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The Validity of a Battery of Phonemic and Orthographic Awareness Tasks for Adults With and Without Dyslexia and Attention Deficit/Hyperactivity Disorder

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The vast majority of adults with learning disabilities are those with deficits affecting reading decoding, reading and writing fluency, and spelling. Many adults with Attention Deficit/Hyperactivity Disorder (AD/HD) also demonstrate problems with reading and writing. Documenting the underlying reasons for reading underachievement among these groups of adults is critical from both an assessment and an accommodation perspective. The purposes of this study are threefold: (a) to extend our understanding of the nature of phonemic and orthographic awareness among various adult populations; (b) to explore the validity and separability of the latent constructs of phonemic and orthographic awareness and tasks used to measure these constructs across a population of 630 university students with dyslexia, AD/HD, dyslexia and AD/HD (comorbid), and no disabilities; and (c) to discuss the implications of these analyses for intervention and accommodation selection.

Keywords: *dyslexia; ADHD; phonemic awareness; orthographic awareness*

The persistence of phonemic and orthographic awareness deficits among the adult population demonstrating dyslexia has been repeatedly documented in the literature (Bruck, 1993; Gregg, Coleman, Stennett, Davis, Nielsen, Knight, & Hoy, 2002; Hatcher, Snowling, & Griffiths, 2002; Holmes & Castles, 2001). Implications of this adult profile for assessment, intervention, and accommodation selection have been discussed by many professionals (Bruck, 1992; Gregg, Coleman, & Lindstrom, in press; Shaywitz, 2003). In contrast, researchers have provided scant empirical data related to the measurement of phonemic and orthographic awareness abilities among adults with attention deficit/hyperactivity disorder (AD/HD) or those with dyslexia and AD/HD (comorbid). The need for a better understanding of the way AD/HD affects achievement was recently highlighted by research findings from a meta-analysis indicating a moderate to large discrepancy for adolescents and adults with AD/HD in reading performance as compared to their normally achieving peers (Frazier, Youngstrom, Glutting, & Watkins, 2007). Given the high reported comorbidity of dyslexia and AD/HD, an investigation of the influence of linguistic and attention deficits is critical to our understanding of reading and spelling underachievement.

The types of tasks developed to measure phonemic and orthographic awareness have been diverse, complicating generalizability within and across populations (McBride-Chang, 1985; Schatschneider, Francis, Foorman, Fletcher,

& Mehta, 1999). Age and literacy experience have been found to influence the predictive ability of phonemic awareness tasks with children despite the apparent unidimensionality of many of the tasks used to measure this construct (Schatsneider et al., 1999). Investigation of the commonality between tasks and proposed latent constructs (i.e., phonemic and orthographic awareness) with the adult population has been lacking despite the critical need for such tasks to document the need for specific interventions and/or accommodations.

Phonemic Awareness Performance of Adults with Dyslexia and AD/HD

Recent research investigating the phonemic awareness of young adults with dyslexia has demonstrated the predictive ability of phonemic knowledge to decoding and spelling underachievement (Bruck, 1993; Gregg et al., 2002; Hatcher et al., 2002). Phonemic awareness has been defined as "the explicit awareness that is needed to segment, identify, and manipulate the phonemes in words" (Westby, 2002, p. 73). Bruck conducted research investigating the phonemic awareness of young adults with documented dyslexia. The populations she studied received a clinical diagnosis of dyslexia during childhood, yet as adults, continued to show inaccurate and particularly slow word-recognition processes. As a group, they overrelied on spelling–sound information, syllabic information, and context for word recognition. Bruck's research also documented that among this adult population, phonemic awareness (measured by phoneme counting [nondigraph items] and phoneme deletion) continued to be an area of deficit when compared to their peers. Difficulties with fluent processing on tasks measuring phonological awareness among adults with dyslexia have also been documented on English-speaking (United States and Great Britain), Spanish-speaking, and German-speaking individuals (Gregg et al., 2002; Hatcher et al., 2002).

The population of adults with AD/HD appears to present a different profile in relation to the predictive strength of phonemic and orthographic awareness tasks for reading decoding and spelling performance. Gregg et al. (2002) found that young adults with AD/HD performed significantly better than those students with dyslexia across sound and syllable segmentation, phonemic localization, and phonological segmentation tasks. Their performance on reading decoding (of nonsense and real words) as well as spelling tasks was also significantly better than that of their peers with dyslexia or dyslexia and AD/HD.

Orthographic Awareness Performance of Adults with Dyslexia and AD/HD

Some researchers hypothesize that phonological decoding is a self-teaching device that facilitates the establishment of orthographic representations (Bruck, 1993; Share & Stanovich, 1995). In other words, normally achieving readers depend less on their knowledge of spelling–sound information, recognizing words more on the basis of direct visual–orthographic information (Andrews, 1982; Seidenberg, Waters, Barnes & Tanenhaus, 1984). A bidirectional relationship between phonemic awareness and reading acquisition occurs for such readers (Bruck, 1993; Perfetti, Beck, Bell, & Hughes, 1987). Among dyslexics, a lack of fluent access to an age-appropriate store of orthographic representations results in overreliance on an already weak sound–spelling system. Orthographic awareness is "the ability to represent the unique array of letters that defines a printed word, as well as the general attributes of the writing system such as segmented dependencies, structural redundancies, and letter position frequencies" (Vellutino, Scanlon, & Chen, 1994, p. 32).

It is unfortunate that orthographic awareness has not received the attention that phonemic awareness has in the literature, particularly with the adult population (Berninger, 1994; Foorman, 1994; Gregg et al., 2002; Roberts & Mather, 1997). Yet researchers have provided evidence that part of the variance in decoding and spelling performance appears to be accounted for by orthographic awareness (Cunningham & Stanovich, 1990; Kim, Taft, & Davis, 2004; Stanovich & West, 1989). In addition, studies have identified orthographic processing as a construct related to but separate from phonological processing (Carr & Posner, 1994; Eviatar, Ganayim, & Ibrahim, 2004; Rumsey, Donohue, Nace, Maisong, & Andreason, 1997).

The degree to which the orthographic representations of a word required for decoding and spelling depend on similar or different memory storage has been debated in the literature (Bosman & Van Orden, 1997; Ehri, 1986, 1991; Holmes & Carruthers, 1998; Holmes & Castles, 2002; Patterson, 1986; Perfetti, 1991). At this time, the results from empirical research appear to support a single latent memory variable that contributes to the ability to read, as well as spell, single words (see Holmes & Castles, 2002, for an in-depth review of the literature).

One group of researchers proposes that phonemic deficiencies are the primary etiology of the poor performance of individuals with dyslexia on reading decoding or spelling tasks (Bruck, 1992; Bruck & Waters, 1988; Burden, 1992; Seidenberg et al., 1984). Bruck (1992) found that young adults with dyslexia, when asked to make phonological judgments, did not make efficient use of orthographic information as did normally achieving peers or younger readers with equivalent or lower levels of word-recognition skill. According to her findings, the adult dyslexics' poor use of orthographic information reflected a weak understanding of the phonemic structure of language.

The case of "good decoders but poor spellers" led Frith (1984) to propose that phonemic awareness may not always be the underlying problem. She discussed the concept of *word-specific* orthographic information (Holmes & Castles, 2002, p. 321). Word-specific refers to orthographic information that might not be necessary to read a word but is vital for accurate spelling. For instance, a reader might phonologically decode the word *rabbit* correctly but spell the word as *rabit*. Therefore, good decoders and poor spellers have problems not because of phonological awareness deficits but because their memory of word-specific information is lacking (Holmes & Castles, 2002). Such spellers, according to Frith (1984), can read words better than they can spell because they are able to extract partial cues from print, a strategy that is not as effective for spelling accuracy. Holmes and Castles supported Frith's empirically driven theory of word-specific orthographic information necessary for spelling by finding that poor spelling among university students appeared to be the result of inferior orthographic awareness.

Adult readers with AD/HD, however, perform significantly better than their peers with dyslexia or dyslexia and AD/HD on phonemic and orthographic awareness tasks, with the exception of tasks tapping into orthographic and verbal fluency. Therefore, young adults with AD/HD and no dyslexia appear to have cognitive deficits (i.e., attention, working memory, executive functioning) that lead to lower performance on fluency tasks than on tasks measuring specific phonemic and/or orthographic abilities.

Dimensionality of Phonemic and Orthographic Processing Tasks

Phonemic and orthographic awareness are latent constructs that have been measured by a wide range of tasks varying in linguistic complexity, including unit information (rhyme, onset rime or phoneme), letter position, word type (psuedoword or real word), and fluency. Recently, researchers have begun to apply exploratory and confirmatory factor analyses to many of the tasks commonly used to measure phonemic and orthographic awareness to investigate their dimensionality. The results of the majority of this research indicate that phonemic awareness tasks appear to be represented as a unidimensional construct (Schatschneider et al., 1999; Stanovich & West, 1989). In other words, many of the tasks designed to measure different aspects of phonemic awareness appear to be sharing a significant proportion of common variance. In one of the largest studies to date investigating the dimensionality of phonemic awareness tasks with the child population (n = 945), Schatschneider et al. (1999) found that seven separate phonemic awareness tasks appear to be represented by a unidimensional construct. Few studies have explored the construct validity and dimensionality of phonemic and orthographic awareness tasks.

The purposes of the current study are threefold: (a) to extend our understanding of the nature of phonemic and orthographic awareness among adult populations by investigating the factor structure of a battery of five phonemic and five orthographic awareness tasks; (b) to explore the relationship between the latent constructs of phonemic and orthographic awareness and tasks used to measure these constructs across 630 university students with dyslexia, AD/HD, dyslexia and AD/HD (comorbid), and no disabilities; and (c) to consider the implications of these analyses for intervention and accommodation selection.

Method

Participant Selection

Populations with documented disabilities. Three groups were identified within this category of young adults. Individuals were identified as demonstrating LD (dyslexia) for Group 1, AD/HD for Group 2, and dyslexia and AD/HD (comorbid) for Group 3. All participants in these three categories were evaluated at the University of Georgia Regents' Center for Learning Disorders. The evaluation of all participants included measures of overall ability, cognitive processing, oral language, achievement, and social–emotional functioning. Assessment instruments were selected on the basis of their psychometric properties and usefulness with the adult population. An interdisciplinary team of experienced master's and doctoral-level diagnosticians and psychologists individually administered tests used in the evaluation process. Clinical judgment was used to interpret test results as well as analyze error responses, writing samples, and other data obtained from informal assessment measures. Quantitative data included results from standardized tests and informal measures. Qualitative data included information gathered from case histories, clinical interviews, and previous records that confirmed the chronicity of learning problems. Both quantitative and qualitative data were considered in a careful study of the performance of each individual participant. No diagnoses were made on the

Table 1
Descriptive Statistics

	Normally Achieving				Dyslexic				Attention Deficit/ Hyperactivity Disorder				Comorbid			
	N	*M*	*SE*	*SD*	*N*	*M*	*SE*	*SD*	*N*	*M*	*SE*	*SD*	*N*	*M*	*SE*	*SD*
Age in years	219	22.811	0.352	5.210	210	22.941	0.399	5.768	131	20.937	.349	3.981	70	21.774	0.524	4.356
Nelson-Denny reading comprehension	209	222.172	1.650	23.857	198	200.005	1.700	23.925	127	207.724	2.384	26.864	66	194.394	3.058	24.840
WRAT III reading standard scores	195	108.667	0.581	8.116	182	98.852	0.829	11.181	107	105.607	1.124	11.624	65	100.262	1.201	9.683
WRAT III spelling standard scores	195	107.882	0.602	8.413	182	96.110	1.019	13.751	107	108.075	2.922	30.228	65	95.846	1.321	10.654
WAIS-III																
full scale	144	113.229	0.957	11.487	170	107.671	.0847	11.043	92	109.967	1.134	10.881	51	108.431	1.410	10.070
WAIS-III Performance Scale	143	110.364	1.057	12.638	171	106.415	1.129	14.759	92	106.130	.956	9.174	51	107.392	1.457	10.404
WAIS Verbal Scale	144	113.819	0.978	11.732	170	107.400	0.880	11.473	92	111.620	1.29	12.450	51	108.451	1.652	11.797
KAIT composite	72	111.125	1.289	10.938	100	103.430	1.086	10.859	35	104.657	1.758	10.401	47	101.064	1.546	10.596
KAIT crystallized	72	109.903	1.329	11.273	100	101.960	1.008	10.084	35	103.514	1.685	9.969	47	99.957	1.688	11.572
KAIT fluid	72	110.333	1.345	11.410	100	104.170	1.219	12.190	35	104.771	1.866	11.038	47	101.872	1.695	11.618

Note: WRAT = Wide Range Achievement Test; WAIS = Wechsler Adult Intelligence Scale; KAIT = Kaufman Adolescent and Adult Intelligence Test.
Source: Brown, Fischo, & Itawna, 1993; Kaufman, & Kaufman, 1997; Wechsler, 1997; Wilkinson, 1993.

basis of a single test score or discrepancy measure; rather, they were based on patterns of problems and errors.

Each of the participants was classified into one of the three categories based on the results of the evaluation process and in accordance with the Georgia System of Universities state documentation guidelines and eligibility criteria for LD and AD/HD (see www.rcld.uga.edu). Participants in Group 1 were clinically diagnosed as having dyslexia but no other developmental and/or acquired disability. Of the 210 students (118 females, 92 males) in Group 1, 60% had received a previous diagnosis of learning prior to coming to the University of Georgia Regents' Center for Learning Disorders. Group 2 (AD/HD) met the Georgia Regents' Criteria for AD/HD but demonstrated no other developmental or acquired disability. Of the 131 students with a diagnosis of AD/HD (62 females, 69 males), 80% had received a prior diagnosis of AD/HD. Group 3 included students with coexisting dyslexia and AD/HD. Of the 70 students in this group (28 females, 42 males), 94% had received previous diagnoses of either LD or AD/HD (see Table 1 for descriptive information pertaining to the participants across groups).

Normally achieving students. All students spoke English as a first language, had no known neurological impairment, had received no special education services (with the exception of gifted education programs), and were enrolled in undergraduate or graduate college courses at University of Georgia. Two hundred nineteen students (138 females, 81 males) made up this category and were referred to as "normally achieving students." All 219 students in this group went through the same psychological evaluation given to students with documented disabilities to ensure that no undetected disabilities would be affecting learning (see Table 1 for descriptive information related to this population).

Materials

Phonemic/orthographic battery. This battery consists of several tasks used by established researchers to assess phonemic and orthographic awareness. The battery consists of five tasks assessing phonemic awareness and five tasks assessing orthographic awareness. A brief description of each task is listed in Table 2, accompanied by the number of items on that task.

Assessment of Measurement Invariance

A set of procedures has been developed to assess questions of measurement invariance across groups using structural equation modeling (SEM) techniques. Using these procedures, a series of increasingly restrictive constraints is imposed to force the model parameters to be equal across groups. These procedures result in a series of nested models that can be tested through the use of

Table 2
Description of Phonemic and Orthographic Battery

Indicator	Subtest	Description	Items
G Rhymn	General Rhyming (Johnson & Blalock, 1987)	Stimulus items are presented orally. Examinee is required to generate three words that rhyme with the stimulus word.	12
Seg syl	Segmenting by Syllables (Johnson & Blalock, 1987)	Stimulus items are presented orally. Examinee is required to segment each word into its constituent syllables.	12
No Syl	Number of Syllables (Johnson & Blalock, 1987)	High-frequency stimulus items are presented orally. Examinee is required to identify number of syllables in each stimulus word.	12
seg sds	Segmenting by Sounds (Johnson & Blalock, 1987)	High-frequency stimulus items are presented orally, and examinee is required to segment stimulus word into its constituent phonemes.	8
phon loc	Phonemic Localization (Vellutino & Scanlon, 1988)	Ten pairs of one-syllable words/pseudowords are presented orally. Examinee is required to identify relative location of phoneme difference in each word pair (beginning, middle, or end).	10
phon seg	Phonemic Segmentation (Berninger & Abbott, 1994)	Multisyllabic pseudowords are presented orally via audio recording. Examinee is required to (a) repeat stimulus word, and (b) delete certain phonemes according to examiner instructions.	24
or ex co	Orthographic Expressive Coding (Berninger & Abbott, 1994)	Computer-printed stimulus pseudowords are presented for 1 second each on 3 × 5 index cards. After each exposure, examinee is required to write the item in its entirety or specified letters from it.	18
or choice	Orthographic Choice (Stanovich, West, & Cunningham, 1991)	Timed measure in which a series of stimulus questions with two homophonic answers is presented. Examinee is required to circle the best answer.	25
hom/pseu	Homophone/Pseudohomophone Choice (Olsen, Forsberg, & Wise, 1994)	Timed measure (3 minutes) in which examinee must select the correct spelling from pairs of orthographically plausible spellings.	78
col ps 1	Colorado Perceptual Speed Test, Trial I (DeFries & Baker, 1983)	Timed measure in which examinee is given 1 minute to scan rows of letter–number clusters and circle the cluster identical to stimulus item presented at the beginning of each row (four choices). Clusters do not resemble pronounceable words.	30
col ps 2	Colorado Perceptual Speed Test, Trial II (DeFries & Baker, 1983)	Timed measure in which examinee is given 1 minute to scan rows of letter–number clusters and circle the cluster identical to stimulus item presented at the beginning of each row (four choices). Clusters do not resemble pronounceable words.	30
col ps 3	Colorado Perceptual Speed Test, Trial III (DeFries & Baker, 1983)	Timed measure in which examinee is given 1 minute to scan rows of letter clusters and circle the cluster identical to stimulus item presented at the beginning of each row (four choices). Clusters are mostly one-syllable pseudowords.	30
or flu	Orthographic Fluency (Coleman & Nielsen, 2000)	Timed measure in which examinee is required to generate words from a printed group of consonants by adding vowels. Six 40-second trials administered.	6

chi-square difference tests, as described below. In the current study, constraints were placed on the factor loadings, measurement error variances, factor variances, and factor covariance, in that order. This series of tests allowed us to determine whether the values of these parameters differed significantly across groups. The significance tests are accomplished through the use of chi-square differences, computed as the difference between the chi-square values of adjacent nested models with degrees of freedom equal to the difference in models' degrees of freedom. These provide a test of whether imposition of the equality constraints in the more constrained model resulted in a significant decrement in the fit of the model across groups. A significant chi-square difference implies that values of the parameters held invariant at that step actually differ significantly across groups.

These tests are analogous to the omnibus test in the analysis of variance in that they indicate that there are group differences within the set of parameters tested (e.g., factor loadings, measurement error variances, etc.) but do not indicate the specific parameters that have resulted in a lack of invariance. In many cases, the lack of invariance is due to only a few parameters. Therefore, some researchers (Byrne, Shavelson, & Muthén, 1989) have suggested that investigation of partial invariance is tenable. This involves retaining indicators with noninvariant parameter values but allowing the values of these parameters to vary across groups. The identification of noninvariant parameter values can be accomplished by allowing each parameter in a set (e.g., each factor loading) to vary across groups in turn. Rensvold and Cheung (1998, 2001) have suggested a more rigorous procedure for identifying noninvariant factor loadings in which each possible pairing of loadings is tested; these procedures were used in the current study. Noninvariant parameters can also be identified by examining statistics such as the Modification Indexes (MIs) provided by the LISREL program. For parameters that have been constrained to be equal across groups, MIs measure the amount by which the chi-square value would decrease (i.e., model fit would improve) if values of the parameter were allowed to vary across groups. Because measurement invariance of the orthographic and phonemic awareness tasks included in the current study has not previously been studied in dyslexic groups, partial invariance of model parameters was allowed to more thoroughly investigate differences in indicator functioning across the dyslexic and normally achieving groups. Parameter values were allowed to vary across groups only if the difference could be supported theoretically. If this was the case, the model was reestimated, allowing the parameter to vary across groups, and the testing sequence was resumed with the noninvariant parameter included.

To compare parameter equivalence across groups, it is necessary to first establish that the basic factor structure is the same across groups in terms of the number of factors and the variables loading on each factor. If this form of invariance, known as "configural invariance," is not supported, groups must be examined separately because what is being measured varies as a function of group membership. Differences in factor structure represent differences in conceptualization and may represent a qualitative difference in the meaning of the underlying factor. Our first set of analyses therefore examined whether configural invariance could be established for the four groups under consideration.

A final issue in measurement invariance studies involves the identification of a metric for the latent factors. Two approaches are commonly used. One approach involves setting the variance of the latent factor equal to 1.0 in each of the groups. However, this approach involves an implicit assumption that the factor variance is equal (to 1.0) across the groups. If the factor variance is not equal across groups, other tests for measurement invariance will be biased. The other approach to standardization is more commonly used in practice (Cheung & Rensvold, 1999; Riordan & Vandenberg, 1994). In this approach, one indicator for each latent factor, sometimes called the *referent indicator,* is selected, and these factor loadings are set to 1.0 across groups. The scales of the factors are thus equated to the scales of the selected indicators. This was the approach taken in the current study.

Data Analyses

All analyses were conducted using LISREL 8.54 software (Jöreskog & Sörbom, 1996). Covariance matrices for each group were produced by PRELIS 2.51. Model fit was assessed according to the guidelines proposed by Hu and Bentler (1999), which involve looking at combinations of fit indexes including the root mean square error of approximation (RMSEA), standardized root mean square residual, comparative fit index (CFI), and incremental fit index in addition to the chi-square test of model fit. In addition, Cheung and Rensvold (1999) have recently examined differences in CFI for tests of model invariance such as those used in the current study. They suggest that a change in CFI of .01 or greater is associated with significant differences in model fit when parameters are constrained between models. Differences in fit between nested models (i.e., a model with constraints compared to a model without constraints) were assessed by the chi-square difference test, the CFI difference test, and inspection of changes in other fit indices. The chi-square difference test and the CFI difference test were the primary statistics used to assess changes in model fit.

Results

Preliminary Model Comparisons

Table 3 shows the correlation matrices, means, and standard deviations for each of the four groups in the study. As a first step, we examined the univariate distributions of the variables within each group for normality. These analyses revealed severe nonnormality for several of the variables. In particular, the variables Rhyme, Orthographic Choice, and Homophone/Pseudohomophone were found to have high negative skew and high positive kurtosis. Because of this, we obtained both the maximum likelihood chi-square and standard errors and the Satorra-Bentler scaled chi-square and adjusted standard errors available in the LISREL program. However, several anomalous results from analyses based on the Satorra-Bentler adjustments caused us to doubt the accuracy of these results. High levels of nonnormality combined with some degree of model misspecification have been found to result in overadjustment of the values of chi-square and related indexes in a previous study (Bandalos, 2003). We therefore used the maximum

Table 3
Correlation Matrices, Means, and Standard Deviations for Normally Achieving, Dyslexia, Attention Deficit/Hyperactivity Disorder, and Comorbid Groups

Normally Achieving Group (*n* = 219)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Seg Syl	1.000												
2. Num Syl	0.374	1.000											
3. Seg Sds	0.239	0.226	1.000										
4. G Rhym	0.122	0.085	0.166	1.000									
5. Phon Loc	0.368	0.230	0.254	0.285	1.000								
6. Phon Seg	0.257	0.160	0.425	0.348	0.460	1.000							
7. Or Ex Cod	0.177	0.197	0.235	0.154	0.362	0.357	1.000						
8. Or Choice	0.167	0.108	0.057	0.034	0.073	0.120	0.096	1.000					
9. Hom Pseu	0.165	0.157	0.040	0.114	0.098	0.115	0.110	0.088	1.000				
10. Col PS 1	0.268	0.289	0.178	0.288	0.283	0.313	0.345	0.272	0.270	1.000			
11. Col PS 2	0.242	0.240	0.126	0.199	0.209	0.292	0.338	0.205	0.351	0.770	1.000		
12. Col PS 3	0.229	0.370	0.240	0.276	0.272	0.300	0.360	0.165	0.301	0.669	0.620	1.000	
13. Or Flu	0.303	0.195	0.242	0.239	0.321	0.488	0.383	0.077	0.147	0.358	0.313	.309	1.000
M	11.13	11.60	7.69	11.62	9.53	18.29	16.81	24.76	76.46	21.37	17.66	27.09	19.11
SD	1.67	1.50	1.94	0.90	0.88	3.72	1.53	0.59	4.54	4.46	3.90	4.22	4.84

Group with Dyslexia (*n* = 210)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Seg Syl	1.000												
2. Num Syl	0.377	1.000											
3. Seg Sds	0.234	0.346	1.000										
4. G Rhym	0.219	0.296	0.272	1.000									
5. Phon Loc	0.230	0.206	0.238	0.185	1.000								
6. Phon Seg	0.269	0.307	0.376	0.334	0.328	1.000							
7. Or Ex Cod	0.126	0.246	0.222	0.348	0.315	0.471	1.000						
8. Or Choice	0.091	0.022	0.043	0.105	0.218	0.208	0.381	1.000					
9. Hom Pseu	0.036	0.251	0.115	0.157	0.281	0.289	0.447	0.386	1.000				
10. Col PS 1	0.085	0.229	0.092	0.215	0.195	0.187	0.380	0.179	0.490	1.000			
11. Col PS 2	0.075	0.208	0.084	0.167	0.190	0.184	0.351	0.167	0.507	0.844	1.000		
12. Col PS 3	0.043	0.296	0.130	0.243	0.176	0.247	0.457	0.229	0.580	0.804	0.809	1.000	
13. Or Flu	0.216	0.273	0.311	0.387	0.311	0.549	0.557	0.202	0.392	0.341	0.345	0.414	1.000
M	10.56	11.44	6.95	11.12	8.95	15.94	16.07	24.48	73.12	18.11	15.17	23.84	15.71
SD	1.83	1.33	2.13	1.52	1.38	3.99	2.08	1.26	7.51	4.21	3.96	5.15	5.06

Group with Attention Deficit/Hyperactivity Disorder (*n* = 131)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Seg Syl	1.000												
2. Num Syl	0.276	1.000											
3. Seg Sds	0.249	0.297	1.000										
4. G Rhym	–0.04	0.003	0.119	1.000									
5. Phon Loc	0.131	0.018	0.196	0.248	1.000								
6. Phon Seg	0.124	0.134	0.333	0.207	0.352	1.000							
7. Or Ex Cod	0.035	0.110	0.172	0.176	0.394	0.304	1.000						
8. Or Choice	–0.14	0.011	–0.10	0.032	–0.20	–0.09	0.112	1.000					
9. Hom Pseu	0.036	–0.15	0.000	-0.07	0.126	0.060	–0.03	–0.42	1.000				
10. Col PS 1	0.184	0.036	0.051	–0.01	0.213	0.149	0.398	–0.11	0.157	1.000			
11. Col PS 2	0.179	0.015	–0.01	–0.02	0.150	0.112	0.358	–0.06	0.176	0.766	1.000		
12. Col PS 3	0.267	0.107	0.084	–0.01	0.254	0.166	0.415	–0.10	0.192	0.706	0.689	1.000	
13. Or Flu	0.163	0.013	0.274	0.051	0.408	0.504	0.385	–0.04	0.111	0.142	0.136	0.256	1.000
M	10.85	11.73	7.46	11.60	9.29	17.99	16.57	24.05	74.15	19.48	16.14	26.15	18.92
SD	1.90	1.38	2.04	0.96	1.05	3.24	1.66	0.74	10.37	3.60	3.37	3.60	4.16

(continued)

Table 3 (continued)

Group with Comorbid Diagnoses (*n* = 70)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Seg Syl	1.000												
2. Num Syl	0.577	1.000											
3. Seg Sds	0.585	0.827	1.000										
4. G Rhym	0.164	0.100	0.116	1.000									
5. Phon Loc	0.190	0.014	0.184	0.269	1.000								
6. Phon Seg	0.233	0.173	0.262	0.194	0.395	1.000							
7. Or Ex Cod	0.205	0.103	0.185	0.177	0.356	0.415	1.000						
8. Or Choice	0.008	–0.21	–0.15	0.214	0.315	0.141	0.185	1.000					
9. Hom Pseu	–0.07	–0.05	–0.10	–0.01	0.182	0.235	0.254	0.311	1.000				
10. Col PS 1	0.029	0.000	–0.05	0.081	–0.22	0.094	0.053	0.147	0.321	1.000			
11. Col PS 2	0.010	–0.06	–0.12	0.104	–0.02	0.145	0.147	0.170	0.417	0.845	1.000		
12. Col PS 3	0.074	0.011	0.000	0.144	0.086	0.189	0.180	0.026	0.396	0.834	0.808	1.000	
13. Or Flu	0.290	0.137	0.188	0.253	0.423	0.644	0.359	0.149	0.262	0.101	0.147	0.209	1.000
M	10.20	11.60	7.67	11.09	8.90	15.64	16.14	24.54	74.00	17.47	14.471	23.96	15.90
SD	2.74	4.58	4.66	1.44	1.18	3.84	1.65	0.93	5.52	4.47	3.79	5.24	4.71

Note: Seg Syl = Segmenting by Syllables; Num Syl = Numbering by Syllables; Seg Sds = Segmenting by Sounds; G Rhym = General Rhyming; Phon Loc = Phonemic localization; Phon Seg = Phonemic segmentation; Or Ex Cod = Orthographic Expressive Coding; Or Choice = Orthographic Choice; Hom Pseu = Homophone and Pseudohomophone Choice; Col PS 1 = Colorado Perceptual Speed Test, Trial I; Col PS 2 = Colorado Perceptual Speed Test, Trial II; Col PS 3 = Colorado Perceptual Speed Test, Trial III; Or Flu = Orthographic Fluency.

likelihood–based fit indexes and standard errors to make our decisions. However, these results should be viewed with caution, because studies have shown that in the presence of nonnormality, maximum likelihood chi-square values tend to be inflated (Chou & Bentler, 1995; Curran, West, & Finch, 1996) whereas standard errors are underestimated (Finch, West, & MacKinnon, 1997; Olsson, Foss, Troye, & Howell, 2000).

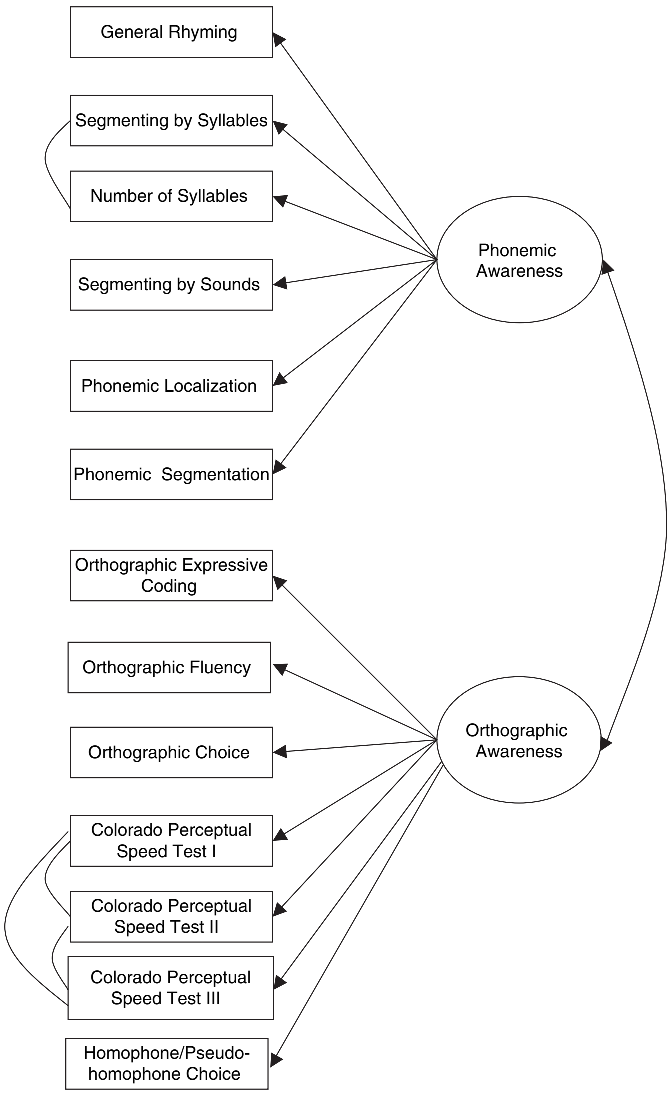
Single-Group Analyses

The first question addressed was whether phonemic and orthographic awareness are distinguishable latent constructs or whether these abilities are so intertwined as to be indistinguishable in the adult population. To assess this question, we first fit both one-factor and two-factor models to the data from each of the four groups separately. The two-factor model is shown in Figure 1. The correlated measurement errors within the Orthographic and Phonemic Awareness models are very understandable. First, the high correlation between the Number of Syllables and Segmenting by Syllables (phonological awareness factor) appears to indicate that the different formats (i.e., identify the number of syllables or actually break the word into syllables) did not elicit different sublexical processes. In addition, the high correlations among the three Colorado Perceptual Speed subtests (orthographic awareness factor) simply reflect the similar task demands of the three trials.

These model comparisons, reported in Table 3, indicate that the two-factor model resulted in a significantly better fit to the data for the dyslexic, comorbid, and normally achieving groups. For the AD/HD group, the chi-square difference test indicates that there was essentially no difference between the one-factor and two-factor models. For this group, therefore, the tasks used appear to elicit no distinction between phonological and orthographic awareness.

Although the χ^2 statistics for all models were significant in each group, other fit indices were indicative of good to excellent model fit for the normally achieving group and the group with dyslexia (see Table 4). For the group with AD/HD, the model fit poorly and three of the factor loadings were nonsignificant for both the one-factor and two-factor models. Values of R^2 for this group were less than .10 for 6 of the 13 tasks included for both factor models. As can be seen in Table 3, the correlations among the variables being analyzed were quite low for this group, which resulted in the low factor loadings. Fit was also poor for the comorbid group. Examination of the MIs for this group indicated correlated uniquenesses for several pairs of variables that were not explained by either the one-factor or two-factor models. This configuration suggests that the pattern of covariation among the

Figure 1
Two-Factor Model



variables was more idiosyncratic for this group than for the other three groups.

Multiple Group Analysis

From the results of the single-group analyses, it appeared that only the group with dyslexia and the normally achieving group shared a common factor structure. For the group with AD/HD, a one-factor model appeared to be most appropriate, although as noted above, several of the tasks failed to load in this group. For the comorbid group, the Orthographic and Phonological Awareness factors were essentially uncorrelated. In addition, little of the variance in the majority of the indicators was explained by the factor(s), indicating that the scales used did not share significant variance for these groups. Multiple group analyses were therefore performed only across the normally achieving students and those with dyslexia.

As explained previously, multiple group analyses involve a series of hierarchically nested models. The models are nested in that each model in the sequence included the constraints imposed in the previous model and adds another set of constraints to these. In our analyses, we first tested a model of configural invariance in which the same factor structure, but not parameter values, were specified to exist in both groups. In the next analysis, metric invariance was tested by holding values of the factor loadings invariant across groups to determine whether a common set of factor loading values could be fit in the two groups. The third model was one in which the measurement error variances as well as factor loadings were specified as invariant across the two groups. It should be noted that the term *measurement error variance* is something of a misnomer in this context because these variances are composites of both unreliable and unique variance. The fourth and fifth models added the specification that the factor variances and covariances, respectively, had to have equal values in the two groups. Finally, in the last model, both factor variances and covariances were held equal across groups, as well as the factor loadings and measurement error variances. This final model allowed for a test of the equivalence of the correlation between the factors across groups.

The tenability of the constraints imposed by each of the models in the hierarchy was gauged by a chi-square difference test. In these tests, each model was compared to the previous model to test whether the imposition of the additional constraints resulted in a significantly worse fit. Such a finding indicates that the additional parameters held invariant in that model vary significantly across groups. Differences in the CFI values between the two models were also considered, following Cheung and Rensvold's (1999) suggestion that a difference of .01 or greater is indicative of a significant decrement in fit. If a set of parameters was found to lack invariance, MIs and residuals were examined in an effort to determine which parameter(s) were causing the lack of fit. These parameters were allowed to vary across groups if the parameter differences could be justified on a theoretical basis.

The test of configural invariance resulted in a good fit to the data. Although the chi-square value was significant at 210.0 with 120 degrees of freedom, the CFI value was .97 and the RMSEA value was .06 based on the guidelines suggested by Hu and Bentler (1999). However, examination of the MIs revealed that allowing the Orthographic Fluency test to load on the phonological

Table 4
Results of One- and Two-Factor Model Analyses for Normally Achieving, Groups With Dyslexia, Attention Deficit/Hyperactivity Disorder, and Comorbidity

	One-Factor Model				Two-Factor Model					
Group	χ^2	*df*	CFI	RMSEA	χ^2	*df*	CFI	RMSEA	$\chi^2\Delta$	CFIΔ
Normally achieving	96.7	61	.97	.05	89.5	60	.98	.05	7.2*	.00
Dyslexia	144.7	61	.95	.09	120.5	60	.96	.07	24.2**	.02
Attention Deficit/Hyperactivity Disorder	113.0	61	.90	.08	112.6	60	.90	.08	0.4	.00
Comorbid	176.8	61	.70	.19	150.5	60	.77	.14	26.3**	.05

*$p < .05$. **$p < .01$.

awareness factor would significantly increase fit. As theoretical justification, performance on this task appears to be influenced more by phonological awareness strategies than the orthographic strategies supposed by the test constructors. This parameter was therefore added to the model, resulting in values of the fit indexes of CFI = .98, RMSEA = .05, and χ^2 (118) = 184.7. Parameter estimates, standard errors, *t* values, and R^2 values from this model for the two groups are shown in Table 5.

The remainder of the invariance analyses was based on the model that allowed the Orthographic Fluency task to load on the Phonemic Awareness factor. Results of these analyses are shown in Table 6. As can be seen from Table 6, the imposition of cross-group constraints on the factor loading estimates resulted in a decrement in chi-square that was significant ($\Delta\chi^2(12) = 44.0$, $p < .001$) and a change of –.01 in the CFI value. We explored possible differences in factor loadings across the two groups using procedures proposed by Cheung and Rensvold (1999) and Rensvold and Cheung (2001). In these procedures, each indicator is taken as the referent indicator in turn and paired with every other indicator to identify sets of indicators that are invariant irrespective of which indicator is used as the referent. Using these procedures, we found all tasks to be invariant for the Phonological Awareness factor. However, for the Orthographic Awareness factor, two tasks (Orthographic Choice and Homophone/Pseudohomophone Choice) were found to be noninvariant. To further explore differences between the two groups, we therefore allowed loadings on these two tasks to vary across groups while constraining all other loadings to be invariant and continued the invariance analyses. This model resulted in a significant improvement in fit ($\Delta\chi^2(2) = 23.1$).

Model 5, in which estimates of the measurement error variances and covariances were constrained to be equal across groups, was estimated next. This resulted in a highly significant increase in chi-square ($\Delta\chi^2(17) = 237.5$, $p < .001$) and a decrease of .07 in the CFI value. Examination of the MIs revealed three measurement error variances that were not invariant across groups. These were for the General Rhyming, Orthographic Choice, and Phonemic Localization tasks. A possible explanation for this lack of invariance could be that many of the normally achieving students ceiling on these tasks. The three measurement error variances were therefore freed one at a time, and the model was re-estimated after each step. This resulted in a significant decrease in chi-square ($\Delta\chi^2$ (3) = 185.1, $p < .001$) and a well-fitting model with χ^2 (142) = 258.0, $p < .01$, CFI = .96, and RMSEA = .06.

The next two models constrained the factor variances and factor covariance, respectively. Holding values of the two factor variances equal across groups resulted in a significant decrease in the chi-square value ($\Delta\chi^2(2) = 15.0$, $p < .001$). Examination of the MIs revealed that the variance of the Orthographic Awareness factor was not invariant across groups. Freeing values of this parameter across groups resulted in a decrease in chi-square of 11.8 ($p < .001$ with 1 *df*). Finally, imposition of the constraint that factor covariances have equal values across groups, conditional on differences in the variance of the Orthography Factor, resulted in no change in chi-square. The final model, with values of two factor loadings, three measurement error variances, and one factor variance allowed to vary across groups but with all other parameter estimates held invariant, resulted in a good fit to the data ($\chi^2(144) = 261.2$, $p < .01$, CFI = .96, and RMSEA = .06).

Discussion

The results of this study provide substantiation that phonemic and orthographic awareness tasks do factor into two constructs for the adult population with and without dyslexia. However, for those adults with AD/HD

Table 5
Group-Specific and Group-Invariant Parameter Estimates, Standard Errors, and *t* Values for Dyslexic (*n* = 210) and Normally Achieving (*n* = 219) Groups

Parameter	Dyslexic			Normally Achieving			Invariant		
Factor Loadings	Estimate *t* Value	*SE*	R^2	Estimate *t* Value	*SE*	R^2	Estimate *t* Value	*SE*	R^2
Phono → Seg Syl	.22 4.51	.05	.13	.27 5.71	.05	.20	.24 7.20	.03	.16
Phono → No Syl	.21 5.82	.04	.22	.18 4.33	.04	.11	.19 7.06	.03	.16
Phono → Seg Sds	.37 6.20	.06	.25	.34 6.20	.06	.24	.35 8.77	.04	.24
Phono → G Rhym	.27 6.31	.04	.26	.14 5.51	.03	.18	.17 8.06	.02	—a
Phono → Phon Loc	.22 5.71	.04	.21	.20 7.67	.03	.38	.21 9.60	.02	—a
Phono → Phon Seg	1.00 b		.54	1.00 b		.56	1.00 b		.56
Phono → Orth Fl	.85 4.60	.19	.55	.72 2.73	.26	.38	.78 5.88	.13	.54[c]
Ortho → Or Ex Cod	1.00a		.56	1.00a		.35	1.00a		.53
Ortho → Or Choice	.36 5.72	.06	.20	.14 2.68	.05	.05	—a		—a
Ortho → Hom/Pseu	3.33 8.52	.39	.48	1.61 3.77	.43	.10	—a		—a
Ortho → Col PS 1	1.51 6.97	.22	.31	3.08 5.92	.52	.39	1.97 9.30	.21	.38
Ortho → Col PS 2	1.39 6.82	.20	.30	2.48 5.60	.44	.33	1.73 9.05	.19	.36
Ortho → Col PS 3	2.23 8.33	.27	.45	2.92 5.94	.49	.40	2.50 10.66	.23	.51
Ortho → Orth Fl	1.04 3.24	.32	.55a	1.30 1.57	.83	.38a	1.14 3.84	.30	.48b
Measurement error variances									
Seg Syl	2.90 9.77	.30		2.24 9.71	.23		2.56 13.79	.19	
No Syl	1.37 9.40	.15		2.00 10.06	.20		1.70 13.83	.12	
Seg Sds	3.40 9.26	.37		2.88 9.55	.30		3.14 13.28	.24	
G Rhym	1.71 9.21	.19		0.66 9.79	.07		—a		
Phon Loc	1.51 9.46	.16		0.48 8.64	.06		—a		
Phon Seg	7.33 6.74	1.09		6.13 6.72	.91		6.49 9.20	.71	
Or Ex Cod	1.91 6.92	.28		1.50 8.08	.19		1.80 11.02	.16	
Or Choice	1.27 9.59	.13		0.33 10.23	.03		—a		
Hom/Pseu	29.55 7.86	3.76		18.50 9.97	1.86		22.02 12.31	1.79	
Col PS 1	12.18 8.95	1.36		12.10 7.82	1.67		12.99 12.54	1.04	
Col PS 2	11.00 9.02	1.22		10.13 7.82	1.29		10.93 12.70	.86	
Col PS 3	14.64 8.10	1.81		10.74 7.20	1.49		12.66 11.40	1.11	
Orth Fl	11.52 7.87	1.46		14.46 8.96	1.61		13.16 11.96	1.10	
Error covariance of OPCPS1 and 2	8.98 7.68	1.17		7.47 5.69	1.31		8.78 10.40	.84	
Error covariance of OPCPS1 and 3	9.33 6.75	1.38		5.16 3.88	1.33		7.54 8.29	.91	
Error covariance of OPCPS2 and 3	9.05 6.89	1.31		4.22 3.69	1.14		6.78 8.23	.82	
Error covariance of OPNOSYL and OPSEGSYL	.50 3.28	.15		.56 3.56	.16		.53 4.78	.11	
Factor Variances									
Phonology	8.57 5.34	1.60		7.70 5.59	1.38		8.35 7.84	1.07	
Orthography	2.41 5.61	.43		0.83 3.98	.21		—a		
Factor covariance	2.96 5.56	.53		1.91 5.31	.36		2.40 7.91	.30	
Factor correlation	.65			.76			.68		

Note: Seg Syl = Segmenting by Syllables; Num Syl = Numbering by Syllables; Seg Sds = Segmenting by Sounds; G Rhym = General Rhyming; Phon Loc = Phonemic localization; Phon Seg = Phonemic segmentation; Or Ex Cod = Orthographic Expressive Coding; Or Choice = Orthographic Choice; Hom Pseu = Homophone and Pseudohomophone Choice; Col PS 1 = Colorado Perceptual Speed Test, Trial I; Col PS 2 = Colorado Perceptual Speed Test, Trial II; Col PS 3 = Colorado Perceptual Speed Test, Trial III; Or Flu = Orthographic Fluency.
a. Value not invariant.
b. Parameter fixed for identification.
c. Values of R^2 for this task are based on loadings on both factors.

Table 6
Results of Multiple Groups Analyses for Dyslexic and Normally Achieving Groups

Model	χ^2	*df*	CFI	RMSEA	$\Delta\chi^2$	Δdf	ΔCFI	ΔRMSEA
1: Equal factor structures	210.0	120	.97	.06				
2. Add ORTH FL → Phonology	184.7	118	.98	.05				
3. Loadings invariant	228.7	130	.97	.06	+44.0**	+12	–.01	+.01
4. Free two noninvariant loadings for Or Choice and Hom/Pseu	205.6	128	.97	.05	–23.1**	–2	.00	–.01
5. Measurement error variances and covariances invariant	443.1	145	.90	.10	+237.5**	+17	–.07	+.05
6. Free measurement error variance of Or Choice	360.1	144	.93	.08	–83.0**	–1	+.03	–.02
7. Free measurement error variance of Phon Loc	306.5	143	.94	.07	–53.6**	–1	+.01	–.01
8. Free measurement error variance of G Rhymn	258.0	142	.96	.06	–48.5**	–1	+.02	–.01
9. Fix factor variances	273.0	144	.96	.07	+15.0**	+2	.00	+.01
10. Free factor variance for Orthography	261.2	143	.96	.06	11.8**	–1	.00	–.01
11. Fix Phonology factor variance and factor covariance	261.2	144	.96	.06	0.0*	+1	.00	.00

Note: All $\Delta\chi^2$ values on based on comparisons to the previous model.
*$p < .05$. **$p < .001$.

or dyslexia and AD/HD (comorbid), the two factor model did not fit. For the group with AD/HD, a one-factor model accounts for the covariation among the scales just as well as the two-factor model. The performance of the adults with AD/HD appears to be influenced significantly by other cognitive factors such as attention, executive functioning, or general processing and motor speed. By contrast, in the comorbid group, the two factors (phonemic and orthographic awareness) were virtually uncorrelated (the factor correlation for this group was a nonsignificant –.13). For both the AD/HD and comorbid groups, the fit was poor for the one-factor and two-factor models, and for the comorbid group in particular, very little variance was explained in the scales.

For the normally achieving and dyslexic groups, although the phonemic and orthographic awareness factors were statistically independent, they were highly correlated to each other, raising the question of whether the phonemic and orthographic awareness tasks were measuring similar but distinct aspects of a single factor (phonemic awareness). Vellutino et al. (1994) proposed that the vast amount of commonly used phonemic awareness tasks measure phonological recall and that those tasks identified as measuring orthographic processing are simply measuring phonemic recognition. Future empirical research with the adult population focused on this issue is essential for a better understanding of the latent constructs of phonemic and orthographic awareness. However, in this study, the one-factor model did not fit the data except in the AD/HD group, indicating that two latent constructs appear to be represented across the tasks with the investigated adult populations (dyslexic and normally achieving). Exactly what these two latent constructs represent is open for debate, given the fact that some differences in factor structure were found for the two groups. These differences in factor structure were almost exclusively confined to parameters of the Orthographic Awareness factor. For this factor, two loadings, two measurement error variances, and the factor variance were all found to differ across the normally achieving group and the group with dyslexia. Lack of invariance in factor loadings can be interpreted as a sign of differences in the relationships between latent factors and groups that were administered the tasks. This may occur if tasks have differential salience across groups. For measurement error variances, a lack of invariance indicates that the tasks contain more unique variance for one group than another. Table 4 shows that measurement error variances for these tasks were consistently higher for the dyslexic group. This could be due to a greater amount of total variance in these tasks for the group with dyslexia or to differential levels of reliability of the tasks.

The importance of phonemic and orthographic awareness to reading and written language performance has been well documented in the literature. However, behavioral measurement of these latent constructs has fueled much debate among researchers (Foorman, 1994; Vellutino et al., 1994). Although a small number of adult standardized measures of phonemic awareness are available, they are plagued by measurement issues (e.g., norming restrictions, construct validity). Standardized measures of orthographic awareness are unavailable for the adult population. Some researchers indicate that it is nearly impossible to design pure measures of phonemic and orthographic awareness due to their bidirectional influence across the life span (Foorman, 1994). The phonemic and orthographic awareness task correlations for the populations we studied documented high collinearity of phonemic and orthographic measures. In the future, with valid and reliable measures of phonemic coding (e.g., phonological segmentation), it seems reasonable to assume that the variance on these tasks could be used to predict the contribution of orthographic coding such that purer measures of orthographic awareness could be developed for the adult population. The need is critical to provide professionals more evidence to support intervention and/or accommodation decision making.

The multigroup analyses provide some of the most interesting results of this study. When reviewing the factor loadings for the Phonemic Awareness factor, the phonemic segmentation task appears to be the strongest measure of the latent construct of phonemic awareness. In addition, the multigroup analyses documented how the different groups of adults (dyslexic, AD/HD) approach phonological coding tasks. The R^2 values for the Phonemic Awareness factor (Table 5) indicate that the tasks have differential salience for the construct of phonemic awareness in the normally achieving and dyslexic groups. However, the factor loadings for phonemic awareness were not found to differ substantially across the two groups. For the Orthographic Awareness factor, differences in R^2 values were more pronounced than those for the Phonemic Awareness factor.

One of the most significant findings of this study pertains to the apparent lack of construct validity of many of the phonemic and orthographic awareness tasks advocated in the literature as strong measures of these constructs. Many of these tasks were found to have low R^2 values, indicating that they share little variance with other tasks designed to measure the same construct. One of the problems with the majority of orthographic awareness tasks used clinically and in research is that they require the examinee to call on his or her reading decoding and spelling skills. This is a significant problem for the adolescent and adult populations. Vellutino et al. (1994) concluded that such tasks do not measure orthographic coding as a basic cognitive process. According to Vellutino et al., orthographic coding is really a visual coding ability, including (but not limited to) such processes as visual feature analysis, visual pattern analysis, and attention to visual detail. However, he goes on to say that the visual system required in orthographic processing, independent of the language system, is small and constrained by the linguistic system. To ignore the interrelationship of basic cognitive and linguistic processes that influence success across reading and spelling tasks perpetuates a modularity of thinking about phonemic and orthographic awareness. Some researchers have proposed that phonemic coding deficits lead to weak orthographic coding and therefore that orthographic awareness is really not a unique latent construct (Bruck, 1992; Seidenberg et al., 1984). On first review of the results of this study, such a hypothesis appears to be plausible. However, the breakdown of the orthographic awareness factor in this study might be due to task limitations rather than the theoretical construct. It is possible that many of the orthographic tasks used in this study were really measuring phonemic recognition.

An alternative to either of the above explanations is that it might be time to call into question viewing orthographic coding as a unidimensional construct. The Colorado Perceptual Speed Tasks (I, II, and III) might possibly represent another factor or facet of orthographic coding (e.g., orthographic fluency). Of the five orthographic awareness measures studied, orthographic working memory (Orthographic Expressive Coding), orthographic recognition (Orthographic Choice and Homophone/Pseudohomophone Choice), and orthographic scanning (Colorado Perceptual Speed) appear to contribute different degrees of influence across tasks. It might be possible that under the rubric of orthographic coding, orthographic working memory, orthographic recognition, and orthographic fluency, there are really several distinct factors. Orthographic awareness tasks designed to measure these distinct factors might lead us to better understanding of the latent orthographic awareness construct.

Vellutino et al. (1994) cautioned that phonemic and orthographic coding are not the only cognitive processes contributing to the ability to decode or spell words. As they noted, "printed words not only have phonological and orthographic attributes, but they also have semantic and syntactic attributes that become part of their lexical description, and it is likely that semantic and syntactic coding abilities also contribute significant variance to facility in word identification" (p. 55). More research centered on the cognitive and linguistic variables influencing decoding and spelling among the adult population, with and without learning disorders, is critically needed to establish construct validity, enhance diagnostic decision making, and better interpret intervention outcomes.

Accommodation and Intervention Implications

Professionals who understand the importance of individual differences (cognitive and language processes), task format (e.g., structured, auditory modality, visual modality), and response choices (e.g., written, oral, read) recognize the many factors that must be considered when recommending specific interventions and/or accommodations. Critical to the success of any intervention and/or accommodation is the information obtained from a comprehensive evaluation. Recognition that low academic achievement is caused by many different cognitive, linguistic, behavioral, educational, and societal factors should guide professionals in the selection of specific intervention and accommodations.

The findings from this research support the wealth of research in dyslexia that underscores the importance of assessing cognitive and linguistic processes such as sound discrimination (rhyming included), auditory and phonological working memory (sometimes called *the phonological loop*), and phonemic awareness (appreciation of discrete sounds or phonemes within spoken words). In addition, it underscores the need to include orthographic awareness tasks in the assessment of reading and spelling performance. Depending on their severity, deficits in phonemic and orthographic awareness can significantly influence a person's spoken language as well as literacy skills.

The importance of exploring the phonemic and orthographic awareness profile of an adolescent or adult cannot be underestimated. An evaluator who interprets only a standardized reading or spelling score may overlook information that is vital to (a) the nature of the examinees' underachievement and (b) the identification of effective intervention or accommodations. Although most adults are likely to make a word-reading or spelling mistake now and then, individuals with dyslexia often exhibit higher error rates and lower plausibility rates. In a recent study, we counted and categorized spelling mistakes in the impromptu essays composed by 130 young adults with and without dyslexia (Coleman, Gregg, McLain, & Belair, in press). The students without disabilities ($n = 65$) averaged about 1 error per 143 words, and about 80% of their incorrect attempts were judged to be plausible (e.g., *airate* for *aerate*). The errors of students with dyslexia ($n = 65$) were considerably more frequent (1 in 40 words) and less plausible (65%). An interesting finding was that in a similar study, participants with AD/HD ($n = 44$), though they made significantly more spelling errors than their peers without disabilities, achieved a similar plausibility rate (Coleman & Gregg, 2005). In other words, students with both dyslexia and AD/HD demonstrated significant spelling problems, but the type of errors they produced were significantly different. Differences across cognitive and linguistic abilities contribute significantly to such different writing profiles.

We suggest that only through a comparison of achievement (i.e., reading decoding and spelling) with other data collected during a comprehensive evaluation (e.g., cognitive, behavioral, and linguistic) can identification of a disorder be determined. Underachievement alone should not constitute a disorder. Intervention and accommodation selection should be based on the findings of a comprehensive evaluation after careful study of the possible causes for underachievement.

Limitations of the Research

In summary, the findings of this study call for the development of cognitive models, empirically driven, to identify the basic cognitive processes directly and/or indirectly related to the ability to decode and spell for adult populations (nondisabled and disabled). Through future SEM and confirmatory factor analysis studies, greater insight into the latent constructs of phonological and orthographic awareness can be obtained for the purpose of guiding diagnosis, accommodation selection, and interventions appropriate for the adult populations.

As with all research, this study has limitations that should be noted. First, the sample size for the comorbid group was quite small for confirmatory factor analysis procedures. Given the time commitment required for participants to complete all of the scales included and the unique nature of the latter population, the results of the small samples are not surprising; nonetheless, they limit the generalizability of these findings. We did not, however, find that the parameter estimates for these groups exhibited any overt signs of instability.

A second limitation involves the nonnormality of the distributions of several of the tasks, including General Rhyming, Phonemic Localization, Orthographic Choice, and Homophone/Pseudohomophone Choice. Probably due to ceiling effects, these variables exhibited excessive negative skew and positive kurtosis in all four groups. Finally, the addition of one empirically derived cross-loading and the release of several cross-group constraints for participants with dyslexia and their normally achieving peers must be viewed with caution. Although we judged these changes to be theoretically justifiable, they may have resulted from capitalization on chance variations in our data. These models should therefore be considered tentative until replication studies are completed.

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