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Electrophysiological correlates of CU traits show abnormal regressive maturation in adolescents with conduct problems

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ABSTRACT

Callous/unemotional (CU) temperament traits may denote a more severe form of conduct disorder (CD) and have been associated with abnormal cortical thinning. The present study investigated the maturational decline in N200 amplitude, and the association between N200 amplitude and callous/unemotional traits, in adolescents with CD. Twenty adolescent males (aged 10–18 years old) with CD were age-matched to 27 clinical controls with Attention Deficit Hyperactivity Disorder (ADHD) and 30 non-clinical, typically developing controls. Participants completed a visual continuous performance task. As expected, N200 amplitude in response to background stimuli was inversely associated with age in controls (at frontal and temporal brain regions). Similar associations were seen in clinical controls. In contrast, the CD group showed a significant positive correlation between age and the right temporal N200 amplitude. Further, CU traits were positively correlated with N200 amplitude at midline frontal and temporal electrodes, even after covarying for age. These results highlight links between CU traits and abnormal neurodevelopment as indexed by N200 amplitude. This is in line with an impairment or delay in regressive maturational changes such as cortical thinning, as suggested by neuroimaging studies, which may underlie the persistence of certain psychopathic tendencies.

1. Introduction

Conduct disorder (CD) is characterised by a persistent pattern of behaviour that violates either the basic rights of others or age-appropriate social norms (DSM-IV; American Psychiatric Association, 2000). Studies of causality are presently inconclusive, perhaps due to illness heterogeneity. Various genetic and environmental factors confer risk (Cappadocia, Desrocher, Pepler, & Schroeder, 2009). However, no single factor provides a satisfactory causal model (Frick, 1998). A severe child-onset subgroup of CD has been identified, with a high (25%) prevalence of callous-unemotional (CU) temperament traits: low fearfulness, absence of guilt or poor empathy (Christian, Frick, Hill, Tyler, & Frazer, 1997; Frick & Hare, 2001). This group shows more pervasive behavioural and cognitive disturbances similar to those observed in adult psychopathy (Barry et al., 2000; Liu et al., 2007; Dadds, Fraser, Frost, & Hawes, 2005), such as impaired processing of emotional stimuli (Frick & Dickens, 2006). The CD/CU clinical group appear to share unique risk factors and show a significantly greater heritability rate than non-CU groups (Frick & Dickens, 2006).

Recent neuroimaging studies suggest that CU traits are underpinned by a regionally specific absence in cortical remodelling (De Brito et al., 2009). Thus positive associations have been reported between CU traits and cortical thickness at frontal and temporal regions, which may reflect a reduction of synaptic pruning and/or poor myelination. Similarly, reduced fronto-temporal white matter (WM) has been observed in adults with psychopathy (Craig et al., 2009), whilst adolescents with CD and high CU traits show reductions right superior frontal WM concurrent to bilateral increases in medial frontal WM (De Brito et al., 2011). In adolescents with CD, Sarkar et al. (2012) show increased fractional anisotropy in the uncinate fasciculus, suggesting more WM connecting the ventromedial frontal cortex and amygdala. Functional imaging studies report poor activation of the right amygdala whilst viewing facial expressions of fear in boys with CD (Jones, Laurens, Herba, Barker, & Viding, 2009), which supports lesion studies in adults that implicate right fronto-temporal disturbance (including the anterior insula) in empathy (Perry et al., 2001; Gorno-Tempini et al., 2004; Kiehl, 2006; Sterzer, Stadler, Poustka, & Kleinschmidt, 2007).

Event-related potentials (ERPs) are electroencephalographic (EEG) activity that is time-locked to stimulus presentation or a behavioural response. They reflect the synchronous post-synaptic potentials of large populations of cortical neurons (Coles & Rugg,

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1995; Luck, 2005) occurring within milliseconds of the eliciting event. N200 is a negative deflection in the ERP occurring around 200 ms post-stimulus. Its amplitude indexes the processing effort involved in stimulus identification, classification, decision-making and executive function (Luck, 2005). Such functions may be important in responding appropriately to affective cues. N200 subcomponents vary in topography and functional significance. For example, the medial frontal N200 purportedly reflects mechanisms involved in attention regulation and behavioural monitoring (Pritchard, Shappell, & Brandt, 1988; Kopp, Tabeling, Moschner, & Wessel, 2006), whilst increases in the lateral N200 amplitude are found with increased task difficulty (Luck, 2005). N200 amplitude to cognitive tasks has been shown to depend on personality traits associated with poor affect, such as depression (Sumich et al., 2006, Sumich, Kumari, Heasman, Gordon, & Brammer, 2006).

As a part of normal development, N200 amplitude tends to decline, at least between childhood and adulthood (Sumich et al., in press, Developmental Neuropsychology). Such regressive development may reflect cortical remodelling and the corresponding improvement in performance on attentional (Sumich et al., in press, Developmental Neuropsychology) and emotional (Lewis, Lamm, Segalowitz, Stieben, & Zelazo, 2006) tasks, due perhaps to a common maturational mechanism. At least during childhood and early adolescence, this regressive development may be particularly evident at parietal and temporal sites (Sumich et al., in press), or to background stimuli, when no motor response is required (Bishop, Hardiman, Uwer, & von Suchodoletz, 2007; Gomot, Giard, Roux, Barthélémy, & Bruneau, 2000). One reason for this is that certain components elicited more frequently to targets and/or errors in motor response may increase with maturation, at least during late adolescence/early adulthood, and are more prominent at midline frontal sites (e.g. medial frontal negativity; Segalowitz & Davies, 2004). However, we have found lower N200 to target stimuli at lateral frontal sites in 15–17 year olds compared to 6–8 year olds (Sumich et al., in press). High N200 amplitude has been observed in adults with psychopathy (Kiehl, Bates, Laurens, Hare, & Liddle, 2006) and in adolescents with co-morbid hyperactive and delinquent behaviour (Satterfield & Schell, 1984), possibly reflecting temporal and frontal lobe dysfunction. However, it is unclear how such findings relate to CU traits.

The current study investigated N200 in relation to age and CU traits in adolescents with CD compared to those with attention-deficit hyperactivity disorder and healthy controls. N200 amplitude was expected to be inversely associated with age, at least in controls. If adolescents show abnormal synaptic pruning, then the normal relationship between N200 and age might be expected to be disrupted. Thus, absence of an inverse association between age and N200 amplitude in boys with CD would suggest abnormal regressive maturational processes. Associations between N200 and CU traits were explored.

2. Method

The study was approved by the joint Institute of Psychiatry and South London NHS ethics committee. All participants and their parents provided written informed consent and were free to withdraw from the study at will.

2.1. Participants

Table 1 shows clinical and demographic data. Adolescents (10–18 years old) with behavioural problems were recruited via an advertisement in the local newspapers and special schools around south London. Twenty males, that met criteria for conduct disorder according to the Children's Interview for Psychiatric Symptoms (*ChIPS*; Weller, Weller, Fristad, & Teare Rooney, 1999; conducted by nonclinical researchers, AS, SS) were included in this study. The *ChIPS* interviews are based on DSM-IV criteria for 12 child and adolescent psychiatric disorders. For the purposes of the present study appropriate sections were administered to participants

Table 1
Age, education, *DASS*, *APSD* and substance use for each group.

		CD (n = 20) Mean (sd)	Controls (n = 30) Mean (sd)	ADHD (n = 27) Mean (sd)
Age		14.05 (1.70)	13.90 (1.87)	14.13 (1.87)
Education		8.35 (2.28)	8.57 (1.87)	8.67 (1.94)
Depression		4.14 (4.62)	0.97 (1.71)	3.83 (4.25)
Anxiety		3.36 (2.69)	0.50 (0.90)	2.35 (2.66)
Stress		5.81 (3.91)	1.43 (1.96)	5.17 (4.59)
Spot score		37.30 (6.79)	41.40 (7.49)	41.56 (6.41)
CU traits[a]		57.33 (9.57)	–	
Narcissistic traits[a]		58.00 (10.39)	–	
Impulsivity[a]		58.11 (8.25)	–	
Total *APSD* score[a]		60.61 (10.02)	–	
Handedness	% Left	20	12.9	14.3
	% Right	80	87.1	85.7
Alcohol use	% Missing	10	–	14.3
	% No	80	100	78.6
	% Yes	10	–	7.1
Marijuana use	% Missing	10	–	–
	% No	75	100	85.7
	% Yes	15	–	14.3
Tobacco use	% Missing	10	–	14.3
	% No	60	100	82.1
	% Yes	30	–	3.6
Other drug use	% Missing	10	–	14.3
	% No	90	100	85.7

CD = Conduct Disorder; ADHD = Attention deficit hyperactivity; *APSD* = *Antisocial Process Screening Device*; *DASS* = *Depression Anxiety Stress Scale*; CU = callous-unemotional traits; sd = standard deviation; education = years of schooling. NB. *APSD* data for controls were not available at the time of writing.

[a] n = 15.