



Impaired attention toward the eyes in psychopathic offenders: Evidence from an eye tracking study

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ABSTRACT

Attention orienting to socially salient cues, such as the eyes of interaction partners, is assumed to be crucial for the development of intact social cognition. Dysfunctions in such basic processes that guide the perception of social cues have been suggested to play a role in the development of psychopathy. The present study investigated gaze patterns in two groups of incarcerated psychopathic and non-psychopathic offenders. While recording their eye movements, participants were asked to categorize either gender (task 1) or emotional expression (task 2) of facial images. Psychopaths exhibited significantly reduced attention orienting toward the eyes, as indicated by absolute dwell time as well as frequency of the initial fixation on the eye region. This pattern was evident across all emotional expressions and independent of the task. The present results suggest a pervasive impairment to attention orienting toward the eyes in psychopaths compared to non-psychopathic offenders. This impairment appears to affect not only general attention but also early attention shifts. Thus, our findings provide evidence that these dysfunctions might particularly contribute to the development of psychopathy instead of antisocial behavior per se. Future studies should further examine the origin, emergence, and consequences of these impairments in order to develop targeted interventions.

1. Introduction

Psychopathy is a developmental condition characterized by profound affective-interpersonal dysfunctions as well as a pervasive pattern of impulsive and antisocial behavior. Psychopathic personality traits are known to emerge during childhood and are associated with early manifestations of conduct problems and development of delinquent behavior (Frick, Cornell, Barry, Bodin, & Dane, 2003). While the prevalence of psychopathy is estimated to be low in the general population (Coid, Yang, Ullrich, Roberts, & Hare, 2009), it has been suggested that 15%–25% of incarcerated males meet the diagnostic cut-off on Hare's Psychopathy Checklist-Revised (PCL-R; Hare, 2003; Hart, Cox, & Hare, 1995). Offenders with high psychopathic traits often exhibit a distinctive pattern of criminal activities (Woodworth & Porter, 2002), persistent violence, a higher risk for recidivism and are particularly less likely to respond to treatment (Hare & Neumann, 2009; Hemphill, Hare, & Wong, 1998). Thus, especially high-psychopathic offenders present a particular challenge for therapeutic interventions as well as for the criminal justice system.

The affective and interpersonal domain of psychopathy includes blunted affect, impaired empathy and remorse, as well as bold,

disinhibited, and egotistical personality traits. Precursors of these characteristics in children and adolescents are often described in terms of callous-unemotional traits (CU traits; Barry et al., 2000). Current etiological models suggest that these affective-interpersonal dysfunctions in psychopaths may arise from early-emerging impairments to basic processing of social cues (Blair, 1995, 2001). One of these basic impairments that has been suggested to play a major role in psychopathy is an impairment in attention orienting to the eyes of an interaction partner. Following the gaze of others is considered to be an entry point into understanding the minds of other individuals and can inform the observer about the other's perceptions, desires, and intentions (Brooks & Meltzoff, 2014). Furthermore, facial features around the eyes (e.g., iris color, eyebrows, pupil dilation, wrinkles, etc.) convey essential information about the identity, gender, as well as emotional state of the counterpart (Itier & Batty, 2009). Thus, shifting attention to the eyes of others to gain access to social signals is pivotal to the appropriate development of social cognition including empathy and an intact theory of mind (Emery, 2000; Itier & Batty, 2009).

In healthy individuals, the preference for the eye region when viewing faces emerges during early infancy as has been documented by numerous studies (Farroni, Csibra, Simion, & Johnson, 2002; Haith,

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Bergman, & Moore, 1977). Accordingly, eye tracking studies have documented a high level of attention to the eyes compared to other regions while scanning facial stimuli (Eisenbarth & Alpers, 2011; Schurgin et al., 2014; Wells, Gillespie, & Rotshtein, 2016). Besides the eyes, particularly the mouth and nose regions tend to attract the attention of the viewer. However, these general gaze patterns are also influenced by task demands (e.g., free viewing, gender discrimination, emotion recognition) as well as characteristics of the stimuli, e.g., emotional expression of the face with specific diagnostic features (e.g., fearful wide-open eyes or happy smiling mouth; Smith & Merlusca, 2014; Eisenbarth & Alpers, 2011). For example, fearful faces have been shown to elicit the highest rates of attention to the eye area, although similar attention binding has also been reported for sad, surprised, or angry faces (Eisenbarth & Alpers, 2011; Schurgin et al., 2014; Wells et al., 2016). In contrast, happy faces in particular seem to be associated with increased attention to the mouth region; similar albeit weaker effects have also been reported for disgust (Scheller, Büchel, & Gamer, 2012; Schurgin et al., 2014; Wells et al., 2016).

In contrast to the preference for the eye region in typically developing individuals, abnormal scan patterns of facial stimuli and reduced gaze to the eyes have been reported in clinical disorders that are characterized by social dysfunctions and difficulties in emotion recognition, such as autism spectrum disorders (Guillon, Hadjikhani, Badauel, & Rogé, 2014; Jones, Carr, & Klin, 2008). The neural structures underlying face processing have been well-studied during the last decades (Behrmann, Scherf, & Avidan, 2016). This line of research has highlighted the importance of the amygdala and the ventromedial prefrontal cortex (vmPFC) as key regions in face perception (Todorov, 2012) as well as in attention orienting to socially salient cues like the eye area (Adolphs et al., 2005; Wolf, Philippi, Motzkin, Baskaya, & Koenigs, 2014). Accordingly, eye tracking studies with lesion patients have shown that amygdala and vmPFC are involved in facial emotion processing and play a crucial role for spontaneous attention orienting to the eye region (Gamer, Schmitz, Tittgemeyer, & Schilbach, 2013; Kennedy & Adolphs, 2010; Wolf et al., 2014). Moreover, amygdala activation in response to emotional faces has been shown to be correlated with the fixation of the eye region in healthy adults (Gamer & Büchel, 2009). Since structural and functional alterations in both amygdala and vmPFC have been reported in psychopathic individuals (Blair, 2007, 2013), it has been hypothesized that early-emerging alterations in these neural circuits might lead to insufficient attention orienting to the eyes of others (Dadds et al., 2006). This, in turn, may compromise the development of adequate emotional and social functioning in psychopaths (Dadds, Jambrak, Pasalich, Hawes, & Brennan, 2011).

However, only few studies to date investigated attention to the eyes in individuals with psychopathic or antisocial tendencies, yielding inconclusive results. While a general lack of spontaneous fixations to the eye region has been reported for boys with high CU traits (Dadds, El Masry, Wimalaweera, & Guastella, 2008; Dadds et al., 2006) another study failed to conclusively link conduct disorder and high CU traits to reduced visual gaze to the eyes and indicated only emotion-specific associations (Martin-Key, Graf, Adams, & Fairchild, 2018). Further, it has been shown that children who were at risk for future criminal behavior exhibited similar levels of eye gaze when compared to healthy controls (van Zonneveld, Platje, de Sonnevile, van Goozen, & Swaab, 2017). Only very few existing studies to date investigated the link between attention to the eyes and psychopathic traits in analogous community samples (Boll & Gamer, 2016; Gillespie, Rotshtein, Wells, Beech, & Mitchell, 2015) and offending populations (Gillespie, Rotshtein, Beech, & Mitchell, 2017). One of these seminal studies (Gillespie et al., 2015) examined eye movements during a facial emotion recognition task in male adults and reported an inverse relationship between psychopathic traits and dwell time on the eyes relative to the mouth across different emotional expressions. This association was particularly pronounced for male models displaying angry expressions

at moderate intensity, as well as fearful and angry female faces displayed at high intensity. Furthermore, Boll and Gamer (2016) investigated particularly initial attention orienting to the eyes compared to the mouth in a community sample of young male and female adults. The results revealed an association between psychopathic traits and a reduced initial orienting to the eye region across all emotional expressions. This link has also been reported for male offenders, despite a lack of differences in the overall scan patterns between the offenders and the healthy control group (Gillespie et al., 2017). Importantly, this study included not only general measures of attention orienting as but also first fixation time as a measure for early attention orienting. The association between psychopathic traits and reduced attention to the eyes relative to the mouth was reported across all emotions, although the effect was stronger for fearful faces.

Taken together, these previous observations suggest that high psychopathic traits (but not antisocial or delinquent behavior per se) are associated with impairments to attention orienting to the eyes. However, the previous findings are inconclusive and mostly based on studies that investigated psychopathic traits in healthy samples or precursors of psychopathy in children. Furthermore, many other important questions remain unanswered: First, evidence is inconclusive whether reduced eye gaze in individuals with high psychopathic traits is independent of facial expression or specific for displayed emotion (e.g., fear). Second, no previous study examined whether these abnormalities are restricted to emotion categorization or generalize across different task demands. Finally, it is important to further delineate which attentional components are impaired and whether early attention orienting is affected as well (like for instance in brain lesion patients; Kennedy & Adolphs, 2010; Wolf et al., 2014).

To address these questions, the current study investigated whether incarcerated criminals with high psychopathic traits exhibit reduced attention orienting to the eyes when compared to a group of low-psychopathic incarcerated offenders. This approach was chosen since we were specifically interested in high-psychopathic offenders due to their particular relevance for the criminal justice system (e.g., more severe criminal behavior, higher risk for recidivism, higher risk to fail treatment, etc.; Kosson, Lorenz, & Newman, 2006; Ogloff, Wong, & Greenwood, 1990; Porter, Birt, & Boer, 2001). To measure attention to the eyes, we recorded the eye movements of the participants during two categorization tasks, in which they judged static emotional (angry, disgusted, fearful, happy, sad, surprised) and neutral faces. Given that viewing patterns can vary according to the nature of the categorization task (Schyns, Bonnar, & Gosselin, 2002; Smith & Merlusca, 2014), we implemented two different manipulations in order to explore gaze to the eyes independent of task demands (compare Scheller et al., 2012). Further, we designed an experiment in order to examine not only general attention guidance (absolute dwell time) but also the early attention shifts (initial fixation). Both offender groups were first asked to label the gender of the facial stimuli (task 1) and to subsequently categorize the emotional expression of the presented face (task 2). We expected the psychopathic group to exhibit less general as well as less spontaneous attention orienting to the eyes as compared to non-psychopathic offenders. Further, we hypothesized that these group differences should occur across all emotional expressions (Dadds et al., 2008; Gillespie et al., 2017; but see also; Martin-Key et al., 2018) and during both tasks (as has been previously demonstrated in brain lesion patients; Adolphs et al., 2005).

2. Materials and methods

2.1. Participants

Two groups of incarcerated male offenders were recruited from four cooperating German correctional facilities (Justizvollzugsanstalt Hohenasperg, Offenburg, Rottenburg, and Heimsheim). They had been convicted for serious crimes such as murder, child molestation, rape,

sexual assault (aggravated) assault, aggravated robbery, etc. (see Table A in supplements for more details). Since previous eye tracking studies have reported sex differences in attention to the eyes while scanning faces (i.e., reduced eye gaze in male relative to female individuals), as well as an impact of age (i.e., reduced eye gaze in older individuals), we assessed solely male samples that were comparable with regard to age (Hall, Hutton, & Morgan, 2010; Murphy & Isaacowitz, 2010; Sullivan, Campbell, Hutton, & Ruffman, 2017). All participants fulfilled the following inclusion criteria: Sufficient knowledge of the German language, aged between 18 and 65 years, no history of schizophrenia, and a score of either ≥ 25 (High) or ≤ 10 (Low) on the Psychopathy Checklist-Revised (PCL-R; Hare, 2003). All offenders provided written informed consent and received monetary compensation for participation. The study was approved by the university's ethics board and was conducted in accordance with the Declaration of Helsinki.

2.2. Measures

Psychopathy was assessed with the PCL-R (Hare, 2003). The PCL-R total score can adopt values between 0 and 40 and is based on a diagnostic interview and criminal records. PCL-R scores had been assigned by independent psychological experts of the correctional facility in Offenburg as part of the standard diagnostic procedure. In accordance with specific recommendations for German-speaking countries (Hartmann, Hollweg, & Nedopil, 2001; Mokros et al., 2013), we classified offenders with a PCL-R score ≥ 25 as psychopaths whereas offenders with a PCL-R score ≤ 10 were categorized as non-psychopaths. According to the meta-analysis of Mokros et al. (2013), a PCL-R score of 25 corresponds with one standard deviation above the mean, whereas a score of 10 can be considered one standard deviation below the mean. To estimate intelligence, we used the 18-item nonverbal Wiener Matrizen-Test 2 (WMT-2; Formann, Piswanger, & Waldherr, 2011). The WMT-2 is a short version of the original Wiener Matrizen-Test (Formann & Piswanger, 1979) that assesses deductive reasoning.

2.3. Gender and emotion categorization task

The design of our experimental tasks (e.g., stimulus selection and presentation duration, background color, and definition of AOIs) is inspired by a previous study exploring scan patterns of affective facial stimuli by Eisenbarth and Alpers (2011). The selected stimulus set of 112 distinct images included images of 16 models from the Karolinska Directed Emotional Faces database (KDEF; Lundqvist, Flykt, & Öhman, 1998) displaying six emotional (i.e., angry, disgusted, happy, fearful, sad, and surprised) as well as neutral expressions. Half of the stimuli were presented in the gender discrimination task and the other half in the emotion recognition task. Each set consisted of four male and four female models and both sets were comparable with regard to recognition rates (Goeleven, De Raedt, Leyman, & Verschuere, 2008). The assignment of stimuli to the tasks was balanced in order to control for possible stimulus effects. Each of the two experimental tasks consisted of 112 trials (8 models \times 7 expressions \times 2 repetitions) which were presented in random order. Task order was fixed for all participants, beginning with the gender discrimination task. The trial structure was as follows: To start the trial, participants were required to fixate a cross on the left or on the right side (presentation side was balanced) of the screen for a 300 ms interval (compare Kennedy & Adolphs, 2010). Since a central start position of gaze at stimulus onset might influence the position of the first detected fixation by allowing a more detailed processing of the fixated stimulus area prior to the initial saccade (Arizpe, Kravitz, Yovel, & Baker, 2012), we ensured that the actual fixation was not within the image at stimulus onset. Subsequently, the face stimulus was presented in the center for 2500 ms, followed by a response screen asking participants to label the gender (task 1) or the emotional expression (task 2) of the face by logging their response via mouse click on the response display.

2.4. Procedure and apparatus

After providing written informed consent, a 9-point calibration was conducted (average calibration error lower than 0.5° visual angle) and participants were introduced to the experimental task. Subsequently, the eye movements were recorded while participants completed the gender discrimination (task 1) followed by the emotion categorization task (task 2). Both tasks started with seven practice trials. Data recording was continuously monitored and a drift check was performed prior to every trial. An EyeLink 1000 eye tracker (SR Research Ltd., Mississauga, Ontario, Canada) was used to binocularly record the eye movements at a sampling rate of 500 Hz during stimulus presentation. The stimuli were displayed in full size (562×762) on a 19 inch computer screen (1024×768 pixel resolution) at a viewing distance of 60 cm. Each participant's head was stabilized with a chin rest. The stimulus presentation and data collection was controlled by an HP laptop via SR Research Experiment Builder software (version 1.10.1630; SR Research Ltd.). After the eye tracking experiment, participants completed the WMT-2.

2.5. Data analysis

Sample size calculation was based on an effect size ($r = -0.37$) derived from the study by Gillespie et al. (2015). Assuming 80% power and $\alpha = 0.05$, an analysis for between factors (group: psychopaths vs. non-psychopaths) in a repeated measures analysis of variance (ANOVA) with $N = 14$ (i.e., 2 tasks \times 7 emotions) repetitions yielded a minimal sample size of 30 participants (calculated with G*Power software version 3.1.9.2; Faul, Erdfelder, Lang, & Buchner, 2007). Accuracy of emotion categorization was analyzed using mixed ANOVA with the factors group and emotion. The analysis of attention to the eyes was based on a predefined Area of Interest (AOI) created by combining AOIs for left and right eye implemented in the study of Eisenbarth and Alpers (2011; see Fig. 2a). Since eyes and mouths of the models are positioned in fixed image coordinates for all pictures of the KDEF, the same AOI definition was applied across all stimuli. As measures for attention to the eyes, we analyzed absolute dwell time on the eye region representing general attention orienting during the whole stimulus presentation. Second, we defined the initial fixation as the first fixation within the image after stimulus onset and examined the relative frequency of the initial fixation on the eyes representing early attention shifts to this salient area. We used the Data Viewer software package (version 2.4.1; SR Research Ltd.) and R (version 3.5.0; R Core Team, 2018; Vienna, Austria) to compute absolute dwell time on the eyes and to analyze the location of the initial fixation and its frequency on the eye region. Subsequently, we analyzed possible main effects and

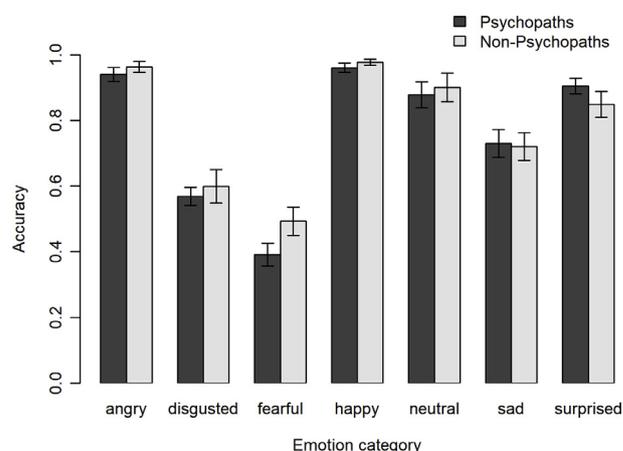


Fig. 1. Accuracy data for the emotion categorization task for psychopathic and non-psychopathic offenders. Error bars represent standard error of the mean.

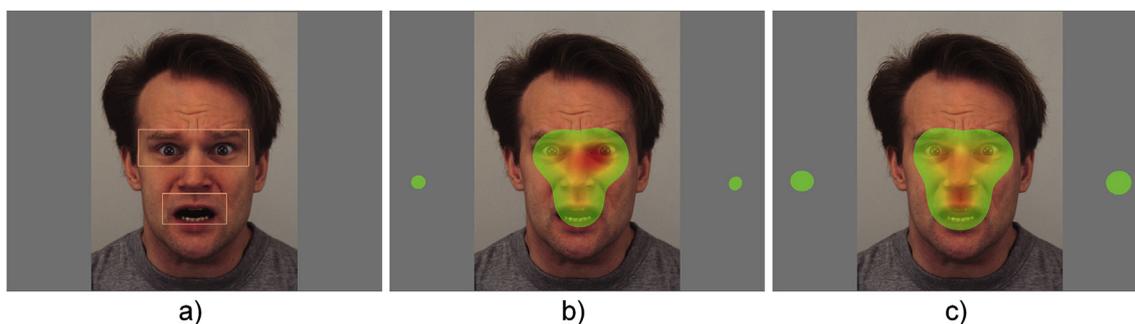


Fig. 2. Example stimulus showing AOI definitions (a) and fixation maps for non-psychopaths (b) and psychopaths (c) depicting the distribution of visual attention during the emotion categorization task. The color indicates the dwell time on the region of the faces with red cueing the longest dwell times. Comparison of the fixation maps of both groups indicate a stronger focus on the eyes in the non-psychopathic offenders whereas the attention seems to be more distributed in the psychopaths and there was a stronger tendency to look at the nose/mouth region. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

interactions of the factors group, task, and emotion using ANOVA for both dependent eye movement parameters describing attention to the eyes (i.e., absolute dwell time and frequency of the initial fixation on the eyes) separately. Significant main effects and interactions were followed by post-hoc ANOVAs or adjusted post-hoc *t* tests.

For an additional analysis of the attention to the mouth, an AOI for the mouth region was defined based on the approach reported by Eisenbarth and Alpers (2011, see Fig. 2a). We calculated the analyses of absolute dwell time and frequency of the initial fixation on the mouth equivalent to analyses for the eye region.

3. Results

3.1. Participant characteristics

We included 36 offenders in our study consisting of 19 psychopathic (PCL-R score ≥ 25) and 17 non-psychopathic (PCL-R score ≤ 10) offenders. Demographic and diagnostic data of both offender groups are displayed in Table 1. Psychopaths and non-psychopaths did not differ in terms of age. However, the level of education and intelligence was lower in the psychopathic compared to the non-psychopathic group.

3.2. Behavioral data

Overall accuracy in the gender discrimination task (task 1) was high (99.63% correct) whereas the emotion categorization task (task 2) was more difficult (77.65% correct). Psychopathic and non-psychopathic offenders performed equally well when judging the gender of emotional faces. Results for the emotion categorization task for both groups and all seven emotions are shown in Fig. 1. Analysis yielded a main effect of displayed emotional expression, $F(3.60, 122.45) = 68.30, p < .001, \eta_p^2 = 0.67$, while neither group, $F(1, 34) = 1.08, p = .306, \eta_p^2 = 0.03$, nor the group \times emotion interaction, $F(3.60, 122.45) = 0.93, p = .439, \eta_p^2 = 0.03$, reached significance.

3.3. Eye tracking data

Fig. 2b and c displays the distribution of visual attention during the emotion categorization task in both groups. The analysis of absolute dwell time on the eyes yielded a significant main effect of group, $F(1, 34) = 10.99, p = .002, \eta_p^2 = 0.24$ (see Fig. 3) indicating an overall shorter dwell time on the eye region for the psychopathic vs. non-psychopathic offenders. Further, there was a significant main effect of emotion, $F(4.02, 136.81) = 26.86, p < .001, \eta_p^2 = 0.44$. Post-hoc *t* tests comparisons between the emotion categories indicated, as expected, shortest dwell times on the eyes for happy and disgusted and longest for surprised, neutral and fearful faces. The main effect of task was non-significant, $F(1, 34) = 1.65, p = .208, \eta_p^2 = 0.05$. Finally, the

main effects were further qualified by a significant interaction between group and task, $F(1, 34) = 8.91, p = .005, \eta_p^2 = 0.21$, indicating that the dwell time on the eyes in task 1 and 2 differed between the groups.¹ Separate follow-up ANOVAs were calculated for each group in order to explore the interaction. A main effect of task was significant for non-psychopaths, $F(1, 16) = 8.49, p = .010, \eta_p^2 = 0.35$, but not for psychopathic offenders, $F(1, 18) = 1.56, p = .228, \eta_p^2 = 0.08$, revealing that absolute dwell time on the eyes was longer in the gender discrimination task compared to the emotion categorization in non-psychopathic offenders. Psychopaths showed comparably short dwell times in both tasks. All remaining interactions were non-significant, all $F_s < 1.68$, all $p_s > .153$.

Consistent with the findings for absolute dwell time, the analysis of the relative frequency of initial fixation on the eye region after stimulus onset yielded a significant effect of group, $F(1, 34) = 8.35, p = .007, \eta_p^2 = 0.20$ (see Fig. 4). Non-psychopathic offenders exhibited a strong tendency for initial fixations on the eyes (59.66% of trials). In contrast, psychopaths had significantly lower rates of initial fixations of the eye region, averaging on 27.58% of the trials.² Furthermore, the main effect of emotion was significant, $F(4.37, 148.74) = 5.74, p < .001, \eta_p^2 = 0.14$. No other main effect or interaction reached significance (all $F_s < 1.94$, all $p_s > .099$).

Our analysis showed generally lower levels of attention to the mouth relative to the eye region (see Fig. 5). Interestingly, psychopaths exhibited an overall longer dwell time on the mouth compared to non-psychopaths. This main effect of group was significant, $F(1, 34) = 7.65, p = .009, \eta_p^2 = 0.18$. Further, there were significant main effects of emotion, $F(4.48, 152.19) = 17.36, p < .001, \eta_p^2 = 0.34$ and task, $F(1, 34) = 73.17, p < .001, \eta_p^2 = 0.68$. These main effects were further qualified by a significant interaction between emotion and task, $F(4.34, 147.57) = 2.80, p = .025, \eta_p^2 = 0.08$, indicating that the influence of displayed emotion on dwell time varied between the tasks. All remaining interactions were non-significant, all $F_s < 1.69$, all $p_s > .202$.

The analysis of the relative frequency of initial fixation on the mouth region after stimulus onset also yielded a significant main effect of group, $F(1, 34) = 4.66, p = .038, \eta_p^2 = 0.12$ (see Fig. 6). In accordance with our findings for absolute dwell time, the relative frequency of an initial fixation on the mouth was higher for psychopaths compared to non-psychopathic offenders. The main effect of emotion, $F(3.80, 129.07) = 2.05, p = .095, \eta_p^2 = 0.06$, as well as the main effect

¹ An analysis of covariance (ANCOVA) with intelligence (WMT-2 sum score) as covariate confirmed the main effect of group and the interaction between group and task on absolute dwell time on the eyes.

² A second ANCOVA with intelligence (WMT-2 sum score) as covariate confirmed the main effect of group on the frequency of initial fixations on the eyes.

Table 1
Demographic and clinical sample characteristics.

	Psychopaths (n = 19)	Non-psychopaths (n = 17)	Statistics
Age (years)	40.32 (11.13)	37.35 (9.01)	$t(33.69) = 0.88; p = .384$
Education (years)	9.11 (1.66)	10.18 (1.42)	$t(33.95) = 2.08; p = .045^*$
WMT-2 sum score	6.53 (3.10)	9.00 (3.55)	$t(32.01) = 2.21; p = .034^*$
PCL-R	29.37 (3.68)	6.12 (3.04)	$t(33.80) = 20.73; p < .001^{***}$

Note. The data represented in the table refers to means and standard deviations for each measure (in parentheses). WMT-2 = Wiener Matrizen-Test 2; PCL-R = Psychopathy Checklist-Revised.

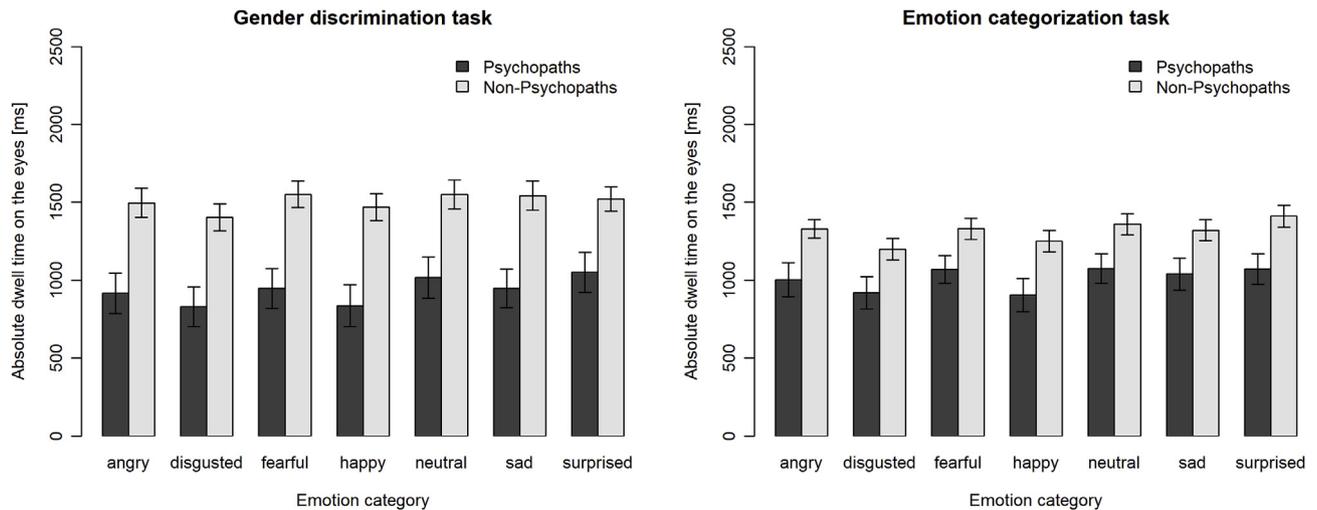


Fig. 3. Absolute dwell time on the eye region for the gender discrimination task (left) and the emotion categorization task (right) for psychopathic and non-psychopathic offenders. Error bars represent standard error of the mean.

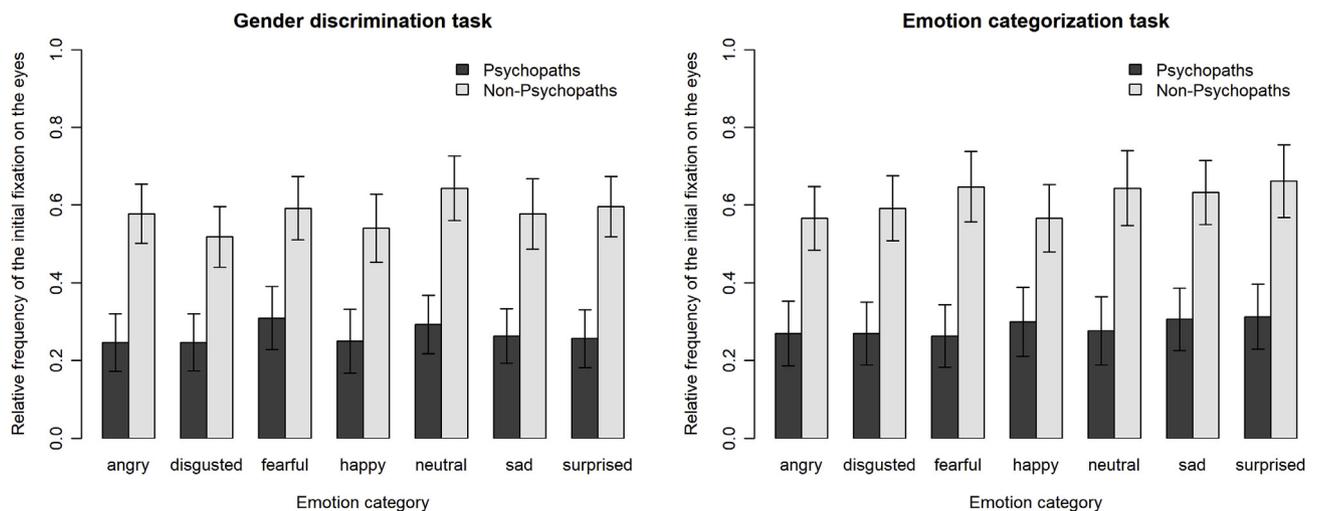


Fig. 4. Relative frequency of the initial fixation on the eye region for the gender discrimination task (left) and the emotion categorization task (right) for psychopathic and non-psychopathic offenders. Error bars represent standard error of the mean.

of task, $F(1, 34) = 0.03, p = .874, \eta_p^2 = 0.00$, and all interactions, all $F_s < 0.83$, all $p_s > .509$, did not reach significance.

4. Discussion

The present study examined visual scan patterns and particularly attention orienting to the eyes while viewing affective facial stimuli in male incarcerated psychopathic and non-psychopathic offenders. The eye movements were recorded during two tasks in which the participants judged either gender or emotional expression of the faces. While non-psychopathic offenders clearly focused on the eyes, psychopaths

were lacking this preference and exhibited reduced eye gaze across tasks and emotional expressions. This was reflected in two central eye movement metrics: 1) Shorter absolute dwell time on the eye region, indicating less overall attention during the entire stimulus presentation 2) lower frequency of the initial fixations on the eye region, indicating less spontaneous attention orienting to the eyes. While psychopaths showed comparably short absolute dwell time on the eyes during both tasks, the overall preference for the eye region in non-psychopathic offenders was even stronger during the gender vs. the emotion categorization task. Further, an additional analysis of the same eye movement measures to the mouth region indicated a higher attention

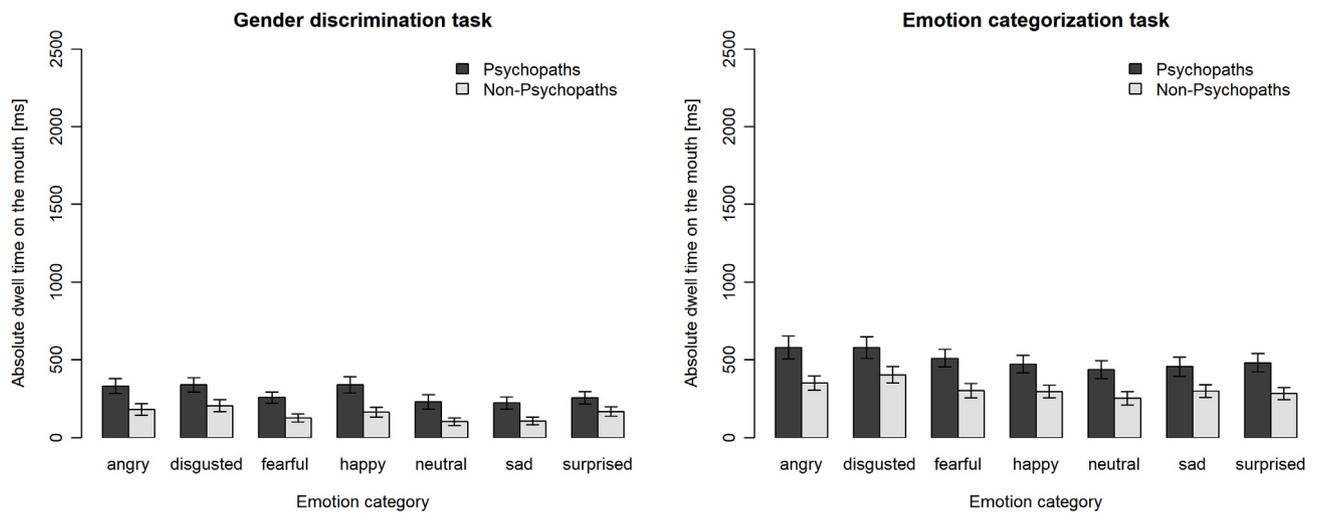


Fig. 5. Absolute dwell time on the mouth region for the gender discrimination task (left) and the emotion categorization task (right) for psychopathic and non-psychopathic offenders. Error bars represent standard error of the mean.

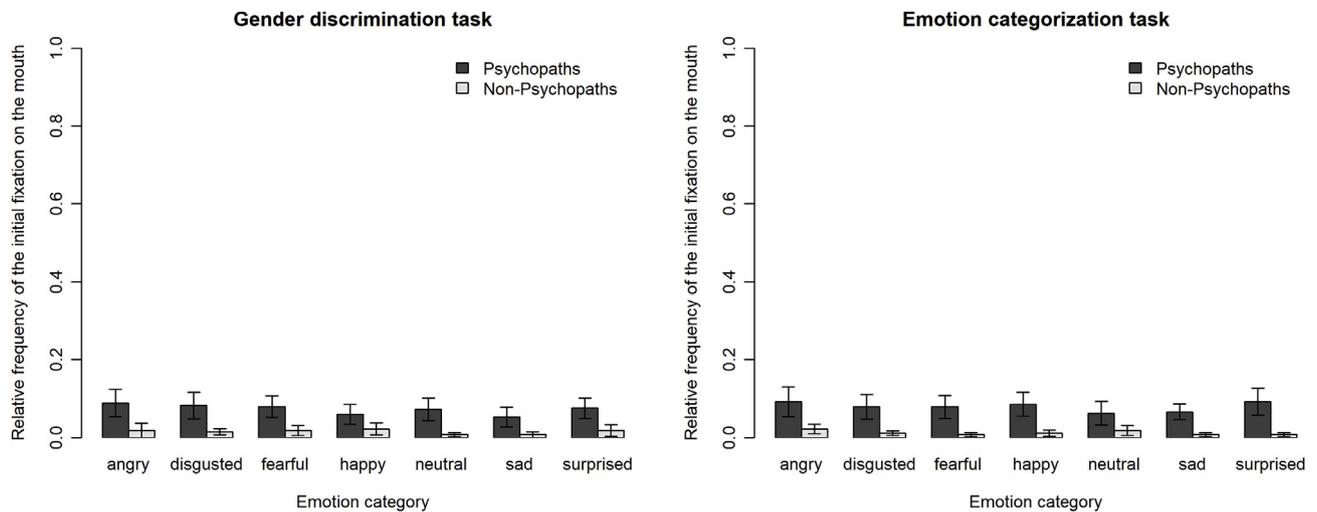


Fig. 6. Relative frequency of the initial fixation on the mouth region for the gender discrimination task (left) and the emotion categorization task (right) for psychopathic and non-psychopathic offenders. Error bars represent standard error of the mean.

orienting to the mouth in psychopaths compared to non-psychopaths, which was also evident across both tasks and all emotional expressions.

The reduced attention orienting toward the eyes in psychopathic offenders across all emotional expressions is in accordance with previous investigations in boys, healthy adults, and offenders, which all suggest a general impairment (Boll & Gamer, 2016; Dadds et al., 2008; Gillespie et al., 2015, 2017). However, other studies reported associations of reduced eye gaze with psychopathic traits that were restricted to specific emotions (i.e., surprise; Martin-Key et al., 2018) or at least particularly pronounced for some expressions (e.g., angry and fearful faces; Gillespie et al., 2015). This assumption of an emotion-specific impairment in attention orienting was also supported by one very recent study that investigated the relationship between fixations to the eyes during an emotion recognition task and psychopathic traits in another offender sample (Dargis, Wolf, & Koenigs, 2018). The findings of this study indicated an association between reduced fixations to the eye region of fearful faces in particular and a specific psychopathy facet (i.e., interpersonal), while PCL-R total scores could not be linked to globally reduced fixations to the eyes. This discrepancy regarding the specificity of the impairment might be due to differences in the study design and the selection of offender samples: While our study compared psychopaths with non-psychopathic offenders exhibiting extremely low

scores (≤ 10) on the PCL-R, Dargis et al. (2018) defined PCL-R scores < 21 as low. Thus, future studies are needed in order to further investigate the emotion-specificity of impaired attention orienting in psychopaths. Interestingly, in the current study, the profoundly reduced attention to the eyes in psychopathic offenders was not only independent of facial expression but also evident across both tasks (gender and emotion categorization) and reflected in both eye movement measures. Accordingly, psychopathy was associated with a general reduction of overall visual attention toward the salient eye region and with less frequent early attention shifts to the eyes (e.g., consistent with Gillespie et al., 2017). To our knowledge, such pervasive impairments to attention orienting have not yet been documented in association with psychopathy but resemble previous findings for patients with amygdala lesions (Adolphs et al., 2005; Gamer et al., 2013; Kennedy & Adolphs, 2010), thereby providing further evidence for the role of the amygdala in psychopathy.

The results of our additional analyses of the mouth region provide some explanation for the deficient attention to the eyes observed in psychopathic offenders, who exhibited higher levels of attention to the mouth compared to non-psychopathic offenders. Since previous studies often investigated varying measures of attention to the eyes relative to the mouth as dependent variables, these results are in accordance with

prior findings (e.g., Gillespie et al., 2017; Martin-Key et al., 2018). However, the group differences in attention to the mouth are smaller than the differences in attention to the eyes. Therefore, the mouth region might not be the only region of the face, which is more attended by the psychopaths, as the fixation maps (see Fig. 2b and c) indicate that attention may also be diverted toward the nose region. Thus, our results suggest that psychopathic offenders might not generally fail to direct attention to relevant features of faces (i.e., eyes, nose and mouth) but lack the preference for the eyes and instead look more at the lower part of facial stimuli including the mouth region.

Another interesting finding of the current study is that offenders with low psychopathic traits showed a general preference to direct attention to the eyes which was comparable to reports for healthy individuals (Eisenbarth & Alpers, 2011; Scheller et al., 2012; Wells et al., 2016). These results support the hypothesis that impairments in attention orienting to the eyes seem to be specifically associated with psychopathy rather than with antisocial and delinquent behavior in general which is in accordance with findings of Gillespie et al. (2017). Furthermore, the tendency to look at the eyes was even stronger for the gender compared to the emotion categorization task, indicating an influence of task demands on gaze patterns (see e.g., Schyns et al., 2002; Smith & Merlusca, 2014). This difference might be explained by task difficulty: Since the recognition of gender is easy and efficient (99.63% correct responses; compare Reddy, Wilken, & Koch, 2004), less exploration is sufficient and therefore, this task could reveal the natural viewing preference of individuals even more clearly. These findings also suggest that impaired attention orienting to the eyes in psychopaths is unlikely due to strategy or adaptation to task demands, as the frequency of initial fixations on the eyes did not differ between tasks. This is consistent with the notion that spontaneous attention orienting is assumed to be less susceptible to top-down influences (Nummenmaa, Hyönä, & Calvo, 2006). Furthermore, in both groups the general attention to the eyes was particularly reduced for emotional expressions with diagnostic features within the nose/mouth region (e.g., smiling happy mouth) which is in accordance with prior findings (Eisenbarth & Alpers, 2011; Scheller et al., 2012).

Previous studies that investigated the link between the attention to the eyes and psychopathic traits also suggest that reduced eye gaze might be a mechanism underlying the impairments of emotion recognition in psychopathy (Dadds et al., 2006, 2008). However, more recent studies yielded no (see e.g., Boll & Gamer, 2016; Dargis et al., 2018; Gillespie et al., 2017) or only weak (see e.g., Gillespie et al., 2015; Martin-Key et al., 2018) evidence for this hypothesis. In the present study, psychopathic and non-psychopathic offenders did not significantly differ in their emotion categorization performance despite the clear differences in scanning patterns. This may be rooted in the experimental set-up, as our tasks were designed to best capture viewing patterns (e.g., long presentation duration, only full-blown emotions) and not behavioral performance. Thus, conclusions regarding a possible relationship between the attention to the eyes and emotion recognition cannot be drawn from this study. Further investigations of the link between gaze patterns and emotion recognition remains an interesting avenue for future research.

Our study has several strengths and limitations. For one, this is one of the first studies to assess carefully recruited offender groups (sentenced for similar offenses) with PCL-R scores assessed by independent psychological experts. However, this may bear a potential limitation, since we were not able to verify the reliability of the ratings. Another methodological strength is the design of the experimental tasks which included a control task, all facial expressions, and allowed for an unbiased interpretation of the initial fixation. A clear limitation is that we only investigated male offenders. Thus, future studies need to examine whether our findings are applicable to female psychopaths as well, especially since sex differences have previously been reported for gaze patterns in facial stimuli (Hall et al., 2010; Sullivan et al., 2017). Moreover, psychopathic and non-psychopathic offenders differed in

intelligence. However, so far, intelligence has not been linked to attention orienting to the eyes and including intelligence as a covariate in the analysis confirmed that group differences in attention to the eyes were not based on differences in intelligence. Further, our approach of comparing two offender groups with extremely high vs. low psychopathic traits (i.e., PCL-R scores) prevents us from investigating which of the psychopathy facets (e.g., affective or interpersonal) is driving the reported effect. Therefore, future studies should investigate larger offender samples and also include the full range of PCL-R scores. Moreover, this approach would be more in line with a dimensional concept of psychopathy, which has gained more support during the last years (Edens, Marcus, Lilienfeld, & Poythress Jr, 2006; Guay, Ruscio, Knight, & Hare, 2007). However, it is still controversial whether psychopathy represents a taxon (psychopath vs. non-psychopath) or rather a dimensional construct (Wright, 2009) whereas others argue it can be used as taxon as well as a continuously measured construct (DeLisi, 2016). Finally, it is unclear whether the reduced attention to the eyes in psychopaths can be generalized to less artificial settings such as viewing videos or interacting with other individuals. Prior findings in children and adolescents suggest that reduced eye gaze associated with high CU traits is not limited to facial categorization tasks but extends to interactions in real-life settings (Dadds et al., 2011, 2014). However, future studies are needed to further investigate this in adult samples as well as offenders with high psychopathic traits.

5. Conclusion

In summary, the present study provides additional evidence linking psychopathy to generally reduced attention toward the eyes of emotional faces. Importantly, this impairment appears to be specifically associated with psychopathy and not antisocial/delinquent behavior per se. Future studies need to further explore why and when these abnormal visual attention processes emerge and how they are linked to the development of social cognition impairments. This knowledge may benefit the development of targeted prevention and intervention strategies which address basic processes underlying social cue processing in psychopathic individuals.

Declarations of interest

None.

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Appendix A. Supplementary data

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