX A

Emotion and Personality Research Study

VANDERBILT UNIVERSITY

Are you the 'sensitive type'?

Ever been called 'heartless'?

Do you put the needs of others above your own?

Can you usually tell how someone is feeling just by looking at them?

Do others describe you as 'fearless'?

If you said 'YES' to any ONE of these questions we are looking for you!

We are currently recruiting healthy adults, at least 18 years of age, for a study of the relationship between emotions and personality. The study involves tests of emotion identification ability, personality tests, and recording brain waves. Participants who complete the study will be compensated for their time.

You may qualify for the study if you are currently psychiatrically healthy, are not taking medications that impact attention or mood, and have normal, or corrected to normal, vision.

For more information, contact:
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Date of Approval:1/2[illegible]/2015

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Emotion and Personality Research Study

Are you rebellious, aggressive, or impulsive?

Are you charming, intelligent, or adventurous?

Do you get bored easily and like to live life on the edge?

Are you always careful or do you always plan ahead?

Were you ever suspended or expelled from grade school or high school?

If you said 'YES' to any ONE of these questions we are looking for you!

We are currently recruiting healthy adults, at least 18 years of age, for a study of the relationship between emotions and personality. The study involves tests of emotion identification ability, personality tests, and recording brain waves. Participants who complete the study will be compensated for their time.

You may qualify for the study if you are currently psychiatrically healthy, are not taking medications that impact attention or mood, and have normal, or corrected to normal, vision.

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