Growth Charting of Brain Connectivity Networks and the Identification of Attention Impairment in Youth.

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Abstract

IMPORTANCE:
Intrinsic connectivity networks (ICNs), important units of brain functional organization, demonstrate substantial maturation during youth. In addition, interrelationships between ICNs have been reliably implicated in attention performance. It is unknown whether alterations in ICN maturational profiles can reliably detect impaired attention functioning in youth.

OBJECTIVE:
To use a network growth charting approach to investigate the association between alterations in ICN maturation and attention performance.

DESIGN, SETTING, AND PARTICIPANTS:
Data were obtained from the publicly available Philadelphia Neurodevelopmental Cohort, a prospective, population-based sample of 9498 youths who underwent genomic testing, neurocognitive assessment, and neuroimaging. Data collection was conducted at an academic and children's hospital health care network between November 1, 2009, and November 30, 2011, and data analysis was conducted between February 1, 2015, and January 15, 2016.

MAIN OUTCOMES AND MEASURES:
Statistical associations between deviations from normative network growth were assessed as well as 2 main outcome measures: accuracy during the Penn Continuous Performance Test and diagnosis with attention-deficit/hyperactivity disorder.

RESULTS:
Of the 9498 individuals identified, 1000 youths aged 8 to 22 years underwent brain imaging. A sample of 519 youths who met quality control criteria entered analysis, of whom 25 (4.8%) met criteria for attention-deficit/hyperactivity disorder. The mean (SD) age of the youth was 15.7 (3.1) years, and 223 (43.0%) were male. Participants’ patterns of deviations from normative maturational trajectories were indicative of sustained attention functioning ($R^2 = 24\%$; $F_6,512 = 26.89\%; P < 2.2 \times 10^{-16}$). Moreover, these patterns were found to be a reliable biomarker of severe attention impairment (peak receiver operating characteristic curve measured by area under the curve, 79.3%). In particular, a down-shifted pattern of ICN maturation (shallow maturation), rather than a right-shifted pattern (lagged maturation), was implicated in reduced attention performance (Akaike information criterion relative likelihood, $3.22 \times 10^{26}$). Finally, parallel associations between ICN dysmuration and diagnosis of attention-deficit/hyperactivity disorder were identified.

CONCLUSIONS AND RELEVANCE:
Growth charting methods are widely used to assess the development of physical or other biometric characteristics, such as weight and head circumference. To date, this is the first demonstration that this method can be extended to development of functional brain networks to identify clinically relevant conditions, such as dysfunction of sustained attention.