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Clarifying the Factors That Undermine Behavioral Inhibition System Functioning in Psychopathy

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Psychopathic individuals are generally unresponsive to motivational and emotional cues that facilitate behavioral regulation. A putative mechanism for this deficiency is Gray's (1981) behavioral inhibition system (BIS). To evaluate the association between psychopathy and BIS functioning, we administered a laboratory-based assessment of BIS functioning to a group of psychopathic offenders assessed with the Psychopathy Checklist–Revised (PCL–R; Hare, 2003). In addition, we tested the hypothesis that the effects of working memory load on BIS functioning would interact differentially with the PCL–R factors. Replicating previous results, psychopathic offenders were less sensitive to BIS-related cues than controls. As predicted, working memory load interacted with Factor 2 (antisocial/impulsive), with higher scores predicting weaker BIS functioning under high-load though not low-load conditions. Results suggest new insights concerning the relationship among working memory, reward sensitivity, and BIS functioning in psychopathy.

Keywords: psychopathy, behavioral inhibition, working memory load, anxiety, PCL–R factors

Psychopathy is distinguished from other antisocial syndromes by a maladaptive interpersonal style that includes glibness, callousness, superficial charm, and shallow affect (Cleckley, 1976). Equally important, it is also associated with unconstrained "antisocial impulses" (Lykken, 2006, p. 7). These dissocial facets result in maladaptive behaviors that are characterized by disinhibition, an inability to regulate one's behaviors in the face of potential consequences (Patterson & Newman, 1993). Thus, psychopathy is often associated with aggressive and violent behavior, high rates of recidivism, and other externalizing behaviors. Despite a wealth of empirical research, little is known about the factors that influence disinhibition or how they might differ for various subtypes and subcomponents of psychopathy.

Although psychopathy is often discussed as a unitary syndrome, there is also a long tradition of distinguishing psychopathic subtypes, especially primary and secondary psychopathy (Brinkley, Newman, Widiger, & Lynam, 2004; Karpman, 1941; Lykken, 1995). Primary psychopathy is presumed to be a consequence of some intrinsic deficit that hampers self-regulation and normal adjustment. It is generally characterized by the lack of anxiety and associated with affective and attention-related deficits. Conversely, secondary psychopathy is believed to stem from social disadvantage, excessive neurotic anxiety, and/or some other form of psychopathology (Cleckley, 1976; Lykken, 1995). Relative to primary psychopaths, secondary psychopaths exhibit greater

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levels of anxiety, but comparable levels of antisocial behavior (Skeem, Johansson, Andershed, Kerr, & Louden, 2007). Thus, hypotheses regarding primary and secondary psychopathy tend to distinguish between a syndrome with a core underlying deficit (i.e., primary) and one that reflects the influence of alternative etiological processes such as excessive emotionality (i.e., secondary).

Reinforcement Sensitivity Theory and Psychopathy

One approach to uncovering the etiological mechanisms that underlie disinhibition in psychopathy is derived from Gray's reinforcement sensitivity theory (RST; J. A. Gray, 1981, 1987).[1] Gray's model is of particular interest because its component parts, the behavioral inhibition and the behavioral activation systems, highlight alternative hypotheses for disinhibited, antisocial behavior (Newman, 1997). The behavioral inhibition system (BIS) inhibits goal-directed behavior when potential threats or inconsistent stimuli are detected in the environment. This inhibition redirects attention to process the threatening or novel stimuli. BIS activation to such stimuli is influenced by the individual's past experiences with punishment and nonreward and, thus, plays an important role in learning to inhibit punished responses. The behavioral activation system (BAS), by contrast, mediates reactivity to reward cues and behavioral approach. According to Gray's theory, as BAS activation increases, so does the probability of goal-directed behavior (J. A. Gray & McNaughton, 2000). There is also a reciprocal relationship between BAS and BIS. Thus, when BAS is too strong, the BIS will fail to interrupt approach behavior in reaction to punishment cues.

A number of investigators have used RST as a means to specify psychobiological mechanisms for psychopathy. In 1980, for instance, Fowles proposed that psychopathy could be understood as a consequence of weak BIS functioning. In support of his proposal, Fowles cited a range of evidence that linked psychopathy to poor passive avoidance learning, weak skin conductance responses in anticipation of aversive events, and other BIS-related deficiencies. Lykken (1995) suggested that differences in BIS and BAS functioning may be useful for distinguishing primary and secondary psychopathy. More specifically, he noted that primary psychopathy is associated with weak BIS but normal BAS whereas secondary psychopathy is related to hyper-reactive BAS and normal BIS functioning. Using self-report measures to assess BIS/BAS, Newman, MacCoon, Vaughn, and Sadeh (2005), found strong support for the association of primary psychopathy with weak BIS and normal BAS. For secondary psychopathy, there was good support for the strong BAS part of the hypothesis but support for the normal BIS prediction was inconsistent. Such findings suggest that the RST model may provide a useful perspective for conceptualizing the disinhibited behavior of psychopathic individuals (Newman & Malterer, 2009; Wallace, Malterer, & Newman, 2009; cf. Poythress et al., 2008).

In contrast to RST, Patterson and Newman's (1993) response modulation model holds that the poorly regulated behavior of psychopathic individuals reflects a failure to reallocate attention to process affective, inhibitory, and other information while engaged in goal-directed behavior. As a result, psychopaths are relatively insensitive to information unless it is an integral aspect of their prepotent focus of attention. Although similar to the weak BIS model proposed by Fowles (1980), the response modulation model focuses on the interruption of goal-directed behavior rather than sensitivity to punishment cues per se. Similar to the response modulation model, the revised RST model presented by J. A. Gray and McNaughton (2000) holds that the relevance of BIS is specific to conditions involving ongoing goal-directed behavior. In other words, BIS activation is specific to approach-avoidance conflicts. Despite postulating different causal mechanisms, both the weak-BIS and response modulation deficit models predict that psychopathic individuals will be less responsive to secondary BIS-related cues when they are actively engaged in approach behavior (see Patterson & Newman, 1993).

[1] In 2004, McNaughton and Corr proposed a revised RST model that includes a Fight-Flight-Freeze System (FFFS) system that initially processes novel stimuli and BIS later resolves approach/avoidance conflict. However, given that this study is a replication, we opted to remain with the original model of BIS used in the Newman et al. (1997) study.

Empirical Evidence: Newman, Wallace, Schmitt, and Arnett (1997)

To assist in understanding the relationship between weak BIS functioning and psychopathy, Newman et al. (1997) developed a laboratory task to measure the extent to which BIS-related punishment cues inhibited approach behavior. The task was administered to criminal offenders and consisted of two phases. In Phase 1, participants performed a go/no-go task. Here, they responded as quickly as possible to strings of letters (go trials) unless the letter Q was present (no-go trials). Participants earned money according to the speed of their responses on go trials and lost money for responding on no-go trials. In Phase 2, participants performed another go/no-go task in which they responded as quickly as possible to a four-symbol array of characters that consisted of all letters (go trials) or a combination of three letters and a number (no-go trials). As in Phase 1, participants were rewarded for fast responses on go trials and punished for responding on no-go trials. In addition, the letter Q appeared in the four-symbol display on 50% of the trials during Phase 2. Although it was not relevant to task performance in Phase 2, the Q was expected to activate the BIS and interrupt approach behavior on go trials. This was expected to occur because the Q was associated with punishment and response inhibition in Phase 1 of the experiment (see also, Kambouropoulos & Staiger, 2004; Loxtona & Dawe, 2007).

With one notable exception, participants behaved as predicted. As expected, the Q elicited weaker inhibition in psychopathic offenders than in nonpsychopathic controls. However, a significant psychopathy by anxiety interaction indicated that the effect for psychopathy was specific to psychopathic and nonpsychopathic groups with relatively high levels of anxiety, with the high-anxious psychopathy (secondary psychopathy) group displaying the weakest BIS functioning. This finding is surprising because as noted above, the combination of high psychopathy and anxiety appears to reflect an overactive BAS and normal, or even elevated, BIS functioning. Conversely primary psychopathy (low-anxious psychopathy) is commonly associated with low fear, low anxiety, and weak BIS functioning (Cleckley, 1976; Fowles, 1980; Lykken, 1995; Newman et al., 2005; Skeem et al., 2007). Thus, it was unclear why in this study secondary psychopaths displayed the weakest BIS functioning.

BIS Functioning and the Two-Factor Model of Psychopathy

A potential explanation for the unexpected finding of the Newman et al. (1997) study can be found in the two-factor (Harpur, Hare, & Hakstian, 1989) and dual-process (Patrick, 2007) models of psychopathy.[2] According to the dual-process model, the interpersonal and affective symptoms of psychopathy (i.e., PCL–R Factor 1) correspond to a fundamental amygdala-related deficit in emotion processing whereas the impulsive and antisocial symptoms (i.e., PCL–R Factor 2) correspond to a deficit in executive control that disinhibits impulsive behavior. Although the putative deficits are different, both mechanisms have been tied to weak behavioral inhibition. In a recent chapter, Patrick (2007) proposed that Factor 1 is associated with a weak defensive system that reduces behavioral and physiological reactions to threat cues directly, whereas Factor 2 is associated with an information processing deficit that interferes with the processing of threat cues, precludes activation of the defensive system, and undermines inhibition of approach behavior.

Although primary and secondary psychopathy are both characterized by high scores on both PCL–R factors, there is growing evidence that the external correlates that distinguish Factor 1 and Factor 2 (e.g., anxiety, impulsivity, substance abuse) parallel those that distinguish primary and secondary psychopathic individuals, respectively (Hicks, Markon, Patrick, Krueger, & Newman, 2004). Therefore Patrick's (2007) propositions appear relevant for understanding both the features of Factor 1 and primary psychopathy on the one hand, and Factor 2 and secondary psychopathy on the other. For instance, both Factor 1 and primary psychopathy have been associated with low scores on measures of anxiety and neuroticism,

[2] Factor analytic studies of the PCL–R have been interpreted as consistent with a unitary model of psychopathy, but studies have also provided evidence for two-factor (e.g., Harpur et al., 1989), three-factor (e.g., Hall, Benning, Patrick, 2004), and four-factor models (e.g., Williams, Paulhus, & Hare, 2007).

whereas Factor 2 and secondary psychopathy are associated with higher scores on these measures (Hare, 2003; Harpur et al., 1989; Patrick, 1994; Ross et al., 2009). Both Factor 1 and primary psychopathy are associated with low scores on self-report measures (Carver & White, 1994; Caseras, Ávila, & Torrubia, 2002) of BIS, whereas Factor 2 and secondary psychopathy are associated with high BAS scores (Ross et al., 2009; Wallace, Malterer, & Newman, 2009). In addition, it has been proposed that secondary psychopathy, as in Factor 2, may be associated with deficits in executive control that undermine response inhibition (Hicks, Markon, Patrick, Krueger, & Newman, 2004; Ross, Benning, & Adams, 2007). Therefore, to the extent that inferences about Factor 2 are applicable to secondary psychopathy, the weak BIS functioning associated with secondary psychopathy (Newman et al., 1997) might be understood as an ancillary effect of a more general problem with executive control that undermines processing of inhibitory cues.

The Present Study

The overall purpose of the present study is to clarify the factors underlying weak BIS functioning in individuals with psychopathy. Toward this end, we used a modified version of the BIS task employed by Newman et al. (1997). The task modifications were designed with two aims in mind. First, in contrast to the embedded location of secondary threat cues used by Newman et al. (1997), secondary threat cues were made peripheral to the primary task. This was done in an attempt to avoid a potential weakness of the Newman et al. (1997) study. In the original study, participants were required to scan all four character locations to identify go trials. This exhaustive search of the locations may have reduced the importance of BIS activation in drawing attention toward the BIS-related cues and thus obviated an important BIS function.

The second modification involved using novel cues rather than punishment cues to evaluate BIS functioning. This change eliminated the need for pretraining used by Newman et al. (1997) to establish the letter Q as a punishment cue (i.e., Phase 1). In addition to being more efficient, the revised procedure eliminates the possibility that differences in the speed or quality of learning during Phase 1 are responsible for individual differences in the primary assessment of BIS functioning. According to J. A. Gray (1987), both signals of punishment and novel stimuli represent effective BIS inputs (p. 262). Thus, our use of novel stimuli in place of punishment stimuli provides a "constructive replication" of the Newman et al. study (i.e., replicates and extends previous findings using an alternative assessment of BIS functioning). A constructive replication intentionally avoids the use of identical procedures because replication of a given association despite the use a different methodology represents more compelling evidence for the association (i.e., because it rules out other variables not shared by the studies as potential explanations for the results). Of course there is no guarantee that such tasks are tapping the same theoretical construct (e.g., BIS activation), but this is a common practice and provides a robust test of the proposed construct. Although it would be useful to evaluate the extent to which these alternative measures of BIS functioning overlap with an independent, well-validated measure of BIS functioning, we are aware of no such measures and so could not provide this additional evidence in the present study.

The third modification of the Newman et al. (1997) task reflects our interest in evaluating the possibility that weak BIS functioning may, in some cases, be an indirect consequence of information processing limitations that undermine behavioral inhibition. Toward this end, we manipulated working memory load to evaluate the effects of limiting cognitive capacity on behavioral inhibition in response to BIS stimuli. In particular, we manipulated working memory load by instructing participants to search for any of two versus four targets across trials (i.e., by varying the size of the target set). As working memory is taxed, processing of BIS cues may be impeded, and preclude activation of BIS. Therefore, under high load, weak BIS functioning should be exacerbated (Patrick, 2007).

Using this modified BIS task, we tested the following hypotheses. First, based on Newman et al.'s (1997) results, we hypothesized that individuals with secondary psychopathy would display weaker sensitivity to BIS-related stimuli (i.e., less inhibition) than nonpsychopathic controls. Second, extrapolating from Patrick's (2007) dual-deficit model to secondary psychopathy, we predicted that the reduced sensitivity to BIS cues shown by individuals with secondary psychopathy would be especially apparent in the high-load condition. Finally, given Patrick's (2007) specific hypothesis regarding diminished executive control in high Factor 2 individuals, we also predicted that high Factor 2 individuals would display weak BIS responses specifically under conditions that taxed working memory capacity.

Method

Participants

Participants were 108 White male offenders from a minimum-security prison in Southern Wisconsin. Participants were only excluded if they met any of the following criteria: age 40 or older, current use of psychotropic medication, clinical diagnoses of schizophrenia, bipolar disorder, or psychosis not otherwise specified scores below the fourth grade reading level on achievement tests administered by the Department of Corrections, or estimated IQ score of less than 70 on the Shipley Institute of Living Scale (SILS; Zachary, 1986). The SILS is a brief measure of general cognitive functioning with vocabulary and abstraction subtests. The combined score from these subtests has shown good reliability (.78) and validity, with an average correlation with full Wechsler Adult Intelligence Scale–Revised (WAIS–R; Wechsler, 1981) scores of .80 (Zachary, 1986). These exclusion criteria are used in our research program because the expression of psychopathy has been found to change with advancing age (Hare, Harpur, Hakstian, 1990), to rule out the effects of other psychopathology on our dependent measures, and to ensure that participants have the intellectual aptitude to complete our laboratory tasks. Elements of consent were presented individually to all participants in verbal and written form. Participants were also informed that their decision to take part in the project or to refuse would have no influence on their status within the correctional system.

All participants were assessed using file information and a semistructured interview that lasts approximately 60 min and provides sufficient information to diagnose psychopathy using the PCL–R (Hare, 2003). The PCL–R contains 20 items that are rated 0, 1, or 2 according to the degree to which a characteristic is present: 2 (*significantly*), 1 (*moderately*), or 0 (*not at all*). Thus, total scores range from 0 to 40 and, following the recommendation of Hare (2003) we classify those with scores of 30 or above as psychopathic, those scoring between 21 and 29 as middles, and those scoring 20 or below as nonpsychopathic. The reliability and validity of the PCL–R is documented in numerous sources (e.g., Hare, 1996, 2003). In this study, the interrater reliability (ICC) for the psychopathy total score was .75 for 13 participants with reliability ratings. The ICCs for Factor 1 and Factor 2 were .71 and .797, respectively. All participants completed the Welsh Anxiety Scale (WAS; Welsh, 1956), a 39-item true/false scale derived from the Minnesota Multiphasic Personality Inventory (Dahlstrom, Welsh, & Dahlstrom, 1975) that measures anxiety and negative affect more generally (see Schmitt & Newman, 1999; Watson & Clark, 1984).

After the initial assessment (approximately 1 to 2 weeks later), all available participants were recalled for behavioral testing. The laboratory task described in this study was one of several tasks administered (in counterbalanced order) on the first day of behavioral testing. After excluding participants whose reaction times for either of the two dependent measures was above or below 2.5 standard deviations from the mean, 104 participants were available for analysis. Of these 104 participants, 19, 13, 16, and 15 qualified for the low-anxious control, low-anxious psychopathy, high-anxious control, and high-anxious psychopathy groups, respectively. Their mean age, intelligence, psychopathy, anxiety scores, and task performance are reported in Tables 1 and 2.

Procedure

Participants were tested individually in a quiet office. They were seated at a table in front of a computer monitor and response box with a row of four buttons mounted on the top side. These buttons were labeled 1 through 4, from left to right. Presentation of stimuli and recording of responses were controlled by PC-based, Micro-Experimental Laboratory software (MEL; Schneider, 1988). All participants were tested by one of two male experimenters.

Table 1
Means and Standard Deviations for Relevant Descriptive Variables by Group

Variable	Group			
	Low-anxious psychopath (n = 13)	Low-anxious control (n = 19)	High-anxious psychopath (n = 15)	High-anxious control (n = 16)
PCL–R	32.7 (2.3)	14.9 (4.2)	31.9 (2.0)	15.3 (4.7)
PCL–R Factor 1	13.3 (1.8)	5.2 (2.6)	12.1 (1.6)	5.3 (3.1)
PCL–R Factor 2	14.5 (2.0)	7.6 (2.4)	14.7 (1.4)	7.9 (2.3)
Welsh Anxiety	3.9 (2.5)	4.3 (3.2)	17.7 (7.4)	19.3 (6.2)
Intelligence (Shipley)	97.4 (9.2)	99.7 (11.4)	95.1 (11.3)	98.9 (12.2)

Note. PCL–R = Psychopathy Checklist–Revised.

Experimental Task

Participants performed 192 trials in which their primary task was to search the stimulus display for the presence of a target letter (see Figure 1). The set of potential targets was presented below the words "Look for" and consisted of either two or four letters appearing centrally on the computer monitor for 2,500 ms. Seventeen letters (i.e., A, C, E, F, H, J, K, L, M, N, P, R, T, V, W, X, Y) served as targets and were chosen because they were easily discriminated from the numerals 1 through 9 (see below). The stimulus display was then presented centrally for 1,000 ms in which four characters (either four letters or three letters and a number) appeared, each character forming one corner of an imaginary square. Participants were instructed to provide a response if either the upper left or the lower right letter was the same letter as one of the targets and to ignore the symbols that appeared in the upper right and lower left positions. Individuals were instructed to withhold a response if a target was not present in either location. Novel/BIS-related cues (i.e., numbers 1 through 9) were frequently presented in the to-be-ignored positions but never occurred in the upper left or lower right positions. Based on J. A. Gray's (1987) model, numbers represent effective BIS inputs because they are unexpected in the context of performing a letter discrimination task and rare (i.e., less than 12% of the characters are numbers whereas more than 88% are letters). Visual feedback was provided in the center of the screen for 2,000 ms. If a participant pressed the button and the response was correct the display read: "Correct Response! You Win 5 Cents." If the button was pressed and the response was incorrect, the feedback read: "Wrong Response! You Lose 5 Cents." Feedback for correct rejections (i.e., withholding a response when the target was absent) read: "Correct!" while feedback for incorrect rejections (i.e., withholding a response when the target was present) read: "Wrong!"

The order of target-present/absent trials was pseudorandomized and presented in the same

Table 2
Means and Standard Deviations for Relevant Task Performance Variables by Group

Variable	Group			
	Low-anxious psychopath (n = 13)	Low-anxious control (n = 19)	High-anxious psychopath (n = 15)	High-anxious control (n = 16)
Reaction time: Low-load BIS cue present (ms)	673.95 (82.19)	637.29 (57.72)	648.45 (66.40)	637.56 (63.36)
Reaction time: Low-load BIS cue absent (ms)	657.05 (76.74)	607.48 (63.55)	626.24 (65.21)	583.78 (70.39)
Reaction time: High-load BIS cue present (ms)	738.00 (71.78)	695.48 (64.66)	687.71 (42.77)	712.15 (81.72)
Reaction time: High load BIS cue absent (ms)	721.08 (68.22)	670.86 (66.56)	695.67 (52.66)	668.59 (100.82)
Interference: Low load (ms)	16.9 (78.5)	29.8 (57.2)	22.2 (72.8)	53.8 (78.0)
Interference: High load (ms)	16.9 (51.1)	24.6 (77.7)	–8.0 (57.4)	43.6 (90.4)

Note. BIS = behavioral inhibition system.

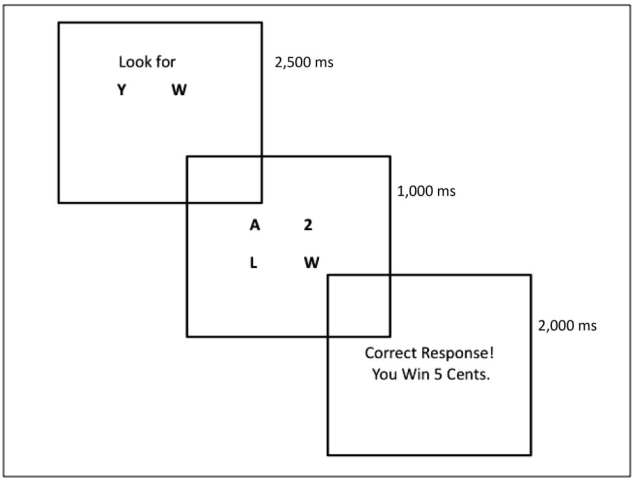

Figure 1. Task Schematic: Participants were presented with a set of potential targets below the words "Look for" for 2,500 ms. The stimulus display was then presented centrally for 1,000 ms in which four characters (either four letters or three letters and a number) appeared. Participants were instructed to provide a response if either the upper left or lower right letter was the same letter as one of the targets and to ignore the characters that appeared in the upper right or lower left positions. BIS-related cues (numbers) were presented in the "to-be-ignored" positions but never occurred in the upper left or lower right positions. Visual feedback was then provided for 2,000 ms.

order for every participant. The set of possible targets changed with every trial. The first 32 trials were practice trials and did not contained BIS-related stimuli, leaving 160 trials for analysis. Fifty percent of the 160 trials were target-present trials and half of these had a target set size (i.e., working memory load) of either two or four letters. The same proportion of target absent trials had a target set size of either two or four letters. In 50% of the target-present trials the target appeared in the upper left corner of the stimulus array, while in the remaining target-present trials the target appeared in the lower right corner of the array. Fifty percent of the target-present and target-absent trials contained novel cues that were to be ignored. Half of these appeared in the upper right corner of the array, half in the lower left corner of the array.

Results

The dependent measure in this task is calculated by subtracting participants' mean response time to targets in the absence of a novel cue from their mean response time to targets in the presence of BIS inputs. This measure of interference indexes the extent to which participants interrupt BAS-mediated approach behavior in response to BIS inputs (i.e., novel cues). Separate interference scores are calculated for each level of working memory load. The inference scores are normally distributed within each condition. Higher interference scores indicate more BIS activation and inhibition of goal-directed behavior. As in previous research (e.g., Newman et al., 1997), analyses focused on the first five valid trials in each experimental condition (e.g., low-load, target present) because normal participants habituate rapidly to novel stimuli that have no bearing on response outcome.

BIS Functioning and Psychopathy

We conducted a 2 (levels of psychopathy) $\times$ 2 (levels of anxiety) $\times$ 2 (levels of working memory load) analysis of variance (ANOVA) to evaluate the effects of group and load on task performance. Anxiety scores were dichotomized based on the SPSS calculated sample median (i.e., Welsh anxiety scores less than or equal to 7 were considered to be low anxious). For the four groups, mean scores on raw reaction time and interference are presented in Table 2. As expected, participants showed significantly more interference when BIS-related stimuli were present than when they were absent, $F(1, 59) = 16.03$, $p < .001$, $\eta^2 = .21$. In addition, consistent with previous results (Arnett, Smith, & Newman, 1997; Newman et al., 1997) the analysis revealed a significant main effect for psychopathy, $F(1, 59) = 4.31$, $p < .05$, $\eta^2 = .07$, with the psychopathic offender group displaying significantly weaker responses to the BIS-related stimuli than the nonpsychopathic control group. In contrast to previous results, the Psychopathy × Anxiety interaction did not reach statistical significance, $F(1, 59) = 1.57$, $p > .20$, $\eta^2 = .03$.

To address our a priori hypotheses, we compared the performance of psychopathic participants and nonpsychopathic participants within level of anxiety to evaluate the extent to which our results replicate those reported by Newman et al. (1997). Replicating earlier results, the high-anxious controls demonstrated significantly greater inhibition to the BIS-related stimuli than the high-anxious psychopathic group, $F(1, 29) = 4.17$, $p = .05$.[3] The contrast involving the low-anxious groups did not approach statistical significance, $F(1, 29) = .5$, $p > .05$.

To evaluate the effect of working memory load on inhibitory processing in secondary psychopathy, we compared the inhibitory responses of the high-anxious psychopathic group and nonpsychopathic controls. As expected, the group difference was greatest in the high-load condition, $M = 43.56$ and $M = -7.96$, for the nonpsychopathic versus psychopathic groups respectively, but this difference did not achieve statistical significance. By contrast, the group difference in the low-load condition was small and nonsignificant (see Table 2). Although it is possible that top-down processes (e.g., attention) moderate BIS-functioning in secondary psychopathy, this assessment was not sufficiently sensitive to lend statistical support to this possibility.

Supplementary Analysis: Continuous Trait Anxiety

Although there is a 40-year history of using median splits on self-report measures of anxiety to successfully distinguish primary and secondary psychopathic types (e.g., see Blackburn, 1975; Doctor & Craine, 1971; Newman & Brinkley, 1997; Newman et al., 2005; Zeier, Maxwell, & Newman, 2009), some researchers deem that a median split of continuous variables is problematic (Maxwell & Delaney, 1993). Therefore, we used a general linear model (GLM) to reanalyze our data using anxiety as a continuous variable. As in the original analysis, the main effect for the psychopathy group was significant and the Psychopathy × Anxiety interaction did not reach statistical significance, $F(1, 59) = .13$, $p > .05$; however it is notable that the mean interference for psychopathic and nonpsychopathic groups with high anxiety (point estimate at 1.5 *SD* above mean) yielded results in the expected direction with means of 45.4 ms and 3.77 ms for the nonpsychopathic and psychopathic groups, respectively.

BIS Functioning, Working Memory Load, and the PCL–R Factors

To evaluate the extent to which working memory load moderates the association between the PCL–R factors and BIS reactivity, we employed a GLM with repeated-measures design. To evaluate the effect of load, we entered working memory load (two levels) as our within-subjects factor and the PCL–R factors as continuous covariates. This analytic strategy provides a number of benefits and allows for greater flexibility compared to classic multiple regression or ANOVA designs. In contrast to multiple-regression analysis, this design allowed us to evaluate interactions involving the repeated measures. Relative to classic ANOVA, this design allowed us to evaluate individual difference variables across the entire range of scores, rather than forcing a dichotomy.

The main effect of working memory load was not significant, $F(1, 101) = 2.09$, $p > .10$, but this effect was qualified by a significant interaction involving working memory load and Factor 2, $F(1, 101) = 7.046$, $p < .01$, $\eta^2 = .07$, and a statistical trend involving working mem-

[3] We recognize that some researchers consider only *p* values less than .05 as significant. However, based on the Newman et al. (1997) study we had an a priori reason to believe that the high-anxious psychopathic group was going to demonstrate reduced sensitivity to BIS-related cues as compared to nonpsychopathic controls. Because we were aware of the direction of the difference we are justified in also using a one-tailed test (Bakan, 1966), in which case the *p* value would be .025, a significant interaction.

ory load and Factor 1, $F(1, 101) = 2.870$, $p = .093$, $\eta^2 = .03$. The interaction involving Factor 2 reflects the fact that high Factor 2 individuals (1.5 *SD* above the mean) displayed greater interference than low Factor 2 individuals (1.5 *SD* below the mean) in the low-load condition ($B = 4.575$), $t(101) = 1.877$, $p = .063$, but less BIS-related interference in the high-load condition ($B = -4.650$), $t(101) = -1.796$, $p = .075$ (see Figure 2). Conversely, high Factor 1 individuals displayed less interference than low Factor 1 individuals in the low-load condition ($B = -5.083$), $t(101) = -2.316$, $p = .023$, while performing similarly under high-load conditions ($B = .217$), $t(101) = .093$, $p = .926$.

Discussion

Despite the use of different methods to assess BIS functioning, the present results are highly similar to those obtained by Newman et al. (1997). As in that study, individuals with psychopathy displayed weaker BIS-related inhibition than nonpsychopathic controls and, moreover, this finding was significant only for the comparison involving participants with high-anxious psychopathy (secondary psychopathy) and nonpsychopathic participants. In light of theoretical explanations and evidence that relate BIS deficiencies to primary (i.e., low-anxious) psychopathy, this finding was unexpected by Newman et al. (1997). However, given our replication of the finding that offenders with high-anxious psychopathy display weaker behavioral inhibition in response to BIS inputs, it seems increasingly important to clarify the factors that undermine BIS functioning in secondary psychopathy.

Secondary Psychopathy and BIS-Related Sensitivity

Secondary psychopathy reflects a combination of high BAS and normal BIS functioning (Lykken, 1995; Newman et al., 2005). To the extent that individuals with strong BAS activation allocate attention disproportionately to potential rewards (J. A. Gray, 1987), they may be less likely to process information that is incongruent with this motivational priority (e.g., threat cues; see Arnett, 1997; Wallace, Bachorowski, & Newman, 1991; Wallace & Newman, 1997). Therefore, in as much as secondary psychopathy is associated with a bias to process reward cues, this bias may hamper the processing of threat cues and reduce BIS-related sensitivity.

Furthermore, recent neuroimaging studies indicate that high BAS participants display less brain activation in prefrontal regions during difficult working memory tasks. On this basis, J. R. Gray and Burgess (2004) concluded that high BAS individuals exhibit more efficient cognitive control and that “some component of the cognitive control network depends on BAS in a true functional sense, albeit the relation is com-

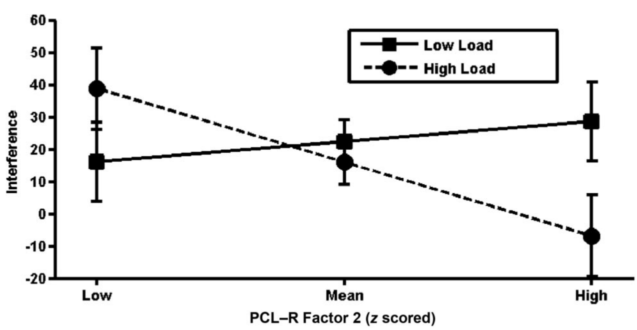

Figure 2. Interference by PCL–R Factor 2 and working memory load: Working memory load significantly moderated the Factor 2 effect on interference by secondary cues. Individuals with high Factor 2 scores displayed greater interference than individuals with low Factor 2 scores in the low-load condition but less BIS-related interference in the high-load condition. Interference values for low and high Factor 2 were calculated at 1.5 standard deviations below and above the sample mean on Factor 2 scores, respectively. Error bars represent the standard error for the point estimate.

plex" (p. 36). Given the association between secondary psychopathy and high BAS scores, it is worth considering the possibility that individuals with secondary psychopathy benefit from some process that directly or indirectly facilitates cognitive control. If so, this process may explain their weaker BIS reactivity in the present study and the one by Newman et al. (1997; see also Arnett et al., 1997).

Although reduced prefrontal cortex (PFC) activation during performance of a demanding working memory task may reflect more efficient cognitive processing as proposed by J. R. Gray and Burgess (2004), it may also reflect an early attentional bias that reduces the need for cognitive control. According to J. A. Gray (1987; see also Ávila & Torrubia, 2008; Wallace et al., 1991), for instance, a strong BAS may be associated with a relatively automatic bias to focus narrowly on goal-relevant cues at the expense of processing cues that are peripheral to one's dominant response set. This may result from the disproportionate allocation of attention to events of immediate significance (Wallace & Newman, 1997). As a result, the possibility of redirecting attention to BIS-related information or other secondary information may be negated.

There is a wealth of evidence that disinhibited individuals with high levels of neuroticism, such as secondary psychopaths are characterized by hypersensitivity to reward (e.g., Ávila, Moltó, Segarra, & Torrubia, 1995; Colder & O'Connor, 2002; Derryberry, 1987; Hundt, Kimbrel, Mitchell, & Nelson-Gray, 2008; McCarthy, Kroll, & Smith, 2001; Molto, Poy, Segarra, Pastor, & Montañés, 2007; Newman, 1997; Newman & Wallace, 1993; Pardo, Aguilar, Molinuevo, & Torrubia, 2007; Quay, 1993; Taylor, Reeves, James, & Bobadilla, 2006). Moreover, there is considerable and growing evidence that sensitivity to reward undermines sensitivity to BIS-related stimuli under a variety of experimental conditions (Arnett & Newman, 2000; Ávila, 2001; Ávila & Parcet, 2000; Ávila & Torrubia, 2008; Daugherty & Quay, 1991; Matthys, Van Goozen, Snoek, & Van Engeland, 2004; Yechiam et al., 2006). In light of this evidence, it is worth considering the possibility that individuals with secondary psychopathy are hypersensitive to reward and that their hypersensitivity to reward undermines their processing of BIS information.

The Effects Working Memory Load on BIS-Related Sensitivity

With regard to our hypotheses concerning the impact of working memory load on BIS functioning in psychopathy, the evidence is mixed. Although inspection of the means shows that individuals with secondary psychopathy displayed less rather than more interference under high- versus low-load conditions, this difference did not approach statistical significance. On the other hand, results from the Factor 2 analyses provided clear support for the hypothesis that high Factor 2 individuals display less sensitivity to BIS stimuli as load increases. The latter hypothesis was based on Patrick's 2007 proposal that Factor 2 is characterized by a deficit in working memory capacity that hampers the inhibition of dominant responses. In general, research has suggested correspondence between the correlates of Factor 2 and secondary psychopathy, however, the present study demonstrated differences in the impact of working memory load on BIS functioning.

Although there were no a priori hypotheses for Factor 1, it is worth noting that the results were opposite to those found for Factor 2. That is, increasing working memory load increased interference in individuals with high Factor 1 scores. More specifically, individuals with high Factor 1 scores displayed relatively little interference under low-load conditions, but appeared less able to inhibit distraction when capacity was reduced by the working memory load manipulation. The fact that individuals with high Factor 1 scores displayed greater interference under high cognitive load suggests that they had been using capacity to suppress responses to the distracting stimuli and that the increase in cognitive load interfered with this process.

In a study that examined the effects of cognitive load on interference, Lavie and de Fockert (2005; see also Lavie, Hirst, de Fockert, & Viding, 2004) found that increases in cognitive load increased distraction and the authors attributed this finding to the importance of cognitive capacity for suppressing distraction. Given this principle, one would expect increases in cognitive load to increase interference in individuals with high Factor 2 scores more than controls if they have fewer cognitive resources to begin with. However, this pattern was more apparent in individuals with high Factor 1 scores than in those with Factor 2 scores. Given these findings, it is unlikely that Lavie's principle applies to the current paradigm, or other effects are overshadowing her expected effect. In contrast to the paradigm employed by Lavie and de Fockert that used target letters as distractors, the current paradigm used novel stimuli (i.e., nonletters). To the extent that processing target letters was prepotent it may be more difficult to suppress responding to such cues. By contrast, novel cues may have elicited weaker responses owing to their lack of relevance and, thus, attending to them may have related more directly to available capacity.

With regard to alternative factors influencing the effects of cognitive capacity on BIS sensitivity, one possibility is that trait-like deficiencies in cognitive capacity of the type described by Patrick (e.g., 1994, 2007) result in reduced BIS sensitivity under high-load conditions. This may be due to insufficient capacity to process stimuli unless their significance is already understood (as is the case with prepotent target stimuli). An alternative possibility is that a trait-like sensitivity to reward biases attentional processing in some individuals such that they focus selectively on reward cues before elaborating on or attending to cues that are inconsistent with their processing priorities (e.g., MacCoon, Wallace, & Newman, 2004; Patterson & Newman, 1993).

It is also possible that these processes interact to curtail BIS responsivity in high Factor 2 individuals. That is, when capacity is taxed as in our high-load condition, the combination of limited capacity and a bias to allocate limited resources to pursuing rewards may hamper their sensitivity to BIS cues. By contrast, the reduced sensitivity to BIS inputs associated with secondary psychopathy is apparent regardless of cognitive load and may primarily reflect a reward bias.

In sum, disinhibition results from an inability to interrupt a dominant response to integrate or adopt alternative goals, such as, delaying gratification or heeding emotion cues (MacCoon et al., 2004). This process is influenced by biased sensitivity to certain stimuli, which in turn, may have important implications for adaptive self-regulation versus maladaptive disinhibition. For example, secondary psychopathy appears to be associated with a bias to focus attention selectively on BAS-as opposed to BIS-related cues. Consistent with this bias, such individuals may devote their limited cognitive resources to reward, leaving fewer resources to perform other functions that are less gratifying. Moreover, such biases may be exacerbated under conditions of high load with the result that they are especially unlikely to process BIS cues and modulate approach behavior as cognitive demands increase.

Limitations and Future Directions

One limitation of the current findings is that they are restricted to the first block of experimental trials. The decision to restrict the number of analyzed trials is due to the fact that participants rapidly habituate to novel stimuli and we wished to study reactivity rather than habituation to BIS cues. Nevertheless, this decision limits the number of data points we could analyze for each participant, therefore reducing the power of the study. A second limitation of the study is that we did not explicitly manipulate the level of reward. Given the apparent importance of reward sensitivity in moderating the association between working memory load and processing of BIS-related cues, it is crucial for future studies to manipulate this variable.

Another issue for consideration follows from our decision to employ novel cues as BIS inputs instead of the punishment cues used by Newman et al. (1997). As already described the purpose of this change was to conduct a constructive replication of the earlier finding. However, our use of different BIS cues raises the possibility that this task tapped slightly different psychobiological processes than the previous study. As a result, it is difficult to determine if our failure to replicate the Psychopathy $\times$ Anxiety interaction reported by Newman et al. (1997) indicates that the interaction is unreliable or reflects procedural changes. One possibility is that punishment cues exert a stronger influence on BIS functioning because they elicit more arousal than do novel cues. Some researchers have proposed that nonspecific arousal exaggerates individual differences in response to BIS cues (J. A. Gray, 1987; see Wallace et al., 1991). In general, high arousal will result in greater response inhibition to BIS cues. However, if inhibition does not occur, arousal causes a paradoxical increase in the intensity of approach behavior. This effect was clearly apparent in the Newman et al. (1997) study, in which the secondary psychopathy group displayed significant response facilitation to punishment cues. In the present study, involving novel cues, this group displayed less inhibition to BIS stimuli than controls, but they did not display the exaggerated behavioral facilitation. This slight difference may explain why, in contrast to the Newman et al. (1997) study, the Psychopathy × Anxiety interaction was not statistically significant. Despite this small difference, however, the present study replicated the key finding reported by Newman et al. (1997). In both studies, individuals with secondary psychopathy displayed significantly weaker interference than controls regardless of whether the BIS inputs involved novel cues or punishment stimuli.

Last, in light of the fact that the analysis with trait anxiety as a continuous variable was not significant, some concern may be raised about the reliability of the dichotomous findings. Despite the generally acknowledged superiority of continuous over discrete analyses, leading psychopathy researchers are increasingly distinguishing discrete primary and secondary psychopathic types using self-report measures of anxiety (e.g., Blackburn, Logan, Donnelly, & Renwick, 2008; Doctor & Craine, 1971; Johns & Quay, 1962; Newman et al., 2005; Poythress & Skeem, 2006; Skeem et al., 2007; Swogger & Kosson, 2007). This trend corroborates a 40-year historic precedent that stems from the success investigators have had distinguishing discrete psychopathic types. Of particular relevance, the use of discrete anxiety cut-scores has yielded extensive evidence that participants with high- and low-anxious psychopathy (i.e., primary and secondary psychopathy scores) perform differently on laboratory assessments of passive avoidance and other etiologically relevant deficits (see Newman & Brinkley, 1997; Newman et al., 2005; Schmitt & Newman, 1999). Though information is necessarily lost when investigators dichotomize, such information may not be crucial in all cases. In the case of psychopathy, we believe that the identification of broad low- and high-anxious types may be more useful than modeling the incremental variance associated with trait-anxiety scores. Nevertheless, we acknowledge that future research using more sophisticated modeling of the continuous variance in anxiety scores may provide a more useful and specific understanding of the role that anxiety plays in moderating the performance deficits of psychopathic offenders. Ultimately, having a better understanding of how anxiety functions in relation to psychopathy can only improve the understanding of primary and secondary psychopathy.

In conclusion, the present study provides further support for the hypothesis that psychopathy, broadly conceived, is associated with weaker BIS-related responses while performing a primary task that involves an opportunity to earn rewards. The study also highlights the diversity of factors that may influence this behavior, specifically, anxiety and working memory load. In addition, it seems likely that experimental manipulations involving reward salience also moderate reactivity to BIS-related cues (Ávila & Torrubia, 2008). Given the importance of BIS functioning for self-regulation and the development of disinhibitory psychopathology, there is a need for more specific and systematic research to parse the diverse motivational, psychopathological, and cognitive influences contributing to such behavior.

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