Personality and Individual Differences 86 (2015) 132–138

Contents lists available at ScienceDirect

Personality and Individual Differences

journal homepage: www.elsevier.com/locate/paid

Disentangling attentional deficits in psychopathy using visual search: Failures in the use of contextual information

Sylco S. Hoppenbrouwers [a,*], Stefan Van der Stigchel [b], Jantine Slotboom [c], Edwin S. Dalmaijer [d], Jan Theeuwes [a]

[a] Department of Cognitive Psychology, Vrije Universiteit Amsterdam, The Netherlands
[b] Helmholtz Institute, Department of Experimental Psychology, Utrecht University, The Netherlands
[c] Tactus Addiction Care, The Netherlands
[d] Department of Experimental Psychology, University of Oxford, United Kingdom

ARTICLE INFO

Article history:
Received 13 February 2015
Received in revised form 28 May 2015
Accepted 3 June 2015
Available online 20 June 2015

Keywords:
Response modulation theory
Psychopathy
Top-down attention
Bottom-up attention

ABSTRACT

Psychopathic patients show a lack of affective reactivity in threatening situations. Previous research has shown that this lack of affective reactivity can be explained by diminished processing of goal-irrelevant information once psychopathic individuals initiate goal-directed behavior. Although the response modulation theory of psychopathy has claimed that this is caused by deficits in top-down–bottom-up integration of information, it is currently unclear whether it is predominantly bottom-up or top-down attention that is affected. To investigate which aspect of attention is causing these deficits, we administered three visual search tasks in which top-down attention was required to find the target (i.e., search for a specific feature) in the presence or absence of bottom-up and top-down cues. The research group consisted of 30 violent offenders, with varying degrees of psychopathy. Dimensional analyses showed no relationship between psychopathy and deficits in processing bottom-up cues but a strong correlation with deficits in processing top-down cues and core psychopathic personality traits. The current study corroborates the notion that psychopathic traits are associated with response modulation problems, and adds that this is predominantly related to deficits in top-down incorporation of contextual information. Interestingly, this failure of top-down incorporation was observed even when top-down cues were beneficial for current goals.

1. Introduction

Psychopathy is a personality disorder that involves inadequate emotional responses to various situations (e.g., threatening situations). While the sympathetic nervous system is activated in non-psychopathic individuals to allow freeze, flight or fight behaviors, psychopathic individuals show little of such reactivity (Patrick, Bradley, & Lang, 1993). One of the major theories on psychopathy, the response modulation theory, has explained this lack of affective reactivity. According to this theory, psychopathic individuals have difficulty suspending a given response set, resulting in behavioral rigidity (Newman & Baskin-Sommers, 2011). Response modulation is defined as a "temporary suspension of a dominant response set and a brief concurrent shift of attention from the organization and implementation of goal-directed responding to its evaluation" (p.717) (Patterson & Newman, 1993). Psychopathic individuals show reduced physiological responsivity to irrelevant auditory stimuli when attention is focused elsewhere (Jutai & Hare, 1983). Newman and colleagues have consistently shown that psychopathic individuals are less susceptible to distracting information once a task-relevant attentional set has been activated. This has been shown in Stroop-type tasks (Hiatt, Schmitt, & Newman, 2004; Vitale et al., 2005), an attentional blink task (Wolf et al., 2012), flanker-type tasks (Zeier, Maxwell, & Newman, 2009; Zeier & Newman, 2013) and self-report questionnaires (Baskin-Sommers, Zeier, & Newman, 2009). Typically, core characteristics of psychopathy (e.g., callous-unemotional, lack of empathy, manipulative and deceitful interpersonal style) are associated with superior attentional control whereas the impulsive and antisocial lifestyle is related to lower attentional control. As noted, this rigid pursuit of current goals occurs even in threatening situations. In this regard, the significance of attention for affective processing in psychopathy has been shown in studies in which fear-potentiated startle (FPS) is normalized in psychopathic individuals (i.e., it does not differ from non-psychopathic offenders) when their attention is focused on threat-relevant stimuli (Newman, Curtin, Bertsch, & Baskin-Sommers, 2010). However, when early in time attention is focused on irrelevant stimuli, FPS is reduced significantly in psychopathic individuals, but not in non-psychopathic individuals. The underlying cognitive mechanism for this finding has been proposed to involve an attentional bottleneck (Newman & Baskin-Sommers, 2011; Newman et al., 2010; Zeier & Newman, 2013). That is, initiation of goal-directed

* Corresponding author at: Van der Boechorststraat 1, 1081BT Amsterdam, The Netherlands. Tel.: +31 20 598 6872.
E-mail addresses: sylcohoppenbrouwers@gmail.com (S.S. Hoppenbrouwers), s.vanderstigchel@uu.nl (S. Van der Stigchel), j.slotboom@tactus.nl (J. Slotboom), Edwin.dalmaijer@gmail.com (E.S. Dalmaijer), j.theeuwes@vu.nl (J. Theeuwes).

http://dx.doi.org/10.1016/j.paid.2015.06.009
0191-8869/

behavior is thought to induce strong selective attention for goal-relevant features, which precludes peripheral information from being processed. As such, affective or inhibitory bottom-up information is thought to be inadequately processed.

Newman and colleagues have discussed the importance of the distinction between early versus late attentional selection, in which early selection refers to a 'fixed bottleneck' that blocks processing of task-irrelevant information (Newman & Baskin-Sommers, 2011). In this early fixed bottleneck, filtering of perceptual information may relate to, for instance, the spatial location of stimuli, and occurs before identification of a stimulus. On the other hand, late attentional selection is thought to involve other cognitive functions such as memory and executive functioning, and relates more to top-down regulatory control. Psychopathic individuals are thought to have an early fixed bottleneck. That is, if attention is focused on irrelevant stimuli early in time, FPS is significantly reduced compared to early focus on threat-relevant stimuli (Baskin-Sommers, Curtin, & Newman, 2012; Newman et al., 2010; Zeier et al., 2009). Because bottom-up processing of salient information is thought to be affected *after* top-down deployment of attention, psychopathy is said to relate to a deficit in top-down–bottom-up integration (Newman & Baskin-Sommers, 2011). However, one earlier study investigated top-down and bottom-up control of attention using a flanker-type task, and found no psychopathy-related difference between the two (Zeier et al., 2009). Thus far, the response modulation theory has been defined in such a manner that it remains difficult to disentangle top-down (i.e., based on current goals) and bottom-up (i.e., based on physical salience of environmental stimuli) control of attention and their respective roles in psychopathy. A crucial point in the response modulation theory is that psychopathic individuals suffer from behavioral and attentional inflexibility. In this study, we therefore employ basic attention tasks in which top-down attention has been deployed (i.e., the search for a specific feature), and either a bottom-up or top-down cue is presented. The current approach allows us to disentangle whether the processing of bottom-up or top-down cues to modulate attention is affected in psychopathy.

To disentangle the attentional deficits in psychopathy, we administered 3 visual selective attention tasks that fall into two overarching classes of selective attention paradigms. First, an additional color singleton task was administered to index bottom-up attentional capture by task-irrelevant but salient stimuli (Theeuwes, 1992). In this task, participants search for a unique shape (i.e., a diamond) among similarly colored but differently shaped elements (i.e., circles). In certain trials, a task-irrelevant element has a different color, thereby briefly capturing attention (Theeuwes, 1992). To assess top-down attention, two visual conjunction search tasks were administered (Kaptein, Theeuwes, & van der Heijden, 1995). In these tasks, participants search for a line-object and are at certain trials aided in their visual search by a written verbal cue. Through the use of these tasks, it is possible to investigate response modulation deficits and differentiate between bottom-up and top-down information.

2. Methods

2.1. Participants

The present study involves data from thirty violent offenders that were recruited from 3 forensic treatment facilities throughout The Netherlands. Offenses included (serial) rape, (serial) murder, manslaughter, theft, breaking and entering, kidnap, grand larceny, extortion, (aggravated) assault and robbery. All offenders were medication-free and younger than 65 years of age. As per the extensive psychiatric screening conducted in these forensic treatment facilities, none of the offenders had any comorbid neurological (e.g., epilepsy) or psychiatric disorders (i.e., psychotic or schizophreniform disorders, schizoid or schizotypal personality disorders, bipolar disorder, depressive or anxiety disorders, obsessive–compulsive disorder, attention-deficit/hyperactivity disorder or autism). All offenders had normal or corrected to normal vision, and none were color blind. Total intelligence quotient had been previously measured with the Wechsler Adult Intelligence Scale-III (WAIS-III).

Participants were first orally informed about the study. Upon interest, they were asked to sign a release of information after which a review of psychological and medical files was conducted to assess eligibility. Hereafter participants were contacted and were asked whether they were still interested in participating in the study. If so, they were again informed about the study and asked to sign the Informed Consent. The study was approved by the local ethical committee and was in line with the declaration of Helsinki (WMA Declaration of Helsinki — Ethical Principles for Medical Research Involving Human Subjects, 2013, October).

2.2. Procedure

The Psychopathy Checklist-revised edition (PCL-R) (Hare, 2003) was used to define psychopathy. In all three forensic treatment facilities trained and certified psychologists administered the semi-structured interview of the PCL-R second edition (Hare, 2003). Two experts independently assessed patient information after which a final consensus score was obtained. With regards to reliability, intraclass coefficients and internal consistency typically exceed .90 and .80, respectively (Hare, Clark, Grann, & Thornton, 2000). Predictive validity of the PCL-R is also good as psychopathic criminals are 3 times more likely to recidivate than non-psychopathic criminals (Hemphill, Hare, & Wong, 1998) (please see (Hare et al., 2000) for a detailed account of the properties of the PCL-R). The PCL-R is considered the gold standard for the assessment of (criminal) psychopathy and can be divided into two main factors. Factor 1 denotes the core personality traits, such as affective dullness, lack of empathy, interpersonal manipulation and deceit, and pathological lying. Factor 2 on the other hand describes the severity of the antisocial lifestyle, and incorporates items such as impulsivity, irresponsibility, unstable and impersonal love/sex life and revocation of conditional release.

2.3. Apparatus and stimuli

All experimental tasks were programmed in OpenSesame (Mathôt, Schreij, & Theeuwes, 2012). All participants were tested in that particular forensic clinic where they lived. In all clinics, participants were tested in quiet rooms, with little auditory or visual input from outside the testing rooms. Participants were seated on a chair in front of a desk on which the laptop was placed. All participants performed the experimental tasks on laptops (Dell Latitude E series) with a 15 in. screen.

3. Experiment 1 and 2

3.1. Experiment 1: bottom-up control of attention

An 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. The participants have to indicate whether the line in the diamond is horizontal or vertical. The lines in the circles are diagonal. Participants use the 'z'-key to indicate a horizontal line and the 'm'-key to indicate a vertical line. In half of the trials, both the diamond and the circles have the same color. In the other half of the trials (36 trials), a distractor is present (See Fig. 1). That is, one of the non-target circles is colored differently (i.e., red), thereby briefly capturing attention. The amount of attentional capture was calculated by subtracting the average reaction time of the condition where the distractor was present, from the condition without a distractor.

This task started with 12 practice trials. Each trial started with a fixation dot that was presented for 600 ms. The lines were white and were presented on a black background. Non-target line-orientations were

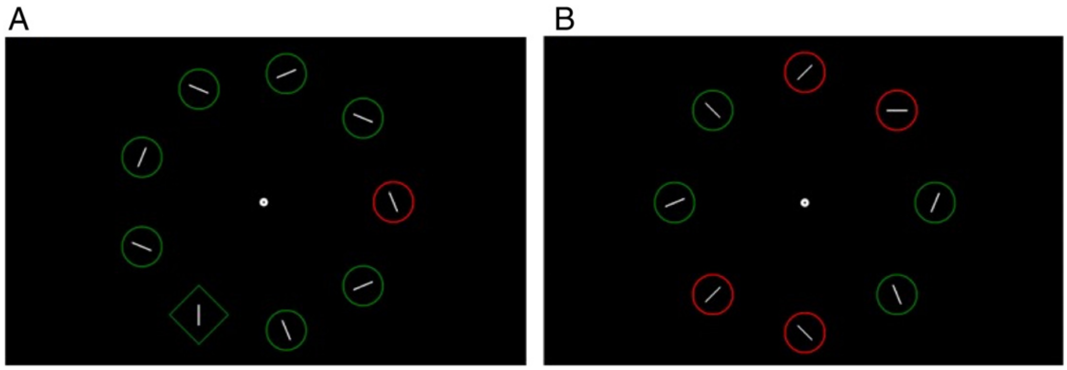

Fig. 1. Representation of the attentional capture task (A), and of the visual search task (B).

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 no longer than 4 s. After an incorrect response, a red fixation dot was shown. After a correct response, a green fixation dot was shown.

3.2. Experiment 2: top-down control of attention

This task was administered to assess top-down control of attention. Previous research has shown that reaction times decrease when features that are relevant for target-selection are known before visual search is commenced (Treisman & Gelade, 1980). In this task, participants searched for a horizontal or vertical line, which was in a green or red colored circle. 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 indicated color (See Fig. 1).

This task started with 12 practice trials. The search display consisted of 8 circles, 4 were red and 4 were green. Each trial started with a written instruction that was presented for 500 ms, after which a fixation dot was presented for 600 ms. The radius of stimuli was 250 pixels. The lines were white and were presented on a black background. Non-target 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 no longer than 4 s. After an incorrect response, a red fixation dot was shown. After a correct response, a green fixation dot was shown.

3.3. Data reduction and analyses

All response times below 200 ms were excluded. For each participant, all response times that were more than 2 standard deviations above the mean were excluded. This was done to prevent outliers from affecting the mean too much. Only correct and non-practice trials were included. Statistical analyses were done via a repeated measures general linear model (GLM) while checking for interactions with overall PCL-R score and Factor 1 and 2. Alpha level of significance was set at 0.05.

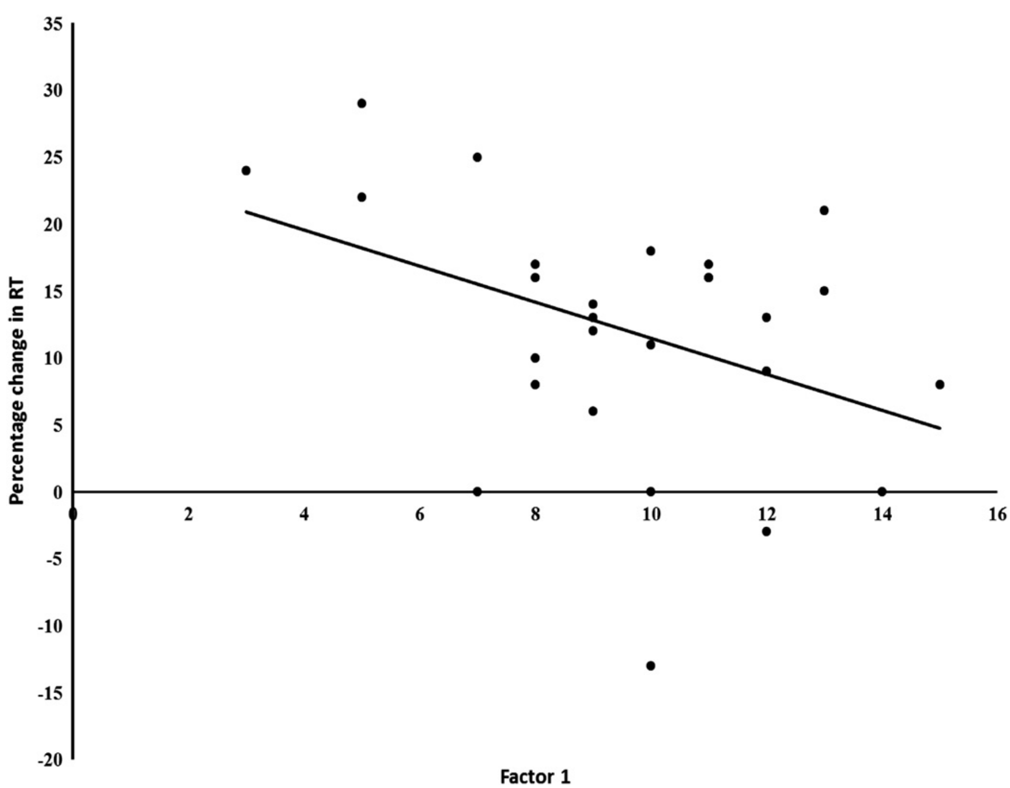

Fig. 2. Dimensional analyses also show a strong inverse relationship between Factor 1 and the ability to use the instruction in the visual search task. The y-axis represents that degree to which the instruction was used. That is, the percentage change from the non-instructed to the instructed conditions is represented on the y-axis, with values closer to zero signifying a smaller difference between the instructed and non-instructed conditions r= -.482, p= .011.

4. Results

4.1. Demographic variables

For 4 offenders, only overall PCL-R scores, and no factor scores, could be retrieved. The average age was 44.6 years (range: 23 to 65; standard deviation (SD) = 12.4 years). Average total IQ was 97.12 (range: 65 to 131; SD = 14.3). The mean PCL-R score was 21.8 (range: 12 to 36.8; SD = 6.2). Ten subjects scored above a PCL-R score of 25 and can therefore be considered clinically psychopathic. The mean score for Factor 1 was 9.6 (range: 3 to 15; SD = 2.7) and 9.3 for Factor 2 (range: 4 to 15; SD = 3.6) (Table 1).

5. Experiment 1: bottom-up control of attention

5.1. Reaction times

A repeated measures GLM with *distractor* as within subjects variable (present vs absent) showed a main effect for distractor presence, $F(1,29) = 8.040$, $p = .008$, partial $\eta^2 = .782$, showing higher reaction times when the distractor was present compared to when it was absent. A second GLM with *distractor* as within subjects variable (present vs absent) and *IQ* as covariate showed no interaction between *distractor* and *IQ*, $F < 1$. A third GLM with *distractor* as within subjects variable (present vs absent) and the PCL-R factors as covariates showed no interactions between attentional capture and psychopathy, all F's < 1.

5.2. Accuracy

More errors were made in the condition where the distractor was present, $F(1,29) = 5.342$, $p = .028$. The GLMs with *distractor* as within subjects variable and IQ, overall PCL-R score and Factor 1 and 2 as covariates, showed no interactions between the number of errors and IQ or degree of psychopathy, all p's > .289.

6. Experiment 2: top-down control of attention

6.1. Reaction times

There was no significant difference in reaction times between the instructed conditions ("attend red" and "attend green"), $p = .535$. Therefore, the instructed conditions were averaged. A repeated measures GLM with *Instruction* (uninformative instruction versus inform instruction) as within-subjects factor over the entire group ($N = 30$) showed a significant main effect of *Instruction*, $F(1,29) = 47.246$, $p < .001$, partial $\eta^2 = .612$. This main effect shows that the instruction was used by participants, indicating task manipulation was successful.

We ran three GLMs with Instruction as a within subjects variable and the PCL-R factors as covariates which showed no interaction between Instruction and overall PCL-R score, $F(2,28) = 2.351$, $p = .136$, nor with Factor 2, $F(2,25) = .191$, $p = .666$. However, a significant interaction between *Instruction* and Factor 1 was observed, $F(2,25) = 9.241$, $p = .005$ partial $\eta^2 = .270$ (Fig. 2). Last, a second GLM with Instruction as a within subjects variable and IQ as a covariate which showed no interaction between Instruction and IQ, $F < 1$.

Table 1
Demographic variables.

	Mean ± SD	Range
Age	44.6 (±12.4)	23–65
Total PCL-R	21.8 (±6.2)	12–36.8
Factor 1	9.6 (±2.7)	3–15
Factor 2	9.3 (±3.6)	4–15
IQ	97.12 (±14.3)	65–131

6.2. Accuracy

A repeated measures GLM over the whole group showed that participants made more errors in the non-instructed compared to instructed condition, $F(1,29) = 4.753$, $p = .041$, partial $\eta^2 = .543$. The GLMs with *Instruction* as within subjects variable and IQ, overall PCL-R score and Factor 1 and 2 as covariates, showed no interactions between the number of errors and IQ or degree of psychopathy, all p's > .155.

7. Experiment 3: top-down control of attention

7.1. Methods

To further evaluate the findings of Experiment 2, a third task measuring top-down attention was administered. In this subset-selective conjunction visual search task, the size of the set containing the target varies. Typically, reaction times increase when the target is in a larger color-defined subset of elements, as compared to a subset with fewer elements (Kaptein et al., 1995). With this task we aimed to replicate the findings of the first visual search task. We hypothesized that participants scoring high on Factor 1 would i) have difficulty using the instruction demonstrated by a negative correlation with Factor 1, and ii) despite the instruction have equal reaction times for smaller and larger color-defined subsets as opposed to participants score low on Factor 1. With regard to the latter prediction: this would entail a threeway interaction between *Instruction*, *Size* and degree of psychopathy (overall PCL-R, Factor 1 or Factor 2).

A potential problem in the instructed visual search task was that the more psychopathic participants simply did not read the instruction because they were only focused on the target. It is possible that they simply ignored the instruction. To circumvent this issue, in the third experiment participants were able to pause after every 20 trials and to continue by pressing any key (instruction on screen: "*Take a rest! Press any key to continue*").

Unfortunately, not all participants that did Experiment 2 were able/willing to do this third task, resulting in a somewhat smaller sample size ($N = 24$).

7.2. Experiment 3: endogenous control of attention

This task was identical to the one used in Experiment 2, with the main difference being that the color-defined subset size varied per trial. In this subset-selective conjunction visual search task, the search display always contained 8 colored circles, of which one circle contained a horizontal or vertical line whereas the other lines were diagonal. The varying subset size consisted of either 2 or 6 elements containing the target. In total there were 288 trials (144 non-instructed trials (72 with a red target element and 72 with a green target element); 144 instructed trials (72 for a red target element and 72 for a green target element)). All other features of this task were identical to those in Experiment 2.

8. Results experiment 3

8.1. Reaction times

To test for differences in reaction time between the red and green target subsets, a repeated measures GLM with *Color* and *Size* (i.e., number of target elements) as within subjects variables was performed. This analysis showed no main effect in reaction times in the red or green subsets, $p = .180$. The interaction between *Color* and *Size* was also not significant, $p = .232$. No correlations were observed between baseline reaction times (i.e., no instruction, subset size 2 and 6) and overall PCL-R or Factor scores, all p's > .140. Therefore, these conditions ('attend red' and 'attend green') were averaged.

A repeated measures GLM with *Instruction* and *Size* as within-subject variables over the entire group ($N = 28$) showed significant main effects for *Instruction*, F(1,27) = 36.134, p < .001, partial η^2 = .582, and *Size*, F(1,27) = 40.108, p < .001, partial η^2 = .607. Also, a significant interaction effect between *Instruction* and *Size* was observed, F(1,27) = 16.583, p = .001, partial η^2 = .389. That is, participants were faster in the instructed versus the non-instructed condition. Importantly, in the instructed condition participants were faster when the subset was smaller (number of elements = 2) compared to when it was larger (number of elements = 6), t(27) = −7.711, p < .001. This was not the case for the uninstructed condition, t(27) = −1.634, p = .114. Together, this showed that our task manipulation was again successful.

We ran three GLMs with Instruction and Size as within subjects variables and PCL-R overall score and the 2 factors as covariates. There was a marginally significant interaction between Instruction and overall PCL-R score, F(1, 23) = 3.79, p = .063. There was no interaction between Instruction and Factor 2, F(1,22) = 2.18. p = .154. Similar to Experiment 2, there was however an interaction between Instruction and Factor 1, F(2,22) = 6.28, p = .02 (See Fig. 3). Last, a GLM with Instruction and Size within subjects variables and IQ as a covariate showed a significant interaction between Instruction and IQ, F(1,20) = 4.624, p = .044, partial η^2 = .188. Therefore, the GLMs with Instruction and Set Size as within subjects variables and PCL-R overall score and the 2 factors as covariates were conducted again while controlling for IQ. This showed that the interactions between Instruction and Factor 1 and Factor 2 remained (marginally) significant, p = .09 and p = .085 respectively. The interactions between Instruction and overall PCL-R score was not significant, p = .130. Crucially, there were no significant interactions between *Instruction*, *Size* and degree of psychopathy (overall PCL-R, Factor 1 or Factor 2), all p's > .405.

8.2. Accuracy

A repeated measures GLM with *Instruction* as within-subjects variable showed that participants made less errors in the instructed condition, F(1,27) = 8.134, p = .008, partial η^2 = .786. . The GLMs with *Instruction* and *Size* as within subjects variable and IQ, overall PCL-R score and Factor 1 and 2 as covariates, showed no interactions between the number of errors and IQ or degree of psychopathy (overall PCL-R, Factor 1 or Factor 2), all p's > .307.

9. Discussion

The response modulation theory states that psychopathic individuals have a deficit in modulating a response set which is thought to be caused be a problem with top-down–bottom-up integration (Newman & Baskin-Sommers, 2011). In this study we endeavored to further disentangle this notion by using visual search tasks that selectively tap into bottom-up and top-down attention. Our results have two important implications. First, the results of Experiment 1 do not show a dimensional relationship between psychopathy and attentional capture. This suggests that initiation of goal-directed behavior (here, the search for a unique shape) in psychopathy does not relate to reduced processing of salient stimuli (i.e. bottom-up cues). Response modulation deficits in psychopathy may therefore not be related to inadequate bottom-up processing of salient information when engaged in goal-directed behavior. Second, the results of Experiment 2 and 3 show that psychopathic individuals have deficits in the top-down guidance of visual attention. This deficit relates most strongly to Factor 1 of the PCL-R. Core psychopathic traits therefore seem to be associated with difficulties in using contextual information to aid top-down visual search, even when the use of this information could be highly beneficial. Our results are in line with the idea that psychopathy is characterized by deficits in modulating attention but suggest that the problem does not lie in top-down–bottom-up integration, but in the adequate use of contextual information for top-down attention. As such, our findings suggest that secondary information is indeed not adequately processed, but only when the nature of this information pertains to top-down cues.

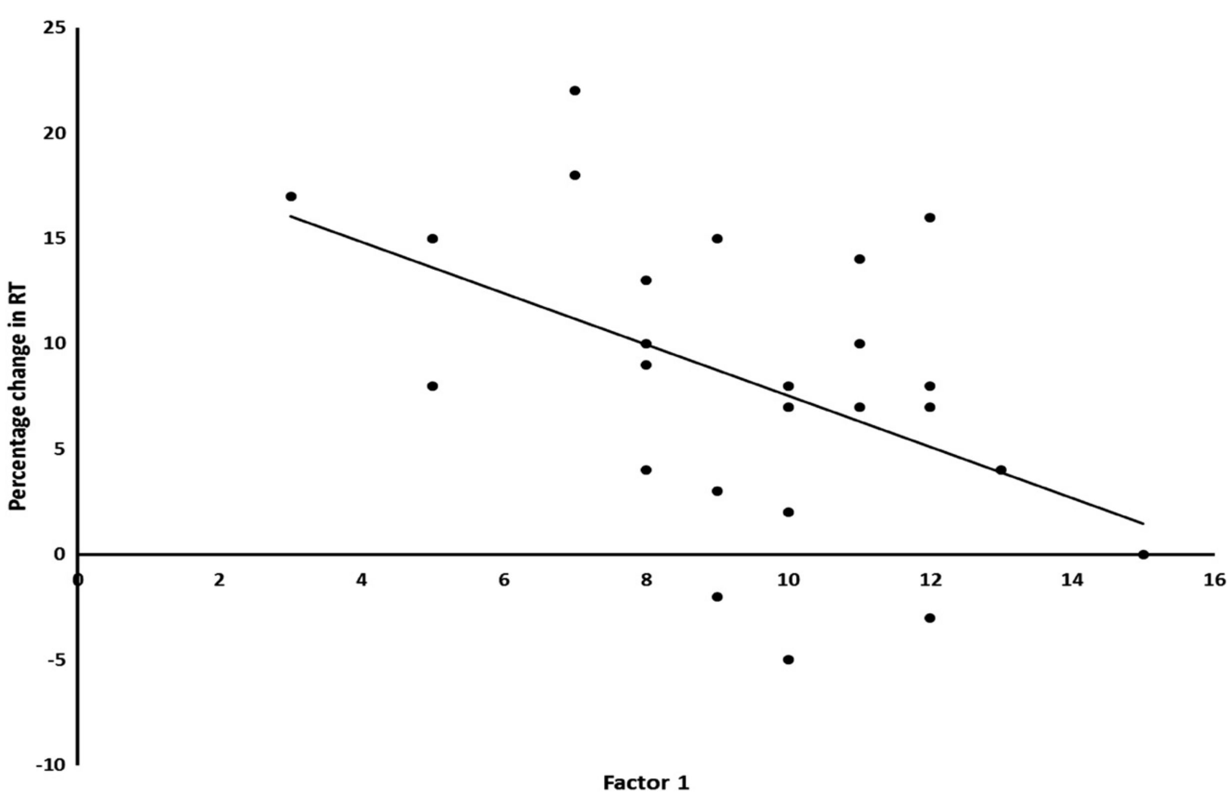

Fig. 3. The results from Experiment 3 replicate those of Experiment 2: Factor 1 is strongly related to decreased use of the instruction in the visual search task 'r= -.430, p= .036.

In many of the studies that support the response modulation theory the distracting or interfering information does not necessarily contain truly bottom-up information. These studies often employ emotionally salient or inhibitory secondary information (Newman & Baskin-Sommers, 2011). Such information is however not 'bottom-up' in the way it is typically defined in the attention literature. Bottom-up cues are typically defined by their physical attributes and predictability in relation to their environment (Theeuwes, 1992). While emotionally or motivationally salient cues may indeed draw more attention in non-psychopathic individuals than in psychopathic individuals (Hodsoll, Lavie, & Viding, 2014; Newman et al., 2010), it is important to note psychopathy is characterized by deficits in such processes (Blair, 2013; Patrick et al., 1993). A strength of the current study is that it assesses attention and psychopathy in the absence of emotional or motivational cues. The findings indicate that bottom-up attention per se is not affected in psychopathy, but that top-down attention is. When emotional and learning deficits are combined with a problem in flexibly modulating top-down attention, they may account for the behavioral perseverance in the presence of emotional events.

It could be argued that psychopathic individuals did not use the instruction in Experiment 2 or 3 because they were less motivated to do so. Three findings argue against this. First, if psychopathic individuals would have been less task-engaged, then we would expect overall reaction times to be slower. However, neither Factor 1 or 2, or the total PCL-R score were related to different reaction times in the non-instructed condition. Second, in Experiment 3, every 20 trials participants needed to read the instruction on the screen and press a key to resume the break. The fact that all participants did in fact do so indicates that they read the instruction on the screen. Third, participants made less errors in the instructed condition in Experiment 2 and 3, for which there was no relationship with Factor 1, 2 or total PCL-R score. This suggests that the more psychopathic individuals may in fact have used the instruction to guide visual search (reflected in higher accuracy in the instructed condition), but were less proficient in using it (reflected in slower reaction times), which further underscores our claim that core psychopathic traits are related to deficits in flexibly using contextual cues to facilitate visual search.

An important prediction can be derived from the conclusion that deficits in top-down attention are related to core psychopathic traits. Recent studies have suggested that some effects that are ascribed to top-down attention can in fact be explained by intertrial priming (Lamy & Kristjánsson, 2013), more broadly ranked under the term 'selection history' (Awh, Belopolsky, & Theeuwes, 2012). Selection history refers to a class of attentional processes that are neither bottom-up nor top-down, but that does influence attention (Awh et al., 2012). Selection history is of particular importance in blocked designs, such as used in a few key studies of the attention bottleneck hypothesis (Baskin-Sommers et al., 2012; Baskin-Sommers, Curtin, & Newman, 2013; Newman et al., 2010). In each block/condition participants need to attend to one particular feature. Participants quickly learn the characteristics of that condition: for instance whether threat-relevant information is signaled first (early threat-focus) or later (late threat-focus), and whether they need to attend to color or shape. As such, the demands for top-down attention are relatively low, but more importantly, the weight on an attentional dimension such as color or shape increases. Subsequently, psychopathic individuals may show regular reaction time speeding in the instructed condition, if this were to be measured in a pure block design, in which participants would only have to search for, for instance, a red color. In this case, the role of selection history would increase (Awh et al., 2012). It may then be the case that a blocked design may relatively mask top-down impairments because participants repetitively perform the same actions (i.e., a more important role for selection history). Future research is therefore advised to separate selection history from top-down attention.

In sum, by parsing the notion of top-down–bottom-up integration, we are able to show that core psychopathic traits (i.e., Factor 1) strongly relate to deficits in flexibly using contextual information to facilitate top-down control of attention.

Financial disclosures

This research is sponsored by ERC advanced grant [ERC-2012-AdG-323413] "What you get is what you see: How Reward Determines Perception" to Jan Theeuwes. Edwin S. Dalmaijer is supported by a European Union FP7 Marie Curie ITN grant (606901). None of the authors report any financial conflict of interest.

Acknowledgments

We thank Anne Koopman, Carmen Sergiou, Tanja Lucker, Willem in 't Hout, Tamar van der Stoep and Toesja Klein for assistance in collecting data.

References

Awh, E., Belopolsky, A. V., & Theeuwes, J. (2012). Top-down versus bottom-up attentional control: A failed theoretical dichotomy. *Trends in Cognitive Sciences*, *16*(8), 437–443. http://dx.doi.org/10.1016/j.tics.2012.06.010.

Baskin-Sommers, A. R., Zeier, J. D., & Newman, J. P. (2009). Self-reported attentional control differentiates the major factors of psychopathy. *Personality and Individual Differences*, *47*(6), 626–630. http://dx.doi.org/10.1016/j.paid.2009.05.027.

Baskin-Sommers, A. R., Curtin, J. J., & Newman, J. P. (2012). Specifying the attentional selection that moderates the fearlessness of psychopathic offenders. *Psychological Science*, *22*(2), 226–234. http://dx.doi.org/10.1177/0956797610396227.

Baskin-Sommers, A. R., Curtin, J. J., & Newman, J. P. (2013). Emotion-modulated startle in psychopathy: Clarifying familiar effects. *Journal of Abnormal Psychology*, *122*(2), 458–468. http://dx.doi.org/10.1037/a0030958.

Blair, R. J. R. (2013). The neurobiology of psychopathic traits in youths. *Nature Reviews Neuroscience*, *14*(11), 786–799. http://dx.doi.org/10.1038/nrn3577.

Hare, R. D., Clark, D., Grann, M., & Thornton, D. (2000). Psychopathy and the predictive validity of the PCL-R: An international perspective. *Behavioral Sciences & the Law*, *18*(5), 623–645. http://dx.doi.org/10.1002/1099-0798(200010)18:5<623::AID-BSL409>3.0.CO;2-W.

Hare, R. D. (2003). *Manual for the revised psychopathy checklist* (2nd ed.). Toronto, ON, Canada: Multi-Health Systems.

Hemphill, J. F., Hare, R. D., & Wong, S. (1998). Psychopathy and recidivism: A review. *Legal and Criminological Psychology*, *3*(1), 139–170. http://dx.doi.org/10.1111/j.2044-8333.1998.tb00355.x.

Hiatt, K. D., Schmitt, W. A., & Newman, J. P. (2004). Stroop tasks reveal abnormal selective attention among psychopathic offenders. *Neuropsychology*, *18*(1), 50–59.

Hodsoll, S., Lavie, N., & Viding, E. (2014). Emotional attentional capture in children with conduct problems: The role of callous-unemotional traits. *Frontiers in Human Neuroscience*, *8*, 570. http://dx.doi.org/10.3389/fnhum.2014.00570.

Jutai, J. W., & Hare, R. D. (1983). Psychopathy and selective attention during performance of a complex perceptual-motor task. *Psychophysiology*, *20*(2), 146–151.

Kaptein, N. A., Theeuwes, J., & van der Heijden, A. H. C. (1995). Search for a conjunctively defined target can be selectively limited to a color-defined subset of elements. *Journal of Experimental Psychology: Human Perception and Performance*, *21*(5), 1053–1069. http://dx.doi.org/10.1037/0096-1523.21.5.1053.

Lamy, D. F., & Kristjánsson, A. (2013). Is goal-directed attentional guidance just intertrial priming? A review. *Journal of Vision*, *13*(3), 14. http://dx.doi.org/10.1167/13.3.14.

Mathôt, S., Schreij, D., & Theeuwes, J. (2012). OpenSesame: An open-source, graphical experiment builder for the social sciences. *Behavior Research Methods*, *44*(2), 314–324. http://dx.doi.org/10.3758/s13428-011-0168-7.

Newman, J. P., Curtin, J. J., Bertsch, J. D., & Baskin-Sommers, A. R. (2010). Attention moderates the fearlessness of psychopathic offenders. *Biological Psychiatry*, *67*(1), 66–70.

Newman, J. P., & Baskin-Sommers, A. (2011). *Early selective attention abnormalities in psychopathy: Implications for self-regulation.* Cognitive neuroscience of attention. New York: Guilford Press.

Patrick, C. J., Bradley, M. M., & Lang, P. J. (1993). Emotion in the criminal psychopath: Startle reflex modulation. *Journal of Abnormal Psychology*, *102*(1), 82–92.

Patterson, C. M., & Newman, J. P. (1993). Reflectivity and learning from aversive events: Toward a psychological mechanism for the syndromes of disinhibition. *Psychological Review*, *100*(4), 716–736.

Theeuwes, J. (1992). Perceptual selectivity for color and form. *Perception & Psychophysics*, *51*(6), 599–606.

Treisman, A. M., & Gelade, G. (1980). A feature-integration theory of attention. *Cognitive Psychology*, *12*(1), 97–136. http://dx.doi.org/10.1016/0010-0285(80)90005-5.

Vitale, J. E., Newman, J. P., Bates, J. E., Goodnight, J., Dodge, K. A., & Pettit, G. S. (2005). Deficient behavioral inhibition and anomalous selective attention in a community sample of adolescents with psychopathic traits and low-anxiety traits. *Journal of Abnormal Child Psychology*, *33*(4), 461–470. http://dx.doi.org/10.1007/s10802-005-5727-X.

WMA Declaration of Helsinki — Ethical Principles for Medical Research Involving Human Subjects (2013, October 19). Retrieved August 4, 2014, from http://www.wma.net/en/30publications/10policies/b3/

Wolf, R. C., Carpenter, R. W., Warren, C. M., Zeier, J. D., Baskin-Sommers, A. R., & Newman, J. P. (2012). Reduced susceptibility to the attentional blink in psychopathic offenders: implications for the attention bottleneck hypothesis. *Neuropsychology*, *26*(1), 102–109. http://dx.doi.org/10.1037/a0026000.

Zeier, J. D., Maxwell, J. S., & Newman, J. P. (2009). Attention moderates the processing of inhibitory information in primary psychopathy. *Journal of Abnormal Psychology*, *118*(3), 554–563. http://dx.doi.org/10.1037/a0016480.

Zeier, J. D., & Newman, J. P. (2013). Feature-based attention and conflict monitoring in criminal offenders: Interactive relations of psychopathy with anxiety and externalizing. *Journal of Abnormal Psychology*, *122*(3). http://dx.doi.org/10.1037/a0033873.