



UNIVERSITY OF GOTHENBURG

This is an author produced version of a paper published in **Comprehensive psychiatry**

This paper has been peer-reviewed but does not include the final publisher proof-corrections or journal pagination.

Citation for the published paper:

Kerekes N, Brändström S, Lundström S, Råstam M, Nilsson T, Anckarsäter H.

ADHD, autism spectrum disorder, temperament, and character: phenotypical associations and etiology in a Swedish childhood twin study.

Comprehensive psychiatry 2013 Nov;54 (8):1140-7.

<http://dx.doi.org/10.1016/j.comppsy.2013.05.009>

Access to the published version may require subscription. Published with permission from: **American Psychopathological Association**

GUP

Gothenburg University Publications

<http://gup.ub.gu.se>

Word count: Abstract: 268; Main text: 3662

References: 40, Tables: 2, Figures: 2

Running title: Personality & Neuropsychiatry

Comprehensive Psychiatry

**ADHD, Autism Spectrum Disorder, Temperament, and Character: Phenotypical
Associations and Etiology in a Swedish Childhood Twin Study**

Nóra Kerekes, PhD ^{1,3} Sven Brändström, PhD ¹ Sebastian Lundström, PhD ^{1,3,4} Maria Råstam,
MD, PhD ² Thomas Nilsson, PhD ¹ and Henrik Anckarsäter, MD, PhD ¹

¹ Centre for Ethics, Law and Mental Health (CELAM), University of Gothenburg, Sweden

² Institute of Clinical Sciences, Lund University, Sweden

³ Swedish Prison and Probation Services, R&D Unit, Gothenburg, Sweden

⁴ Gillberg Neuropsychiatry Centre, Institution of Neuroscience and Physiology, University of
Gothenburg, Sweden

Corresponding author:

Nóra Kerekes, PhD

CELAM, University of Gothenburg,

Wallinsgatan 8, 43141 Mölndal, Sweden

Email address: nora.kerekes@neuro.gu.se

Acknowledgments

Eva Carlström and Camilla Palm provided professional assistance with data management, Åse Holl with secretarial duties, and Amanda Hicks with language correction. Data was retrieved from the ongoing Child and Adolescent Twin Study in Sweden (CATSS) with the kind permission of Professor Paul Lichtenstein.

Funding

The CATSS-9/12-study is supported by the Swedish Council for Working Life and Social Research and the Swedish Research Council (Medicine).

Abstract

Objective: To explore the links between neurodevelopmental disorders—attention deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD)—and personality in a population-based, genetically sensitive study of children.

Method: A population-based sample of 1886 twins aged 9 and 12, enriched for childhood mental health problems, was recruited from the Child and Adolescent Twin Study in Sweden (CATSS). Parents were interviewed over the telephone using the Autism–Tics, AD/HD and other Comorbidities (A-TAC) inventory, and in a second step they rated their children according to the Junior Temperament and Character Inventory (JTICI).

Results: ADHD was strongly correlated with novelty seeking, while ASD was correlated positively with harm avoidance and negatively with reward dependence. The strongest associations between personality traits and neurodevelopmental disorders were negative correlations between the character dimensions of self-directedness and cooperativeness and ADHD and ASD alike. Cross-twin cross-trait correlations between ADHD, ASD, and personality dimensions in monozygotic twins were more than double those in dizygotic twins, indicating a strong genetic effect behind the phenotypic covariation between neurodevelopmental disorders and personality.

Conclusions: Neurodevelopmental disorders are linked specifically to particular temperament profiles and generally to hampered development of the self-governing strategies referred to as “character.” Poor self-agency and cooperation may be core functional outcomes in the separation of children with handicapping conditions from those with traits only reminiscent of neurodevelopmental disorders. The associations between neurodevelopmental disorders and personality are at least partly due to genetic effects influencing both conditions. As a consequence, personality must be broadly considered in neuropsychiatry, just as

neuropsychiatric disorders and their genetic, neurodevelopmental, and cognitive susceptibilities have to be in personality research and clinical treatment.

Key words: neuropsychiatry, child and adolescent psychiatry, personality, Junior Temperament and Character Inventory (JTCI), Autism—Tics, AD/HD and other Comorbidities Inventory (A-TAC)

INTRODUCTION

Attention deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD) are childhood-onset neurodevelopmental disorders, stemming from aberrant brain development affecting specific cognitive or social abilities (1). Deficient executive control of attention, activity, and emotional regulation have been proposed as key cognitive mechanisms behind the ADHD phenotype (2), while deficits in the cognitive–emotional integration of social interaction (empathy), communication skills, and flexibility form the core of ASD (3). The notion that ADHD and ASD are related to deviant neurodevelopment is supported by evidence of strong, partially overlapping, genetic influences (4), an increased prevalence of ASD and ADHD in children with medical disorders affecting brain development (e.g., fetal alcohol syndrome, cerebral palsy, and chromosomal disorders), overrepresentation of neurological symptoms (such as epilepsy and motor dyscoordination) in children with neurodevelopmental disorders, and the fact that both conditions are more common in boys than in girls, (1)). In fully developed clinical forms, ADHD affects about 5% of all children (5), and ASD about 1% (6). Broader phenotypes or sub-threshold conditions were first reported for autism in systematic family studies (7), while recent population studies and twin analyses support the notion that the same genetic effects are involved in both narrow and broad definitions of the conditions (8, 9).

The conceptualization of ADHD and ASD as persistent alterations of mental functions with early childhood onset points to analogies with personality disorders and personality traits. In adults, ADHD has been associated with the Cluster B “dramatic” personality disorders, especially borderline personality disorder (BPD) (10-12) and antisocial personality disorder (APD) (13, 14). In children and adolescents, clinical descriptions of ADHD include traits analogous to those in BPD and APD, such as antisocial attitudes towards others,

impulsiveness, and emotional dysregulation (1). In contrast, ASD has been linked to the “withdrawn” Cluster A disorders, such as schizoid personality disorder (15), and to traits implying avoidance and rigidity (3). Systematic assessments of all types of personality disorders in adults diagnosed with ASD and/or ADHD show less clear-cut patterns that involve all three clusters of personality disorders, often in the form of several overlapping diagnoses (16).

Cloninger’s biopsychosocial model, a dimensional assessment of personality, has been useful in studies of the relationship between personality and neurodevelopmental disorders (17). This model distinguishes between four dimensions of temperament and three of character. The former are defined as individual differences in basic emotional drives and patterns of reaction to stimuli, and the latter as individual differences in higher cognitive processes identifying a person’s style of mental self-government (17, 18). The temperament dimensions include novelty seeking (impulsive and irritable vs. rigid and stoical), harm avoidance (pessimistic and anxious vs. optimistic and risk-taking), reward dependence (sociable and warm vs. aloof and cold), and persistence (persevering and ambitious vs. easily discouraged and lazy). The character dimensions are defined as self-directedness (responsible and resourceful vs. blaming and inept), cooperativeness (helpful and principled vs. hostile and opportunistic), and self-transcendence (intuitive and insightful vs. concrete and conventional). The original theory suggested a substantial genetic influence on the temperament dimensions, while culture and social learning were held to be more important to the character dimensions. Quantitative genetic studies have since shown a more complex picture, and the impact of genetics seems to be at least equally important in the development of the character dimensions as in dimensions of temperament (19, 20).

In studies of children with ADHD, novelty seeking has been high and persistence low, combined with immature character (low self-directedness and cooperativeness) (21-23) and, in some studies, with low reward dependence (21, 23). High novelty seeking in ADHD has been linked specifically to impulsivity/hyperactivity rather than to problems with inattention (24). Similar patterns of personality traits have been found in adults diagnosed with ADHD (16, 25). Adults with ASD have also shown very low self-directedness and cooperativeness, but with a different temperament profile, including high harm avoidance and, at least in the absence of coexisting substance-use disorders, low novelty seeking and reward dependence (16, 25). The finding of character immaturity in both disorders is consistent with the model in which the *presence* of a personality disorder is indicated by very low self-directedness and cooperativeness (defined on average as equal to or less than 2 standard deviations below average), while the *type* of disorder is indicated by the temperament configuration (26). This study aimed to assess in a twin child population the previously described phenotypic associations between neurodevelopmental disorders and personality traits. The specific aims of this paper were

- (1) to test whether the previously reported temperament and character profiles of ADHD (from studies on both children and adults) and ASD (in adults) could be replicated in a large, population-based study of children;
- 2) to assess whether the presence of immature character (low self-directedness and/or cooperativeness) reported in both ADHD and ASD depends on the severity of the neurodevelopmental disorder; and
- 3) to test whether phenotypic associations are due to common etiological factors acting on both neurodevelopmental disorders and personality.

METHODS

Subjects

Parents of all Swedish 9- and 12-year-old twins identified through the Swedish twin registry were contacted for telephone interviews that followed a strict construct of selected inventories on somatic and mental health, including the A-TAC inventory, as part of the Child and Adolescent Twin Study in Sweden (CATSS) (27). A follow-up questionnaire that tapped into more detailed information was sent both to parents of twins in whom at least one twin screened positive for ASD, ADHD, conduct disorder, oppositional defiant disorder, tics disorder, eating disorder, developmental coordination disorder, or learning disabilities (about 15% of the total population) and to parents of age- and sex-matched random control pairs, representing about 5% of the total population. This questionnaire study was piloted in the total population during the first months of the CATSS. The overall response rate was 80% for the telephone interview and 60% for the follow-up questionnaire. Data for the present paper was drawn from the database in January 2010, when telephone interviews and questionnaire data were available for 2032 children, including 1286 children from pairs with at least one screen-positive individual and 352 controls. Also included were 394 twins from the pilot study. Due to too many missing responses, 146 children were excluded from the present study. The final study population thus consisted of 1886 children with a close to equal distribution of genders and ages (59% were 9 years old, 41% were 12 years old; 55% were boys, and 45% were girls).

Zygoty was determined by a panel of 48 single nucleotide polymorphisms, or an algorithm based on twin similarity. Only twin pairs with > 95% probability of correct classification were assigned a zygoty, which yielded a total of 471 children from monozygoty pairs, 752 from same-sex dizygoty pairs, 612 from opposite-sex dizygoty pairs, and 51 with an unknown

zygosity, resulting in 234 complete monozygotic twin pairs and 363 same-sex dizygotic twin pairs for genetic analyses.

Responders

Among the responders in the study group, mothers answered 89.4% of the questionnaires, fathers 9.0%, and some other guardian of the children answered 1.6%. No significant differences were detected between mothers', fathers', and guardians' ratings.

A-TAC: The A-TAC is a parental telephone interview designed for large-scale epidemiological research that covers a broad range of neurodevelopmental disorders. It consists of 96 questions divided into several problem areas (e.g., ADHD and ASD), worded to reflect DSM-IV criteria and clinical features. Questions are answered from a lifetime perspective and scores for single items are coded as 0 for “no,” 0.5 for “yes, to some extent,” and 1.0 for “yes.” The single item scores are added together to form dimensional scores for each module that can then be added to form sum scores measuring the resemblance to clinical diagnoses (e.g., attention and activity/impulsiveness for ADHD; social interaction, language, and flexibility for ASD). Two clinical validation studies (28, 29) have shown that the instrument has an overall high validity in identifying ADHD and ASD, with areas under the receiving operating characteristic (ROC) curves of 0.94 and 0.96, respectively. Chronbach's alpha for the ADHD score is 0.90 and for ASD 0.86 (27, 29). Cutoffs to yield proxies for clinical diagnoses with high specificity have been established.

JTCI: The Temperament and Character Inventory is a self-report inventory to measure personality traits according to Cloninger's model, which has had good reliability and validity in several studies on adult populations (18, 30). The inventory has been adapted for children and adolescents as the Junior Temperament and Character Inventory (JTCI) (31), which consists of 108 true/false items to be answered by parents, teachers, or the children themselves. The Swedish parental version of the JTCI was tested in a twin population (32)

and showed comparable statistical characteristics to both a Korean (33) and the original American study (31). Individuals with low character maturity were identified by their scores on the self-directedness and cooperativeness dimensions of the JTCI. Scores within one standard deviation under or above the mean (± 1 SD) were considered to indicate average character maturity. Scores on self-directedness and/or cooperativeness below this range were considered to indicate low character maturity.

Statistical methods

Nonparametric Spearman analyses were used to calculate correlations between raw scores on the JTCI dimensions and the ADHD and ASD A-TAC scores.

To assess genetic influences in personality traits, intra-class correlations were calculated separately for monozygotic and same-sex dizygotic twin pairs, and were subsequently recalculated cross-twin, cross-trait to form a test of common etiological effects behind different phenotypes. In cross-twin, cross-trait correlations, the continuous score of a JTCI dimension in one twin was correlated with the continuous score of ADHD or ASD in the second twin. Again, these correlations were assessed separately for monozygotic and same-sex dizygotic pairs.

Ethical considerations

The study was designed in accordance with the Helsinki declaration and approved by the ethical review board of Karolinska Institutet (Dnr: 02-289). All participants consented to the study after receiving written and oral information. All analyses were performed using anonymized data files.

RESULTS

Phenotypical correlations between ADHD, ASD scores, and personality dimensions

Correlation coefficients between the JTCI dimensions and the A-TAC ADHD and ASD scores showed a pattern, which was characterized by very strong negative correlations between both ADHD and ASD and the self-directedness dimension (Spearman $\rho < -0.5$ for both) and between ADHD, ASD and the cooperativeness dimension ($\rho \leq -0.35$) (Figure 1). There was also a positive correlation between ADHD and novelty seeking ($\rho = 0.35$) and between ASD and harm avoidance ($\rho = 0.25$). The reward dependence and persistence dimensions correlated negatively, but weakly, to both neurodevelopmental disorders.

< Please insert Figure 1 about here >

The associations with the JTCI dimensions were also assessed for each module (subdomain) of ADHD and ASD, respectively, yielding very consistent results across the subdomains, all significant on the same level ($p < 0.01$) (Table 1).

< Please insert Table 1 about here >

The relation between character maturity and neurodevelopmental problems: Overall, character maturity was indicated as low (defined as < -1 SD in self-directedness and/or cooperativeness) in one fourth of the study population, average (± 1 SD) in 70%, and high ($> +1$ SD) in 5%. The risk of character immaturity was clearly related to the number of ADHD and ASD symptoms reported (Figure 2). About 8% of children who scored zero for ADHD or ASD symptoms in the A-TAC had low character maturity. The prevalence of character immaturity then started to increase by lower ASD scores than ADHD scores. At three ASD points or seven ADHD points, half of the children showed low self-directedness. Self-

directedness was more sensitive than the cooperativeness to low-grade scores of neurodevelopmental disorders. All children who scored ≥ 12 in ASD scores (out of 17 points) had low character maturity, while a substantial group of children with ADHD scores well into the pathological range (> 12 points out of 19 points) still had an average character maturity.

< Please insert Figure 2 about here >

Etiological factors behind neurodevelopmental disorders and personality dimensions:

Intraclass correlations (Table 2) for all dimensions in the JTCI were higher for monozygotic twins than for dizygotic twins—more than double on the dimensions of novelty seeking, harm avoidance, cooperativeness, persistence, and reward dependence, suggesting a strong influence of genetic effects. Self-directedness and self-transcendence had higher monozygotic intra-class correlations than did all the other dimensions, but also showed considerable dizygotic correlations, indicating genetic and shared environmental effects.

The cross-twin, cross-trait analyses showed stronger correlations in monozygotic pairs than in dizygotic pairs for most combinations of neurodevelopmental disorders and personality dimensions (Table 2). For both ADHD and ASD, the cross-trait, cross-twin correlations with novelty seeking, persistence, self-directedness, and cooperativeness were more than twice as strong in monozygotic pairs as in dizygotic pairs, indicating that the phenotypic correlation may be primarily related to common genetic effects that influence both neurodevelopmental disorders and personality dimensions. For harm avoidance and persistence, this pattern was found only in relation to ASD.

<Please insert Table 2 about here>

DISCUSSION

This study confirms that in children, as in adults, ADHD and ASD are associated specifically with two different temperament profiles and with a generally restricted development of character.

Phenotypical associations

In both children and adults, ADHD is associated with a high propensity for novelty seeking (12, 16, 22, 24). There is a considerable content overlap between ADHD symptom items and questions assessing novelty seeking in the TCI/JTCI (e.g. impulsiveness, disorderliness, restlessness, and fidgeting); therefore, the two concepts likely measure (at least in part) the same underlying trait (commonly referred to as deficient “executive functions” in neurocognitive literature). However, novelty seeking also incorporates many “positive” traits such as curiosity, the wish to explore the unknown, generosity, and spontaneous extroversion in social situations, while ADHD also includes symptoms of impaired attention. The results of this study indicate that the extremes in neurocognitive abilities that give rise to ADHD (deficient attention span, heightened need for arousal, and disinhibition) also create the inter-individual variation of the personality trait, while the positive aspects of novelty seeking may be specific assets of individuals with ADHD that can be acknowledged and used in treatment. The association between ADHD and harm avoidance was weaker in this study on children than it has been in previous reports on adults. This could be due to adults being more prone to anxiety and worry after years of experiencing the consequences of novelty seeking, or it could be due to a higher probability of co-existing mental disorders in adults with ADHD as compared to children, which has been a recurrent finding in longitudinal follow-ups of children with ADHD or related conditions (reviewed in Hofvander et al., 2009 (34)). A recent study (35) showed personality profiles characterized by increased novelty seeking and harm

avoidance in children with attention problems, aggressive behaviors, and anxious-depressive symptoms.

The variation of character maturity in children with scores above the established diagnostic cutoff for ADHD (≥ 12.5 point, (29)) indicate that children with ADHD may be a more heterogeneous group in terms of actual impairment, deficient behavior control and underlying neurodevelopmental problems as compared to adults with the same diagnosis. The likelihood that ADHD is combined with socio-communicative problems (e.g.: autistic-like traits) seems to be larger in adults than in children (36), consistent with higher phenotypic correlations between the two conditions reported from adult studies (37) as compared to childhood data (38).

The temperament profiles of children with ASD in our study were similar to previously reported profiles of adults with diagnoses on the autism spectrum (16), such as extremely high harm avoidance (indicating disproportionate worry, pessimism, fear, and doubt) and low reward dependence (indicating insensitivity to rewards and incapacity for maintaining constructive behaviors through social reinforcements such as emotional, humorous, or verbal signals of social approval). A difference between children and adults with ASD could be seen on the novelty seeking dimension, which tended to be positively, if weakly, associated with the ASD score in children, but was lower than normal for adults with ASD. This may be attributable to the natural decline of novelty seeking with age, or to the relatively lower persistence of ADHD as compared to ASD with age. Of course, novelty seeking will differ between studies of individuals with ASD that exclude ADHD and those that allow for the coexistence of ASD with ADHD.

In both adults and children, ADHD and ASD have uniformly been associated with low scores on self-directedness and cooperativeness. Given that ADHD and ASD, including broader phenotypes, are found in at least 10% of all children (9, 39), these neurodevelopmental

problems must contribute considerably to the variance of personality problems in the general population, where the prevalence of personality disorders is estimated at between 10% and 20% (40). Based on the present study, it may even be suggested that a part of the genetic impact on personality is mediated through the strongly genetic conditions of ADHD and ASD, or through neurocognitive deficits related to these disorders.

This indicates that character development cannot be seen as the result of a “free” learning process, but is rather the result of a series of conceptual neurocognitive and volitional strategies to deal with and overcome both external and internal constrictions, such as reaction patterns, abilities, and drives. Inversely, these results also indicate that poor conceptual learning and maturation each play a role in neurodevelopmental disorders. Conceptualizing ADHD and ASD as handicaps that can be managed only by adaptations of the environment and lower psychosocial and educational demands may be a dangerous simplification. After the trend during the psychoanalytical era of blaming parents, clinical attention shifted to the genetic and neurological origins of behavior problems, with emphasis on pharmacotherapy, educational efforts, and a tolerance for “neurodiversity.” Because a considerable proportion of children who scored several points on ADHD nevertheless had normal character maturity, educational efforts aimed at strengthening self-agency, responsibility, and ethical attitudes toward others may be important in improving the overall severity of lower-degree neurodevelopmental disorders or “sub-threshold” problems.

Severity of ADHD and ASD and the risk for character immaturity

The present study showed a clear relation between the severity of neurodevelopmental disorders and the probability of having a hampered character maturity, which is in line with previous findings from a Korean child study (22). The self-directedness dimension was the most sensitive indicator of the neurodevelopmental disorders. Individuals with substantial intellectual and/or social disabilities may rate low on self-directedness as a function of having

experienced a true inability to care for themselves or make their own decisions, while other mechanisms are at hand to cause similar governmental deficits in less disabled individuals. Since ASD is often more disabling than ADHD, self-directedness is impaired by a smaller number of symptoms of ASD as compared to the ADHD scores (it has to be remembered that no psychiatric rating scales provide accurate quantifications of symptoms, such as interval data, when speculating on these effects). Overall, the negative correlations between neurodevelopmental problems and character scores may be understood in terms of character immaturity being both the result of more severe neurodevelopmental disorders and a contributing factor to the severity of neurodevelopmental symptoms. The direction of causality will only be understood when we have access to longitudinal data from both non-interventional and interventional studies.

Etiological factors

Strong genetic effects were identified in all four temperament dimensions and the character dimension cooperativeness, while the high intra-class correlations in dizygotic twins indicated shared environmental effects in self-directedness and self-transcendence. Cloninger's original personality theory suggested that dimensions of temperament are substantially, and independently, influenced by genetics, and the character aspects of personality develop during adolescence through learning and self-insight (17). However, some quantitative genetic studies have indicated that genetic factors play more important roles in the development of character than in temperament (19, 20). The results obtained here suggest that genetic and shared environmental factors account for a substantial amount of the inter-individual variation in both temperament and character. In twin research, the variance not attributable to genetics or shared environment is ascribed to environmental factors that make twins in a pair dissimilar, which does not say that stochastic and/or free development may not contribute to this part of the variance.

Cross-twin, cross-trait analyses suggest that the phenotypic associations between defined neurodevelopmental disorders and defined personality traits might be due to common genetic effects; that is, genes giving rise to both types of phenotypes, to one phenotype that leads to the other, or to features assessed both as neurodevelopmental disorders and as personality traits.

Limitations

ADHD and ASD were assessed only by parental telephone interviews. Teachers' rating scales, self-report scales, or data from clinical measures may have contributed more optimal data. More sophisticated twin statistical analyses (GEE, Cholesky model) could not be used, because the study group did not represent the full normal distribution.

CONCLUSIONS

Personality, according to psychobiological theory and assessed by the JTICI's dimensional approach, is useful to disentangle clinical features in individuals with ADHD and/or ASD. These neuropsychiatric disorders and their genetic, neurodevelopmental, and cognitive susceptibilities have to be considered in all scientific studies and clinical work with personality disorders and personality variation, just as personality—especially the conceptual maturity of self-regulation and cooperation—have to be considered in neuropsychiatry. The severity of neurodevelopmental disorders is phenotypically linked to the risk for character immaturity, and there is an etiological overlap between ADHD/ASD and personality.

Clinical implications

Neurodevelopmental disorders have usually been described in categorical terms. Based on the results presented here, it would seem that the parent-rated version of the JTICI could be useful both to screen for ADHD and ASD and to detail the clinical presentation in order to tailor treatment efforts to the individual's needs and resources. In the future, the TCI self-

directedness and cooperativeness scales might also be used as an overall measure of psychosocial functioning in etiological and treatment studies.

Future research

The most important challenge for future investigations is to assess whether a change in the neurodevelopmental disorder will lead to a change in personality or vice versa. Either or both possible directions of change would have a great impact on the treatment of both neurodevelopmental disorders and personality disorders.

Table and figure legends

Figure 1. Spearman correlation coefficients between JTCI dimensions and the A-TAC, ADHD, and ASD scales.

Figure 2. Prevalence of children with low character maturity (self-directedness, cooperativeness < -1 SD) in relation to the ADHD and ASD scores in the A-TAC (n = 1886).

Table 1 Spearman correlation coefficients between JTCI dimensions and the ADHD and ASD A-TAC scores.

Table 2. Intraclass correlations (ICC) and cross-twin, cross-trait correlations according to zygosity.

REFERENCES

1. Gillberg C. Clinical child neuropsychiatry. Cambridge: Cambridge University Press; 1995.
2. Nigg JT, Casey BJ. An integrative theory of attention-deficit/ hyperactivity disorder based on the cognitive and affective neurosciences. *Dev Psychopathol.* 2005 Summer;17(3):785-806.
3. Wing L. Language, social, and cognitive impairments in autism and severe mental retardation. *J Autism Dev Disord.* 1981 Mar;11(1):31-44.
4. Lichtenstein P, Carlstrom E, Rastam M, Gillberg C, Anckarsater H. The genetics of autism spectrum disorders and related neuropsychiatric disorders in childhood. *Am J Psychiatry.* 2010 Nov;167(11):1357-63.
5. Lecendreux M, Konofal E, Faraone SV. Prevalence of attention deficit hyperactivity disorder and associated features among children in France. *J Atten Disord.* 2010 Aug;15(6):516-24.
6. Posserud M, Lundervold AJ, Lie SA, Gillberg C. The prevalence of autism spectrum disorders: impact of diagnostic instrument and non-response bias. *Soc Psychiatry Psychiatr Epidemiol.* 2009 Mar;45(3):319-27.
7. Folstein S, Rutter M. Infantile autism: a genetic study of 21 twin pairs. *J Child Psychol Psychiatry.* 1977 Sep;18(4):297-321.
8. Larsson H, Anckarsater H, Rastam M, Chang Z, Lichtenstein P. Childhood attention-deficit hyperactivity disorder as an extreme of a continuous trait: a quantitative genetic study of 8,500 twin pairs. *J Child Psychol Psychiatry.* 2011 Jan;53(1):73-80.
9. Lundstrom S, Chang Z, Rastam M, Gillberg C, Larsson H, Anckarsater H, et al. Autism spectrum disorders and autistic like traits: similar etiology in the extreme end and the normal variation. *Arch Gen Psychiatry.* 2012 Jan;69(1):46-52.

10. Rutter M, Kim-Cohen J, Maughan B. Continuities and discontinuities in psychopathology between childhood and adult life. *J Child Psychol Psychiatry*. 2006 Mar-Apr;47(3-4):276-95.
11. van Dijk FE, Lappenschaar M, Kan CC, Verkes RJ, Buitelaar JK. Symptomatic overlap between attention-deficit/hyperactivity disorder and borderline personality disorder in women: the role of temperament and character traits. *Compr Psychiatry*. 2011 Jan;53(1):39-47.
12. Philipsen A. Differential diagnosis and comorbidity of attention-deficit/hyperactivity disorder (ADHD) and borderline personality disorder (BPD) in adults. *Eur Arch Psychiatry Clin Neurosci*. 2006 Sep;256 Suppl 1:i42-6.
13. Nigg JT, Silk KR, Stavro G, Miller T. Disinhibition and borderline personality disorder. *Dev Psychopathol*. 2005 Fall;17(4):1129-49.
14. Soderstrom H, Sjodin AK, Carlstedt A, Forsman A. Adult psychopathic personality with childhood-onset hyperactivity and conduct disorder: a central problem constellation in forensic psychiatry. *Psychiatry Res*. 2004 Jan 1;121(3):271-80.
15. Wolff S, McGuire RJ. Schizoid personality in girls: a follow-up study--what are the links with Asperger's syndrome? *J Child Psychol Psychiatry*. 1995 Jul;36(5):793-817.
16. Anckarsater H, Stahlberg O, Larson T, Hakansson C, Jutblad SB, Niklasson L, et al. The impact of ADHD and autism spectrum disorders on temperament, character, and personality development. *Am J Psychiatry*. 2006 Jul;163(7):1239-44.
17. Cloninger CR. The genetic structure of personality and learning: a phylogenetic model. *Clin Genet*. 1994 Jul;46(1 Spec No):124-37.
18. Cloninger CR. Temperament and personality. *Curr Opin Neurobiol*. 1994 Apr;4(2):266-73.

19. Ando J, Ono Y, Yoshimura K, Onoda N, Shinohara M, Kanba S, et al. The genetic structure of Cloninger's seven-factor model of temperament and character in a Japanese sample. *J Pers.* 2002 Oct;70(5):583-609.
20. Ando J, Suzuki A, Yamagata S, Kijima N, Maekawa H, Ono Y, et al. Genetic and environmental structure of Cloninger's temperament and character dimensions. *J Pers Disord.* 2004 Aug;18(4):379-93.
21. Purper-Ouakil D, Cortese S, Wohl M, Aubron V, Orejarena S, Michel G, et al. Temperament and character dimensions associated with clinical characteristics and treatment outcome in attention-deficit/hyperactivity disorder boys. *Compr Psychiatry.* 2010 May-Jun;51(3):286-92.
22. Cho SC, Hwang JW, Lyoo IK, Yoo HJ, Kin BN, Kim JW. Patterns of temperament and character in a clinical sample of Korean children with attention-deficit hyperactivity disorder. *Psychiatry Clin Neurosci.* 2008 Apr;62(2):160-6.
23. Yoo HJ, Kim M, Ha JH, Chung A, Sim ME, Kim SJ, et al. Biogenetic temperament and character and attention deficit hyperactivity disorder in Korean children. *Psychopathology.* 2006;39(1):25-31.
24. Rettew DC, Copeland W, Stanger C, Hudziak JJ. Associations between temperament and DSM-IV externalizing disorders in children and adolescents. *J Dev Behav Pediatr.* 2004 Dec;25(6):383-91.
25. Sizoo B, van den Brink W, Gorissen van Eenige M, van der Gaag RJ. Personality characteristics of adults with autism spectrum disorders or attention deficit hyperactivity disorder with and without substance use disorders. *J Nerv Ment Dis.* 2009 Jun;197(6):450-4.
26. Svrakic DM, Whitehead C, Przybeck TR, Cloninger CR. Differential diagnosis of personality disorders by the seven-factor model of temperament and character. *Arch Gen Psychiatry.* 1993 Dec;50(12):991-9.

27. Anckarsater H, Lundstrom S, Kollberg L, Kerekes N, Palm C, Carlstrom E, et al. The Child and Adolescent Twin Study in Sweden (CATSS). *Twin Res Hum Genet.* 2011 Dec;14(6):495-508.
28. Hansson SL, Svanstrom Rojvall A, Rastam M, Gillberg C, Anckarsater H. Psychiatric telephone interview with parents for screening of childhood autism - tics, attention-deficit hyperactivity disorder and other comorbidities (A-TAC): preliminary reliability and validity. *Br J Psychiatry.* 2005 Sep;187:262-7.
29. Larson T, Anckarsater H, Gillberg C, Stahlberg O, Carlstrom E, Kadesjo B, et al. The autism--tics, AD/HD and other comorbidities inventory (A-TAC): further validation of a telephone interview for epidemiological research. *BMC Psychiatry.* 2010;10:1.
30. Brandstrom S, Sigvardsson S, Nylander PO, Richter J. The Swedish version of the Temperament and Character Inventory (TCI). A cross-validation of age and gender influences. *Eur J Psych Asses.* 2008;24(1):14-21.
31. Luby JL, Svrakic DM, McCallum K, Przybeck TR, Cloninger CR. The Junior Temperament and Character Inventory: preliminary validation of a child self-report measure. *Psychol Rep.* 1999 Jun;84(3 Pt 2):1127-38.
32. Kerekes N, Brandstrom S, Stahlberg O, Larson T, Carlstrom E, Lichtenstein P, et al. The Swedish version of the parent-rated Junior Temperament and Character Inventory (J-TCI). *Psychol Rep.* 2011 Dec;107(3):715-25.
33. Lyoo IK, Han CH, Lee SJ, Yune SK, Ha JH, Chung SJ, et al. The reliability and validity of the junior temperament and character inventory. *Compr Psychiatry.* 2004 Mar-Apr;45(2):121-8.
34. Hofvander B, Ossowski D, Lundstrom S, Anckarsater H. Continuity of aggressive antisocial behavior from childhood to adulthood: The question of phenotype definition. *Int J Law Psychiatry.* 2009 Jul-Aug;32(4):224-34.

35. Althoff RR, Ayer LA, Crehan ET, Rettew DC, Baer JR, Hudziak JJ. Temperamental profiles of dysregulated children. *Child Psychiatry Hum Dev.* 2012 Aug;43(4):511-22.
36. St Pourcain B, Mandy WP, Heron J, Golding J, Smith GD, Skuse DH. Links Between Co-occurring Social-Communication and Hyperactive-Inattentive Trait Trajectories. *Journal of the American Academy of Child and Adolescent Psychiatry.* 2011 Sep;50(9):892-902.
37. Reiersen AM, Constantino JN, Grimmer M, Martin NG, Todd RD. Evidence for shared genetic influences on self-reported ADHD and autistic symptoms in young adult Australian twins. *Twin Res Hum Genet.* 2008 Dec;11(6):579-85.
38. Ronald A, Simonoff E, Kuntsi J, Asherson P, Plomin R. Evidence for overlapping genetic influences on autistic and ADHD behaviours in a community twin sample. *Journal of Child Psychology and Psychiatry.* 2008 May;49(5):535-42.
39. Constantino JN, Todd RD. Autistic traits in the general population: a twin study. *Arch Gen Psychiatry.* 2003 May;60(5):524-30.
40. Torgersen S, Kringlen E, Cramer V. The prevalence of personality disorders in a community sample. *Arch Gen Psychiatry.* 2001 Jun;58(6):590-6.

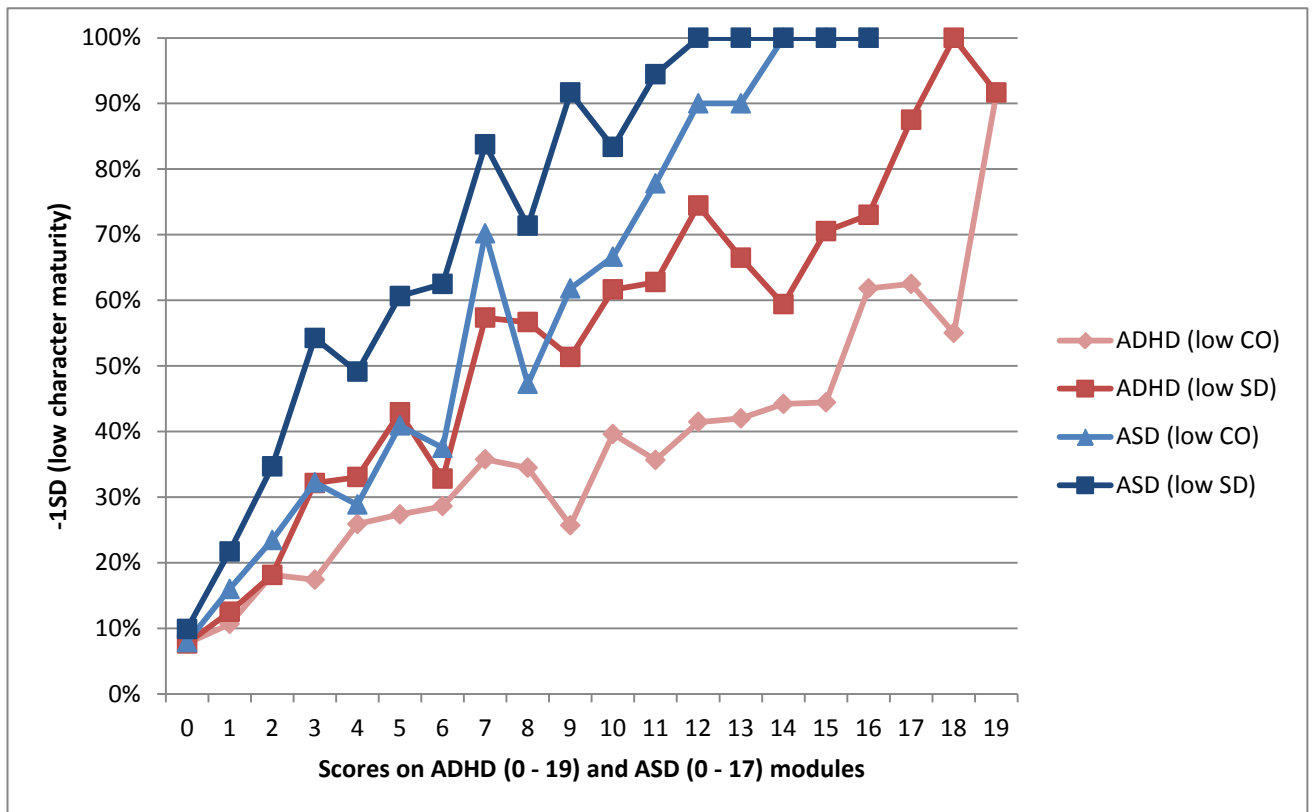
Figure 1. Spearman correlation coefficients between JTCI dimensions and the A-TAC, ADHD, and ASD scales.



ADHD = attention deficit hyperactivity disorder; ASD = autism spectrum disorder

NS = novelty seeking, HA = harm avoidance, RD = reward dependence, P = persistence, SD = self-directedness, CO = cooperativeness, ST = self-transcendence

Figure 2. Prevalence of children with low character maturity (self-directedness, cooperativeness <math>< -1\text{ SD}</math>) in relation to the ADHD and ASD scores in the A-TAC (n = 1886).



ADHD = Attention deficit hyperactivity disorder; ASD = autism spectrum disorder; CO = cooperativeness; SD = self-directedness

Table 1. Spearman correlation coefficients between JTCI dimensions and the A-TAC, ADHD, and ASD scales including detailed correlations with their building modules.

	Spearman 's rho						
	ADHD	Attention	Activity/ Impulsiveness	ASD	Language	Social- interaction	Flexibility
NS	.35**	.30**	.37**	.17**	.09**	.24**	.09**
HA	.12**	.16**	.07**	.25**	.18**	.21**	.27**
RD	-.21**	-.20**	-.17**	-.29**	-.23**	-.27**	-.26**
P	-.29**	-.33**	-.20**	-.17**	-.11**	-.21**	-.10**
SD	-.53**	-.54**	-.41**	-.51**	-.39**	-.50**	-.38**
CO	-.35**	-.31**	-.33**	-.36**	-.23**	-.38**	-.31**
ST	.08**	.12**	.03	.12**	.12**	.08**	.10**

**correlation is significant at the 0.01 level (2-tailed)

ADHD = attention deficit hyperactivity disorder; ASD = autism spectrum disorder

NS = novelty seeking, HA = harm avoidance, RD = reward dependence, P = persistence, SD = self-directedness, CO = cooperativeness, ST = self-transcendence

Table 2. Intraclass correlations (ICC) and cross-twin, cross-trait correlations according to zygosity.

	ICC		Cross twin-cross trait			
	MZ	DZs	ADHD		ASD	
			MZ	DZs	MZ	DZs
NS	0.57	-0.07	0.25	-0.03	0.18	0.03
HA	0.59	0.10	0.13	0.13	0.17	0.08
RD	0.55	0.25	-0.10	-0.18	-0.18	-0.08
P	0.40	0.02	-0.13	0.02	-0.09	0.00
SD	0.73	0.39	-0.38	-0.17	-0.39	-0.15
CO	0.56	0.06	-0.22	-0.09	-0.30	-0.03
ST	0.67	0.52	0.06	0.06	0.11	0.18

NS = novelty seeking; HA = harm avoidance; RD = reward dependence; P = persistence; SD = self-directedness; CO = cooperativeness; ST = self-transcendence; MZ = monozygotic; DZs = dizygotic same sex; n (MZ) = 468 (1 missing pair in ASD cross-twin cross-trait analysis); n (DZs) = 726