SUPPLEMENTAL MATERIALS

S1. Sample Diagnostics

All parents/participants provided written informed permission/assent as approved by the Institutional Review Board. DSM-IV diagnoses for all children were obtained through a semi-structured diagnostic interview with the primary caretaker (usually mother) and a direct interview with the child (if 8 years of age or older) using the full KSADS-PL (Kaufman et al., 1997). Diagnostic interviews were administered by masters or Ph.D. level clinicians and final differential diagnoses were made by licensed child psychiatrist (JJM). Both parent and teacher behavior ratings were used in making final diagnostic determinations. Inclusion criteria were: males or females between the ages of 7 to 14 years and both parent/child were able to complete diagnostic interviews in English. Additional inclusion criteria for the ADHD group were: DSM-IV ADHD (any subtype) diagnosed by the KSADS-PL and clinical interview and Clinical Global Impression Severity (CGI-S) score $\geq$4 for ADHD. Exclusion criteria were as follows: neurological disorder, head injury resulting in concussion, most major Axis I diagnoses (including autism, psychosis, depression and anxiety, with the exception of ODD and simple phobia), systolic or diastolic blood pressure >95th or <5th percentile for age and body mass index (BMI); need for chronic use of central nervous system medications other than stimulants of alpha agonist; or estimated Full Scale IQ < 80. Participants on ADHD stimulant medications were asked to discontinue use for 24-48 hrs (consistent with medication half-life) prior to testing.

S2. Independent Component Analysis

Individual-subject ICA results in many different ICs (sources) per subject, requiring comparable ICs from different subjects to be identified by some sort of similarity measure (c.f., Lenartowicz et al. (2014) for details). To do this, we used k-means clustering, an iterative algorithm that assigns individual observations (ICs) from all subjects into *k* clusters, within a coordinate system defined by functional features (topography, event-related spectral change and voltage potential), such that each IC belongs to the cluster with the nearest centroid (Onton & Makeig, 2006). The algorithm would thus group, from all subjects, those ICs that have an occipital topography, for instance, into one cluster. It is possible, however, that some participants are excluded from a cluster, if their data did not produce an IC with the identifying cluster features. This was the case for five participants in our study, who were excluded from further analyses. The number of clusters was selected based on our prior analysis (Lenartowicz et al., 2014) and was set as 12. An additional, "outlier" cluster was identified for ICs whose distance to any cluster centroid was greater than 3 standard deviations. Clusters of interest were identified visually based on desired characteristics. Namely, we identified one cluster with mid-occipital topography to evaluate effects of alpha in the data and one cluster with mid-frontal topography to evaluate effects of theta and P2 in the data.

S3. Sample Characteristics

Table S1. ***Sample Characteristics***

	ADHD Mean (SD)	TD Mean (SD)	Group Difference
	CBCL t-scores		
Anxiety/Depression	58.1 (8.0)	51.7 (3.2)	**t=4.0, p<.001**
Withdrawal	58.1 (7.6)	52.1 (4.3)	**t=3.8, p<.001**
Somatic Complaints	57.4 (8.3)	51.8 (2.8)	**t=3.4, p=.001**
Social Problems	59.9 (7.3)	52.4 (4.4)	**t=4.9, p<.001**
Thought Problems	59.6 (8.2)	51.3 (2.1)	**t=5.1, p<.001**
Attention Problems	70.0 (8.5)	51.8 (3.7)	**t=10.5, p<.001**
Delinquency	59.9 (7.8)	52.5 (3.8)	**t=4.7, p<.001**
Aggression	61.5 (9.0)	52.4 (4.8)	**t=4.9, p<.001**
Affect Problems	60.9 (7.8)	51.6 (2.5)	**t=5.9, p<.001**
Anxiety Problems	56.9 (7.0)	51.4 (3.2)	**t=3.9, p<.001**
Somatic Problems	56.3 (8.7)	51.6 (3.4)	**t=2.7, p<.001**
ADHD	66.2 (7.2)	51.8 (4.0)	**t=9.7, p<.001**
ODD	61.9 (8.9)	53.4 (5.2)	**t=4.7, p<.001**
Conduct Disorder	60.2 (8.2)	52.0 (4.3)	**t=5.0, p<.001**
Internalizing	57.5 (9.7)	43.5 (9.0)	**t=6.5, p<.001**
Externalizing	59.8 (10.0)	46.2 (9.0)	**t=6.2, p<.001**
Total Problems	62.4 (7.5)	42.7 (10.2)	**t=10.8, p<.001**
	DKEFS (scaled scores)		
Trails (scan)	9.4 (3.2)	10.3 (2.3)	t=1.5, p=.13
Trails (number)	9.8 (3.4)	10.4 (2.9)	t=.96, p=.34
Trails (letter)	9.1 (3.8)	8.7 (4.1)	t=.43, p=.67
Trails (number-letter switch)	8.1 (4.0)	9.3 (3.7)	t=1.5, p=.15
Trails (motor)	10.9 (2.4)	10.9 (2.0)	t=.08, p=.94
VF (letter)	10.7 (2.7)	10.9 (3.1)	t=.32, p=.75
VF (category)	8.1 (4.1)	9.3 (4.6)	t=1.4, p=.17
VF (switch correct)	9.2 (3.2)	10.4 (3.0)	**t=2.0, p=.05**
VF (switch total)	10.4 (2.8)	11.1 (2.8)	t=1.4, p=.17
CW (color)	9.6 (3.2)	10.2 (3.3)	t=.87, p=.39
CW (word)	10.6 (2.3)	10.4 (2.3)	t=.30, p=.77
CW (color-word)	10.0 (2.9)	10.6 (2.5)	t=.90, p=.37
CW (switching)	10.0 (3.0)	11.2 (2.1)	**t=2.2, p=.03**
	Academic Achievement (scaled scores)		
GORT (rate)	30.0 (13.1)	31.8 (12.0)	t=.85, p=.40
GORT (accuracy)	24.9 (13.3)	28.2 (11.0)	t=1.3, p=.40
GORT (fluency)	54.5 (26.0)	60.0 (22.3)	t=1.1, p=.28
GORT (comprehension)	29.3 (14.0)	31.4 (13.1)	t=.72, p=.48
GORT (oral reading index)	98.7 (16.0)	104.8 (13.0)	**t=2.0, p=.05**
WRAT spelling	106.9 (14.2)	111.7 (14.8)	t=1.6, p=.11
WRAT math	105.6 (13.3)	113.7 (13.6)	**t=2.9, p=.004**
WJ (word attack)	103.8 (9.0)	109.1 (8.8)	**t=2.9, p=.01**
WJ (letter-word ID)	105.3 (10.4)	108.8 (10.0)	t=1.7, p=.10

Notes. VF = verbal fluency; CW = color-word interference test; GORT = Gray Oral Reading Test, 4th edition; WRAT = Wide Range Achievement Test, 4th edition; WJ = Woodcock Johnson IV Achievement Test..

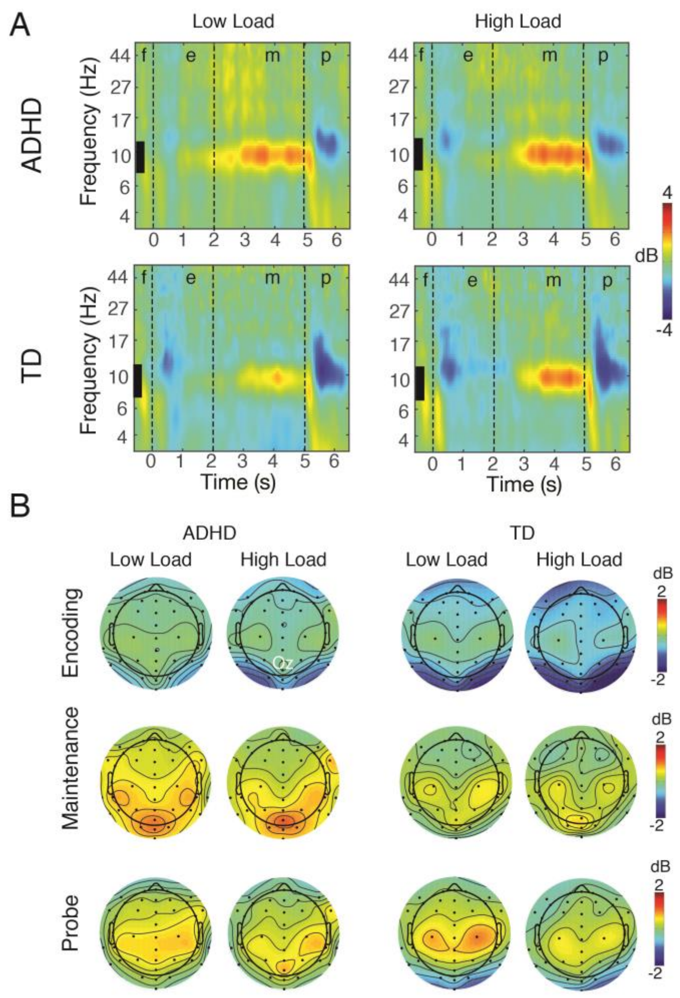
S4. Single Electrode Event-Related Spectral Analyses

Event-related power modulation in mid-occipital (alpha) and mid-frontal (theta) bands of the EEG signal was analyzed at electrode Oz and electrode FCz, respectively, for reference and comparison to previous literature. The results are comparable with those reported for the mid-occipital and mid-frontal independent component (IC) sources in the main text. Though note that the latter represent data of independent cortical sources rather than data from mixed sources, recorded at a single electrode. Consistent with the expectation of noisier data at single electrodes (mixed source signals) than at ICs (independent source signals), the significant effects reported here for single electrodes are analogous to those obtained from IC data, but show weaker effect sizes. The results highlight robustness of the alpha power effects, and suggest that theta effects are not reliable.

Visual Attention: Alpha Power at Electrode Oz

During the SWM trials, Oz alpha decreased in power during encoding and retrieval (Fig. S1).

Figure S1



Group Effects. A main effect of group was significant during encoding ($F(1,101)=9.5$, p=.003, *Cohen's f*=.31). Children with ADHD had weaker alpha decrease than TD children (-1.59 dB vs. -.47 dB). A similar effect was observed during retrieval ($F(1,101)=3.7$, p=.06, *Cohen's f*=.19) (-

1.86 dB vs. -1.10 dB), consistent with the strong correlation in alpha power during encoding versus retrieval (i.e., the stimulus processing phases).

Age Effects. A main effect of age was significant during encoding (F(1,101)=9.2, p=.003, *Cohen's f*=.30) and retrieval (F(1,101)=10.4, p=.002, *Cohen's f*=.32). Consistent with prior findings, alpha modulation increased with age. This was true for encoding (Young: -.46 dB, Old: -1.6 dB) and retrieval (Young: -.83 dB, Old: -2.1 dB). Age did not show any significant interactions.

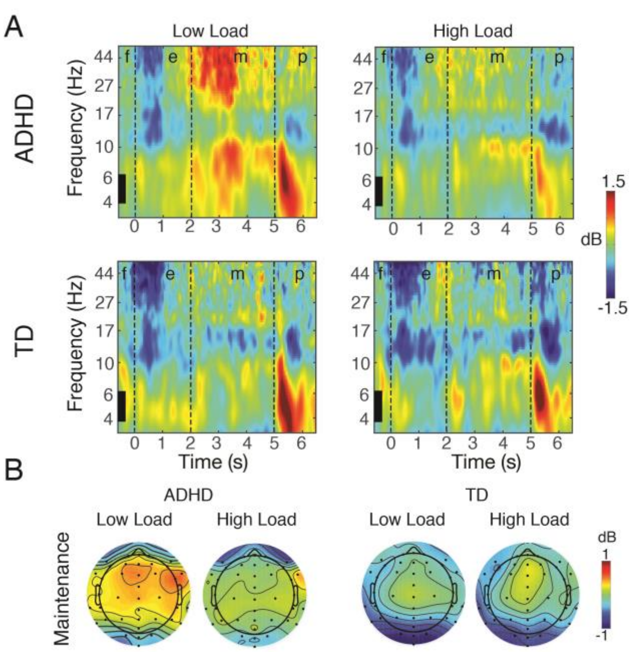
Load Effects. The effect of load was not significant during encoding (F(1,101)=2.1, p=.15, *Cohen's f*=.14) or retrieval (F(1,101)=.2, p=.63, *Cohen's f*=.05). During encoding, a stronger alpha decrease was present at high load than at low load (Low Load: -.73 dB, High-Load: -1.4 dB).

Correlations Across Phases and Analyses. Modulation of alpha power was strongly correlated across task phases ($r_{encodeXmaintain}$(106)=.78, p=.001; $r_{encodeXprobe}$(106)=.77, p<.001; $r_{probeXmaintain}$(106)=.63, p<.001). Oz electrode results were strongly correlated with data obtained from mid-occipital IC alpha at each phase of the trial (r_{encode} (106)=.69, p<.001; $r_{maintain}$(106)=.74, p<.001; r_{probe} (106)=.63, p<.001).

Maintenance: Theta Power at Electrode FCz and Alpha Modulation at Electrode Oz

Qualitatively, during the SWM trials FCz theta power increased (Fig. S2). The effects were qualitatively similar to those reported for the mid-frontal ICs, and also not significant. Similarly, Oz alpha power increased during maintenance (Fig. S1 above), and, like for the mid-occipital ICs this increase was statistically significantly.

Figure S2



Group Effects. We did not find significant effects of group in theta power during maintenance (F(1,101)=.23, p=.63). Alpha power during maintenance showed a significant group effect

(F(1,101)=6.5, p=.013, *Cohen's f*=.27), because children with ADHD has a greater alpha power during the maintenance interval than TD children (-.14 dB vs. 1.13 dB).

Age Effects. We also did not find significant effects of age during maintenance F(1,101)=.18, p=.67, *Cohen's f*=.05. in theta power at FCz. A main effect of age was significant in Oz alpha power during maintenance (F(1,101)=7.3, p=.008, *Cohen's f*=.27). Consistent with prior findings, alpha power decreased with age (Young:1.19 dB, Old: -.20 dB).

Load Effects. Theta power did not show significant effects of load during maintenance (F(1,101)=.06, p=.83, *Cohen's f*=.03). Alpha power also did not show significant effects of load during maintenance (F(1,101)=.13, p=.7, *Cohen's f*=.03).

Correlations Across Analyses. As was the case for alpha effects, theta power at FCz was also significantly correlated with theta power at mid-frontal ICs (r(115) = .61, p<.001).

S5. Dipole Analysis P2

In order to validate the hypothesis that the mid-frontal topography in the IC solution was anterior to, and thus not representative of that of the P2, we performed a dipole analysis on both. This was done using the *dipfit* plug in in EEGLAB. Source localization was done by fitting an equivalent current dipole model using a non-linear optimization technique, and a standardized boundary element head model of the Montreal Neurological Institute brain template. A template channel montage was used for channel co-registration. The best-fitting dipole (residual variance = 6.5%) for the mid-frontal IC topography was located in medial superior frontal cortex (MNI: x=1.5mm, y=20.7mm, z=44.1mm, Brodmann Area 8). The best-fitting dipole (residual variance = 3.5%), for the P2 topography was located about 4 cm posterior, at the superior edge of Pulvinar (MNI: x=18mm, y=-25mm, z=20mm). Thus, the mid-frontal topography of the IC solution was not an accurate representation of the P2.

S6. Full-scale IQ Covariate in EEG Prediction of Academic Achievement, Executive Function & Symptoms

In Table S2 are the multiple regression results with inclusion of FSIQ as an additional covariate.

Table S2. ***Multiple Regression: EEG Predictors of Outcome Variables***

	t_β *(regression coefficient)*						*Model Fit*	
	Alpha$_e$	**Alpha$_{m\perp e}$**	**Theta**	**P2**	**Age**	**FSIQ**	**R$^2_{adj}$**	**F**
Symptom Factor	**-2.1***	.40	.49	-.65	.07	1.3	.02	1.3
Executive Function Factor	**-1.9†**	**2.5***	.18	.86	**2.0†**	**4.1*****	.27	**6.2*****
Basic Reading Factor	-.37	1.2	-.47	.15	.12	**4.0*****	.15	**3.5*****
Reading Comprehension/Math Factor	**-1.7†**	.25	-.49	1.5	-.63	**4.5*****	.21	**4.7*****
Task Accuracy	**-2.1***	-.62	**1.7†**	1.3	**4.8*****	**3.5*****	.36	**10.5*****
Task Reaction Time	.50	-.30	-.79	.05	**-7.7*****	-.03	.43	**13.4*****
Task Reaction Time SD	.50	.39	-.25	.59	**-4.8*****	**-2.4***	.22	**5.7*****

*Notes. †p<.1, *p<.05, **p<.01, ***p<.001. SD=standard deviation*

FSIQ was significantly correlated with several variables of interest and accounted for a significant portion of variance as indicated by improved model fit. However, the pattern of results reported in the manuscript, albeit weakened with the inclusion of FSIQ, was unchanged.

S7. EEG Prediction of CBCL Scales

Given the broad impairment in the ADHD sample across CBCL scales of impairments (c.f., S3 above), it is possible that the EEG indicator prediction of attention symptoms is non-specific, but rather, reflects any impairment. To test the specificity of the relationship between the EEG indicators and ADHD symptoms, we repeated the multiple regression for each CBCL symptom scale. As shown in Table S3, the EEG indicators are predictive of ADHD-related symptoms (Attention Problems and ADHD problems), as well as withdrawal and affect problems. The EEG indicators are not broadly predictive of other symptoms, or total symptoms. This result suggests that the encoding alpha power metric is specific in predicting ADHD related problems, with a potential additional relationship to symptoms of depression such as withdrawal, which may be indicative of a sub-sample of the ADHD population or characteristic of a comorbid symptom group.

Table S3. *Multiple Regression: EEG Predictors of CBCL*

	t_β (regression coefficient)					*Model Fit*	
	Alpha$_e$	**Alpha$_{m\perp e}$**	**Theta**	**P2**	**Age**	**R^2_{adj}**	**F**
Anxiety/Depression	.96	-.36	-.07	-.25	**2.1***	.002	.96
Withdrawal	**2.1***	-.96	.11	-.44	**2.4***	.04	1.8
Somatic Complaints	-.08	-.12	-.47	-.83	**1.7**†	.01	.82
Social Problems	.26	.81	.06	-.38	.33	.05	.18
Thought Problems	1.3	.61	.19	-.04	.19	.02	.56
Attention Problems	**2.1***	-.58	-.26	1.1	.05	.01	1.2
Delinquency	.28	.24	.14	.69	.20	.04	.15
Aggression	.92	-.80	.11	-.67	.05	.03	.46
Affect Problems	**1.9**†	.35	-.35	-.19	**2.8****	.04	1.8
Anxiety Problems	1.0	-.12	-.55	-1.0	.53	.04	.25
Somatic Problems	-.27	-.21	-.57	-.69	-.63	.04	.33
ADHD	**1.8**†	-.23	-.11	.36	-.37	.004	.92
ODD	1.0	-.34	.43	-.78	.77	.03	.43
Conduct Disorder	1.2	-.66	.98	-.75	-.65	.007	1.1
Internalizing	1.3	-.52	-.25	-.45	**2.2***	.006	1.1
Externalizing	.90	-.61	.18	-.97	-.09	.02	.57
Total Problems	1.6	-.13	.14	-.23	.80	.02	.58

*Notes. †p<.1, *p<.05, **p<.01, ***p<.001. SD=standard deviation*

S8. Sample Differences

To evaluate potential sources of differences between our Lenartowicz et al 2014 report and the present analysis, we tested for sample differences. As shown in Table S4, we found no differences in gender, age, or IQ. Within the ADHD group, there were no differences in gender (χ^2(1, n=121)=.31, p=.31) or sub-type (χ^2(1, n=121)=1.6, p=.45). The samples appear comparable in demographics. However, the new sample showed poorer accuracy on task, lower neuropsychological test scores & academic achievement measures, as well as higher ADHD symptoms. These results suggest that the prior sample may be associated with weaker impairment with respect to ADHD relative to the present report. The absence of the mid-frontal theta during maintenance in the current report may be related to the greater impairment in the present sample.

Table S4. ***Previous vs Current Sample Characteristics***

	Previous	**Current**	**Group Difference**
N	80	119	
Males	50 (62.5%)	82 (68.9%)	χ^2=0.1, p=.80
Age	10.9yrs	10.5yrs	t=1.4, p=.16
FSIQ	107.1	105.2	t=0.9, p=.36
SWAN inattention	26.6	20.3	**t=3.3, p=.001**
SWAN hyperactive	30.2	25.4	**t=2.7, p=.008**
	Task Performance		
Accuracy	79.4%	75.8%	**t=2.5, p=.01**
RT	1348ms	1362ms	t=0.38, p=.70
RTsd	415ms	422ms	t=0.54, p=.59
	CBCL Scores		
Anxiety/Depression	54.9	56.6	t=1.6, p=.11
Withdrawal	54.9	56.7	t=1.7, p=.09
Somatic Complaints	56.4	56.0	t=0.4, p=.41
Social Problems	55.6	58.1	**t=2.5, p=.01**
Thought Problems	55.5	57.7	**t=2.1, p=.04**
Attention Problems	61.7	65.7	**t=2.5, p=.02**
Delinquency	55.6	58.1	**t=2.6, p=.01**
Aggression	56.4	59.4	**t=2.2, p=.03**
Affect Problems	56.2	58.7	**t=2.1, p=.04**
Anxiety Problems	54.6	55.6	t=0.7, p=.17
Somatic Problems	56.3	55.2	t=1.1, p=.28
ADHD	59.0	62.8	**t=2.9, p=.005**
ODD	56.8	60.0	**t=2.6, p=.009**
Conduct Disorder	55.7	58.3	**t=2.5, p=.013**
Internalizing	51.8	54.2	t=1.5, p=.14
Externalizing	52.4	56.6	**t=2.8, p=.006**
Total Problems	53.2	57.8	**t=2.8, p=.006**
	DKEFS		
Trails (scan)	10.0	9.6	t=0.9, p=.37
Trails (number)	10.9	10.0	**t=2.5, p=.01**
Trails (letter)	9.9	8.9	**t=2.1, p=.04**
Trails (number-letter switch)	9.2	8.5	**t=1.9, p=.07**
Trails (motor)	11.0	10.9	t=.12, p=.91
VF (letter)	10.9	10.7	t=1.0, p=.30
VF (category)	8.8	8.4	t=1.3, p=.21
VF (switch correct)	10.0	9.5	t=1.3, p=.21
VF (switch total)	10.9	10.6	t=0.6, p=.52
CW (color)	9.8	9.8	t=0.6, p=.58
CW (word)	10.6	10.5	t=0.3, p=.77
CW (color-word)	10.4	10.2	t=0.7, p=.51
CW (switching)	10.4	10.4	t=0.1, p=.91
	Academic Achievement		
GORT (rate)	11.4	10.5	**t=2.0, p=.05**
GORT (accuracy)	10.0	9.0	**t=2.3, p=.02**
GORT (fluency)	10.9	9.6	**t=2.5, p=.02**
GORT (comprehension)	10.4	10.5	t=0.3, p=.77
GORT (oral reading index)	103.7	100.4	t=1.3, p=.21
WRAT spelling	111.5	108.3	t=1.4, p=.16
WRAT math	108.1	107.9	t=0.1, p=.94
WJ (word attack)	106.3	105.4	t=0.6, p=.56
WJ (letter-word ID)	108.2	106.3	t=1.1, p=.27

Notes. VF = verbal fluency; CW = color-word interference test; GORT = Gray Oral Reading Test, 4th edition; WRAT = Wide Range Achievement Test, 4th edition; WJ = Woodcock Johnson IV Achievement Test; SWAN = Strengths and Weaknesses of ADHD symptoms and Normal behavior rating scale (higher indicates better scores); FSIQ = Full Scale IQ

S9. Variable Correlations

Below we provide first order correlations between regression variables. The factor variables (top left around diagonal, *red*) show significant correlations, justifying choice of oblique rotation in the analysis. Regression predictors (bottom right around diagonal, *purple*) indicate low to mid-range correlations indicating that collinearity was not a factor in the analysis. The first-order correlations of alpha during encoding with each of the outcome variables (bold) is consistent with the results of the regression analysis. The correlation between alpha during encoding and reading comprehension/math-factor scores is negative but not significant, indicating that the significant

Table S5.

	Symptom Factor	Executive Function Factor	Basic Reading Factor	Reading Comprehension/ Math Factor	ACC	RT	RTSD	SWANinatt	SWANhyper	Alpha Encode	Alpha Maintain[a]	Theta Maintain	P2	Age
Symptom Factor	1	0.177†	0.116	0.017	.223*	-0.052	-0.166†	.780**	.762*	-.209*	0.058	-0.013	0.049	0.004
Executive Function Factor	0.177†	1	.433**	.392**	.269**	-.290**	-0.141	.287**	0.189†	-.253*	.245*	0.058	0.048	.221*
Basic Reading Factor	0.116	.433**	1	.577**	.329**	0.122	-0.118	0.091	0.047	-0.049	0.163	-0.021	-0.066	-0.095
Reading Comprehension/ Math Factor	0.017	.392**	.577**	1	.416**	0.112	-0.122	0.129	0.049	-0.143	0.113	-0.057	0.015	-0.052
ACC	.223*	.269**	.329**	.416**	1	-.267**	-.443**	.187*	.308**	-.388**	-0.049	0.114	.204*	.447**
RT	-0.052	-.290**	0.122	0.112	-.267**	1	.386**	0.021	-0.13	.261**	0.02	-0.087	-0.144	-.644**
RTSD	-0.166†	-0.141	-0.118	-0.122	-.443**	.386**	1	-0.067	-.189*	.201*	0.05	0.043	-0.056	-.336**
SWANinatt	.780**	.287**	0.091	0.129	.187*	0.021	-0.067	1	.636**	-.254**	0.146	0.086	0.026	-0.114
SWANhyper	.762**	0.189	0.047	0.049	.308**	-0.13	-.189*	.636**	1	-.261**	0.014	0.114	.225*	0.156†
Alpha Encode	**-.209***	**-.253***	**-0.049**	**-0.143**	**-.388****	**.261****	**.201***	**-.254****	**-.261****	**1**	**0.037**	**-0.015**	**-.211***	**-.317****
Alpha Maintain[a]	0.058	.245*	0.163	0.113	-0.049	0.02	0.05	0.146	0.014	0.037	1	0.114	0.023	-0.099
Theta Maintain	-0.013	0.058	-0.021	-0.057	0.114	-0.087	0.043	0.086	0.114	-0.015	0.114	1	0.073	0.106
P2	0.049	0.048	-0.066	0.015	.204*	-0.144	-0.056	0.026	.225*	-.211*	0.023	0.073	1	.283**
Age	0.004	.221*	-0.095	-0.052	.447**	-.644**	-.336**	-0.114	0.156†	-.317**	-0.099	0.106	.283**	1

*Notes. †p<.1, *p<.05, **p<.01, ***p<.001, [a]Maintenance alpha residualized with respect to encoding alpha.*

relationship between these variables as identified by the regression analysis is likely of small effect size and is strengthened by partialing out the contribution of the other predictors.