Intact prioritization of fearful faces during continuous flash suppression in psychopathy

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Abstract

Affective state recognition and in particular the identification of fear is known to be impaired in psychopathy. It is unclear, however, whether this reflects a deficit in basic perception ('fear blindness') or a deficit in later cognitive processing. To test for a perceptual deficit, 63 male incarcerated offenders, assessed with the Hare Psychopathy Checklist-Revised (PCL-R), and 59 age-matched control participants detected fearful, neutral, and happy facial expressions rendered invisible through continuous flash suppression (CFS), a strong interocular suppression technique. Consistent with previous CFS studies on children, student and community samples, fearful faces were detected faster than neutral faces, which were detected faster than happy faces. Detection of emotional faces was unimpaired in offenders, with strong evidence for a full-blown fear advantage. Moreover, the fear advantage was not reduced in the 20 offenders qualifying as psychopaths according to the PCL-R, and there was no correlation between the fear advantage and PCL-R scores in the 63 incarcerated offenders. These results show that basic visual detection of fearful faces is unimpaired in psychopathy. Deficits in the processing of fearful facial expressions in psychopathy may thus not reflect fear blindness, but impairments at later post-perceptual processing stages related to attention, memory, decision-making, or language.

Keywords: Psychopathy, visual perception, fear processing, fearful expressions, continuous flash suppression

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Psychopathy is a mental disorder characterized by a unique constellation of callous and unemotional personality traits (Hare, 1991). Psychopaths engage in impulsive, antisocial and aggressive behaviors, and show little empathy, guilt, or remorse. It is widely believed that a deficit in perceiving affective states in others is a hallmark of psychopathy. In this view, impaired perception of distress cues such as fearful facial expressions may underlie the lack of empathy and cause antisocial and aggressive behaviors (Blair, 2001, 2006; Dolan & Fullam, 2006). Indeed, many studies provide evidence for impaired recognition of fearful faces in psychopathy and in antisocial populations (Blair et al., 2004; Marsh & Blair, 2008; Montagne et al., 2005). Such results have often been interpreted as evidence for a basic perceptual impairment to process fearful faces ('fear blindness') in psychopathy (Dadds et al., 2008). However, these studies typically used facial affect recognition paradigms that require participants to explicitly categorize and label expressive photographs by producing a verbal or motor response. In these tasks, successful recognition thus not only requires perceptual encoding but also a range of other processes, i.e., categorization, assigning a linguistic label ("fear"), and initiating the motor response associated with the corresponding label.

Thus, rather than reflecting basic perceptual 'fear blindness', the impairment in fear recognition in psychopathy could reflect deficits at any of these later post-perceptual processing stages. Indeed, several lines of research indicate that non-perceptual, cognitive factors can influence the fear recognition deficit in psychopathy. For example, larger fear recognition deficits have been observed when tasks require verbal rather than nonverbal responses (Wilson et al., 2011), pointing to impairments in language rather than perception. Similarly, two recent studies reported fear deficits in antisocial populations only under task demands with explicit categorization of the facial expression but not when another feature of the face (valence or gender) was task-relevant (Jusyte et al., 2019; Jusyte & Schönenberg, 2017). Such findings suggest that psychopathy and antisociality is associated with suboptimal use of otherwise intact perceptual information, perhaps reflecting altered top-down attention to fear information (Baskin-Sommers et al., 2011; Newman et al., 2010). Indeed, cueing psychopathic or antisocial observers to attend to the eye regions can improve fear recognition (Dadds et al., 2008; Schönenberg et al., 2014). Together, these studies indicate that alterations in top-down attention and post-perceptual cognitive processing contribute to the fear recognition deficit in psychopathy.

Determining the perceptual vs. post-perceptual origin of the fear deficit in psychopathy is important for the development of targeted interventions. For example, evidence for genuine 'fear blindness' would indicate that perceptual training promoting improved detection of fear (and

perhaps sadness) could be highly effective in treating individuals with psychopathy (Schönenberg et al., 2014). Such interventions would have little effect, however, if the fear deficit originated from inaccurate categorization or labeling of otherwise intact perceptual information.

To provide direct evidence for a perceptual origin of the fear deficit, here we rendered fearful, neutral, and happy faces invisible through continuous flash suppression (CFS, Tsuchiya & Koch, 2005) and measured the time it took these faces to become accessible to conscious awareness. CFS is a strong interocular suppression technique in which a photograph of a face presented to one eye can be rendered invisible for up to several seconds by presenting a continuous sequence of masks to the other eye (Figure 1a). In the breaking CFS (b-CFS) paradigm, access to awareness is measured by asking participants to simply indicate the location of the perceptually suppressed stimulus as soon as it becomes visible (Gayet et al., 2014; Jiang et al., 2007; Stein, 2019; Stein et al., 2011). Previous studies in healthy volunteers that measured the duration of perceptual suppression under CFS with simple localization tasks found that fearful faces were localized more quickly than neutral faces, which were localized more quickly than happy faces (Sylvers et al., 2011; Yang et al., 2007). As the b-CFS paradigm does not require explicit emotion categorization or other cognitive processes related to top-down attention, memory, decision-making, or language, the fear advantage in b-CFS is therefore typically considered to index an unconscious, preattentive perceptual processing advantage of fearful faces (Sylvers et al., 2011; Tsuchiya et al., 2009; Yang et al., 2007), and thus represents an ideal measure to test for fear blindness in psychopathy.

Three previous b-CFS studies provided some evidence for a perceptual origin of the fear deficit in individuals with psychopathic traits. Two studies found negative correlations between the CFS fear advantage and affective psychopathic traits in a community sample (Oliver et al., 2015) and in children with conduct disorder (Sylvers et al., 2011), and one study found a negative correlation between self-reported unemotional traits and the fear advantage in young antisocial offenders (Jusyte et al., 2015). Importantly, no previous b-CFS study tested participants formally diagnosed with psychopathy. Here, we tested the CFS fear advantage in 63 male incarcerated offenders rated using the Hare Psychopathy Checklist-Revised (PCL-R; Hare, 1991), and 59 age-matched control participants. We predicted a general CFS fear advantage, i.e., faster localization of fearful than neutral and happy faces. If the fear deficit in psychopathy indeed reflected a basic perceptual deficit, we expected a smaller fear advantage in individuals diagnosed with psychopathy (PCL-R score 25 or higher) and a negative correlation between psychopathy and the fear advantage.

Figure 1. Procedure and stimuli. (a) Participants viewed a CFS sequence composed of a fearful, neutral, or happy face presented through either the red or the green RGB channel (here, the green and CFS masks presented through the other RGB channel. Because participants were wearing red-green anaglyph glasses, the face stimulus was presented to one eye, while the CFS masks were presented to the other eye. A face stimulus was gradually faded in over the first second of a trial, while the transparency of the CFS masks (flashing at 10 Hz) was slowly reduced over the course of a trial. Participants indicated as quickly and accurately as possible on which side of fixation the face or any part of the face became visible. (b) Example face stimuli.

Method

Participants

Offenders were recruited from cooperating German correctional facilities (Justizvollzugsanstalten Heimsheim, Rottenburg, Hohenasperg) through advertisement via pamphlets and blackboards within the facilities. The advertisement specified that we sought inmates aged 18–65 years with a primary conviction for violent offenses and sufficient knowledge of the German language. Interested individuals were contacted by the facility's psychological service to schedule the assessments. All assessments were carried out in designated rooms of the facility by trained psychologists from our research group unrelated to the correctional facility in any way. All assessors were bound to confidentiality regarding any information about the mental health status disclosed during assessments or the behavioral test results. Exclusion criteria were: Primary conviction for drug-related crime, psychotic spectrum, or bipolar disorders (as assessed by clinical interview). Two offenders were excluded because their localization accuracy was close to chance (56.3% and 61.8% correct only, more than 5 *SDs* below the grand mean from all participants). The final sample consisted of 63 offenders.

Control participants were recruited through advertisements in newspapers and university's mailing list (inclusion criteria: 18–65 years, no self-reported convictions, no ASPD, no history of bipolar or psychosis-spectrum disorder). One control participant was excluded because localization accuracy was close to chance (54.2% correct, more than 5 *SDs* below the grand mean from all participants). The final sample consisted of 59 control participants.

Individual participant data were coded via pseudonyms and were at no point accessible to the correctional facility's staff members. The study was approved by the local ethics committee and was conducted in accordance with the Declaration of Helsinki. Participants received monetary compensation.

Clinical and control measures

To control for cognitive abilities related to IQ, the 18-item short version of the Wiener Matrizen Test (WMT, Formann et al., 2011) was used. The 29-item Buss-Perry Aggression Questionnaire (BPAQ, Buss & Perry, 1992) was used to assess self-reported aggression. To assess psychopathy the Psychopathy Checklist-Revised (PCL-R, Hare, 1991) was used. Trained independent psychologists of the correctional facilities had assigned the scores as part of a standard diagnostic procedure.

Procedure and apparatus

Prior to the assessment, all participants were notified about the purposes of the study and signed a written informed consent. Subsequently, the participants completed self-report questionnaire measures and the WMT. Following diagnostic assessments, participants were introduced to the CFS task. For the controls, all assessments were carried out in unitary settings in laboratory rooms. The offender group data were gathered in designated rooms within the facility; none of the security or psychological service staff members were present in the room during testing. The experiment was run on a 14.1-inch HP laptop computer at a free viewing distance of approximately 40 cm. Stimulus presentation and data collection were controlled by MATLAB (The MathWorks, Natick, MA) using the Psychtoolbox functions (Brainard, 1997).

CFS task

Stimuli were viewed dichoptically through red-green anaglyph glasses. Participants viewed a stimulus sequence composed of a fearful, neutral, or happy face presented through either the red or the green RGB channel and CFS masks presented through the other RGB channel. Stimuli were presented in a box (184 × 184 pixels) surrounded by a border consisting of noise pixels (width 12 pixels) that was presented in the center of the screen. The background of the box was assigned the mean luminance of the face stimuli. Faces were presented in one of the four quadrants within the

box (Figure 1a), and participants were asked to maintain stable fixation on a central white fixation cross.

We selected twelve face identities (five female, seven male) with fearful, neutral, and happy expressions, eight from the Nimstim set of facial expressions (Tottenham et al., 2009), and four from the Ekman and Friesen (1976) set (Figure 1b). These faces were fit to a rectangle (76×92 pixels) that excluded outer facial features (Yang et al., 2007; Stein et al., 2014) and were assigned identical luminance and root-mean-square contrast values. We generated 120 CFS masks (184×184 pixels) that consisted of randomly arranged circles with different luminance (diameter 8–34 pixels).

Trials began with a 1-s presentation of the box and the fixation cross only. Next, a face was introduced through either the red or the green RGB channel (i.e. to the participant's left or right eye) by linearly ramping down its transparency over a period of one second from 100 to 0% while CFS masks flashing at 10 Hz were presented through the other RGB channel (i.e. to the participant's other eye). Beginning one second after trial onset, the contrast of the CFS masks was linearly ramped down to zero over seven seconds (for a schematic of a trial, see Figure 1a). Trials ended when participants responded or after a maximum duration of 12 s. Participants pressed the left or right arrow key to indicate as quickly and accurately as possible the side of fixation on which the face or any part of a face became visible.

There were 144 trials, in which each combination of two eyes for face presentation (right eye/red filter, left eye/green filter), three facial expressions (fear, neutral, happy), and 12 face exemplars occurred twice. Face location was randomized, with the constraint that all four locations occurred equally often for all six combinations of eye for face presentation and facial expression. Trial order was randomized. After 72 trials there was one obligatory break.

Analysis and statistics

Only trials with correct localization responses (controls $M = 98.0\%$ correct, $SD\ 2.3$, offenders $M = 96.9\%$ correct, $SD\ 3.3$) were included in the analyses. To account for their positive skew, suppression times were log-transformed (Gayet & Stein, 2017). For descriptive statistics and for Figure 2 log-transformed RTs were transformed back. We report both standard frequentist statistics and Bayes factors (BFs) calculated in JASP (JASP-Team, 2020) with default prior scales (Cauchy distribution, scale 0.707). When the assumption of sphericity was violated, we used Greenhouse-Geisser correction and report corrected degrees of freedom.

Table 1

Demographic Diagnostic Sample Description

Variable	Offender (<i>N</i> = 63)	Controls (<i>N</i> = 59)	Statistics	Cohen's <i>d</i> (95% CI)	Bayes factor
Age	40.49 (11.65)	43.20 (11.42)	$t(120) = -1.30$	-0.24 (-0.59, 0.12)	$BF_{01} = 2.43$
WMT sum score	7.38 (4.01)	7.14 (3.36)	$t(120) = 0.37$	0.07 (-0.29, 0.42)	$BF_{01} = 4.88$
BPAQ					
Physical aggression	22.35 (9.06)	14.92 (5.89)	$t(120) = 5.34^{***}$	0.97 (0.59, 1.34)	$BF_{10} = 2.91 \times 10^4$
Verbal aggression	14.71 (3.69)	12.93 (3.19)	$t(120) = 2.85^{**}$	0.52 (0.15, 0.88)	$BF_{10} = 7.02$
Anger	15.02 (5.19)	10.78 (3.97)	$t(120) = 5.04^{***}$	0.91 (0.54, 1.29)	$BF_{10} = 8.81 \times 10^3$
Hostility	21.44 (6.71)	16.95 (6.21)	$t(120) = 3.83^{***}$	0.69 (0.33, 1.06)	$BF_{10} = 115.33$
Total score	73.52 (18.04)	55.58 (15.73)	$t(120) = 5.84^{***}$	1.06 (0.68, 1.44)	$BF_{10} = 2.44 \times 10^5$

Note. The data refer to mean sum scores and standard deviations for each measure (in parentheses).

WMT = Wiener Matrizen Test. BPAQ = Buss-Perry Aggression Questionnaire. $^{**}p < .01$. $^{***}p < .001$.

Results

Participants

Demographic and clinical sample descriptions are presented in Table 1. Offenders and controls did not differ significantly with regard to age or cognitive abilities (WMT scores). Offenders scored significantly higher than controls on self-reported aggression (all subscales and total score of the BPAQ). On the PCL-R, offenders had a mean score of 19.4 (*SD* 8.5), with 20 offenders scoring 25 or higher, thus qualifying as psychopaths (this subgroup had a mean PCL-R score of 28.9, *SD* 3.3).

Overall emotion effects under CFS

We first tested whether our CFS task revealed the expected pattern of shorter suppression times for fearful faces and longer suppression times for happy faces. Across both subject groups, a repeated-measures ANOVA revealed a significant effect of emotion ($F(1.68, 202.64) = 67.09$, $p < .001$, $\eta_p^2 = .36$, $BF_{10} = 5.08 \times 10^{20}$). As evident in Figure 2a, compared to neutral faces, suppression times were significantly shorter for fearful faces ($t(121) = -5.68$, $p < .001$, $d_z = -0.51$, 95% CI for d_z [-0.70, -0.32], $BF_{10} = 1.21 \times 10^5$) and significantly longer for happy faces ($t(121) = 7.48$, $p < .001$, $d_z = 0.68$, 95% CI for d_z [0.48, 0.87], $BF_{10} = 6.28 \times 10^8$).

CFS effects in offenders vs. controls

Next, we tested whether suppression times for emotional faces differed between offenders and controls. A mixed ANOVA with the within-subject factor emotion and the between-subjects factor participant group revealed a significant main effect of group ($F(1, 120) = 6.65$, $p = .011$, $\eta_p^2 = .05$, $BF_{10} = 5.08 \times 10^{20}$), reflecting overall longer suppression times for controls ($M = 6.32$ s, *SE* 0.23) than for offenders ($M = 5.42$ s, *SE* 0.23). Such overall differences may reflect nonspecific differences in experimental settings between the university laboratories and the testing facilities in prison (e.g.

lighting). Importantly, there was strong evidence against an interaction between emotion and group ($F(1.68, 201.28) = 0.45, p = .602, \eta_p^2 < .01, BF_{01} = 54.06$). As can be seen in Figure 2b, the magnitude of the fear advantage (difference in suppression times between neutral and fearful faces) was similar in both groups (controls: $M = 0.25$ s, SE 0.05; offenders: $M = 0.30$ s, SE 0.08), and significant both for controls ($t(58) = 4.78, p < .001, d_z = 0.62$, 95% CI for d_z [0.34, 0.90], $BF_{10} = 1.48 \times 10^3$) and for offenders ($t(62) = 3.79, p < .001, d_z = 0.48$, 95% CI for d_z [0.22, 0.74], $BF_{10} = 69.24$). Similarly, the happy advantage (difference in suppression times between happy and neutral faces) was of comparable size across groups (controls: $M = 0.30$ s, SE 0.05; offenders: $M = 0.31$ s, SE 0.06), and significant both for controls ($t(58) = 6.10, p < .001, d_z = 0.79$, 95% CI for d_z [0.50, 1.08], $BF_{10} = 1.47 \times 10^5$) and for offenders ($t(62) = 4.83, p < .001, d_z = 0.61$, 95% CI for d_z [0.34, 0.88], $BF_{10} = 1.91 \times 10^3$).

CFS fear advantage in psychopathy

Finally, we tested whether psychopathy was associated with a smaller fear advantage. The comparison of a sub-group of individuals with psychopathy (PCL-R score 25 or higher, $N = 20$) with the remaining sample of offenders ($N = 43$) revealed no emotion-by-group interaction ($F(1.70, 103.80) = 0.46, p = .635, \eta_p^2 < .01, BF_{01} = 5.51$). As can be seen in Figure 2c, the fear advantage magnitude was similar in the two groups (psychopaths $M = 0.32$, SE 0.13, remaining sample $M = 0.29$, SE 0.09) and significant in both groups (psychopaths: $t(19) = 2.29, p = .034, d_z = 0.51$, 95% CI for d_z [0.04, 0.97], $BF_{10} = 1.90$; remaining sample: $t(42) = 3.03, p = .004, d_z = 0.46$, 95% CI for d_z [0.15, 0.78], $BF_{10} = 8.50$). Second, as shown in Figure 2d, there was no correlation between the fear advantage magnitude and PCL-R scores within the whole offender group ($r(61) = -0.08, p = .558, BF_{01} = 5.38$).

Figure 2. (a) Mean suppression times across all participants. The dashed line represents suppression times for neutral faces, and the error bars show the 95% CIs for the pairwise comparisons between fearful and neutral faces and between happy and neutral faces, respectively. (b) The fear effect (difference in suppression times between neutral and fearful faces) and the happy effect (difference in suppression times between happy and neutral faces), separately for controls and offenders. Circles represent individual participants, horizontal bars the group mean, and error bars the 95% CIs. (c) The fear effect separately for participants with and without psychopathy, as measured with the PCL-R. (d) Correlation between psychopathy as measured with the PCL-R and the fear effect across the whole group of offenders. Every circle represents a participant, the solid line the best-fitting linear regression line and the dashed lines the associated 95% confidence bands.

Discussion

The b-CFS task yielded the predicted differences between conditions: fearful faces were detected faster than neutral and happy faces. However, this robust fear advantage under CFS was the only of our predictions that was confirmed. To our surprise, results revealed a full-blown fear advantage in the offender group and in the subgroup of offenders diagnosed with psychopathy. There was no evidence for correlations between the fear advantage and psychopathic traits. As Bayesian statistics provided moderate-to-strong evidence in support of the null hypotheses, these results are unlikely due to a lack of statistical power. Thus, these results indicate that detection of fearful faces is intact in psychopathy. Rather than reflecting impaired basic perceptual processing of fearful faces, the widely reported deficit in fear recognition in psychopathy (Blair et al., 2004; Marsh & Blair, 2008; Montagne et al., 2005; Wilson et al., 2011) may reflect impairments in later, post-perceptual processing stages, related to attention, memory, decision-making, or language.

Our finding of an intact fear advantage is inconsistent with previous CFS studies that found smaller fear effects in individuals with higher psychopathic traits in a community sample (Oliver et al., 2015), in antisocial children (Sylvers et al., 2011), and in young antisocial offenders (Jusyte et al.,

2015). Importantly, while these studies relied on self-report measures of psychopathic traits, the present study is the first to test adult participants that were evaluated on psychopathy using the PCL-R. Our findings are incompatible with the notion of a general link between psychopathic traits and impaired preattentive fear detection.

While our results demonstrate unimpaired preattentive fear processing in psychopathy, they do not necessarily argue against studies suggesting that psychopathy is related to impaired threat processing in amygdala-centered neural circuits (Blair, 2007; Blair, 2005). Although the CFS fear advantage had originally been linked to subcortical pathways involving the amygdala (Tamietto & De Gelder, 2010; Yang et al., 2007), more recent evidence indicates that the effect reflects enhanced visual processing of salient physical features of fearful faces (e.g. in the eye region) in visual pathways (Gray et al., 2013; Hedger et al., 2015; Stein et al., 2014). Indeed, a full-blown CFS fear advantage has been obtained in a patient with bilateral amygdala lesion (Tsuchiya et al., 2009). As such, while our findings speak against the idea that psychopathy is associated with a context-independent deficit for fear (Blair, 2006), they do not argue against the idea that the amygdala is affected in psychopathy (R. J. R. Blair, 2007) which may impair emotional modulation of later aspects of stimulus processing that follow initial fear detection.

Although we only tested basic fear perception, our findings add to a growing body of literature that casts doubt on the general fear deficit hypothesis in psychopathy (Hoppenbrouwers et al., 2016). For example, some studies failed to obtain fear deficits even in recognition tasks (Dawel et al., 2012; Glass & Newman, 2006), and there is little evidence for impaired subjective experience of negative affect in psychopathy (Derefinko, 2015). Our findings will resonate with the idea that, to better understand the functional mechanisms underlying psychopathy, complex tasks (such as emotion recognition), need to be parsed into their sub-components, so that impairments can be identified at distinct levels of processing (Hoppenbrouwers et al., 2016). Our hope is that this 'divide and conquer' strategy will yield tailored interventions not only for psychopathy but mental disorders more generally.

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