Small, but not perfectly formed: decreased white matter concentration in boys with psychopathic tendencies

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Neuroimaging studies on adult psychopaths have shown white matter abnormalities in fronto-temporal neural circuitry critical for emotional processing, but it is not known if children who show psychopathic tendencies exhibit white matter abnormalities.
In this study, we found that boys with psychopathic tendencies showed decreased white matter concentration (WMC) compared with typically developing boys. This finding suggests that psychopathic traits are characterized by atypical white matter even in childhood, possibly as a result of aberrant brain maturation.

Psychopathy, a personality disorder defined by a constellation of affective, interpersonal and behavioural features, is associated with severe and persistent antisocial behaviour that emerges early in life.[1] Brain imaging work on adult populations suggests that psychopathy is characterized by structural and functional brain abnormalities in frontotemporal neural circuitry implicated in emotional processing and moral reasoning.[2] Theoretical models of psychopathy suggest that it is a neurodevelopmental disorder.[2,3] Consistent with this hypothesis, we have recently found that boys with psychopathic tendencies (conduct problems coupled with callousunemotional traits), compared with typically developing boys, had increased grey matter concentration (GMC), possibly indicative of aberrant brain maturation.[4] Using the same sample, we report here the results of the first structural magnetic resonance imaging study examining white matter integrity in boys with psychopathic tendencies. A few studies of adult psychopaths have reported white matter abnormalities in the fronto-temporal areas in this population (Tiihonen et al.[5]; Craig et al.[6]). On the basis of longitudinal evidence of normal brain development showing a linear increase in white matter from childhood to adulthood,[7] and in line with possible

aberrant brain maturation in boys with psychopathic tendencies,[4] we expected this group to show decreased WMC, as compared with the typically developing boys. We did not make specific predictions regarding the loci of these differences, although we expected some of the group differences to be located in brain areas where we had previously reported differences in GMC.[4]

The 48 participants were 10- to 13-year old (M = 11 years 7 months, s.d. = 0.8) boys; 23 with psychopathic tendencies and 25 typically developing boys for whom structural brain images were acquired using a General Electric Signa 3.0 Telsa Excite II MRI scanner (Milwaukee, WI, USA; voxel size = 1mm, TR/TE/TI = 8/2.9/450 ms; excitation flip angle = 201). Data were processed using SPM5 (http:// www.fil.ion.ucl.ac.uk/spm/software/spm5) (see De Brito et al.[4]). Consistent with our previous work, between-group differences in WMC were then assessed using analysis of covariance with global white matter, cognitive ability and hyperactivity–inattention symptoms as covariates of no interest. Results for the whole-brain analysis were considered significant at the threshold of $P < 0.001$, uncorrected for multiple comparisons, using an extent threshold of 100 contiguous voxels (see Brito et al.[4]).

Compared with typically developing boys, those with psychopathic tendencies showed decreased WMC in a subset of the brain areas where we had previously reported increased GMC for boys with psychopathic tendencies, including the right superior frontal lobe (subgyral), right dorsal anterior cingulated (limbic lobe), right superior temporal gyrus and left precuneus (Figure 1; Supplementary Results) Surprisingly, boys with psychopathic tendencies also showed increased WMC bilaterally in one region, the middle frontal gyrus; note that no GMC differences were found in this area in our earlier study.[4] We also found a significant group by age interaction in the superior frontal lobe ($x = 18$, $y = 15$, $z = 46$; $b =\_0.36$, $P = 0.021$); typically developing boys showed the expected pattern of age-related WMC increase, whereas among boys with psychopathic tendencies WMC decreased with age (Figure 1e). These findings indicate that boys with psychopathic tendencies show anomalous patterns of WMC.

This is consistent with the view that psychopathy is characterized by atypical neural structure and function before adulthood, possibly as a result of aberrant brain maturation.[4] One strength of this study is that at this age group the results are unlikely to be confounded by prolonged substance misuse. Recent brain imaging evidence in normative samples indicates that white matter increases from childhood to adulthood in a linear manner throughout the brain,[7] which is contrary to what we observed for the boys with psychopathic tendencies in the right superior frontal lobe. To the best of our knowledge, this is the first evidence of white matter differences in children with psychopathic tendencies.

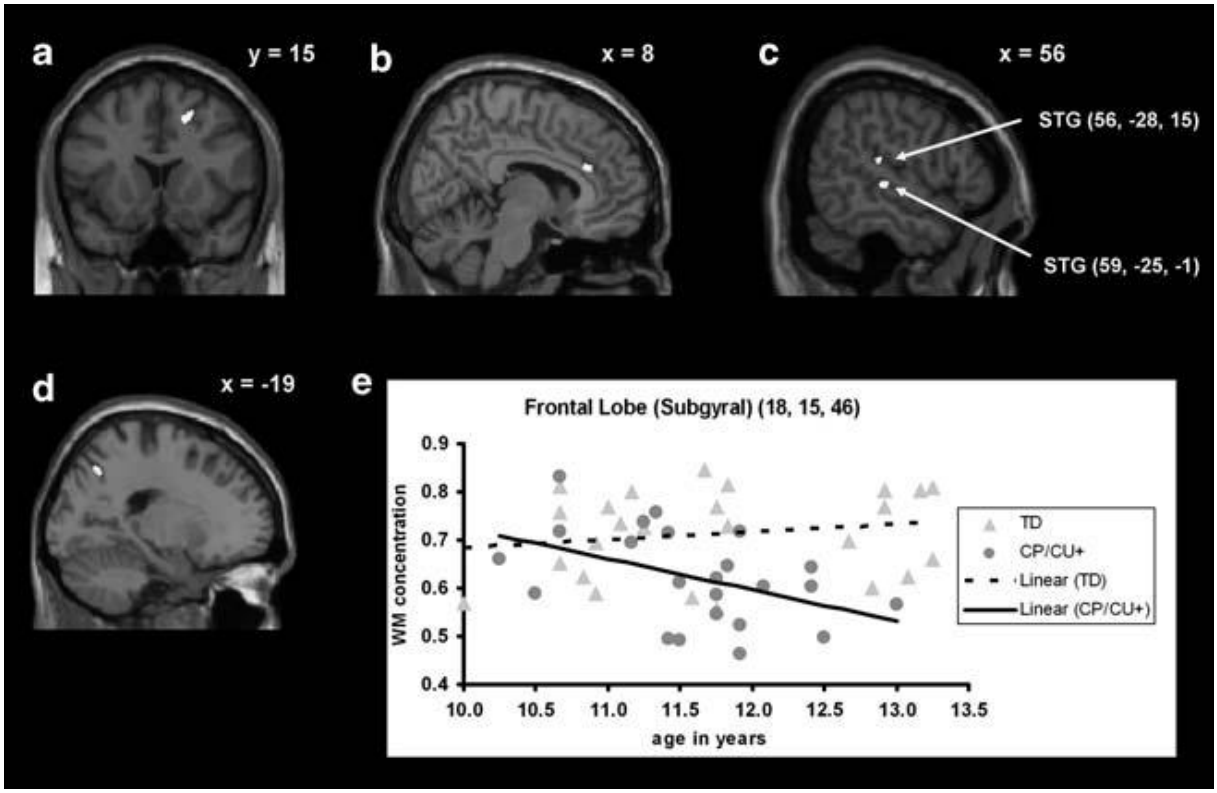

Figure 1

Loci of significant decreases in white matter concentration among boys with psychopathic tendencies (n = 23) relative to typically developing boys (n = 25) in (a) the right superior frontal lobe (18, 15, 46; 282 voxels, Z= 4.00, P < 0.001); (b) right dorsal anterior cingulate (8, 31, 22; 204 voxels, Z= 3.77, P < 0.001); (c) right superior temporal gyrus (59, _25, _1; 214 voxels, Z= 3.74, P < 0.001 and 56, _28, 15; 121 voxels, Z= 3.55, P < 0.001) and (d) left precuneus (_19, _65, 45; 103 voxels, Z= 3.53, P < 0.001). (e) Scatter plots showing for the typically developing boys and the boys with psychopathic tendencies the association between age and white matter concentration in the right superior frontal lobe (18, 15, 46). Anatomical label: STG, superior temporal gyrus.

Conflict of interest

The authors declare no conflict of interest.

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Supplementary Information accompanies the paper on the Molecular Psychiatry website (http://www.nature.com/mp)