

Heterogeneity of executive functions among comorbid neurodevelopmental disorders

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Supplemental Information

Diagnostic Measures

ADI-R. The Autism Diagnostic Interview- Revised (ADI-R, Rutter, Le Couteur, Lord, & Faggioli, 2005) is a parent clinical interview that assesses key diagnostic features of autism like reciprocal social interaction, communication, and repetitive/stereotyped behaviors. All participants with ASD had scores of 7 or higher on the three subscales.

ADOS-G and ADOS-2. The Autism Diagnostic Observation Schedule-Generic (ADOS-G (Lord et al., 2000) and the Autism Diagnostic Observation Schedule-2 (ADOS-2, Lord et al., 2012) are child clinical interviews with structured and semi-structured parts that focus on social and communicative behaviors in children. Participants recruited prior to the release of the ADOS-2 received the ADOS-G. Community diagnoses of ASD were confirmed by a score of ≥ 7 for the total score on the ADOS-2 or the communication and social interaction score on the ADOS-G.

Conners' PRS. The Conners' Parent Rating Scales- Revised, Long Version (CPRS-R:L, Conners, 1997) and the Conner's Parent Rating Scales- 3rd Edition, Full-length (CPRS-3, Conners, 2008) are parent reports of their child's ADHD symptoms, oppositional defiant disorder and conduct disorder. T-Scores of 60 or higher on the *DSM-IV* (for the Revised version) and *DSM-IV-TR* (for the 3rd Edition) Hyperactive/Impulsive or Inattentive scales were used to confirm community ADHD diagnoses. TD participants who had T-Scores >65 on either the Hyperactive/Impulsive or Inattentive scales were excluded from the study.

ADHD-RS-IV, Home version. The ADHD Rating Scale-IV, Home version (DuPaul, Power, Anastopoulos, & Reid, 1998) is a parent report of their child's ADHD symptoms

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over the previous 6 months. Community diagnoses of ADHD were confirmed if children met for 6 out of 9 *DSM-IV* symptoms on either the Hyperactive/Impulsive or Inattention scales. TD participants who met on 4 out of 9 symptoms on either the Hyperactive/Impulsive or Inattention scales were excluded from the study.

DICA-IV. The Diagnostic Interview for Children and Adolescents IV (Reich, Welner, & Herjanic, 1997) is a structured parent interview to evaluate current psychiatric diagnoses in the child. The Attention Deficit Disorder subscale was used to: 1) confirm community ADHD diagnoses and 2) to determine whether the children with community ASD diagnoses also had comorbid ADHD. Any child who met criteria for conduct disorder, mood disorder, generalized anxiety disorder, or obsessive-compulsive disorder was excluded from the study. TD children who met criteria for any disorder were excluded. Scores on the DICA-IV and clinical judgment by a child neurologist (S.H.M) determined ADHD subtype.

Supplemental Tables**Table S1.** Differences in indicators across classes using 10 indicators.

	Above Average	Average	Impaired	F	Post-hoc
	Mean (SE)	Mean (SE)	Mean (SE)		
BRIEF- Parent					
-Inhibition T	42.27 (.71)	55.58 (2.15)	67.56 (1.41)	231.51	I > A > AA
-Shift T	41.85 (.67)	52.86 (1.97)	67.00 (1.81)	178.09	I > A > AA
-Emotional Control T	41.21 (.66)	51.92 (1.67)	62.45 (1.51)	146.67	I > A > AA
-Initiation T	42.63 (.91)	54.41 (1.69)	65.97 (1.11)	287.39	I > A > AA
-Working Memory T	42.02 (1.05)	57.86 (2.81)	71.58 (.83)	557.59	I > A > AA
-Plan/Organize T	41.43 (.91)	55.76 (2.74)	70.00 (.86)	582.5	I > A > AA
-Org Materials T	44.96 (1.22)	56.34 (1.44)	64.61 (.83)	178.22	I > A > AA
-Monitor T	39.60 (1.20)	56.16 (2.17)	68.23 (1.05)	428.43	I > A > AA
WISC B-Digit span	12.11 (.33)	11.43 (.48)	10.09 (.30)	16.71	AA=A>I
Statue Total	27.25 (.41)	24.10 (1.09)	20.31 (.89)	30.16	AA>A>I

All F-tests were significant at the $p < .001$ level. Note that for the BRIEF, higher scores indicate greater impairment, but for the B-Digit span and Statue, higher scores indicate lower impairment. I: Impaired class; A: Average class; AA: Above Average class; Org Materials T: Organization of Materials T-score; WISC B-Digit span: Wechsler Intelligence Quotient for Children IV Backward Digit span scaled score; Statue Total: total score on the NEPSY-II statue subtest.

Table S2. Logistic regression of diagnosis on latent class.

	Probability (SE)	Odds Ratio (SE)	95% CI	χ^2
Above Average				AA v I
TD	0.99 (.01)	118.36 (123.46)	15.32-914.32	5502.96 ^c
ADHD	0 (0)	-- ^a	-- ^a	
ASD	.01 (.01)	-- ^b	-- ^b	
Average				A v AA
TD	0.18 (.08)	-- ^b	-- ^b	123.44 ^c
ADHD	0.55 (.08)	-- ^b	-- ^b	
ASD	0.28 (.06)	-- ^b	-- ^b	
Impaired				I v A
TD	0 (0)	-- ^a	-- ^a	
ADHD	0.39 (.05)	.33 (.13)	.15-.72	17.92 ^c
ASD	0.61 (.05)	-- ^b	-- ^b	

Note: Uninterpretable odds ratios for: ^a = 0 (CI: 0-0) and ^b = 1 (CI: 1-1). ^c = $p < .001$

Table S3. Differences in behavioral problems between EF classes

	Intercept	SE	95% CI
Distal Outcome			
1. Anxiety/Depression			
Above average	50.87	0.18	50.51-51.23
Average	53.42	0.87	51.72-55.12
Impaired	58.51	1.57	55.43-61.58
2. Social Problems			
Above average	52.16	0.40	51.38-52.94
Average	53.19	1.36	50.52-55.85
Impaired	57.49	2.00	53.57-61.42
3. Attention Problems			
Above average	50.75	0.13	50.49-51.01
Average	52.88	0.73	51.46-54.30
Impaired	62.15	1.60	59.02-65.28
4. Aggression			
Above average	50.44	0.12	50.20-50.68
Average	53.46	1.05	51.40-55.51
Impaired	60.47	2.08	56.39-64.54

Four mixture regression analyses were performed, one for each distal outcome. Intercepts are the means of the distal outcome adjusted for diagnosis. Non-overlapping confidence intervals indicate significant differences between EF classes. CI: confidence interval.

Results of supplementary latent profile analysis excluding NEPSY-II Statue subtest

Table S4. Latent Profile Analysis results excluding NEPSY Statue.						
	1 class	2 classes	3 classes	4 classes	5 classes	6 classes
LL	-10554.78	-9697.28	-9532.18	-9446.06	-9398.30	-9357.48
AIC	21145.56	19450.55	19140.37	18988.12	18912.61	18850.96
BIC	21213.39	19556.06	19283.56	19168.96	19131.17	19107.21
SA BIC	21156.30	19467.25	19163.03	19016.75	18947.21	18891.53
Entropy	-	0.92	0.88	0.88	0.86	0.86
	-	2 v 1	3 v 2	4 v 3	5 v 4	6 v 5
LMR LRT	-	1685.79 ^a	324.56 ^a	169.32	93.88 ^a	102.75 ^a
N for each class	N=320	C1=136 C2=184	C1=102 C2=80 C3=138	C1=59 C2=129 C3=98 C4=34	C1=64 C2=56 C3=63 C4=29 C5=108	C1=62 C2=63 C3=14 C4=56 C5=96 C6=29

Note: One hundred different sets of start values were generated and a full iteration was completed for the ten best sets. LL= Log Likelihood; AIC= Aikake Information Criterion, BIC= Bayesian Information Criterion; SA BIC= Sample Adjusted BIC; LMR= Lo, Mendell, Rubin Likelihood Ratio Test; BLRT= Bootstrapped Likelihood Ratio Test. ^a $p < .05$.

Table S5. Differences in indicators across classes excluding NEPSY Statue.					
	Above Average Mean (SE)	Average Mean (SE)	Impaired Mean (SE)	F	Post-hoc
BRIEF- Parent					
-Inhibition T	42.1 (0.49)	55.33 (0.97)	67.51 (0.97)	231.51	I > A > AA
-Shift T	41.65 (0.54)	52.88 (1.16)	66.83 (1.07)	182.36	I > A > AA
-Emotional Control T	41.02 (0.51)	51.86 (1.06)	62.35 (0.99)	151.22	I > A > AA
-Initiation T	42.5 (0.56)	53.93 (0.72)	66.06 (0.78)	291.66	I > A > AA
-Working Memory T	41.79 (0.54)	57.26 (0.89)	71.74 (0.59)	566.83	I > A > AA
-Plan/Organize T	41.21 (0.51)	55.5 (0.78)	69.95 (0.62)	555.09	I > A > AA
-Org Materials T	44.72 (0.74)	56.13 (0.97)	64.64 (0.64)	185.65	I > A > AA
-Monitor T	39.33 (0.67)	55.8 (0.91)	68.25 (0.66)	423.69	I > A > AA
WISC B-Digit span	12.3 (0.31)	11.51 (0.36)	9.97 (0.27)	16.70	AA=A>I

All F-tests were significant at the $p < .001$ level. Note that for the BRIEF scores higher indicates greater impairment, but for the WISC, higher scores indicate less impairment. I: impaired class; A: average class; AA: above average class; PlanOrg T: Org Materials: Organization of Materials T-score; WISC B-Digit span: Wechsler Intelligence Quotient for Children IV Backward Digit span scaled score.

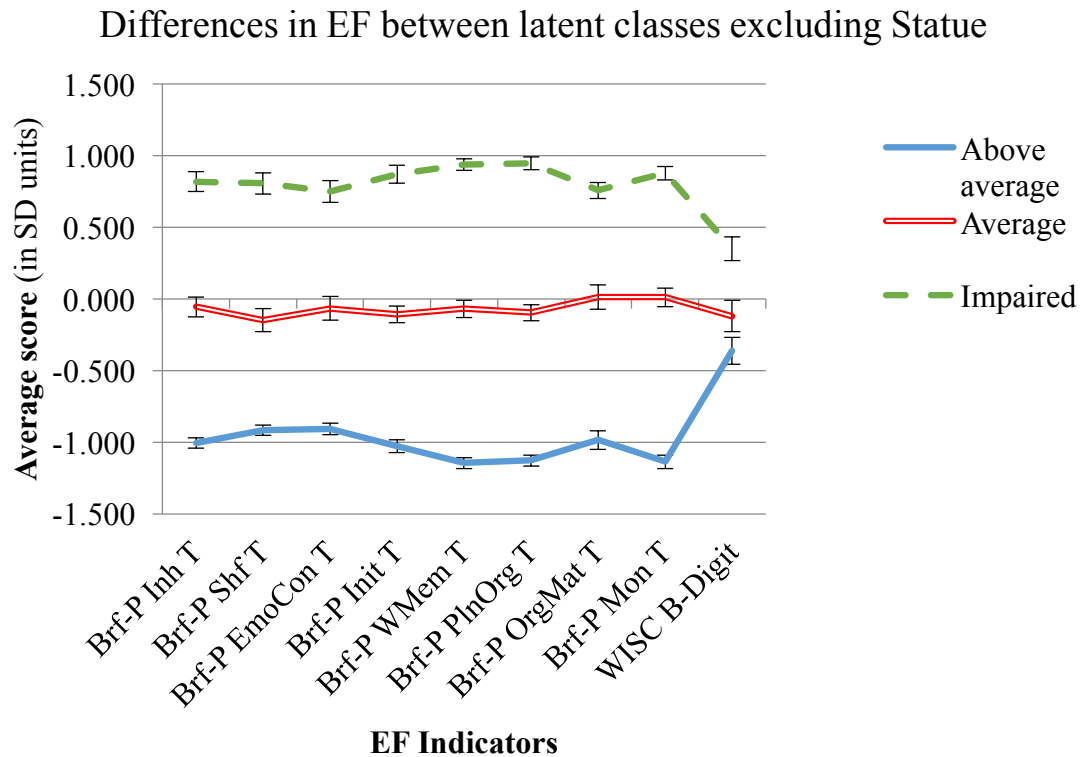


Figure S1. Latent Profile Analysis results excluding NEPSY Statue subtest. The three EF classes differed on their scores across the indicators. Scores are in standard deviation units based on data from the present sample. The WISC Backward Digit span was reverse-scored such that for all indicators, higher scores indicate greater impairment. Note: All EF indicators had a significant difference between Above average, Average, and Impaired groups except the WISC B-Digit, which only had a difference between Above average/Impaired groups and Average/Impaired groups. Brf-P Inh T: BRIEF-Parent report inhibition T-score; Shf T- Shift T-score; EmoConT: Emotional Control T-score; Init T: Initiation T-score; WMem T: Working memory T-score; PlnOrg T: Plan/Organize T-score; OrgMat: Organization of Materials T-score; Mon T: Monitor T-score; WISC B-Digit: Wechsler Intelligence Quotient for Children IV Backward Digit span scaled score (reverse scored); Statue Total: total score on the NEPSY-II statue subtest (reverse scored).

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