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ERN varies with degree of psychopathy in an emotion discrimination task

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Abstract

It is hypothesized that anterior cingulate cortex (ACC) function may be disrupted in psychopathy. Since ACC is considered the generator of the error-related negativity (ERN), we expected the ERN to be sensitive to the degree of psychopathy among violent offenders. EEG was collected while offenders and controls responded to a standard letter flanker task and to a face flanker task that required discrimination between angry and fearful expressions. Offenders were as accurate as controls on the letter flanker task but made more errors in emotion discrimination on the face flanker task. ERNs elicited by letter flanker errors did not differ across groups but were markedly reduced in the offenders in the face flanker condition. These effects were related to the degree of psychopathy within the offender group. Source modelling of the ERN also indicated an atypical response for psychopaths when error monitoring required the discrimination of affectively based information.

Keywords: Antisocial personality disorder; Limbic system; Event-related potentials; ERPs; Emotion perception; Facial expressions; Letter flanker; Face flanker

1. Introduction

1.1. Neurocognitive processes involved in response monitoring

The anterior cingulate cortex is considered central to the integration of attentional, affective, and visceral information (Allman et al., 2001; Critchley, 2005; Thayer and Lane, 2000). It has been associated with the control and modulation of ongoing behavior and with assessing the motivational significance of external stimuli (Devinsky et al., 1995). The ACC has been differentiated into two functionally distinct regions (Vogt et al., 1992). The more dorsal and caudal portions of the ACC have reciprocal projections with cortical regions involved in the control of attention, whereas rostral/ventral regions share projections with limbic, paralimbic, and brainstem regions, and are involved in the processing of affective information (Bush et al., 2000). The ACC provides entry for limbic influence on the voluntary motor system (Morecraft and Van Hoesen, 1998).

The ACC is specifically involved in the brain's error-processing system (e.g., Miltner et al., 2003). The caudal regions of the ACC have consistently been modeled as the generator site of the error-related negativity (ERN; e.g., Dehaene et al., 1994; Holroyd and Coles, 2002; Mathewson et al., 2005). The ERN is observed as a negative deflection in the response-locked event-related potential (ERP) that is maximal at fronto-central sites and specific to errors (Coles et al., 1991; Falkenstein et al., 1990). There is some debate as to the functional significance of the ERN, with researchers linking it alternately to response conflict (e.g., van Veen and Carter, 2002) or reinforcement learning (Holroyd and Coles, 2002). Others (e.g., Bernstein et al., 1995; Falkenstein et al., 2000; Miltner et al., 1997) believe it to be involved in a generic response monitoring system, reflecting a process by which actual and desired outcomes are compared or evaluated and related to their consequences (see also, Rushworth et al., 2004; Scheffers and Coles, 2000).

A number of subjective motivational factors have also been reflected in the ERN (Luu et al., 2000). Hajcak et al. (2005) reported that participants generated larger-amplitude ERNs to

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errors committed on highly rewarded than on poorly rewarded trials. Similar findings have been reported under other reward conditions (e.g., Gehring et al., 1993). The ERN also appears to be sensitive to personality factors associated with anxiety (e.g., Hajcak et al., 2003; Pailing and Segalowitz, 2004a). ERNs of increased amplitude have been reported in individuals diagnosed with obsessive compulsive disorder (OCD), a condition associated with over-activation of cingulate cortex and related brain regions (Gehring et al., 2000; Hajcak and Simons, 2002; Santesso et al., 2005a). Such data raise questions as to whether personality traits associated with under-activation of the ACC would be linked with impairments in response monitoring and a reduced ERN, reflecting that under-activation.

1.2. Neurocognitive correlates of psychopathy

Psychopathy is a personality disorder accompanied by a spectrum of affective abnormalities such as lack of empathy, callousness, and lack of remorse (Cleckley, 1964; Hare, 1991). It has also been associated with abnormal ACC function under some circumstances, specifically during the processing of affective information (Kiehl et al., 2001; Müller et al., 2003), and emotional facial expressions—especially fear (Blair et al., 2004; Montagne et al., 2005). There is also evidence that psychopaths may show impairments in other processes associated with the limbic system and ACC, including reduced neurophysiological responses to aversive conditioning (e.g., Birbaumer et al., 2005) and electrodermal hyporeactivity in anticipation of aversive stimuli (e.g., Fung et al., 2005; Gatzke-Kopp et al., 2002). These arousal-based deficits seem to occur in the presence of largely intact higher-order cognitive abilities (Hart et al., 1990).

There is, however, some evidence that psychopaths may have more general difficulties with response monitoring. They have been shown to differ from controls in passive avoidance learning (Newman and Schmitt, 1998) and in their failure to exhibit post-error slowing after negative feedback (Newman, 1987). Indeed, it has been suggested that psychopaths may display a failure to monitor, and hence learn from, the response-based feedback they encounter (a response monitoring deficit). However, an alternate explanation is that, in the presence of ACC or paralimbic dysfunction, their visceral response to negative feedback is simply not sufficient to engage their attention or to be experienced as sufficiently aversive to lead to behavioral change (an emotional reactivity deficit).

In the present study, we were interested in examining the affective and cognitive processes involved in response monitoring as they relate to psychopathy, a condition in which affect and cognition appear to be dissociated. In an earlier investigation, Dikman and Allen (2000) recorded ERNs associated with errors made on the Eriksen flanker task (Ericksen and Eriksen, 1974) under avoidance-learning or reward conditions. They used a sample of undergraduates and divided them on the basis of whether they scored high or low on the socialization scale of the California Psychological Inventory (CPI; Gough, 1994), a scale purported to capture variance in socialization in healthy populations analogous to that provided by standard measures of psychopathy. They found that highly socialized participants produced ERNs of approximately the same size irrespective of the feedback situation, whereas low socialized individuals seemed differentially motivated in the reward versus the avoidance learning condition resulting in a modification of the ERN. It may be, however, that those in the high socialized group were higher in social anxiety and would, therefore, be more internally motivated to perform well under either condition (see Pailing and Segalowitz, 2004a) rendering reward-related instructions less relevant to them.

Using the same task, Santesso et al. (2005b) recorded ERNs from 10-year-old children who varied on socialization as measured by the Junior Eysenck Personality Questionnaire-Revised (Corulla, 1990). The researchers did not introduce reward contingencies but, nonetheless, found that higher scores on the Psychoticism scale (an index of poor socialization) were associated with a reduction in the amplitude of the ERN. While it is true that low socialization scores in normal young populations can be predictive of antisocial behaviors in adulthood (e.g., Eysenck, 1997), we expected that the relation between error monitoring and socialization would be better understood if we increased the variance on the socialization dimension. To this end, we sought to include adults who provided a range on socialization, including those who would meet the criteria for psychopathy.

1.3. The present study

Thus, in the present study our goal was to determine whether incarcerated violent offenders, assumedly low in socialization, would show impaired error monitoring and produce a diminished ERN, both suggestive of diminished ACC function. We also wanted to determine whether such deficits would vary with the degree of socialization deficit within the offender group by including individuals who meet the criteria for psychopathy. As well, since the reduced activity of the ACC in psychopaths has been observed primarily in response to affective stimuli (Kiehl et al., 2001), we proposed that adding an affectively based error-monitoring task would further impair error monitoring in the offender group and further diminish the ERN.

2. Methods

2.1. Participants

Violent offenders ($N = 15$; all male) were inmates at a maximum security forensic hospital. Control participants ($N = 15$; all male) were recruited from among staff members of that facility. All participants were free from recent psychotic illness and history of severe head injury. Age did not differ between offenders ($M = 45.9$, S.E. = 3.5 years) and controls ($M = 46.6$, S.E. = 1.78 years), t (27) = 0.16, $p = .87$, $d = .06$. Offenders had fewer years of education ($M = 10.9$, S.E. = .67 years) than controls ($M = 14.8$, S.E. = .42 years), t (28) = 4.89, $p < .001$, $d = 1.9$,[1] but all participants scored within the average range on a standard index of general intelligence (Shipley Institute of Living

[1] Variance due to education was subsequently examined with respect to all effects of interest and did not change the outcome.