Biological Psychology 90 (2012) 50–59

Contents lists available at SciVerse ScienceDirect

Biological Psychology

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

# Fear conditioning in psychopaths: Event-related potentials and peripheral measures

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ARTICLE INFO

*Article history:*
Received 23 September 2011
Accepted 15 February 2012
Available online 23 February 2012

*Keywords:*
Psychopathy
Pavlovian conditioning
Aversive learning
EEG
Startle

ABSTRACT

Aversive pavlovian delay conditioning was investigated in a sample of 11 criminal psychopaths as identified by using the Psychopathy Checklist-Revised and 11 matched healthy controls. A painful electric stimulus served as unconditioned stimulus and neutral faces as conditioned stimuli. Event-related potentials, startle response potentiation, skin conductance response, corrugator activity, and heart rate were assessed, along with valence, arousal, and contingency ratings of the CS and US. Compared to healthy controls, psychopathic subjects failed to differentiate between the CS+/CS− as shown by an absence of a conditioned response in startle potentiation and skin conductance measures. Through use of a fear-eliciting US, these data confirm previous findings of a deficient capacity to form associations between neutral and aversive events in psychopathy that appears unrelated to cognitive deficits and is consistent with hypothesized frontolimbic deficits in the disorder.



## 1. Introduction

Previous research indicates that psychopathy as indexed by Hare's (1991, 2003) Psychopathy Checklist-Revised (PCL-R) encompasses two distinguishable symptomatic components (factors)—emotional detachment and antisocial deviance (cf. Hare et al., 1991; Patrick et al., 1993)—that can be further partitioned into affective, interpersonal, lifestyle, and behavioral facets (Cooke and Michie, 2001; Hare, 2003; Hare and Neumann, 2005; Vitacco et al., 2006). In contrast with healthy controls, high psychopathic individuals appear deficient in the capacity to form appropriate associations between a cue and an aversive (Hare et al., 1978; Flor et al., 2002) or fear-evoking event (Patrick et al., 1994; Birbaumer et al., 2005)—despite intact cognitive processing of stimuli (Flor et al., 2002; Birbaumer et al., 2005; Kiehl, 2006).

In healthy individuals, aversive or threatening cues result in the mobilization of defensive actions, which can be measured by fear-associated responses such as the startle reflex that increase during presentation of aversive stimuli (Davis, 1989; Lang et al., 1990; Patrick et al., 1996). In psychopathic individuals, who are theorized to lack the ability to anticipate and learn from punishment (Lykken, 1957; Hare and Quinn, 1971; Hare et al., 1978; Veit et al., 2002; Blair, 2004; Birbaumer et al., 2005; Mitchell et al., 2006), the fear-associated startle reflex has been found to be diminished or absent (Patrick et al., 1993; Levenston et al., 2000; Pastor et al., 2003; Benning et al., 2005). Startle potentiation in response to aversive events (Davis, 1992; Angrilli et al., 1996; Pissiota et al., 2003) as well as an anticipatory skin conductance response (Bechara et al., 1999) are known to be mediated by amygdalar connections, suggesting a deficit in the amygdala or affiliated structures in psychopathic individuals. Consistent with this, recent imaging studies have revealed reduced activity in limbic circuits including the amygdala in individuals with psychopathy (Kiehl et al., 2001; Birbaumer et al., 2005; Mitchell et al., 2006). Other imaging work focusing on functional or structural frontal brain abnormalities has yielded evidence of decreased activity in orbito-frontal and limbic regions (Veit et al., 2002; Birbaumer et al., 2005) and reduced prefrontal volume of gray matter (Raine et al., 2000; Yang et al., 2005), indicating decreased activity in emotion processing circuits in high psychopathic individuals.

In contrast with these apparent deficits, cognitive processing of affective stimuli in psychopaths appears to be intact as

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doi:10.1016/j.biopsycho.2012.02.011

demonstrated by studies showing overactivation in frontotemporal areas (Kiehl et al., 2001) and an enhanced P300 brain response at frontal electrode sites (Flor et al., 2002). Taken together, these findings support the theory of psychopathy as involving a specific type of emotional dysfunction as proposed by Blair (2004). According to Blair's model, altered activation in the amygdala as well as the ventrolateral and orbitofrontal cortex leads to deficiencies in basic emotional activation to stimuli that have motivational significance (cf. Lang et al., 1997). The cognitive evaluation of stimulus contingencies, however, should be unimpaired.

Newman et al. (1997) proposed the response modulation model which posits that psychopaths' deficient emotional responses may be a consequence of a dysfunction in attentional control. According to this model, the processing of emotional information is proposed to be diminished in situations where this information is not necessary for the ongoing task, resulting in differences between psychopaths and healthy controls that have been misinterpreted as innate fearlessness in psychopaths. An advantage of this model is that it yields testable hypotheses on the influences of situational variables on task performance (Newman et al., 2010). Empirical support for the model comes from studies reporting reduced interference in psychopaths in the Stroop task under certain conditions (e.g., Blair et al., 2006), which is not readily explained by models based on emotion dysfunction (Blair et al., 2005). However, the specific reduction of interference in certain Stroop test paradigms has been identified as a challenge to Newman's response modulation model (Blair and Mitchell, 2009). In addition, the ability of this model to accommodate other empirical findings of psychopathy remains a topic of debate (Blair and Mitchell, 2009).

In a previous conditioning study (Flor et al., 2002) we used aversive odors rather than painful stimulation in studying evoked responses and peripheral psychophysiological responses in psychopaths. However, this was not a true fear conditioning study, as unpleasant odors may evoke disgust rather than fear and may be more related to activations of the anterior insula and the anterior cingulate cortex (Wicker et al., 2003). For the study of fear conditioning, a painful electric shock has traditionally been used as an unconditioned stimulus (Hamm and Weike, 2005). However, findings on altered pain perception in psychopaths have been mixed, with a heightened threshold for pain reported in one study (Fedora and Reddon, 1993), but not in others (e.g., Hare, 1968). In a follow-up functional magnetic resonance imaging (fMRI) study that used painful shock as the unconditioned stimulus (US) Birbaumer et al. (2005) found a lack of conditionability in high psychopathic individuals along with deficient activation of a frontolimbic circuit comprising the orbitofrontal cortex, the amygdala, the insula, and the anterior cingulate cortex, in conjunction with regional activations indicating normal perception of the US.

The purpose of the present study was to examine peripheral and central correlates of fear conditioning in high psychopathic individuals using the same unconditioned and conditioned (CS) stimuli (i.e., painful shock and neutral face images) that were used in the aforementioned fMRI study. Since in that study, the processing of the CSs and the US as well as the processing of CS-US consistency did not seem to be compromised in psychopathic individuals, we hypothesized that psychopathic participants would show intact information processing as indexed by normal event-related potential (ERP) responses to the CS and US, as well as contingency ratings comparable to those of control subjects. The ERP components investigated in the current study were based on our previous conditioning study (Flor et al., 2002): there, the N100 component showed significant CS+/CS− differentiation in individuals with psychopathy, but not in the healthy controls, during periods of the acquisition phase. The psychopathic group also displayed an increased P200 amplitude to the CS+ during the acquisition phase, which is considered to reflect increased stimulus intake (Siegel, 1997). This pattern of results was interpreted as evidence for a specific emotional deficit in psychopathy, unrelated to alterations in attentional processing. The P300 response, which has been found to be enhanced in amplitude for psychopaths in some studies (Raine, 1992) and decreased in others (Kiehl et al., 1999a), displayed differential conditioning in frontal regions only, supporting the assumption that attentional processing in frontal areas is intact in psychopathic individuals (Kiehl et al., 1999b). One additional brain potential response that is known to reflect stimulus expectancy (Rosahl and Knight, 1995; Mnatsakanian and Tarkka, 2002), the contingent negative variation (CNV) has been shown to be altered in psychopaths during anticipation of aversive stimuli (Forth and Hare, 1989). Since the initial and terminal components of the CNV (iCNV, tCNV) differed between the groups and across phases in our previous study, we examined these components separately in the current study. Also, as in Flor et al. (2002), we investigated the late positive complex (LPC), which prior has shown to differentiate the reactions of psychopathic subjects and healthy controls to affective stimuli versus neutral (e.g., Williamson et al., 1991; Kiehl et al., 1999a,b).

At the same time, in line with the results of Flor et al. (2002), we hypothesized that psychopathic participants would show deficient emotional conditioning as indexed by a failure to differentiate between CS+ and CS− in valence and arousal ratings. We further hypothesized a lack of differentiation in response to CS+ versus CS− for startle potentiation, corrugator EMG reactivity, heart rate (HR), and skin conductance response (SCR), and in anticipation of US delivery for CNV. Regarding skin conductance, we hypothesized a lack of responsivity in the psychopathy group on the basis of prior findings (Hare and Quinn, 1971; Flor et al., 2002), but not necessarily in conjunction with altered self-reported arousal ratings as would be expected for healthy controls (Flor et al., 2002; Cleckley, 1955). The hypothesized lack of startle potentiation to the CS is considered to be a more specific indicator of impaired defensive activation than lack of SCR differentiation (Lang et al., 1990) and has been demonstrated specifically in relation to the emotional detachment ('Factor 1') component of psychopathy (Patrick, 1994). In the case of HR, our previous results contradicted earlier findings (e.g., Hare and Craigen, 1974; Hare et al., 1978), precluding clear a priori hypotheses.

## 2. Methods

### 2.1. Participants

Eleven psychopathic men (PPs) with prior criminal records and 11 healthy male controls (HCs) participated in the study. The PPs consisted of offenders either on bail and awaiting trial or on parole who were selected from a larger sample on the basis of scores on a screening version of the PCL-R (PCL-SV; Hart et al., 1995). The control subjects were recruited by signs posted in the university and local supermarkets. Exclusion criteria for the study were as follows: (a) age below 18 or over 45, (b) left-handedness, (c) history of cardiovascular or mental disorder, (d) history of drug or alcohol dependence, and (e) intake of alcohol or drugs within the previous 12 h. The mean age was 31 years ($SD = 6.4$, range = 22–40) for the PPs and 28 years ($SD = 6.7$, range = 22–43) for the HCs ($t(20) = 1.2$; n.s.; $d = 0.54$). The groups were matched in terms of employment status (categories: unemployed, employed, training/apprenticeship and student; $Z = -0.92$; n.s.). Procedures for the study were approved by the local Human Subjects Committee and adhered to the Human Subjects Guidelines of the Declaration of Helsinki. All participants were informed about the nature of the study and provided written informed consent prior to participation. The psychopathic participants received 80 Euros, and the controls 40 Euros, for their participation.

The overall mean PCL-SV score for individuals screened for inclusion in the PP group was 15.45 ($SD = 2.54$; range = 12–21), with $M$s of 9.55 ($SD = 1.29$; range = 8–12) for Factor 1 and 5.90 ($SD = 1.81$; range = 2–9) for Factor 2. Subjects with Factor 1 scores of 8 or higher were included in the PP group, without regard to scores on Factor 2. We emphasized Factor 1 of the PCL-SV (Emotional Detachment) in the selection of participants over Factor 2 (Antisocial Behavior) because (a) scores on Factor 1 are more predictive of deficits in emotional reactivity (e.g., Patrick, 1994; Verona et al., 2004; Vanman et al., 2003; Vaidyanathan et al., 2011), and (b) scores on Factor 2 were expected to be generally lower for non-incarcerated individuals with criminal records than for incarcerated offenders. Control subjects had an overall