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Electrophysiological study of the violence inhibition mechanism in relation to callous-unemotional and aggressive traits

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ABSTRACT

The violence inhibition mechanism (VIM) proposes that observing another's distress inhibits responses that can lead to violent behaviour. Dysfunction of this system is associated with disorders characterised by aggressive and callous-unemotional traits, such as psychopathy. This study examines electrophysiological indices of face processing and motor extinction, in the context of aggressive and callous-unemotional traits. Fifty-four participants completed the inventory of callous and unemotional traits, the aggression questionnaire, and a Facial Affect Stop-Go task whereby facial distress was used as stop signals. Uncaring traits inversely associated with N170 amplitude across all facial expressions and aggressive traits inversely associated with Stop-P300 amplitude to facial distress. The N170 and Stop-P300 might provide useful electrophysiological markers for deficits across face processing and motor extinction stages of the VIM, respectively.

1. Introduction

Robert Stelmack's work has improved understanding of the biological bases of personality, and how individual variation might be reliably indexed through electrophysiology. Noteworthy, is his work evidencing differences in cortical activity between introverts and extroverts (Stelmack, 1990); a personality spectrum associated with both pro- and anti-social behaviours. The current investigation delineates electrophysiological variation as a function of aggression and psychopathy-related traits.

The ability to suppress a planned or ongoing motor response in reaction to socially relevant information is important for adaptive behaviour (Huster, Pils, Lavallee, Calhoun, & Hermann, 2014). The violence inhibition mechanism (VIM) (Blair, 1995, 2001) comprises at least two stages of affect perception (including empathy) and motor extinction, whereby organisms typically learn to modulate aggression through perceiving expressions of distress in others. Dysfunction of this system is implicated in the development of psychopathy, and reflected through callous, unemotional, and uncaring (CU) traits (Blair, 1995, 2001).

CU and aggressive traits are associated with atypical categorisation of, and responses to, facial distress (Marsh & Blair, 2008; Seidel et al., 2013; Wilson, Juodis, & Porter, 2011). Although inconsistent findings exist (Eisenbarth, Alpers, Segrè, Calogero, & Angrilli, 2008; Glass & Newman, 2006), meta-analysis supports the presence of face processing deficits in affective psychopathy not specific to expressions of distress nor explained fully by aggressive behaviour (Dawel, O'Kearney, McKone, & Palermo, 2012).

In regards to motor extinction proficiency, deficits in VIM-related executive function (e.g. error monitoring, response inhibition) have been reported in violent offenders (Vilà-Balló, Hdez-Lafuente, Rostan, Cunillera, & Rodriguez-Fornells, 2014) and in association with trait aggression (Pawliczek, Derntl, Kellermann, Gur, & Schneider, 2013). However, to our knowledge, no investigation has used facial affect as an inhibitory stimulus. Such research is important to better understand the motor extinction stage of the VIM.

To establish processing deficits across the aforementioned stages of the VIM, precise temporal measurements are required. Electroencephalography (EEG) reflects gross post-synaptic cortical activity of neuronal clusters with high temporal resolution, and offers a useful tool for distinguishing the time-course of neurological responses elicited during face processing (Gow et al., 2013) and motor extinction (Sumich et al., 2008). Time-locked EEG, to stimulus presentation or behavioural response, is termed the event-related potential (ERP).

Face stimuli elicit several well-documented ERPs including the N170 (150–200 ms post-stimulus) and P300 (300–500 ms post-stimulus). The N170 is best observed over temporo-parietal sites and is typically larger over the right hemisphere (Hinojosa, Mercado, & Carretié,

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2015). The N170 purportedly represents the conjoined processing of face identity and expression, and larger N170 amplitudes have been observed to angry and fearful (but not sad) faces, possibly as a function of their biological significance and representation of potential threat (Hinojosa et al., 2015).

N170 attenuation (lower amplitudes) has been observed in non-clinical cohorts presenting low emotional expressivity (Meaux, Roux, & Batty, 2014) and high fearless dominance (Almeida et al., 2014); arguably linked to uncaring traits and a lack of concern for oneself and others (Kimonis, Branch, Hagman, Graham, & Miller, 2013). In contrast, N170 augmentation (larger amplitudes) has been related to cold-heartedness, possibly indicating a need for greater cortical effort when processing facial affect (Almeida et al., 2014). Cold-heartedness is associated with callousness (i.e. disregard for the feelings of others) and unemotional (i.e. blunted affect) traits (Patrick, 2010). Thus, qualitatively different CU traits might differentially modulate the N170. Whilst no difference in N170 amplitude has been reported in antisocial personality disorder (Eisenbarth et al., 2013; Pfabigan, Alexopoulos, & Sailer, 2012), measurement of the N170 in these studies was from atypical electrode sites and so direct comparison with findings of other studies is limited. Accordingly, the relationship between N170 responses to facial affect and individual differences in aggression (investigated in regards to face processing but not on an electrophysiological level) and CU traits remains unclear.

The P300 is associated with attention orientation and stimulus evaluation (Polich, 2007). Lower P300 amplitudes are considered a common characteristic across externalising behaviours (e.g. alcohol and drug dependence, antisocial behaviour; Hicks et al., 2007), and have been associated with reactive aggression in offender (Barratt, Stanford, Kent, & Felthous, 1997; Bernat, Hall, Steffen, & Patrick, 2007) and non-offender (Bartholow, Bushman, & Sestir, 2006; Gerstle, Mathias, & Stanford, 1998) cohorts.

During tasks that require inhibiting a motor response, the P300 is characterised by an anterior topography thought to reflect inhibitory control and motor extinction efficiency (Kok, Ramautar, de Ruiter, Band, & Ridderinkhof, 2004). Lower P300 amplitudes evoked during response inhibition have been reported in relation to delinquency (Meier, Perrig, & Koenig, 2012) and in individuals with psychopathic traits (Kim & Jung, 2014). However, one investigation reported larger inhibitory P300 amplitude in violent offenders (Munro et al., 2007), a finding in line with intact (Patrick, 2008) or even augmented (Carlson & Thái, 2010; Flor, Birbaumer, Hermann, Ziegler, & Patrick, 2002) P300 responses, evoked to non-inhibitory stimuli, in relation to CU traits.

The current study investigates face processing and motor extinction stages of the VIM using a distress-cued motor extinction task in relation to CU traits and physical aggression. Specifically, N170 responses to facial stimuli and P300 responses to stop signals cued by facial expressions of distress (fear, sadness) were investigated. N170 amplitude was hypothesised to be [1] larger to fearful and angry, but not sad and neutral facial stimuli, and show [2] a positive association with callous and unemotional traits, but [3] an inverse relationship with uncaring and aggressive traits. Stop-P300 amplitude was hypothesised to be [4] inversely associated with aggressive and CU traits.

2. Methods

2.1. Participants

Fifty-four psychology students (aged 19.06 ± 1.25 years, 61% female) provided written informed consent. No participants reported psychiatric disorders or medication that might affect electrophysiology. Participants were compensated for their time with research credits.

2.2. Measures

2.2.1. Aggression

The Aggression Questionnaire version 2 (AQ-2) (Buss & Warren, 2000) measures the propensity to aggress and comprises five subscales: physical aggression, verbal aggression, anger, hostility, and indirect aggression. The current investigation reports on physical aggression (Cronbach's $\alpha = 0.80$). Following standard scoring procedures, scores were transformed according to age and sex. Higher scores indicate greater aggression.

2.2.2. CU traits

The Inventory of Callous–Unemotional Traits (ICU) (Frick, 2003) measures the occurrence and intensity of CU traits and comprises three subscales: callousness, uncaring, and unemotional. Higher scores indicate greater CU traits.

2.2.3. The Facial Affect Stop-Go task (FAST)

The FAST (Fig. 1) was created by the researchers and presented in two blocks using OpenSesame v3.0 (Mathôt, Schreij, & Theeuwes, 2012). Stimuli consisted of neutral, angry, sad, fearful, and surprised expressions (open mouths) from 17 identities (IDs 01, 03, 05, 06, 07, 08, 09, 10, 20, 21, 23, 25, 26, 32, 34, 35, 36; MacBrain NimStim Face Stimulus Set (Tottenham et al., 2009)). Each block began with a 4000 ms lead-in, followed by 136 trials. Each trial involved the presentation of a pair of facial stimuli (800 ms; 100 ms jitter) separated by black screen (160 ms; 40 ms jitter), with a red fixation cross presented between trials (1800 ms; 200 ms jitter) (see Fig. 1). Facial stimuli pairings were divided across Background (Fear-Fear; Sad-Sad; Neutral-Sad; Neutral-Fear), Go (Anger-Anger; Anger-Surprise), and Stop (Anger-Fear; Anger-Sad) conditions, with each pairing presented 17 times per block. Participants were instructed to move their right index finger from a red key to an adjacent green in response to go stimuli (angry faces [stimulus 1]); but to interrupt their response and return their finger to the red key, following stop stimuli (i.e. sad/fearful faces [stimulus 2]). No response was

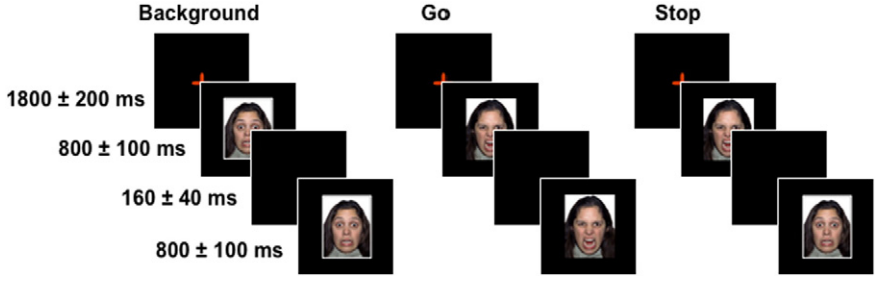

Fig. 1. Facial Affect Stop-Go task (FAST). Participants responded to infrequent go (angry) stimuli among frequent background (neutral, fearful, or sad) stimuli (800 ± 100 ms) by moving their finger from a red to a green button after the go stimulus had expired. Facial stimuli were followed by a black screen lasting 120 to 200 ms. Afterwards, participants were either presented with an [1] angry or surprised facial stimulus, indicating the go response should be completed, or a [2] fearful or sad facial stimulus, indicating the go response should be extinguished by returning their finger to the red button without pressing the green button.