Differential Influences of Dimensional ASD and ADHD Symptom Severity on Adaptive Functioning in Youth Based on the Inclusion of Typical Control Group

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Background

- While Autism Spectrum Disorder (ASD) and Attention-Deficit/Hyperactivity Disorder (ADHD) do not share any diagnostic features in common, children with one diagnosis often show elevated symptoms of the other, and between 17-43% of children with ASD meet full criteria for a comorbid ADHD diagnosis (Surén et al., 2012; Supekar et al., 2017)
- Children with comorbid ASD/ADHD exhibit a more severe behavioral phenotype with higher levels of ASD symptomatology and lower adaptive functioning skills (Craig et al., 2015; Rao & Landa, 2014; Sikora et al., 2012; Yerys et al., 2009)
- Both ASD and ADHD lie at the extreme ends of dimensional trait continua in the general population (Constantino & Todd, 2003; Marcus & Barry, 2011)
- A single study to date has examined the relationship between dimensional ASD/ADHD traits and adaptive functioning (Ashwood et al., 2015)
  - In a group of boys with ASD, ADHD or comorbid ASD/ADHD, all subscales of the Vineland Adaptive Behavior Scales – Second Edition (VABS) were significantly predicted by ASD but not ADHD symptoms scores
  - The predictive ability of ASD symptoms severity remained after controlling for ADHD symptom scores
- This investigation seeks to replicate and expand upon the work by Ashwood et al. by:
  - Utilizing a sample with both males and females
  - Controlling for sex and full-scale IQ in the regression analyses
  - Employing total ADHD symptoms rather than inattention and hyperactivity separately
  - Including typically-developing (TD) to span the entire range of dimensional traits
    - Regression analyses performed with and without the TD children included in the sample, so as to more closely expand upon prior analyses

Method

Participants:

- 110 intellectually-able (FSIQ > 70) children and adolescents between 7 and 18 years of age evaluated as part of various electrophysiological studies at the Yale Child Study Center
- 37 TD, 33 ASD only, 30 ASD/ADHD
  - ASD diagnoses confirmed using gold-standard instruments (ADOS+ADI-R)
  - ADHD diagnoses determined using parent-reported DSM symptoms on Child and Adolescent Symptom Inventory – 5 (CASI-5)
- An additional 10 children were enrolled as either TD or suspected ASD but were diagnosed with ADHD instead. These children were retained for dimensional analyses only

	TD	ASD	ASD/ADHD	ADHD	Group Differences*
Sex Ratio (M:F)	19:18	22:11	20:10	9:1	*n.s.*
Age	12.7 (2.8)	13.3 (3.0)	13.2 (2.4)	12.2 (2.7)	*n.s.*
DAS-II GCA (FSIQ)	105.4 (12.4)	105.0 (17.7)	99.5 (21.0)	96.6 (19.1)	*n.s.*
SRS-2 Total (0-195)	16.9 (13.3)	65.0 (26.6)	103.6 (26.7)	88.5 (25.6)	ASD/ADHD > ASD > TD
CASI-5 ADHD Total (0-54)	6.3 (5.5)	15.5 (7.9)	35.2 (7.9)	36.0 (7.8)	ASD/ADHD > ASD > TD
VABS Composite	97.5 (13.7)	76.1 (10.3)	69.1 (6.2)	74.8 (7.0)	TD > ASD > ASD/ADHD
VABS Communication	100.9 (16.6)	81.4 (13.7)	73.3 (7.7)	75.8 (7.0)	TD > ASD = ASD/ADHD
VABS Daily Living Skills	93.3 (15.2)	76.3 (11.0)	71.6 (9.4)	75.2 (8.0)	TD > ASD = ASD/ADHD
VABS Socialization	100.8 (10.8)	76.9 (12.1)	67.7 (7.7)	79.8 (10.6)	TD > ASD > ASD/ADHD

Table 1: Group Statistics: Sex ratio, Subject Age, Full-Scale IQ (DAS-II GCA), Raw scores of ASD and ADHD symptoms, and VABS Domain Standard Scores. Comparisons are significant at the Tukey HSD-corrected 0.05 level.
* Due to its size and unrepresentativeness, the ADHD only group was not included in any group-level comparisons

Method

Measures:

- SRS-2 School-Age: Parent-report of quantitative autistic traits
  - Raw total score used as measure of ASD symptoms
- CASI-5 ADHD Scale: 0-3 Likert-scale ratings of the 18 DSM-5 ADHD symptoms
  - 9 inattentive symptoms, 9 hyperactive-impulsive symptoms
  - Symptom scored as present if rated 2 (Often) or 3 (Very Often)
  - ADHD diagnosis assigned if more than 6 symptoms present in either subscale
  - Sum of Likert-scored items used as total measure of ADHD symptoms
- Differential Ability Scales II – School Age (DAS-II): Child/Adolescent IQ test
- Vineland Adaptive Behavior Scales – II (VABS): Parent interview surveying the adaptive behaviors performed by child on a regular basis
  - Three sub-domains (Communication, Daily Living Skills, Socialization) and an Adaptive Behavior Composite (ABC) Standard Scores used as DVs in the regression analyses

Statistical Analysis:

- Stepwise hierarchical linear regressions performed with each VABS domain standard score and the VABS ABC as dependent variables
  - Step 1: Age, Sex, and FSIQ entered as covariates
  - Step 2: SRS2 Total Score and CASI-5 ADHD Total entered in stepwise manner
- Analyses repeated twice, once with entire sample and once with just the ASD, ADHD, and ASD/ADHD groups

Results

Model	Predictors*	R^2 (Step 1)	R^2 (Step 2)	ΔR^2 (Step 2)
VABS ABC	**Age**, Sex, **IQ** **SRS-2 Total**	0.184	0.628	0.444
VABS ABC†	**Age, Sex, IQ** **CASI-5 ADHD**	0.317	0.481	0.164

Table 2: Final regression models for the VABS Adaptive Behavior Composite with and without incorporating the TD Control group
* Names of variables that are significant predictors in the final model ($p < 0.05$) are bolded
† Regression performed without TD children (ASD, ADHD, and ASD/ADHD groups only)

Regressions: Whole Group

- All of the regression models succeeded in predicting the DV of interest (R^2=0.41–0.65)
  - Age was a significant predictor in all models, and IQ significantly predicted VABS ABC and all subscales except for Daily Living Skills (p=0.059)
  - Sex did not serve as a significant predictor in any of the models
  - SRS-2 Total Score, but not CASI-5 ADHD score was added in step 2 of all four models and significantly improved the strength of each model (ΔR^2=0.26–0.54, ps<0.05)
  - SRS-2 Total Score remained a significant predictor in all models after CASI-5 ADHD score was added in a third step
  - Among the three domains the addition of SRS-2 Total to the model caused the largest ΔR^2 for the Socialization subscale, followed by Communication, then Daily Living Skills

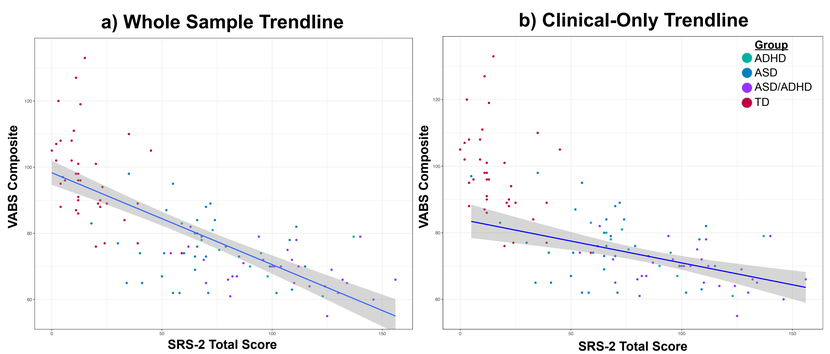

Figure 2: Scatter plot of SRS-2 Total vs. VABS Composite Score. Trendlines are superimposed for a) the entire sample and b) only the clinical children (ASD, ADHD, and ASD/ADHD groups only)

Results

Model	Predictors*	R^2 (Step 1)	R^2 (Step 2)	ΔR^2 (Step 2)
VABS Communication	**Age**, Sex, **IQ** **SRS-2 Total**	0.218	0.584	0.366
VABS Communication†	**Age**, Sex, **IQ** **CASI-5 ADHD**	0.292	0.434	0.142
VABS Daily Living	**Age**, Sex, IQ **SRS-2 Total**	0.145	0.409	0.264
VABS Daily Living†	**Age**, Sex, IQ **CASI-5 ADHD**	0.175	0.238	0.063
VABS Socialization	**Age**, Sex, **IQ** **SRS-2 Total**	0.111	0.649	0.540
VABS Socialization†	**Age, Sex, IQ** **SRS-2 Total**	0.251	0.427	0.176

Table 3: Final regression models for the VABS Domain Standard Scores with and without incorporating the TD Control group
* Names of variables that are significant predictors in the final model ($p < 0.05$) are bolded
† Regression performed without TD children (ASD, ADHD, and ASD/ADHD groups only)

Regressions: Clinical Group

- All models succeeded in predicting the DV of interest, but to a lesser degree (R^2=0.24–0.48)
  - Age was a significant predictor in all models, and IQ significantly predicted VABS ABC and all subscales except for Daily Living Skills (p=0.136)
  - Sex was a significant predictor of VABS Socialization and ABC (with females being more impaired relative to population norms)
  - CASI-5 ADHD score was added in step 2 of all models except for socialization, in which SRS-2 score was still added in step 2. No model included both trait variables.
  - The Step-2 trait measure significantly improved the strength of each model, though much more modestly than in the whole-group analysis (ΔR^2=0.06–0.18, ps<0.05).
  - Removing the 10 ADHD-only children from the analysis did not significantly alter any of the regression equations

Conclusions

- Dimensional ASD and ADHD symptoms are significantly associated with reduced adaptive functioning across domains.
- ASD symptomatology was a superior predictor of all VABS domains and the ABC score after controlling for age, sex, and full-scale IQ
- However, when only the clinical children were included in the sample, ADHD symptoms were most related to impairment in two of the three VABS domains
  - Although the use of a clinical-only sample brought our analysis more in line with that performed by Tye and colleagues, the exclusion of control children caused our findings to diverge from theirs
- Further research is needed to discern the relationships between dimensions of ASD and ADHD while accounting for other sources of impairment such as comorbid psychopathology, academic difficulties, or peer rejection
- Additionally, given pronounced effects of age in the various models, understanding the differential influence of symptom clusters over the lifespan may allow for better clinical management of both ASD and ADHD

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