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BRIEF REPORT

Top-Down Attention and Selection History in Psychopathy: Evidence From a Community Sample

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Psychopathy is a severe personality disorder, the core of which pertains to callousness, an entitled and grandiose interpersonal style often accompanied by impulsive and reckless endangerment of oneself and others. The response modulation theory of psychopathy states that psychopathic individuals have difficulty modulating top-down attention to incorporate bottom-up stimuli that may signal important information but are irrelevant to current goals. However, it remains unclear which particular aspects of attention are impaired in psychopathy. Here, we used 2 visual search tasks that selectively tap into bottom-up and top-down attention. In addition, we also looked at intertrial priming, which reflects a separate class of processes that influence attention (i.e., selection history). The research group consisted of 65 participants that were recruited from the community. Psychopathic traits were measured with the Psychopathic Personality Inventory (PPI; Uzieblo, Verschuere, & Crombez, 2007). We found that bottom-up attention was unrelated to psychopathic traits, whereas elevated psychopathic traits were related to deficits in the use of cues to facilitate top-down attention. Further, participants with elevated psychopathic traits were more strongly influenced by their previous response to the target. These results show that attentional deficits in psychopathy are largely confined to top-down attention and selection history.

General Scientific Summary
Psychopathic individuals have difficulty modulating their behavior once attention is focused on attaining a goal. Here, we show that psychopathic traits are related to 2 aspects of attention. Elevated psychopathic traits are related to deficits in disengaging from previous responses, and with deficits in deliberately focusing attention.

Keywords: psychopathy, response modulation theory, top-down attention, bottom-up attention, selection history

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Although the charming and manipulative disposition of psychopathic individuals is well known, the behavioral rigidity that characterizes psychopathy remains largely unfamiliar. However, these patients show response perseverance (Newman, Patterson, & Kosson, 1987), reversal learning difficulties (Brazil et al., 2013; Budhani, Richell, & Blair, 2006), and attentional inflexibility (Newman, Curtin, Bertsch, & Baskin-Sommers, 2010)—all indicating that once behavior is initiated, or an environmental contingency has been learned, psychopathic individuals have trouble disengaging from that behavior. The response modulation theory (RMT) states that psychopathic individuals are impaired in altering behavior when they start to pursue a goal. It is claimed that attention plays an important role in this: When top-down attention is deployed, psychopathic individuals are thought to no longer process information that is irrelevant for the task at hand (Newman & Baskin-Sommers, 2011). As a consequence, psychopathic individuals do not process salient bottom-up stimuli, even when such stimuli contain information that is potentially important, such as impeding threat cues (Larson et al., 2013).

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Recently, we endeavored to disentangle this notion of "top-down-bottom-up integration" (Newman & Baskin-Sommers, 2011). We define bottom-up attention as attentional control by external stimuli, whereas top-down attention is steered by current goals (Awh, Belopolsky, & Theeuwes, 2012). A well-controlled sample of violent offenders conducted visual search tasks in which they searched for a particular feature (Hoppenbrouwers, Van der Stigchel, Slotboom, Dalmaijer, & Theeuwes, 2015), ensuring that a top-down set was activated. Depending on the experiment, bottom-up or top-down cues were then presented to alter this top-down set. We found that bottom-up cues (i.e., salient stimuli) influenced top-down attention in a normal fashion in psychopathic individuals. However, deficits in top-down attention were correlated with core psychopathic traits. Psychopathic individuals had difficulty integrating contextual information to facilitate top-down attention, even when this contextual information was highly goal-relevant (Hoppenbrouwers et al., 2015).

When studying top-down and bottom-up attention, it is important to take the influence of intertrial priming into account. When a feature is repeated that was previously important for attentional selection (e.g., color or shape), performance improves (i.e., reaction times (RTs) speed up and accuracy improves), whereas switching the relevant feature impoverishes performance (i.e., RTs increase, whereas accuracy decreases; Lamy & Kristjánsson, 2013). It has been suggested that the traditional dichotomy of bottom-up and top-down attention should be complemented with a separate class of attentional processes, termed *selection history* (Awh et al., 2012). Stimuli that have previously been associated with reward (Anderson, Laurent, & Yantis, 2011; Failing & Theeuwes, 2014) or threat (Schmidt, Belopolsky, & Theeuwes, 2015) attract more attention than would be expected based on their physical salience. As such, the classical dichotomy between top-down and bottom-up attention cannot explain the heightened attentional priority that certain stimuli receive (e.g., rewarded stimuli; Munneke, Hoppenbrouwers, & Theeuwes, 2015). The influence of selection history can linger over time, but can also manifest on a trial-by-trial basis. These trial-by-trial effects are referred to as *intertrial priming* and reflect a specific example of selection history. Importantly, intertrial priming reflects behavioral rigidity: Features that were previously relevant for attentional selection determine current behavior. With regard to psychopathy, this aligns with the response perseveration that has been observed in this disorder (Moltó, Poy, Segarra, Pastor, & Montañés, 2007; Newman et al., 1987). Independent of attending to competing response contingencies (Newman, Widom, & Nathan, 1985) or overall reflection (Moltó et al., 2007), the possibility also exists that features that were previously relevant for attentional selection have a stronger influence on current behavior in those with elevated psychopathic traits. As such, elevated psychopathic traits may be associated with stronger intertrial priming.

To further investigate these attentional categories in relation to psychopathic traits, bottom-up and top-down visual attention experiments were conducted in a community sample. It is anticipated that the earlier finding—that elevated psychopathic traits are related to the deficits in the use of top-down cues but not bottom-up cues—will be replicated. In addition, intertrial priming effects were calculated for (a) the response on the previous trial, (b) the instruction on the previous trial, and (c) the target color on the previous trial. Given that psychopathic individuals show response perseverance and are highly goal-focused (Newman et al., 1987), we hypothesized that elevated psychopathic traits would be correlated with a stronger influence of response priming.

With the current study, we aim to show that the aforementioned findings also exist within the normal population. Within the field of psychopathy, there is debate about the use of the concept of psychopathy (Koenigs, Baskin-Sommers, Zeier, & Newman, 2011). In some studies, clinically psychopathic individuals are compared with nonpsychopathic individuals (Decety, Skelly, & Kiehl, 2013; Hoppenbrouwers et al., 2013, 2014; Newman et al., 2010), whereas in other studies the concept is used dimensionally (Buckholtz et al., 2010). Although neurophysiological data are inconclusive about whether psychopathy is a disorder with an underlying categorical cause (Koenigs et al., 2011), it is generally agreed that psychopathic traits are normally distributed over a population (Edens, Marcus, Lilienfeld, & Poythress, 2006). To assess the robustness of empirical findings, it is important to replicate empirical findings, especially if findings derived from an offender sample can be replicated in a community sample.

Method

Participants

For the present study, a community sample of 65 volunteers (15 females) was recruited. Participants were recruited via online advertisements. Before enrollment, participants were screened via a standardized interview for psychiatric or neurological disorders, traumatic brain injury, and drug use in the week prior to the testing session. Upon arrival at the lab, participants were again informed about the study and asked to sign an informed consent form. IQ was estimated via two subtests (i.e., vocabulary and matrix reasoning) of the Wechsler Adult Intelligence Scale-III (Tellegen & Briggs, 1967; see Table 1). The study was approved by the local ethics committee and was in line with the Declaration of Helsinki (World Medication Association, 2013).

Participants were, on average, 28.0 years of age (±10.2 *SD*) and had, on average, 8.6 years of education (±2.5 *SD*). Average IQ was 108.1 (±14.4 *SD*).

Assessment of Psychopathic Traits

The Dutch version of Psychopathic Personality Inventory (PPI; Uzieblo, Verschuere, & Crombez, 2007) was used to assess psychopathic traits. The PPI is a self-report questionnaire that is composed of 187 questions that are scored on a 4-point Likert scale. The PPI has been developed to index psychopathic traits in nonclinical samples (Sellbom, Ben-Porath, Lilienfeld, Patrick, & Graham, 2005). Factor analysis has shown that the PPI is composed of two main factors on which seven of eight subscales load: stress immunity, social potency, fearlessness, Machiavellian egocentricity, blame externalization, carefree nonplanfulness, impulsive nonconformity, and coldheartedness (Benning, Patrick, Hicks, Blonigen, & Krueger, 2003). The average total PPI score was 382.9 (±39.7 *SD*), and the average PPI-I and PPI-II scores were 146.6 (±20.2 *SD*) and 184.3 (±24.7 *SD*).

Apparatus and Stimuli

All experimental tasks were programmed in OpenSesame (Mathôt, Schreij, & Theeuwes, 2012). Experiments were run on a

Table 1
Bivariate and Partial Correlations (Controlling for the Other Factor) Between PPI-I, PPI-II, and Measures of Attention

	Bottom-up attention		Top-down attention		Response repetition	
	Bivariate correlation	Partial correlation	Bivariate correlation	Partial correlation	Bivariate correlation	Partial correlation
PPI-I	$r = -.096$	$r = .203$	$r = -.281$	$r = -.204$	$r = .348$	$r = .297$
	$p = .464$	$p = .126$	$p = .027^*$	$p = .115$	$p = .006^*$	$p = .020^*$
PPI-II	$r = .103$	$r = -.055$	$r = -.348$	$r = -.292$	$r = .258$	$r = .179$
	$p = .434$	$p = .683$	$p = .006^*$	$p = .022^*$	$p = .043^*$	$p = .168$

Note. PPI-I = Psychopathic Personality Inventory Factor 1; PPI-II = Psychopathic Personality Inventory Factor 2. An asterisk (*) indicates that the correlation is significant at $\alpha < .05$.

HP Compaq 6300 Pro, and stimuli were presented on a 120-Hz Samsung Syncmaster 2233, with a screen diagonal of 22 in. Participants were seated in a dimly lit room, at a distance of 75 cm from the monitor. With a chinrest, viewing distance was kept constant.

Experiment 1: Bottom-up Control of Attention

The additional color singleton task was used to measure processing of salient task-irrelevant stimuli (Theeuwes, 1992). In this task, participants search for a diamond among circles. Participants have to indicate whether the line inside the diamond is oriented either horizontally (press the "Z" key) or vertically (press the "M" key). The lines in the circles are diagonal (see Figure 1). In half of the trials, all display elements have the same color. In the other half of the trials (36 trials), a color distractor is present: One of the nontarget circles has a different color (i.e., red).

This task started with 12 practice trials. Each trial started with a fixation dot presented for 600 ms. The lines were white and were presented on a black background. Nontarget line orientations were randomly picked from the following orientations: 22.5°, 45°, 67.5°, 112.5°, 135°, or 157.5°. The display remained on the screen until a response was made, but not longer than 4 s. After an incorrect response, a red fixation dot appeared. After a correct response, a green fixation dot appeared.

Experiment 2: Top-Down Control of Attention

This task was administered to assess top-down control of attention. Previous research has shown that RTs decrease when features that are relevant for target selection are known before visual search starts (Kaptein, Theeuwes, & van der Heijden, 1995; Treisman & Gelade, 1980). In this task, participants searched for a horizontal or vertical line, which was either located in one of the green or red circles. The proportion of red and green circles present in the display was varied while the total number of circles remained constant. Before each trial, a written instruction was presented ("attend," "attend red," or "attend green"). For the latter two instructions, the target was always in the circle having the color indicated by the instruction (i.e., a 100% valid cue). This task started with 12 practice trials. Each trial started with a written instruction that was presented for 500 ms, after which a fixation dot was presented for 600 ms. The search display contained eight colored circles, of which one circle contained a horizontal or vertical line (see Figure 1).

Data Reduction and Analyses

All response times below 200 ms were excluded. For each participant, all response times that were more than two standard deviations above the mean were excluded.

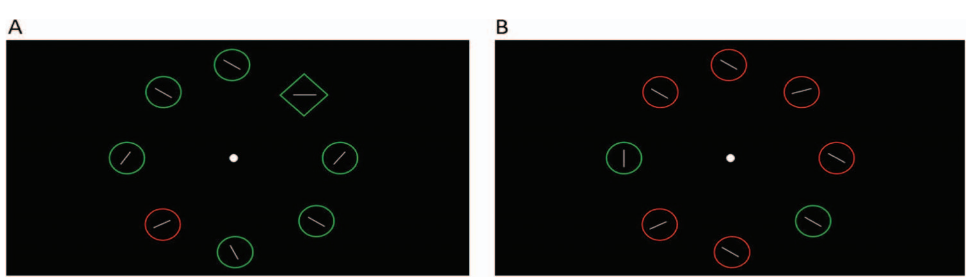

Figure 1. A graphical representation of the experiments. Panel A reflects the additional singleton paradigm that was used to index bottom-up attention. In this display, the target is the green diamond (participants respond to the line segment inside of it, i.e., vertical), and the red colored circle serves as a distractor. Panel B represents the subset selective visual search task that measures top-down attention. In this display, the target is a green circle that contains either a vertical or horizontal line segment (in this example, the line segment is vertical). Prior to the onset of the search display, in 50% of trials, subjects were instructed on which color the target was to be presented in (see the online supplemental materials for additional information on the experiments). See the online article for the color version of this figure.

Intertrial Priming

We compared *same* trials (i.e., a particular feature of the previous trial was identical to the current trial) against *different* trials (i.e., a particular feature of the previous trial was different than the current trial). This was done for three factors that played a role in Experiment 2: (a) the previous instruction, (b) the color in which the target was presented, and (c) the response to the target orientation. A repeated measures general linear model (GLM) was conducted for these three factors. Interactions between degree of psychopathy and intertrial priming were checked by entering degree of psychopathy (PPI-I and PPI-II) as a covariate in the repeated measures GLM.

Results

A significant correlation between PPI-I and PPI-II was observed, $r = .265$, $p = .033$, suggesting that both factors share covariance. Importantly, these factors have also been reported to be independent and to be associated with different external correlates (Benning et al., 2003). Therefore, for significant associations between PPI-I, PPI-II, and the outcome variables of Experiment 1 and 2, partial correlations were conducted to look at the unique associations between the PPI factors and the measures of attention.

Experiment 1

Five subjects had a mean reaction (>2 *SD* above the mean group average). Four of these subjects also scored below 75% accuracy. In total, these five subjects were excluded from this experiment.

Reaction time (RT). A repeated measures GLM with distractor (absent vs. present) as the within-subjects variable showed a significant main effect of distractor, $F(1, 59) = 11.401$, $p = .001$, $\eta_p^2 = .162$. This main effect showed that participants were significantly slower when a distractor was present ($M \pm SD = 902 \pm 262$ ms) compared with when it was absent ($M \pm SD = 862 \pm 231$ ms).

Two repeated measures GLMs with distractor (absent vs. present) as the within-subjects variable and degree of psychopathy (PPI-I and PPI-II) as the covariate showed no interaction between distractor and degree of psychopathy, all $ps > .147$. This suggests that psychopathy is not related to deficits in bottom-up attention.

To quantify the evidence for accepting the null hypothesis (i.e., that psychopathy is not related to deficits in bottom-up attention; Rouder, Speckman, Sun, Morey, & Iverson, 2009; Wetzels, Raaijmakers, Jakab, & Wagenmakers, 2009), Bayesian statistics were used (Love et al., 2015). The Bayes factor (BF_{01}) is the probability of the data under the null relative to the probability of the data under the alternative. BF_{01} was 13.45 for the total PPI score, in favor of the null hypothesis, indicating that, given the data, the null hypothesis is roughly 13 times more probable than the alternative hypothesis. For PPI-I and PPI-II, BF_{01} was 6.39 and 15.16, respectively (see the online supplemental material for further evidence on the acceptance of the null hypothesis).

Accuracy. A repeated measures GLM with distractor (absent vs. present) as the within-subjects variable showed no main effect of distractor, $F(1, 59) = 1.169$, $p = .284$, $\eta_p^2 = .019$, suggesting participants did not make more errors when a distractor was present.

Two repeated measures GLMs with distractor (absent vs. present) as the within-subjects variable and degree of psychopathy (PPI-I and PPI-II) as the covariate showed no interactions between distractor and degree of psychopathy, all $ps > .203$.

Experiment 2

For the average RT, two subjects were identified as outliers (>2 *SD* above the mean). One subject scored below 75% accuracy. In total, three subjects were excluded from this experiment.

RT. Two paired samples *t* tests were used to check for differences between the two instructed conditions ("attend red" and "attend green") for both set sizes. There were no significant differences, $ps > .291$. The two instructed conditions were therefore averaged.

A repeated measures GLM with instruction (instructed vs. noninstructed) and set size as within-subjects variables showed a main effect of instruction, $F(1, 61) = 118.665$, $p < .001$, $\eta_p^2 = .660$, indicating that participants were faster in the condition in which a specific instruction was given (e.g., attend red, or attend green). A main effect of set size was also observed, $F(1, 61) = 122.766$, $p < .001$, $\eta_p^2 = .668$, indicating that participants were faster when the target was in the smaller set (i.e., two circles within which the target could be found) compared with the larger set (i.e., six circles within which the target could be found; see Figure 1 of the online supplemental materials). In addition, an interaction between instruction and set size was observed, $F(1, 61) = 38.762$, $p < .001$, $\eta_p^2 = .389$. RT differences between the instructed and noninstructed condition in the smaller set size were significantly larger than between the instructed and noninstructed condition for the larger set size, $t(61) = 6.226$, $p < .001$. Together, these analyses showed that the instruction was used and that set size modulated search times indicating that task manipulation was successful.

Two repeated measured GLMs with instruction (instructed vs. noninstructed) and set size as within-subjects variables and degree of psychopathy (PPI-I and PPI-II) as the covariate were conducted to check for the influence of psychopathy on top-down attention.

For PPI-I, a significant interaction between instruction and PPI-I was observed, $F(1, 60) = 7.026$, $p = .010$, $\eta_p^2 = .105$. No other significant interactions with PPI-I were observed, all $ps > .279$. Controlling for PPI-II, the partial correlation between instruction and PPI-I no longer reached significance, $r = -.204$, $p = .115$.

For PPI-II, a significant interaction between instruction and PPI-II was observed, $F(1, 60) = 9.100$, $p = .004$, $\eta_p^2 = .132$. No interaction between set size and PPI-II was observed, $p > .576$. Controlling for PPI-I, the partial correlation between instruction and PPI-II remained significant, $r = -.292$, $p = .022$.

The correlations between the PPI factors and top-down attention, respectively, were tested against each other, but did not reach significance (all $ps > .64$).

Accuracy. Two repeated measured GLMs with instruction (instructed vs. noninstructed) and set size as within-subjects variables and degree of psychopathy as the covariate (PPI-I and PPI-II) were then conducted. No interactions with degree of psychopathy were observed, $ps > .123$.

Intertrial priming. For the previous instruction, three repeated measures GLMs were conducted with previous trial (same vs. different) as the within-subjects factor and degree of psychopathy as the covariate (PPI-I and PPI-II). There was a main effect of previous trial, $F(1, 60) = 4.024$, $p = .047$, $\eta_p^2 = 0.063$, showing a significant difference between the repetition versus switching of the instruction. Subjects were faster after repetition of exactly the same instruction (1,232 ms) than after switching of the instruction (1,246 ms). There were no significant interactions between priming and degree of psychopathy, all $ps > .592$.

For the color in which the target was contained, two repeated measures GLMs were conducted with previous trial (same vs. different) as the within-subjects factor and degree of psychopathy as the covariate (PPI-I and PPI-II). There was a significant main effect of previous trial, $F(1, 60) = 64.744$, $p < .001$, $\eta_p^2 = 0.519$. Subjects were faster after color repetition (1,207 ms) than after color switching (1,271 ms). There were no significant interactions with degree of psychopathy, all $ps > .117$.

For response repetition, two repeated measures GLMs were conducted with previous trial (same vs. different) as the within-subjects factor and degree of psychopathy as the covariate (PPI Total, PPI-I, and PPI-II). Although there was no main effect of previous trial, $F(1, 60) = 1.109$, $p = .296$, $\eta_p^2 = 0.018$, degree of psychopathy interacted significantly with previous trial: For PPI-I, $F(1, 60) = 8.281$, $p = .006$, $\eta_p^2 = 0.121$, and for PPI-II, $F(1, 62) = 4.292$, $p = .043$, $\eta_p^2 = 0.067$.

Controlling for PPI-II, the partial correlation between PPI-I and response repetition was still significant, $r = .297$, $p = .02$. When controlling for PPI-I, the partial correlation between PPI-II and response repetition did not reach significance, $r = .179$, $p = .168$ (see Table 1).

The correlations between the PPI factors and response repetition, respectively, were tested against each other, but did not reach significance (all $ps > .43$).

Discussion

The current study provides evidence for the idea that psychopathy is characterized by deficient attentional modulation (Newman & Baskin-Sommers, 2011). Next, the three main findings are discussed.

Bottom-Up Attention in Psychopathy

It has previously been noted that salient bottom-up stimuli (including threat cues) do not modulate attention in psychopathy (Newman & Baskin-Sommers, 2011). However, we found no relationship between psychopathic traits and bottom-up attention suggesting that salient stimuli affect top-down attention independent of the degree of psychopathic traits. This finding is particularly relevant, as it stresses the importance of consistent use of terminology: It is important to clearly describe what types of stimuli do and do not attract attention in psychopathy. Our data suggest that it is unlikely that the processing of salient stimuli (such as these stimuli are defined in the visual attention literature; Theeuwes, 1992) is affected in psychopathy. Even though, on the face of it, this conclusion seems to be inconsistent with studies that have shown that elevated psychopathic traits are related to reduced emotional attentional capture (Hodsoll, Lavie, & Viding, 2014), it should be realized that emotional capture is quite different from capture that is purely bottom-up in origin. Psychopathic individuals may be unresponsive to stimuli that are salient in an emotional manner (e.g., threat cues, fearful facial expressions), whereas truly bottom-up attention is intact.

Top-Down Attention in Psychopathy

In Experiment 2, there was a significant inverse correlation between the degree of psychopathy and the use of the verbal written cue to facilitate top-down visual search. As this was also demonstrated in an offender sample (Hoppenbrouwers et al., 2015), replication in this community sample suggests that the relationship between psychopathy and deficient use of contextual information is robust and already manifests in the absence of severe psychiatric symptoms. Typically, the response modulation theory proposes that goal-irrelevant information is not processed in psychopathy. Here, however, top-down cues were in fact goal-relevant, leaving room for the idea that it may be the very use of contextual information that is deficient is psychopathy, aligning with recent data on contextual processing in psychopathy (Baskin-Sommers, Curtin, & Newman, 2015).

Intertrial Priming in Psychopathy

It was hypothesized that the influence of the previous response would have a greater influence in participants with elevated psychopathic traits. Indeed, participants with elevated psychopathic traits were more strongly influenced by their previous response.

It is important to note that participants responded with one hand to a certain target orientation and with the other hand to the other target orientation. The current design does therefore not allow us to separate attentional selection of the target from the selection of a motor response. In addition, it is unclear whether participants with elevated psychopathic traits sped up during a target repetition or whether they slowed down after switching of a response. However, in light of response reversal deficits (Brazil et al., 2013; Budhani et al., 2006) and response perseverance (Moltó et al., 2007; Newman et al., 1987), one may interpret this finding as indicating a deficit in modulating a previously executed response. Our data therefore indicate that psychopathic traits are related to rigid continuation of motor behavior, and it could be argued that this deficit manifests particularly when behavior is directed toward a target.

Conclusion

Two visual attention experiments were conducted to index bottom-up attention, selection history, and top-down attention. Our results suggest that bottom-up attention is intact in psychopathy, whereas psychopathic traits are related to abnormalities in top-down attention and deficits in selection history.

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