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Reduced Susceptibility to the Attentional Blink in Psychopathic offenders: Implications for the Attention Bottleneck Hypothesis

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Objective: Newman and Baskin-Sommers (in press) have proposed that psychopathy reflects an attention bottleneck that interferes with processing contextual information, including the timely processing of affective and inhibitory cues that initiate self-regulation. Despite a wealth of evidence that attention moderates the affective, inhibitory, and self-regulation deficits of psychopathic offenders, to date there is little or no evidence that psychopathic offenders perform abnormally on a canonical measure of selective attention. In this study, we address this gap in the literature and clarify the attention-related abnormality in psychopathy. ***Method:*** We administered the attentional blink (AB) task to 37 male prisoners assessed with Hare's (2003) Psychopathy Checklist-Revised. In the AB paradigm, participants identify targets in a rapid serial visual presentation. Distracters' temporal proximity to the first target elicits a conflict between attending to the target and attending to the distracters. Greater conflict results in a larger AB (i.e., reduced accuracy for the second target). ***Results:*** As predicted, psychopathic offenders displayed a significantly smaller AB (i.e., better accuracy throughout the blink interval) than nonpsychopathic offenders. ***Conclusions:*** Consistent with the attentional bottleneck hypothesis, psychopathic participants were less susceptible to distracter effects following presentation of an initial target. The results clarify the nature of the attention bottleneck in psychopathy, the circumstances in which it enhances versus interferes with performance, and its implications for more ecologically valid conditions involving the sequential presentation of goal-relevant and goal-incongruent information.

Keywords: psychopathy, attention, attentional blink

Psychopathy is a personality disorder involving a cluster of behavioral, affective, and interpersonal abnormalities that include impulsivity, lack of empathy and remorse, and the callous manipulation of others (Cleckley, 1976; Hare, 2003). Historically, etiological explanations of psychopathy have focused on the emotional deficits that distinguish psychopathy from other antisocial syndromes. According to prominent emotion-deficit theories, an emotion deficit either undermines motivation to regulate behavior (e.g., Lykken, 1995) or interferes with the formation of associations that lend emotional weight to emotion-related stimuli (e.g., Blair, 2007). Although the emotion-deficit theories may explain many of the salient phenotypic features of psychopathy, such theories cannot account for the prominent role of attention in moderating the affective and other inhibitory deficits commonly found in psychopathy (Hiatt & Newman, 2006; Jutai & Hare, 1983; Kiehl, 2006; Kosson & Newman, 1986; Suchy & Kosson, 2006).

Toward this end, Newman and colleagues have proposed that psychopathic offenders are characterized by an abnormal attention bottleneck that diminishes their capacity to process important information that is peripheral to their goal-directed focus of attention (Baskin-Sommers, Curtin & Newman, 2011; MacCoon, Wallace, & Newman, 2004; Newman & Baskin-Sommers, in press; Patterson & Newman, 1993). The attention bottleneck constrains the range of information that may be processed at a given point in time and, thus, acts like a fixed filter to determine what information is gated in or out in accord with current processing priorities. According to the attention bottleneck hypothesis of psychopathy, psychopathic individuals are normally responsive to threat-relevant and other inhibitory cues when they are directly related to their goal-directed focus of selective attention, but they are unresponsive to affective and inhibitory information when it is peripheral to their primary goal.

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A key strength of the attention bottleneck hypothesis is that it can account for observed cognitive abnormalities as well as affective and inhibitory deficiencies associated with psychopathy (see Newman & Baskin-Sommers, in press). For example, Hiatt, Schmitt, and Newman (2004) reported that psychopathic inmates are abnormally resistant to Stroop-like interference effects. This resistance was observed specifically under conditions that enable them to establish an attentional focus on the goal-relevant aspect of the display at an early stage of processing. However, psychopathic inmates showed normal interference on the standard color-word Stroop task. Because the incongruent information (i.e., color and word) in the standard Stroop task is perfectly overlapping, participants necessarily perceive the conflicting information and must then resolve it using executive attention/cognitive control (Botvinick, Braver, Barch, Carter, & Cohen, 2001; MacLeod, 1991). Conversely, in the nontraditional (i.e., picture-word, box-word) Stroop tasks employed by Hiatt et al. (2004), the incongruent elements of the display were spatially separated, so that participants could focus selectively on the goal-relevant aspect of the display at an early stage of processing. Consistent with the attention bottleneck hypothesis, this early focus on the goal-relevant stimuli differentially undermined perception of the conflicting information in psychopathic offenders.

In a related experiment, Zeier, Maxwell, and Newman (2009) presented psychopathic and nonpsychopathic inmates with a modified Eriksen flanker task. On each trial, a centrally presented arrow indicated whether the target was to the left or right of center. Simultaneously, a character (e.g., an 8 or M) appeared peripherally on either side of the arrow. Participants had to respond as to whether the arrow pointed to a number or a letter. Additionally, for some trials the location of the target was cued prior to stimulus presentation (i.e., in order to establish the target location as an early prepotent focus of attention); while on other trials participants saw a bidirectional cue which did not inform them of the target's location. Paralleling results for the Hiatt et al. (2004) studies and consistent with the attention bottleneck hypothesis, offenders with primary psychopathy displayed significantly less interference than controls under conditions that cued the relevant spatial location prior to presenting the incongruent information, yet displayed as much interference as controls under conditions that directed attention to both target and distracter locations.

Taken together, findings such as those by Hiatt et al. (2004) and Zeier et al. (2009) provide compelling support for the attention bottleneck hypothesis of psychopathy. To date, however, the type of evidence supporting the attention bottleneck hypothesis is limited in several respects. First, virtually all of the evidence supporting this model involves either modifying tasks to include an attentional focus manipulation or using a novel, nontraditional (i.e., nonstandard) measure of attention (Baskin-Sommers et al., 2011; Hiatt et al., 2004; Newman & Kosson, 1986; Zeier et al., 2009). In the absence of evidence documenting attention-related abnormalities on canonical measures of attention, it is difficult to integrate the research in psychopathy with the broader cognitive-neuroscience literature on attention. Second, to date, the critical evidence supporting the attention bottleneck hypothesis involves spatial separation of target and distracter information. Thus, it is unclear whether the bottleneck is a function of this manipulation or reflects a more general gating out of information, including subsequent centrally presented information, once psychopathic offenders allocate attention to goal-relevant stimuli. In light of the fact that psychopathic individuals often fail to use centrally presented information to modify maladaptive goal-directed behavior, it is crucial to evaluate the generality of the attention-related abnormality in this way. Finally, many of the most relevant (i.e., ecologically valid) studies of psychopathy evaluate the effects of peripheral emotion cues on goal-directed behavior. Although some of these studies involve sequential presentation of target and distracter (i.e., emotion) cues (e.g., Baskin-Sommers et al., 2011; Mitchell, Richell, Leonard & Blair, 2006; Newman & Kosson, 1986) and may, therefore, reflect an attention bottleneck, investigators commonly interpret psychopathic individuals' lack of distraction by emotion cues in such tasks as reflecting insensitivity to emotional stimuli (e.g., Blair & Mitchell, 2009). In the absence of research demonstrating similar results with affectively neutral stimuli, the potential importance of the attention bottleneck for such findings is more difficult to appreciate.

To address these limitations, there is a need for research that evaluates the attention bottleneck hypothesis using a standard (i.e., unaltered) measure of selective attention, sequential presentation of targets and distracters in a central location, and affectively neutral rather than emotionally significant distracter stimuli. An advantage of using a well-researched measure of attention to assess the attentional abnormalities in psychopathy is that linking the research on psychopathy to the more established literature on attention would provide a richer framework for clarifying the attention-related abnormalities (e.g., bottleneck) in psychopathy. Further, to the extent that psychopathic individuals' attention bottleneck is apparent under such circumstances, it would increase the plausibility of interpreting their insensitivity to sequentially presented punishment cues (Newman & Kosson, 1986), emotion distracters (Mitchell et al., 2006), and threat-stimuli (Baskin-Sommers et al., 2011) as reflecting an attention bottleneck as opposed to an emotion deficit.

The attentional blink (AB) task is well suited for testing the extent to which psychopathic individuals gate out distracting stimuli that are temporally separated from task-relevant information, but are presented at the same spatial location. Two targets are embedded within a stream of distracters in a rapid serial visual presentation (RSVP), with the second (T2) appearing at different temporal "lags" in relation to the first (T1). The first stimulus following T1 is said to occur at lag-1, the second stimulus after T1 occurs at lag-2, and so on. The classic pattern of results identified in the AB task reflects a participant's reduced ability to report the identity of T2 if it is presented between approximately 100 ms and 600 ms after onset of T1 (i.e., an AB; Raymond, Shapiro, & Arnell, 1992). However, participants generally display high accuracy when T2 occurs immediately after T1 (i.e., called lag-1 sparing). Although the exact cognitive mechanism responsible for the AB has yet to be determined, it is generally agreed that both targets require processing by a common attentional mechanism for successful encoding into working memory, and that T1 processing makes this resource temporarily unavailable for T2 processing (Shapiro, Arnell, & Raymond, 1997).

One interpretation of the AB is that it reflects the conflict between consolidating one's perception of T1 and reallocating attention in response to a lag-1 distracter (Marois, Chun, & Gore, 2000). Consistent with this view, Raymond et al. (1992) failed to detect an AB when replacing the lag-1 distracter with a 90 ms blank interval, but found the typical AB when a distracter occurred at lag-1 and the 90 ms blank interval appeared in place of the lag-2 stimulus (also see Chun & Potter, 1995). More specifically, Warren et al. (2009) have related the magnitude of the AB (i.e., reduction in T2 accuracy) directly to the competing demands of processing T1 and the lag-1 distracter. A logical extension of such proposals is that individual differences associated with reduced processing of the lag-1 distracter will reduce the experienced conflict and the magnitude of the AB.

Given the overlapping processes purported to underlie the attention bottleneck and performance on the AB task, the AB paradigm is well suited to testing hypotheses regarding the attention bottleneck in psychopathy. Thus, we administered a standard (i.e., typical) version of this task to a sample of incarcerated psychopathic and nonpsychopathic offenders. Based, on previous psychopathy findings (Hiatt et al., 2004; Zeier et al., 2009; see also Mitchell et al., 2006), we assumed that psychopathic offenders would allocate less attention to distracters, experience less conflict, and thus, allocate fewer attentional resources to resolving the conflict than nonpsychopathic controls. As a result, we predict that psychopathic offenders will display a smaller AB (i.e., better accuracy for T2 during the blink interval) than nonpsychopathic individuals.

Method

Participants

Participants were 53 Caucasian incarcerated men in a medium security correctional facility in Wisconsin. To be eligible for participation all participants had to be 45 years old or younger, free of any history of bipolar disorder or psychosis, and not taking psychotropic medication currently or in the past six months. Only participants scoring at least 70 on the Shipley Institute of Living Scale (Zachary, 1986), a brief intelligence assessment, were included in analyses. As described below, only 37 participants are included in the principle analyses because three participants had IQ scores less than 70, one participant's accuracy was unacceptably low (see Procedure section), and 12 participants received psychopathy ratings that did not qualify them for inclusion in the psychopathic or nonpsychopathic group (see below). Participants received $5 for their completion of the task.

Psychopathy Checklist–Revised. Psychopathy was assessed using the Psychopathy Checklist–Revised (PCL-R; Hare, 2003). Raters used information obtained from a 60–90 min interview and a review of the inmate's institutional file to generate the individual's total PCL-R score. Each participant was rated for the presence of 20 different items, with each item scored 0–2, depending on the degree to which the participant manifested a particular trait or behavioral pattern related to psychopathy. Each individual received $8 as payment for his participation in the interview. Participants scoring 20 or lower on the PCL-R were considered nonpsychopathic ($n = 20$), and participants scoring 30 or higher were considered to be psychopathic ($n = 17$). Interrater reliability was assessed using intraclass correlation (ICC). Although dual, independent PCL-R ratings were available for only five of the participants in this study, ICC was .975. To supplement this assessment, we analyzed interrater reliability for 470 inmates who received dual ratings during the past three years. ICC for this group was .925. Thus, interrater reliability for our PCL-R ratings is consistently above .90. In addition to the total score, the PCL-R is commonly subdivided into a PCL-R Factor 1 score that taps the interpersonal and affective aspects of psychopathy and a PCL-R Factor 2 score that taps the impulsive and antisocial lifestyle aspects of psychopathy.

Intelligence. Intelligence was measured using the Shipley Institute of Living Scale (Zachary, 1986). This brief measure of intelligence consists of two parts: a 40-item vocabulary section and a 20-item abstract reasoning section. Scoring procedures allow for computation of a reliable estimate of Wechsler Adult Intelligence Scale—Revised scores. Information on these intelligence scores for the current sample is presented in Table 1.

Apparatus

The AB task was presented on a PC with a 16-inch monitor. The task was programmed in Matlab (Version 7.10.0). The monitor was refreshed at 60 Hz. The stimuli subtended on average 1.7° of visual angle horizontally. Participants' eyes were about 55 cm from the screen. Participants entered their responses using the letter keys of a keyboard.

Task

The task consisted of eight 30-trial blocks (i.e., 240 trials) and took approximately 20 minutes to complete. On each trial, a fixation cross appeared at the center of the screen for 600 ms, followed immediately by an RSVP sequence of 26 characters. Each sequence contained 24 distracter digits that were selected in a quasi-random manner from digits 2 to 9, inclusively. A digit never repeated consecutively within a trial. The targets consisted of two letters, drawn randomly for each trial from 20 of the 26 letters of the English alphabet with the constraint that T1 and T2 were never the same letters on a single trial. Due to their visual similarity to digits, we excluded the letters B, I, O, Q, D, and S from the pool of potential target stimuli. At the end of each trial,

Table 1
Descriptive Sample Statistics Nonpsychopathic and Psychopathic Groups

	Nonpsychopathic group	Psychopathic group
	Mean (*SD*)	Mean (*SD*)
n	20	17
Age	35.60 (5.45)	32.94 (6.52)
Total Years of Education**	11.30 (1.08)	9.0 (2.16)
GED Corrected Years of Education[1]	11.9 (0.45)	12.0 (0.0)
WAIS-R Estimated IQ	105.15 (11.05)	98.15 (10.68)
Total PCL-R Score**	14.32 (4.17)	31.26 (1.22)
PCL-R Factor 1 Score**	5.01 (2.81)	11.82 (1.74)
PCL-R Factor 2 Score**	7.64 (3.07)	16.60 (1.08)

[1] In comparison to controls, psychopathic individuals often have a lower number of years of education due to the earlier age at which they come in contact with the legal system. For this reason, we also present Graduate Equivalency Degree (GED) corrected years of education. This correction is calculated by assuming years of education to be 12 for any individual who has earned a, GED and using actual years of education for any individual who has not earned a GED.
** Group comparison significant at the .001 level.

the computer prompted participants to enter the first target they saw by pressing the corresponding letter on the keyboard. Upon answering, participants were then prompted to enter the second target that they saw (see Figure 1). Participants were instructed to guess if they were unsure of a target's identity. Because we were primarily interested in target detection, identification of a target was coded as correct regardless of whether or not the participant entered it in the correct order (see also, Warren et al., 2009).

T1 appeared randomly at any location between the eighth and thirteenth stimulus slot, inclusively. T2 appeared anywhere between lag-1 and lag-10, inclusively. Therefore, T2 could never appear later that the 23rd stimulus slot, and was always followed by at least three distracter characters before the end of a trial. Within blocks, the appearance of T2 at a given lag was quasi-random, with the constraint that T2 appeared equally often at lags 1 through 10. Each stimulus in the RSVP sequence appeared onscreen for 80 ms such that lag-1 occurred at 80 ms, and subsequent lags appeared at 80 ms increments.

Procedure

Participants were tested in a quiet and private testing room. Before beginning, participants read through onscreen instructions, and were given the opportunity to ask the experimenter for clarification before they initiated the practice trials. At the end of the practice block, participants received accuracy feedback that consisted of a screen displaying the percentage of trials in which the participant correctly identified at least one target, and the percentage of trials in which both targets were correctly identified. The experimenter reexplained the instructions before beginning the critical trials if the participant had abnormally low accuracy. Participants received accuracy feedback at the end of each subsequent block. To be included in the analyses, participants were required to exceed an accuracy threshold of 70% for identifying T1 during trials in which T2 occurred at lag-6 or later. Our intention in using this cutoff was to select participants who performed at 70% accuracy or better under conditions of minimal interference. As noted in the Participants section, this accuracy criterion resulted in the exclusion of one participant.

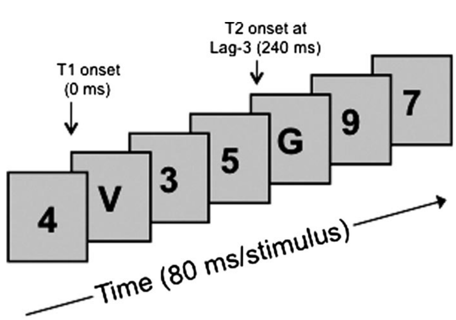

Figure 1. Graphic representation of the critical portion of one trial in the attentional blink task, with T2 shown at lag-3. Actual events involved 26 stimuli (24 distracters and 2 targets) and a beginning fixation cross presented for 600 ms. T2 could appear at any lag between 1 and 10, and was always followed by at least one distracter. The stimuli were displayed for 80 ms each.

Results

Preliminary Analyses

Prior to conducting the principle analyses, we used an analysis of variance to compare the intelligence scores of our psychopathic and nonpsychopathic groups. This analysis revealed a statistical trend, $F(1, 35) = 3.80$, $p = .059$, $\eta^2 = .098$, with psychopathic participants earning lower scores ($M = 98.15$; $SD = 10.68$) than nonpsychopathic individuals ($M = 105.15$; $SD = 11.05$) on the Shipley estimate of intelligence (Zachary, 1986). Owing to the trend-level group difference in intelligence, we employed intelligence as a covariate in all subsequent analyses.

To test whether the groups differed in their ability to identify a target in an RSVP sequence, we analyzed T1 accuracy (i.e., ability to identify the initial target) using a mixed-model Analysis of Covariance (ANCOVA) with two groups (psychopathic individuals vs. nonpsychopathic individuals) and 10 repeated measures related to the proximity of T2 (i.e., for T2 presentation at lag-1 through lag-10), and Shipley estimated IQ as the covariate. There were no significant main effects or interactions, all ps $> .29$. The lack of significant differences in T1 accuracy suggests that any differences in T2 accuracy (below) are not related to group differences in the overall ability to identify targets in an RSVP sequence.

Principal Analyses

To test our hypothesis that psychopathic individuals would have a smaller AB than nonpsychopathic individuals, we used a mixed-model ANCOVA with two groups (psychopathic individuals vs. nonpsychopathic individuals), 10 repeated measures (lag-1 through lag-10), and the Shipley estimated IQ as the covariate.[1] For this and all other analyses involving the repeated measure (i.e., lag), Mauchly's test indicated that sphericity had been violated (chi-square $= 159.31$, $p < .001$), so degrees of freedom are adjusted using the Greenhouse-Geisser correction in all analyses involving the lag variable. Consistent with prior research (e.g., Warren et al., 2009), analysis of T2 accuracy was conditional on the accurate reporting of T1 to ensure that conditions sufficient for inducing an AB were met on a given trial.

The ANCOVA for T2 revealed significant main effects for Lag, $F(3.6, 123.7) = 3.54$, $p = .011$, $\eta^2 = .094$; Intelligence, $F(1, 34) = 5.82$, $p = .021$, $\eta^2 = .146$; and Psychopathy, $F(1, 34) = 4.28$, $p = .046$, $\eta^2 = .112$. The main effect for lag indicates that, across groups, T2 accuracy decreased following Lag 1 as expected in AB tasks. The significant main effect for intelligence indicates that higher IQ scores were associated with higher accu-

[1] It is standard practice in psychopathy research to use a cut-off of 70 for intelligence scores, but the use of this low cut-off raises concerns that our results may be unduly influenced by a few participants with extremely low intelligence. To address this concern, we reanalyzed the data and omitted the participants with IQ scores less than 80 ($N = 2$). Despite the smaller number of participants, the psychopathy by lag interaction remained significant, $F(3.86,123.6) = 3.05$, $p = .021$, $\eta^2 = .087$. As a further check, we divided the sample into high and low IQ using a median split on the IQ variable and repeated our analyses with IQ Group as a factor. The effects for psychopathy remained significant and the Psychopathy x IQ interaction yielded an F of approximately 1.0 (no interaction). Thus, the possibility of low IQ scores does not seem to be distorting our results.

racy overall. However, this main effect for IQ was qualified by a significant IQ by Lag interaction, $F(3.6, 123.7) = 2.69$, $p = .039$, $\eta^2 = .073$. Although IQ was associated with higher accuracy at every lag interval, these associations were stronger and statistically significant specifically for the later lag intervals (i.e., lag-5 through lag-9). The significant main effect for psychopathy indicates that psychopathic offenders displayed higher T2 accuracy overall than nonpsychopathic offenders. However, this main effect was qualified by a significant Psychopathy x Lag interaction, $F(2.6, 123.7) = 2.98$, $p = .025$, $\eta^2 = .081$. As clarified below, the superior performance of psychopathic offenders reflects the fact that they displayed a reduced AB (see Figure 2).

To clarify the Psychopathy by Lag interaction we used orthogonal Helmert contrasts. A Helmert contrast compares each level of a repeated measure with the mean of all of the subsequent levels of that repeated measure (e.g., comparing lag-1 vs. lag-2 through lag-10). As shown in Figure 2, the psychopathy-related difference in performance begins early and remains stable over time. Thus, an advantage of the Helmert contrasts is that they allow us to identify the lag at which the groups begin to perform differently. Examination of the Helmert contrasts reveals that group differences were significant beginning with the first Helmert contrast which involves comparing T2 accuracy at lag-1 to T2 accuracy collapsed across all later lags, $F(1, 34) = 5.89$, $p = .021$, $\eta^2 = .148$. To unpack this significant interaction contrast, we used univariate ANOVA to compare the mean performance of psychopathic and nonpsychopathic offenders at lag-1 and during lags 2 through 10. There was no evidence of a group difference at lag-1, $F(1, 34) = .012$, $p = .914$, $\eta^2 = .000$. Conversely, the difference between the means of the two groups for lags-2 through 10 was statistically significant, $F(1, 34) = 4.77$, $p = .036$, $\eta^2 = .123$. This pattern of group differences indicates that the groups are well matched for T2 accuracy at lag 1 and that psychopathic offenders display a smaller AB than nonpsychopathic offenders.

Supplementary Analyses

In recognition of the potential for PCL-R Factor 1 and Factor 2 traits to explain unique variance in task performance (Patrick, 2001; Patrick, Bradley, & Lang, 1993) we employed correlational and regression analyses to evaluate the association between the PCL-R factors and T2 accuracy (collapsed across lag-2 through lag-10), while controlling for IQ. For the purposes of these analyses, we included those participants whose PCL-R scores fell in between the cutoff for the control group and the psychopathic group (i.e., all participants meeting the IQ and AB accuracy inclusion criteria). Thus, the sample size for these supplementary analyses is 49. The results for these correlations controlling for intelligence are reported in Table 2.

Using hierarchical multiple regression and mean T2 accuracy at lag-2 through lag-10 as the criterion variable, we entered Shipley intelligence at step 1 and entered PCL-R Factors 1 and 2 simultaneously at step 2. At step 1, the effect of intelligence was significant, $F(1, 48) = 5.99$, $p = .018$. Entering the two factor scores at step 2 accounted for an additional .129 change in R^2 [$F(2, 48) = 3.83$, $p = .029$]. In contrast to the partial correlations reported in Table 2 however, neither PCL-R Factor 1 nor PCL-R Factor 2 remained significant after controlling for the other factor. These analyses suggest that T2 accuracy in this study was related to the shared variance rather than the unique variance associated with the PCL-R factors.

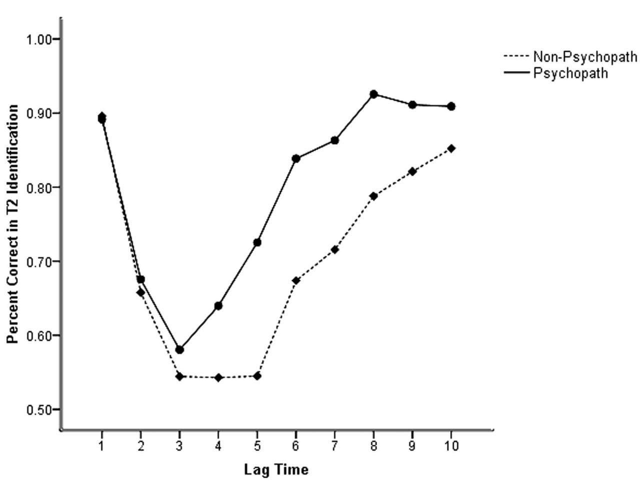

Figure 2. Graph of groups' accuracy percentages in identifying T2 by lag.

Discussion

As predicted by the attention bottleneck hypothesis, psychopathic offenders showed an attenuated AB. Specifically, compared to nonpsychopathic offenders, psychopathic offenders were more accurate in identifying T2 when T2 occurred during the blink period (i.e., lag-2 through lag-10). On the other hand, the groups displayed comparable accuracy in identifying T1 and identifying T2 when it occurred at lag-1 (i.e., in the absence of distracter interference). Thus, the smaller AB shown by psychopathic versus nonpsychopathic offenders was not simply due to differences in the ability to identify a target in an RSVP sequence and, thus, appears to reflect reduced distracter interference.

The results of this study corroborate earlier findings that revealed superior selective attention among psychopathic offenders (Hiatt et al., 2004; Zeier et al., 2009). In contrast to this earlier work, however, the present study employed a rapid serial presentation of goal-relevant targets and goal-irrelevant distracters in the same spatial location. Thus, the superior selective attention of psychopathic offenders is apparent in situations that involve temporal (i.e., serial) as well as spatial separation of targets and distracters and also applies to centrally presented (i.e., focal) information that follows goal-relevant stimuli. In conjunction with previous findings, these results indicate that, once they allocate attention to goal-relevant stimuli, psychopathic offenders are characterized by an attention bottleneck that serves to gate out a broad range of goal-irrelevant information.

In addition, the current findings complement an earlier study by Mitchell et al. (2006) that examined selective attention in psychopathic and nonpsychopathic participants under conditions involving temporal separation of target and distracter stimuli. The task involved categorizing simple symbols that were temporally bracketed by emotional versus neutral images presented in the same spatial location as the symbols. Nonpsychopathic participants responded more slowly and less accurately when symbols were bracketed by emotional as opposed to neutral images, but psycho-

Table 2
Partial Correlations and p Values for T2 Accuracy Collapsed Across Lag-2 Through Lag-10 and PCL-R Factor and Total Scores (N = 49). Partial Correlations Refer to IQ-Adjusted Correlations

Measure	Partial correlation	*p*-value
PCL-R Factor 1	.343	.017
PCL-R Factor 2	.304	.036
PCL-R Total Score	.357	.013

pathic offenders displayed minimal interference from the emotional images. While briefly noting the potential relevance of the Hiatt et al. (2004) findings for interpreting their results, Mitchell et al. (2006) concluded that their results provide "further evidence of emotional dysfunction in individuals with psychopathy but does so by demonstrating superior, rather than inferior, task performance relative to comparison individuals" (p. 565). In light of the fact that psychopathic offenders display superior selective attention in paradigms using nonaffective stimuli and temporally as well as spatially separated targets and distracters, we suggest that emotion-related deficits of the type reported by Mitchell and colleagues may reflect a more general attentional problem (e.g., an attention bottleneck; Newman & Baskin-Sommers, in press).

In contrast to results involving traditional versions of the Stroop and Flanker task, the attention-related abnormalities of psychopathic offenders were apparent on a standard (i.e., typical) version of the AB paradigm. Notably, goal-relevant and distracting (i.e., incongruent) stimuli are presented simultaneously in standard versions of the Stroop and Flanker tasks, but the goal-relevant target (T1) is presented prior to the distracting stimuli in the AB task. Thus, as in other studies demonstrating superior selective attention in psychopathy (e.g., Zeier et al., 2009), the AB task allows participants to establish an early focus of attention on goal-relevant information that, in turn, appears to gate out distracting information with minimal effort (see also, Baskin-Sommers et al., 2011).

In light of the fact that the attention bottleneck is generally associated with deficient processing of peripheral information, it is noteworthy that psychopathic offenders were as good or better at identifying a second target (i.e., T2) in the rapid serial presentation of stimuli. Despite pronounced differences in the experimental task, this finding resembles results reported by Hiatt et al. (2004). Specifically, these authors reported that psychopathic participants displayed as much or more facilitation as controls on a modified Stroop task when peripheral stimuli were congruent with their goal-relevant focus attention, but showed minimal interference in response to incongruent distracters. Overall then, these findings indicate that once established, the attention bottleneck in psychopathy appears to filter subsequent information processing based on the goal-relevance of the information.[2] Furthermore, to the extent that their attention bottleneck results in psychopathic offenders allocating fewer resources to distracting information, it may paradoxically enhance their detection of peripheral goal-relevant stimuli.

As noted in the introduction, an additional advantage of demonstrating psychopathy-related differences using a well-researched measure of attention pertains to the substantial literature linking performance differences on the task to potential psychobiological mechanisms. In this regard, Nieuwenhuis et al. (2005a) have proposed that AB task performance is associated with individual differences in the locus coeruleus-norepinephrine (LC-NE) system. The LC-NE theory of AB is predicated on evidence that NE improves the signal-to-noise ratio in target neural networks (e.g., Servan-Schreiber, Printz & Cohen, 1990), and posits that NE is released in reaction to T1 to facilitate T1 processing in the face of noise from the distracters. Owing to the auto-inhibitory nature of the LC, which quickly and temporarily arrests further NE release, NE is unavailable to assist in processing T2, giving rise to the AB. Thus, a potential explanation for the present results is that psychopathic individuals display a weaker LC-NE response to target-distracter interference, allocate fewer attentional resources to the preservation of T1, and therefore have more resources available for processing T2 (see also Warren et al., 2009). To date, much of the research on the LC-NE theory has been carried out using event-related potentials (Martens, Munneke, Smid, & Johnson, 2006; Nieuwenhuis et al., 2005b; Vogel, Luck, & Shapiro, 1998). Using similar methods, it would be possible to evaluate the extent to which psychopathy-related differences in AB performance are consistent with this model or reflect different attention-related processes.

An alternative model of AB performance relates to individual differences in tonic dopaminergic function. Specifically, Colzato and colleagues (Colzato, Slagter, Spape, & Hommel, 2008; Colzato, Spape, Pannebakker, & Hommel, 2007) have proposed that attentional gating of stimuli is mediated by dopamine release, and that individuals with higher tonic dopamine activity are better able to discriminate between targets and distracters in a rapid serial display by gating out distracters. According to this view, the superior AB performance of psychopathic offenders may reflect a highly efficient dopamine-mediated attentional gating system. Further research using more sophisticated methods (e.g., neuroimaging, event-related potentials) is warranted to evaluate these alternative possibilities and clarify the biochemical processes underlying the attention bottleneck in psychopathy.

In addition to the principal analyses, supplementary analyses were conducted to evaluate the continuous association between the psychopathy factors and the extent of AB attenuation. Both PCL-R Factor 1 and Factor 2 were significantly correlated with AB

[2] The fact that psychopathy and intelligence were both associated with superior AB performance despite being negatively associated with each other is potentially confusing and thus, merits clarification. AB performance is commonly associated with working memory capacity (Arnell, Stokes, MacLean, & Gicante, 2010; Colzato et al., 2007), but there is little evidence that it is associated with intelligence in the general population (cf., Arnell et al., 2010; Colzato et al., 2007). Thus, the significant relationship with intelligence found in this study may relate to the fact that prisoners typically display lower intelligence levels than nonincarcerated individuals (Lynam, Moffitt, & Stouthamer-Loeber, 1993). In such samples, it is possible that intelligence, like working memory capacity, influences a person's ability to ignore the distracting information so that they may better identify subsequent target stimuli. Regardless of the mechanism underlying this superior performance, it is important to note that it is largely independent of the mechanism underlying the superior AB performance of psychopathic individuals. The fact that psychopathy and intelligence were both significantly related to AB performance in the same analysis indicates that these variables represent independent pathways to enhanced AB performance.

attenuation, but when analyzed simultaneously within the regression analysis, neither factor remained statistically significant. This fact indicates that the AB attenuation observed in this study relates to their common variance or, in other words, a more general psychopathy dimension. In light of the fact that this study employed a task that is devoid of explicit affective stimuli and manipulations, it is noteworthy that performance on the task was significantly associated with the affective-interpersonal features of psychopathy. The fact that AB attenuation was correlated with the affective-interpersonal features of psychopathy tentatively suggests that an attention abnormality contributes to the expression of the affective and interpersonal symptoms of psychopathy as well as to their impulsive and antisocial symptoms (see also, Baskin-Sommers et al., 2011; Newman, Curtin, Bertsch, & Baskin-Sommers, 2010).

A potential limitation of this study pertains to sample size. Although the sample size is roughly comparable to other AB studies and laboratory studies of psychopathy, we did not have enough participants to analyze psychopathic subtypes (e.g., primary vs. secondary psychopathy). In addition, our participant recruitment resulted in relatively few participants with midrange psychopathy scores. Owing to this limitation, our ability to examine the continuous association between psychopathy (and psychopathy factor) scores and the AB is partially compromised. Although we report these correlations in Table 2, the correlations should be interpreted with caution because there is a disproportionate number of participants with high (> 29) and low (> 21) PCL-R scores.

In summary, the results complement previous studies in which psychopathic individuals showed reduced distracter interference while engaged in goal-relevant processing. (Baskin-Sommers et al., 2011; Hiatt et al., 2004; Mitchell et al., 2006; Zeier et al., 2009). However, in contrast to previous studies, the present task did not involve spatial separation or emotionally significant stimuli. Thus, the current findings broaden the scope of etiological theories that implicate attentional abnormalities as an explanation for the symptoms of psychopathy (e.g., Newman & Baskin-Sommers, in press) and warrant further research to specify the behavioral, neurochemical, and psychobiological mechanisms underlying their attention abnormalities.

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