

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

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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 (JTCI).

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.

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1. 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 has been proposed as the key

cognitive mechanism 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 paresis, 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

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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 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.

2. Methods

2.1. 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 were 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).

Zygosity 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 zygosity, which yielded a total of 471 children from monozygotic pairs, 752 from same-sex dizygotic pairs, 612 from opposite-sex dizygotic pairs, and 51 with an unknown zygosity, resulting in 234 complete monozygotic twin pairs and 363 same-sex dizygotic twin pairs for genetic analyses.

2.2. 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.

2.3. 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., concentration/attention and impulsiveness/activity for ADHD; language, social interaction, 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. Cronbach'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.

2.4. 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.

2.5. 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.

2.6. 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.

3. Results

3.1. 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 ≤ -0.35) (Fig. 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.

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

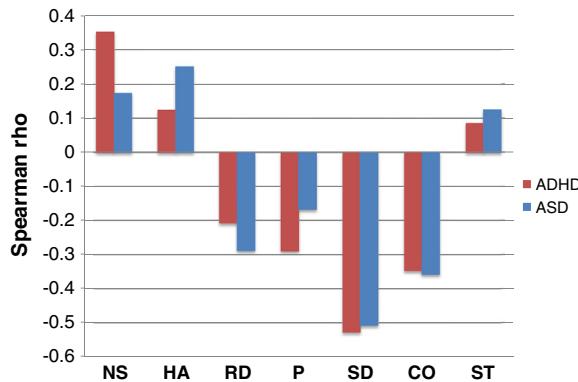


Fig. 1. Spearman correlation coefficients between JTCI dimensions and the A-TAC, ADHD, and ASD scales. ADHD = attention deficit hyperactivity disorder; ASD = autism spectrum disorder; NS = novelty seeking, HA = harm avoidance, RD = reward dependence, P = persistence, SD = self-directedness, CO = cooperativeness, ST = self-transcendence.

3.1.1. 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 (Fig. 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.

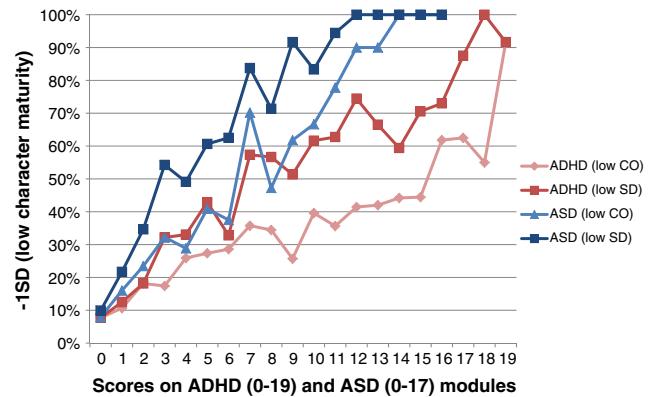


Fig. 2. Prevalence of children with low character maturity (self-directedness, cooperativeness < -1 SD) in relation to the ADHD and ASD scores in the A-TAC ($n = 1886$). ADHD = Attention deficit hyperactivity disorder; ASD = autism spectrum disorder; CO = cooperativeness; SD = self-directedness.

3.1.2. 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

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	Concentration/Attention	Impulsiveness/Activity	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**	

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.

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

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.

dimensions. For harm avoidance and persistence, this pattern was found only in relation to ASD.

4. 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.

4.1. 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 points, [29]) indicates 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.

4.2. 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.

4.3. 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.

4.4. 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.

5. Conclusions

Personality, according to psychobiological theory and assessed by the JTCI'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 – has 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.

5.1. 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 JTCI 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.

5.2. 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.

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