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Evidence for substantial genetic risk for psychopathy in 7-year-olds

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Background: Individuals with early warning signs of life-long psychopathy, callous-unemotional traits (CU) and high levels of antisocial behaviour (AB) can be identified in childhood. We report here the first twin study of high levels of psychopathic tendencies in young children. **Methods:** At the end of the first school year, teachers provided ratings of CU and AB for 3687 twin pairs from the Twins Early Development Study (TEDS). For the analyses of extreme CU, we selected same-sex twin pairs where at least one twin scored 1.3 or more standard deviations above the mean on the CU scale (612 probands, 459 twin pairs). For the analysis of extreme AB, we selected same-sex twin pairs where at least one twin scored 1.3 or more standard deviations above the mean on AB scale (444 probands, 364 twin pairs). Furthermore, the extreme AB sample was divided into those who were also extreme on CU (children with psychopathic tendencies; 234 probands, 187 twin pairs) and those who did not score in the extreme for CU (children without psychopathic tendencies; 210 probands, 177 twin pairs). **Results:** DeFries–Fulker extremes analysis indicated that exhibiting high levels of CU is under strong genetic influence. Furthermore, separating children with AB into those with high and low levels of CU showed striking results: AB in children with high levels of CU is under extremely strong genetic influence and no influence of shared environment, whereas AB in children with low levels of CU shows moderate genetic and shared environmental influence. **Conclusions:** The remarkably high heritability for CU, and for AB children with CU, suggests that molecular genetic research on antisocial behaviour should focus on the CU core of psychopathy. Our findings also raise questions for public policy on interventions for antisocial behaviour. **Keywords:** Callous-unemotional traits, genetics, antisocial behaviour. **Abbreviations:** CU: callous-unemotional traits; AB: antisocial behaviour; SDQ: Strengths and Difficulties Questionnaire.

'Mark does not feel guilty if he has done something wrong, he does not show feelings or emotions, and he is rarely helpful if someone is hurt.' This description of one of the 7-year-old children (name changed) in our twin study captures the core emotional impairment of individuals with psychopathy. Psychopathy in both childhood (psychopathic tendencies) and adulthood involves both affective-interpersonal impairment (callous-unemotional traits; e.g., lack of empathy, lack of guilt, shallow emotions) and overt antisocial behaviour (Blair, 2001). As such, individuals with psychopathy represent a subset of those who would meet diagnostic criteria for Conduct Disorder (CD) in childhood or Antisocial Personality Disorder (APD) in adulthood (Blair, 2001). Diagnostic criteria for these childhood and adulthood manifestations of antisocial behaviour include overt antisocial acts (such as violence towards other people or stealing), but do not distinguish subgroups of antisocial individuals on the basis of their callous-unemotional profile (DSM-IV, APA, 1994; Hart & Hare, 1997). Most adults diagnosed with APD do not fulfil the diagnostic criteria for psychopathy, as they lack the concomitant callous-unemotional features (Hart & Hare, 1997). Equally, not all children who have CD also display callous-unemotional traits (CU).

Children who show antisocial behaviour from early childhood are at great risk for showing antisocial and criminal behaviour in adulthood, a pattern known as life-course persistent antisocial behaviour (Moffitt, 2003). Such individuals can be 10 times more costly to the society than the average citizen (Scott, Knapp, Henderson, & Maughan, 2001). It is important to learn about risk factors that predict persistent antisocial behaviour early in life. Callous-unemotional traits may be one such risk factor that makes children vulnerable for life-course persistent antisocial behaviour of a particularly serious nature (Frick & Hare, 2001; Frick, 1998). Indeed, antisocial individuals who present with the affective core of callous-unemotional traits (individuals with psychopathy) start offending at a young age and continue across the lifespan with acts that are often predatory in nature (Hart & Hare, 1997). The predatory nature of their crimes reflects the lack of empathy (CU personality core) of psychopaths. A recent study found that psychopathic murderers were highly likely to have committed premeditated murder, whereas this was not the case for non-psychopathic murderers, whose offence was often a result of a heated dispute or a 'crime of passion' (Woodworth & Porter, 2002). Even when residing in a correctional

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institution, individuals with psychopathy are six times as likely to offend as their convicted peers (Wong, 1985).

Mirroring the findings on adults, children with psychopathic tendencies have a greater number and variety of conduct problems and are also more likely to come into contact with the police than children with conduct problems who do not have elevated CU scores (Christian, Frick, Hill, Taylor, & Frazer, 1997). Children with psychopathic tendencies are also less distressed about their behavioural problems than other children with extreme externalising pathology, suggesting that psychopathic personality traits moderate the level of distress experienced by the perpetrator (Barry et al., 2000), presumably facilitating persistent antisocial conduct seen in these individuals.

Given the early emergence of antisocial behaviour in individuals with psychopathy and its long-term impact – even as compared with other antisocial individuals – it is important to understand the heritable and environmental origins of the callous-unemotional traits, and their function as a risk factor for early emerging antisocial behaviour (itself a risk marker for life-course persistent antisocial behaviour). Broadening this understanding will inform future research, as well as design of prevention and treatment programmes.

Genetically sensitive study designs, such as twin studies, can provide a much-needed perspective on the developmental origins of callous-unemotional traits and on heterogeneity within individuals with antisocial behaviour. Genetic research on antisocial behaviour has generally found that both early-onset and persistent antisocial behaviour show moderate to substantial genetic influence, as well as moderate shared and non-shared environmental influences (Moffitt, 2003). However, none of the studies to date have investigated whether the aetiology of extreme antisocial behaviour differs between those individuals with CU (or individuals with psychopathy/psychopathic tendencies) and those without CU (individuals lacking psychopathy/psychopathic tendencies). It is particularly important to investigate this question in children because preventative efforts early in life are likely to be most successful in combating life-course persistent antisocial behaviour.

The Twins Early Development Study, a birth-record-based representative sample of twins born in the UK 1994–96 (Trouton, Spinath, & Plomin, 2002), includes teacher assessments of CU as well as AB for 3487 pairs of twins at 7 years of age. We used the twin method to investigate the extent to which extreme callous-unemotional traits are heritable at this early age and to consider the extent to which callous-unemotional traits distinguish aetiologically different groups of children with antisocial behaviour (i.e., antisocial children with and without psychopathic tendencies).

Method

Participants

The sampling frame for the present study was 7374 twins from the 1994 and 1995 birth cohorts of the Twins Early Development Study (TEDS). The average age of the participants at the time of assessment was 7.1 years (SD = .23 years). The sample and its history are described in detail elsewhere (Trouton, Spinath, & Plomin, 2002).

For the analyses of extreme CU, we selected same-sex twin pairs where at least one twin scored 1.31 or more standard deviations above the mean on CU scale (612 probands, 459 twin pairs). For the analysis of extreme AB we selected same-sex twin pairs where at least one twin scored 1.28 or more standard deviations above the mean on AB scale (444 probands, 364 twin pairs). This cut-off score was closest to the cut-off score on the CU scale. This selection procedure guaranteed that the probands would score beyond the 'average range' (i.e., not within one SD), yet yielded enough probands to perform the twin analyses. Furthermore, the selection conferred approximately the top 10% of the sample for both CU and AB. This is the percentage band which is designated as 'abnormal' for AB according to the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997).

The extreme AB sample was further divided into those who were also extreme on CU (children with psychopathic tendencies; 234probands, 187 twin pairs) and those who did not score in the extreme for CU (children without psychopathic tendencies; 210 probands, 177 twin pairs). Maternal educational level was not significantly different for the two groups of children with extreme antisocial behaviour.

Testing procedures

Informed, written consent was obtained from all of the families who agreed to take part in the study. Teachers were approached only if there was family consent to teacher involvement.

Measures

Teachers provided ratings of CU and AB. The response rate of teachers was high: 88% of the approached teachers responded by filling in the TEDS assessment. Teachers are familiar with a broad range of children and have expertise regarding normative child development. Teacher ratings have been found to show higher internal consistency and stability than parent ratings (Gomez, Harvey, Quick, Scharer, & Harris, 1999), and twin analyses indicate that teacher ratings are free of rater bias typically found in parent ratings (Nadder, Silberg, Rutter, Maes, & Eaves, 2001). In line with this, we found that while teacher ratings for CU and AB showed good internal consistency (see below), indicating reliable detection of the latent constructs of interest, parent ratings of CU and AB showed much poorer levels of internal consistency ($\alpha = .45$ and $\alpha = .58$ for the CU and AB scales respectively). In addition, parent ratings correlated even less than usual with teacher ratings ($r = .20$ and .27 for the CU and AB scales, respectively). Finally, the means and variances for the CU scale were

lower for parents than teachers, indicating that parents did not discriminate children high in CU. These problems with the parent rating scales led us to focus on the teacher ratings.

Although CU was not assessed directly in TEDS, we were able to create a novel CU scale by using 7 items available in TEDS: three Antisocial Process Screening Device (Frick & Hare, 2001) items, as well as four items from the SDQ. These items were either original CU items ('Does not show feelings or emotions', 'Feels bad or guilty if he/she does something wrong' [reverse scored], 'Is concerned about how well he/she does at school' [reverse scored]) or were selected to reflect CU (e.g., Considerate of other people's feelings [reverse scored]). None of the items overlapped with any of the AB items (see Table 1 for the complete list of items on both scales).

Teacher ratings on the CU scale showed good internal consistency ($\alpha = .74$). Our AB scale was the SDQ 5-item scale used to assess conduct problems (e.g., 'Often fights with other children or bullies them', 'Often has temper tantrums or hot tempers'). The SDQ scales have both good reliability and validity (Goodman, 1997), and the teacher ratings on the AB scale showed good internal consistency in the TEDS sample ($\alpha = .71$). The scale scores on CU and AB were converted to *z*-scores to facilitate comparison between the two scales. The two scale scores correlated .51, indicating that, although there was overlapping variance, the scales were not measuring an identical construct.

Analyses

For same-sex twin pairs, the estimates of group heritability and group shared environment were calculated using the DF extremes analysis regression model (DeFries & Fulker, 1988), which is illustrated in Figure 1. The basic DF model is represented as the regression, $C = B_1P + B_2R + A$, in which the co-twin's score (C) is predicted from the proband's score (P) and the coefficient of relatedness (R), which is 1.0 for MZ and .5 for DZ pairs. Proband means for both MZ and DZ probands are transformed to 1.0 and the population mean is transformed to 0. The regression weight B_2 estimates group differences heritability; it compares the MZ and DZ co-twin means taking into account genetic relatedness (R). Group heritability (h^2g) can be interpreted as the extent to which the average difference between the probands and the population on the quantitative trait measure can be ascribed to genetic influences. Group shared environmental influence (c^2g), twin resemblance not explained by genetic factors, is estimated by subtracting group differences heritability from MZ group differences familiality (the transformed MZ co-twin mean). Group non-shared environmental influence (e^2g) is estimated by subtracting h^2g and c^2g from 1. Analyses were conducted using a double-entered dataset such that both members of a twin pair could be selected as probands. Standard errors were corrected in order to take into account the artificial inflation of sample size (Stevenson, Pennington, Gilger, DeFries, & Gillis, 1993).

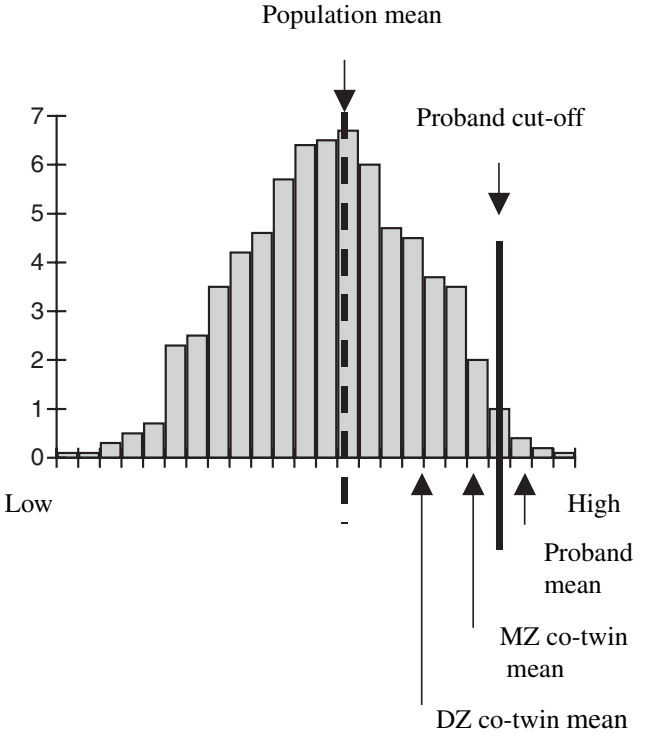

Figure 1 DF extremes analysis examines the extent to which the mean quantitative score of the co-twins of the probands (i.e., those individuals with a score above a cut-off) regresses back to the population mean. To the extent that extreme group membership is genetically influenced, the co-twins of monozygotic (MZ) probands should regress less towards population mean (i.e., look more similar to the probands) than the co-twins of dizygotic (DZ) probands. The figure displays a hypothetical example

Results

Table 2 shows the mean *z*-scores for CU and AB scales for probands with extreme CU and probands

Table 1 Scales assessing callous-unemotional traits and antisocial behaviour. R = Reverse scored

Callous-Unemotional scale	Antisocial Behaviour scale
1. Does not show feelings or emotions	1. Often has temper tantrums or hot tempers
2. Helpful if someone is hurt, upset or feeling ill (R)	2. Generally obedient, usually does what adults request (R)
3. Feels bad or guilty when he/she does something wrong (R)	3. Often fights with other children or bullies them
4. Has at least one good friend (R)	4. Often lies or cheats
5. Considerate of other people's feelings (R)	5. Steals from home, school or elsewhere
6. Kind to younger children (R)	
7. Is concerned about how well he/she does at school (R)	

with extreme AB (divided into two groups, those with and without concomitant extreme CU scores). We first conducted DF analyses selecting same-sex twins assessed by their teachers as extreme on callous-unemotional traits. As indicated by the co-twin means in Table 2a, co-twins of MZ extreme CU probands were 73% similar to the probands, whereas co-twins of DZ probands were only 39% similar. Doubling the difference in these co-twin means, which can be considered as twin 'group' correlations, yields an estimate of .68 for group heritability. This estimate of group heritability (.68) is nearly as great as the MZ twin group correlation (.73), suggesting that group shared environment is minimal (.73–.68 = .05). DF extremes analysis confirms these findings, yielding minimal estimates of group shared environmental influence ($c_g^2 = .06$) and high group heritability ($h_g^2 = .67$). In other words, two-thirds of the difference between the extreme callous-unemotional children and the population can be explained genetically.

We then examined whether the aetiology of extreme AB, a concomitant feature of psychopathic syndrome, is different for children with and without psychopathic tendencies as indexed by extreme CU. As shown in Table 2b, for the psychopathic tendencies antisocial group (AB/CU+), DF regression analysis yielded a group heritability estimate of .81 and no shared environmental influence for extreme AB. Shown in Table 2c, for antisocial children without psychopathic tendencies (AB/CU–), we found modest group heritability ($h_g^2 = .30$) and moderate shared environmental ($C_g^2 = .34$) influence. Although the difference in heritabilities for the (AB/CU+) (.81) and (AB/CU–) (.30) groups was large, their overlapping confidence intervals indicate that the difference is not statistically significant. The results replicated when twin pairs were rated by the same teachers (2/3 of the sample) and by different teachers (1/3 sample) were analysed separately. This was done to ascertain that having a common rater does not introduce bias to heritability and environmental estimates. The result, also replicated at 5% and 15% severity cut-offs (results available from EV).

Because probands in the AB/CU+ (psychopathic tendencies) group had a higher mean AB score than probands in the AB/CU– (without psychopathic tendencies) group (see Table 2b and 2c), it is possible that this difference is responsible for the difference in group heritability between the two groups. For this reason, we assessed the heritability of AB at different severity cut-offs without regard to psychopathy status. The heritability estimates for AB did not vary as a function of severity of AB (results available from EV). This indicates that the high heritability of AB seen in the AB/CU+ group is not mediated by mean levels of AB and is thus more likely to be mediated by the CU traits.

Discussion

Our results indicate that exhibiting high levels of callous-unemotional traits (CU) at 7 years, as assessed by teachers at the end of the first year of school, is under strong genetic influence. Minimal shared environmental influences on callous-unemotional traits were detected, suggesting that at the age of 7, environmental factors common to both members of the twin pair (such as socio-economic status, school and neighbourhood) do not account for extreme CU. Moreover, antisocial behaviour (AB)

Table 2 Heritability of psychopathy. a) DF extremes analysis for callous-unemotional personality traits (CU), the core component of psychopathy. b) DF extremes analysis for antisocial behaviour (AB) in children with psychopathic tendencies (extreme CU + extreme AB). c) DF extremes analysis for AB in children without psychopathic tendencies (extreme AB without extreme CU). Note that all children in the second (b) set of analyses were part of the analysis for extreme callous-unemotional traits. The Proband standardised mean represents the average proband deviation from the population mean on the trait. The cut-off *z*-score assigning proband status was 1.31 for callous-unemotional traits (13% of the sample) and 1.28 for antisocial behaviour (10% of the sample). The transformed co-twin mean is the ratio of the co-twin mean to the proband mean and can be interpreted as a twin group correlation. h2g is group heritability and c2g is group shared environment, which are estimated from the MZ and DZ transformed co-twin means. 95% confidence intervals are reported

	Proband standardised mean (SD)	Co-twin standardised mean (SD)	Transformed co-twin mean	h^2g	c^2g
a) Extreme callous-unemotional MZ twins ($N = 612$)					
MZ twins	1.79 (.56)	1.30 (.96)	.73	.67 (.47–.87)	.06 (–.23–.35)
DZ twins	1.80 (.57)	.71 (1.05)	.39		
b) Extreme antisocial behaviour in children with psychopathic tendencies ($N = 234$)					
MZ twins	2.82 (1.13)	2.15 (1.52)	.76	.81 (.50–1.12)	–.05 (.00–.72)
DZ twins	2.81 (1.26)	1.00 (1.72)	.36		
c) Extreme antisocial behaviour in children without psychopathic tendencies ($N = 210$)					
MZ twins	2.02 (.62)	1.29 (1.24)	.64	.30 (–.10–.70)	.34 (–.40–1.08)
DZ twins	2.15 (.88)	1.05 (1.66)	.49		

We assessed heritability of antisocial behaviour at different severity cut-offs without regard to psychopathic tendencies status (results available from EV). The heritability estimates for antisocial behaviour did not vary as a function of severity. This indicates that the higher heritability of antisocial behaviour in the group with psychopathic tendencies was not merely a consequence of slightly higher-mean-level antisocial behaviour seen in this group.

for children who are high on CU (i.e., children with psychopathic tendencies) is highly heritable. In contrast, the extreme AB of those without psychopathic traits was under strong environmental influence – shared as well as non-shared.

Before discussing the implications of our findings, some general limitations of the study should be mentioned. First of all, the twin data may not be generalisable to singletons. We are currently collecting CU and AB information on the younger siblings of our twins and will be able to repeat our analysis with that sample in the future. Another possible limitation is that our CU scale was not a standard instrument. However, it is worth noting that teacher ratings on this scale showed good internal consistency and distinguished an aetiologically distinct group of children with early-onset antisocial behaviour. Relying on a single source of measurement could also be considered to be a limitation of our study. Given that CU was used as a moderator for dividing our group of children with extreme levels of antisocial behaviour, we were concerned that the CU measure should show good internal consistency, indicating reliable measurement of a latent construct. As the parent ratings of CU did not show good internal consistency, it seemed dubious to use parent ratings of this trait to divide children into subgroups for the purposes of our analyses. Finally, it could be argued that collection of data at a single age and using questionnaire measurement only is a limitation. We are currently following up the twins at nine years of age and will thus be able to add a longitudinal aspect in the future. Furthermore, we are collecting cognitive data at nine, to add endophenotype measurement to the questionnaire information. Regardless of these possible limitations, we think that our present findings have important implications as discussed below.

Although it should be emphasised that not all children with the combination of callous-unemotional traits and antisocial behaviour will become psychopathic criminals as adults, our findings have clear implications for research, treatment, and public policy. With regard to research, it will be important to document how developmental trajectories differ for antisocial children with and without CU. In contrast, children who commence their antisocial behaviour prior to puberty are currently often treated as a single group, without differentiating them on the basis of those traits. Whether presence or absence of CU has long-term implications for crime is a matter for empirical enquiry – although current retrospective data suggests that it does (Hart & Hare, 1997). In addition, the remarkably high heritability for CU and for AB in children with CU suggests that molecular genetic research on antisocial behaviour should focus on the callous-unemotional core of psychopathy. Finally, combining neuroscience and genetic methodologies should be at the forefront of future research on psychopathy (Viding, in press). Current research implicates emotion-related dysfunction in the amygdala and orbitofrontal cortex (both important for emotion processing) as possible brain correlates of adult psychopathy (Abbott, 2001; Blair, 2001, 2003). Preliminary neuropsychological evidence suggests that similar brain dysfunction is also found in children with psychopathic tendencies (Blair, 2001; Viding, in press). This dysfunction might be related to genetic vulnerability. When genes are found that are associated with psychopathy/psychopathic tendencies or with brain circuits, brain scans of groups selected on the basis of genotype will shed light on 'genes–brain–behaviour' pathways in psychopathy.

This approach is also likely to inform treatment options. Better understanding of how genetic vulnerability translates into brain function will contribute to both pharmacological and environmental interventions. This gives hope that psychopathy can be treated as successfully as are other emotional disorders, such as Generalised Anxiety Disorder or Depression. A more immediate clinical implication of the present results is the confirmation of the importance of focusing on CU as well as AB in diagnosis and prevention/treatment efforts (Frick & Hare, 2001).

Finally, with regard to public policy, these results confirm the notion that prevention efforts need to begin in the preschool years. As the large genetic component to psychopathic antisocial behaviour is likely to reflect not only the direct effects of genes, but also gene–environment interaction (Moffitt, 2003), preventative efforts for psychopathy will benefit from developmental investigations of this interaction using measured genes and environments. Finding a large shared and non-shared environmental influence on the AB of children without psychopathic tendencies suggests that this subgroup of children with early onset AB is probably amenable to traditional interventions aimed at improving family, school and neighbourhood conditions. Consideration of the aetiological differences between children with early onset AB will thus assist in evaluation of true effectiveness of prevention and treatment programmes, as well as give pointers to the steps needed for devising more effective and targeted future prevention and treatment efforts.

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