Running Head: ADULT LOW LITERACY READING COMPREHENSION

A path analysis of reading comprehension for adults with low literacy

Daryl F. Mellard
Emily Fall
Kari L. Woods
Center for Research on Learning
University of Kansas

Abstract

Adult literacy interventions often rely on models of reading validated with children or adult populations with a broad range of reading. Such models do not fully satisfy the need for intervention research and development for adults with low literacy. Thus, the authors hypothesized that a model representing the relationship between reading component skills would be predictive of reading comprehension for an adult population with low literacy and beneficial to adult literacy researchers. Using data from 174 adults participating in adult basic education and secondary education programs, the authors performed a path analysis of component skills' contribution to reading comprehension. The findings are clear that existing reading models do not describe this population. The implications are discussed in terms of instructional and curricular interventions.

Acknowledgement

This article reports data from a study funded by the National Institute of Child Health and Human Development, National Institute for Literacy, and the U.S. Department of Education Office of Vocational and Adult Education (Award #RO 1 HD 43775).

The National Assessment of Adult Literacy survey found that 43% of U.S. adults lacked the basic knowledge and skills needed to read and understand moderately dense texts, summarize, make simple inferences, determine cause and effect, or recognize an author's purpose (Kutner, Greenberg, & Baer, 2005). More than 60 million (79%) of these adults with low literacy were between 16 and 64 years old, indicating that a large literacy deficit exists among the current and future U.S. workforce (Kutner, et al., 2005; Kutner, et al., 2007; U.S. Census Bureau, 2000). To address the economic, civic, and cultural implications of this literacy deficit, Title II of the Workforce Investment Act (WIA; P.L.105-220) supports basic literacy programs for adults.

WIA requires that funded adult education (AE) programs use evidenced-based approaches to service delivery to ensure that participants receive effective instruction. Intervention researchers attempting to address this requirement are faced with the challenge of understanding which reading skills this population lacks and in which reading processes they experience breakdowns that impede reading development (Kruidenier, 2002; Rapp, van den Broek, McMaster, Kendeou, & Espin, 2007). Although several studies of adults with low literacy provide evidence of individual reading components' contributions to reading, no theory-based models of reading exist that represent the processes in which adult struggling readers engage (Comings & Soricone, 2007). Thus, as a substitute for such a model, adult literacy interventions often rely on theory, research, and models of reading that are based on studies of children or adults with a broad range of reading abilities (Kruidenier, 2002; McShane, 2005).

The current approach to providing evidence for interventions is pragmatic, but ultimately may be incomplete or inaccurate because of such factors as a high prevalence of learning disabilities among adult literacy learners (Patterson, 2008) and developmental and experiential differences between children and adults (e.g., Bell & Perfetti, 1994; Davidson & Strucker, 2002; Gough, Hoover & Peterson, 1996; Greenberg, Ehri, & Perin, 2002; Sabatini, 2002). Thus, proxies for theory-based models do not fully satisfy the needs of adult literacy intervention researchers and developers because they may not address appropriate skill and processing deficits exhibited by these adults (Comings, 2003; Comings & Soricone, 2007).

To contribute to a better understanding of this population's current reading skills and processes, we asked, How do reading component skills relate to and predict one another in a sample of adults with low literacy? To answer this question, we examined the research literature and hypothesized a model of reading comprehension for this population. We conducted a path analysis using data from 174 adults with low literacy to test and revise our hypothesized model.

Models of Reading

The National Reading Panel's (2000) assessment of scientific research on reading instruction with children cited five major components of reading: phonemic awareness, phonics, fluency, vocabulary, and text comprehension. These components reflect such theoretical models of reading as the simple view of reading (Dreyer, & Katz, 1992; Gough & Tunmer, 1986; Joshi & Aaron, 2000), the convergent skills model of reading development (Vellutino, Tunmer, Jaccard, & Chen, 2007), and the direct and inferential mediation (DIME) model of reading comprehension (Cromley & Azevedo, 2007). In addition to these models, other studies evaluate the contributions of individual component skills to reading comprehension (e.g., Catts, Hogan, & Fey, 2003; Cutting & Scarborough, 2006; Mellard, Fall, & Mark, 2008; Sabatini, Scarborough, Shore, Bruce, & Sawacki, 2007; Vellutino, Scanlon, & Tanzman, 1994).

The simple view of reading (Gough & Tunmer, 1986) theorizes that reading comprehension results from two necessary sets of reading skills—decoding and language comprehension. Word recognition and listening comprehension, component skills that are relatively independent of one another, in combination have been shown to account for between 65% and 85% of variance in reading comprehension among young readers (Catts, Hogan, & Adolf, 2005). "Simply stated, the word recognition component translates print into a linguistic form, and the comprehension component makes sense of this linguistic information" (Catts, et al., 2003, p. 151). The simple view predicts that as readers progress from beginning reading tasks to more advanced tasks, the primary sources of variability in reading shift from decoding skills to language comprehension skills; however, no studies have directly evaluated this developmental transition beyond adolescence (Catts, et al., 2005).

The simple view, as presented by Gough and Tumner (1986), hypothesizes that decoding and language interact in a multiplicative fashion. Dreyer and Katz (1992), however, found that an additive model of decoding and language ability predicted comprehension equally well. Joshi and Aaron (2000) found that with third-grade readers, the multiplicative model accounted for 47.6% of variance in comprehension, whereas the additive model accounted for 46.2%.

Wolf and Bowers (1999) advocate the idea that some struggling readers lack speed of processing skills, thus positioning speed as an important component of reading ability. In fact, a speed-of-processing component (i.e., rapid letter naming) added to the simple view model significantly improved prediction of reading comprehension among third-grade readers (Joshi & Aaron, 2000). Yet with fourth- and eighth-grade students, a fluency component (i.e., a combination of non-word and word reading efficiency, and rate and accuracy reading connected text) added to the simple view model was not a significant, independent contributor to reading comprehension (Adolf, Catts, & Little, 2006).

To better understand the underlying developmental relationships represented in the simple view model, Vellutino et al. (2007) employed structural equation modeling techniques with data from second- to third-grade students and sixth- to seventh-grade students. In this model, they identified two exogenous variables (visual and phonological coding) that contributed to six intermediary variables (visual analysis, phonological awareness, semantic knowledge, syntactic knowledge, phonological decoding, and spelling). These six variables, in turn, contributed to two additional intermediary variables that parallel the Simple View (i.e., context-free word identification and language comprehension) and directly affect reading comprehension. This model has not been tested with a low-literacy adult population.

The DIME model (Cromley & Azevedo, 2007), developed with adolescent readers (i.e., ninth grade), hypothesizes five domains that predict reading comprehension: background knowledge, inferences, strategies, vocabulary, and word reading skills. This model reflects theories addressing the relation between reading comprehension and higher order thinking or coherence (Lewis & Smith, 1993; Rapp, et al., 2007), by which readers connect prior knowledge to new information in the text and manipulate or extend the information through inference or other cognitive processes (Cain, Oakhill, & Bryant, 2004; Carr & Thompson, 1996; Long, Oppy, & Seely, 1994; van den Broek, Tzeng, Risden, Trabasso, & Basche, 2001). The DIME model explained 66% of the variance in reading comprehension. However, for readers scoring below 30% in comprehension, vocabulary and background knowledge were the most distal variables; the authors suggested instruction in these areas could make the largest contribution to these students' academic text comprehension.

Reading Components Research in Adult Literacy

Multiple studies of adults with low literacy have examined how individual components of reading contribute to reading ability (Bruck, 1990, 1992, 1993; Cunningham, Stanovich, & Wilson, 1990; Davidson & Strucker, 2002; Durgunoglu & Oney, 2002; Greenberg, Ehri, & Perin, 1997; Greenberg, et al., 2002; Malicky & Norman, 1989; McKane & Greene, 1996; Sabatini, 2002). The National Institute for Literacy and the Partnership for Reading (Curtis & Kruidenier, 2005) summary of such research organized scientifically based research principles for teaching adults to read into four reading component categories: alphabetics, vocabulary, fluency, and reading comprehension. However, no model exists to describe the relation of components one to another or to quantify the variances each contributes to reading comprehension.

In the adult literacy field, alphabetics is defined as the "process of using the written letters…to represent meaningful spoken words…and includes both phonemic awareness and word analysis" (Curtis & Kruidenier, 2005, p. 4). Phonemic awareness relates to how a reader manipulates the basic sounds (phonemes) of oral language, whereas word analysis deals with the connections between written letters or letter combinations and the sounds they represent.

Vocabulary as a component of adult literacy refers to the set of individual words whose meanings a reader knows and understands. Beginning and struggling readers' speaking and listening vocabularies are often larger than their reading vocabularies—that is, the words they can both decode and understand (Curtis & Kruidenier, 2005). The breadth and depth of an adult's reading vocabulary is thought to contribute to his or her ability to comprehend the meaning of texts.

Fluency has been defined as the ability to read at "a level of accuracy and rate where decoding is relatively effortless; where oral reading is smooth and accurate with correct prosody; and where attention can be allocated to comprehension" (Wolf & Katzir-Cohen 2001, p. 218). Alphabetic and vocabulary skills appear to be necessary but not sufficient for fluency; likewise, fluency would appear to be necessary, but not sufficient for reading comprehension.

Reading comprehension—constructing meaning from what is read—is the end goal of reading and draws upon at least some skill or ability in each of the other component categories, which are considered requisite to reading comprehension. "To comprehend, a reader must decode words and associate them with their meanings. Phrases and sentences must be dealt with fluently enough so that their meanings are not lost before the next ones are processed" (Curtis & Kruidenier, 2005, p. 9). However, comprehension itself may contribute context clues that enable better word analysis, increase vocabulary, and result in more fluent reading.

Although these basic reading components may be similar for adults and children, the relationships between the components may differ, particularly for adults with low literacy skills. For example, in normal reading development, the correlation between word reading and comprehension decreases with age (Gough, et al., 1996); however, studies conducted with college students with low reading ability (with and without reading disabilities) found less effective word processes, in both speed and accuracy of their word identification, compared to proficient adult readers (Bell & Perfetti, 1994). Greenberg et al. (2002) found adult literacy learners' underlying word reading deficits differed from normally developing children matched for reading level, suggesting that adult literacy learners and children "tend to utilize different cognitive processes and approaches to the tasks, possibly with the use of compensatory strategies" (p. 238). Further, Davidson and Strucker's (2002) study of component skills of adults reading at fourth- to sixth-grade equivalencies found low-literacy, native English speakers tended to score higher on reading comprehension than on word recognition, perhaps by compensating for low word recognition skills by using context and substitution of real words for unrecognizable words. Braze, Tabor, Shankweiler, and Mencl's (2007) analysis of reading skills among 16 to 24-years-olds found that vocabulary made a unique contribution to reading comprehension, even as the researchers controlled for differences in decoding and language comprehension skills. Finally, Sabatini's (2002) study of word reading among adult readers suggested that general processing speed limitations and working memory may affect the reading ability of adults with low literacy as compared to children or adults with normal reading development. Collectively, these differences between children and adults underscore Comings and Soricone's (2007) call for a model of reading specifically describing adults with low literacy from which to build interventions that can selectively target the skill or process areas hindering reading development.

A Model of Reading Comprehension for Adults with Low Literacy

We synthesized the literature on child, adolescent, and adult readers to hypothesize a reading comprehension model to describe adults with low literacy (Figure 1). Because our study population reads at about the fifth-grade level, we began with the premise that they are better represented by a model adapted from the simple view of reading (Gough & Tunmer, 1986) rather than models representing more advanced readers (e.g., DIME; Cromley & Azevedo, 2007). We expanded the model to more distinctly understand relationships of several components encompassed by the constructs of word recognition and language comprehension, and we added components to represent working memory, speed of processing, and fluency. In addition, we hypothesized an additive rather than multiplicative model based on findings Dreyer and Katz (1992) and Joshi and Aaron (2000).

Specifically, the hypothesized model includes two components representing the word identification construct: phonemic decoding, which is making connections between written letters or letter combinations and the sounds they represent; and word reading, whether by decoding or whole word recognition. We positioned phonemic decoding as an exogenous variable with a path to word reading. In addition, we tested paths from phonemic decoding to reading fluency and language comprehension.

We treated word reading as an intermediate variable with a path predicting reading comprehension. However, we also explored paths leading from word reading to vocabulary and language comprehension because word reading increases opportunity for learning new word meanings. We included a path to reading fluency, which requires a reader to efficiently integrate read words with syntax and context.

Language comprehension is a complex construct that includes knowledge of vocabulary and information, as well as such higher order abilities as recalling and sequencing events, and making predictions and inferences. The hypothesized model, however, isolates expressive vocabulary as a distinct component, and positions it as an intermediate variable because we expected it to contribute not only to language and reading comprehension, but also to reading fluency.

In the simple view model, language comprehension leads to reading comprehension and reflects the connections between higher order thinking and reading comprehension found in models of child or adolescent reading (Cromley & Azevedo, 2007; McKown & Barnett, 2007; Rapp, et al., 2007). Because research points to working or short-term memory as an area for possible breakdown among adult readers (Bell & Perfetti, 1994; Sabatini, 2002), we positioned a memory variable ahead of language comprehension in our hypothesized model. Unsworth and Engle (2007) suggested that short-term and working memory largely measure the same basic subcomponent processes; thus, we chose to reflect this construct through a measure of auditory working memory.

Given the prevalence of learning disabilities among adults with low literacy (Patterson, 2008) and evidence of the importance of speed of processing to fluent reading (Joshi & Aaron, 2000; Wolf, Bowers, & Biddle, 2000), we chose to include a rapid automatic naming component as an exogenous variable in the hypothesized model. We chose to include paths leading from this variable to word reading, language comprehension, reading fluency, and reading comprehension.

Although Adolf, et al. (2006) did not find fluent reading of connected text to be an independent contributor to reading comprehension, we opted to include reading fluency as a variable that represents efficient integration of many skills required to read a text. From an information processing perspective, fluent reading theoretically frees limited cognitive capacity for other comprehension tasks (e.g., integration of textual information, connecting the text with prior knowledge, accessing vocabulary knowledge, making inferences) and therefore is an important contributor to both language and reading comprehension.

Method

Research Design

We chose a path analysis approach to test the fit of our hypothesized model (Figure 1) with the empirical data because simple correlation or classical regression methods would, perhaps, oversimplify the problem of low literacy in an adult population (Stage, Carter, & Nora, 2004). A common value of path analysis is that the results provide estimates of the magnitude and significance of hypothesized connections among the variable sets represented in the path diagrams. Figure 1 indicates our predicted causal or path relationships among our assessed variables. The single-headed arrow points from the “cause” to the “effect.” A double-headed arrow indicates that the variables are correlated, but no causal assumption is made. The path coefficients reported in Figure 2 indicate the direct effect of one causal variable on another variable, which is assumed to be the effect. We tested our model using data collected in our study of adult literacy learners.

Study Population and Sample

In the broadest sense, the study population may be construed as representing more than 90 million adults with below basic or basic literacy skills (Kutner, et al., 2005). More narrowly, the population may be thought of as the 1.4 million individuals who annually enroll in adult basic education (ABE) or adult secondary education (ASE) programs, or the 5,600 adults in Kansas—the state in which we primarily conducted the study (U.S Department of Education, Office of Vocational and Adult Education, 2005).

Research staff collected data from adults enrolled in 13 Midwestern Adult Education and Family Literacy Act programs, excluding participants receiving instruction in English as a second language (ESL). Subjects had to be at least 16 years old; withdrawn from secondary education without earning a secondary credential or without attaining basic reading, writing, or math skills; have U.S. citizenship or authorization to work in the U.S. as a foreign national in order to receive a nominal participation payment; and volunteer to participate in the study.

Sampling method. From approximately 713 learners who volunteered for our broader study, we drew a stratified sample of 309 individuals based on the six educational functional reading levels as defined by the U.S. Department of Education (U.S. Department of Education, Office of Adult and Vocational Education, 2001) National Reporting System and determined by Comprehensive Adult Student Assessment System (2001) reading diagnostic scores. To develop a representative model of adult ABE and ASE learners from our stratified sample, we randomly selected by reading level 174 cases in proportion to the Kansas adult education ABE and ASE population (Glass, 2007). The resulting sample for this analysis includes the following cases by level: 9 in Level 1, ABE Beginning Literacy; 28 in Level 2, Beginning ABE; 42 in Level 3, Low Intermediate ABE; 52 in Level 4, High Intermediate ABE; 12 in Level 5, Low ASE; and 31 in Level 6, High ASE (Table 1).

Table 1. *Demographics and Functional Reading Levels*

	United States[a]	Kansas[a]	Sample
Age (% under 25 years)	38%	50%	47%
Gender (% female)	55%	56%	60%
Race (% non-white)	72%	63%	65%
Annual household income (% under $20,000)	n/a	n/a	49%
Self-reported learning disability (% of total)	n/a	n/a	26%
Functional reading level placement (% of ABE and ASE enrollees)			
Level 1, Adult Basic Education Beginning Literacy	6%	5%	5%
Level 2, Low Adult Basic Education	14%	16%	16%
Level 3, Low Intermediate Adult Basic Education	21%	24%	24%
Level 4, High Intermediate Adult Basic Education	29%	30%	30%
Level 5, Low Adult Secondary Education	16%	7%	7%
Level 6, High Adult Secondary Education	14%	18%	18%

Note: [a] Includes Adult Basic Education, Adult Secondary Education, and English as a Second Language program participants.

Sources: Glass, D. (2007) *Kansas Board of Regents adult education fiscal 2007 annual performance report*. Topeka: Kansas Board of Regents; U.S. Department of Education http://wdcrobcolp01.ed.gov/CFAPPS/OVAE/NRS/reports/index.cfm.

Demographics. The sample was 60% female, slightly higher than the 55% rate in AE participants in the United States and Kansas (including ESL participants; Glass, 2007; U.S. Department of Education, Office of Vocational and Adult Education, 2005). The sample's mean age was 32 years (*SD* = 15.2); 47% of the sample was under 25 years old, similar to all AE program in the state (50%), but differing from the national profile (38%). Sixty-five percent of the sample members were non-white, which is a smaller percentage than the average in AE programs nationally (72%), but is similar to Kansas' AE population (63%). Nearly half (49%) reported having an annual household income of less than $20,000, and an additional 14% did not know their income. Twenty-six percent of the sample self-reported having a specific learning disability diagnosis.

Reading abilities. The sample's mean reading comprehension equates to about fifth-grade level. Likewise, they are able to read words at about a fifth-grade equivalent, but their phonemic decoding of nonwords averages a 3.8 grade equivalency. Compared to the norm groups for observed measures of reading subskills, the sample on average ranks between the 3rd and 9th percentiles; and at the 37th percentile for auditory working memory and language comprehension (Table 3). Differences in reading ability exist even within the sample, as demonstrated in Table 4, reading component scores by National Reporting System reading levels.

Observed Measures and Instruments

To represent the eight reading components in our model, we selected observed measures from the battery of assessments administered in our study. Table 2 describes each of these measures and their psychometric properties. Trained graduate research assistants administered a battery of assessments to individual subjects at AE sites.

Table 2. *Measurement of Variables*

Variable	Measurement Instrument	Description	Psychometric properties
Rapid Automatic Naming	Comprehensive Test of Phonological Processing (CTOPP) Rapid Letter Naming subtest Wagner, Torgesen, & Rashotte, 1999	Measures the time required to name a series of randomly arranged letters on a printed page	Test-retest reliability .70 – .92 Construct-identification validity comparative fit index of .99 and a chi square of 27.6 with 6 degrees of freedom.
Auditory Working Memory	Woodcock-Johnson Auditory Working Memory subtest Mather & Woodcock, 2001	Assesses memory span through tasks that require listening to words and numbers, separating the words from the numbers, and stating the words in sequential order followed by the numbers in sequential order	Median reliability .84 for adults
Phonemic Decoding	Woodcock Reading Mastery Test-Revised (WRMT-R) Word Attack subtest Woodcock, 1998	Measures ability to use phonetic and structural skills to pronounce unfamiliar or non-words	Internal reliability.87 – .98 Concurrent validity .79 – .92
Word Reading	WRMT-R Word Identification subtest Woodcock, 1998	Measures sight word reading skills along with phonetic skills using familiar words	Internal reliability .87 – .98 Concurrent validity .79 – .92
Expressive Vocabulary	Wechsler Adult Intelligence Scale III (WAIS) Vocabulary subtest Wechsler, 1997	Assesses expressive vocabulary by requiring oral definitions for 33 words stated aloud by an examiner	Reliability coefficients for age group of 16-24 .90 to .94
Language Comprehension	Clinical Evaluation of Language Fundamentals (CELF) Semel, Wiig, & Secord, 1987	Assess language ability independent of reading through listening to a passage and answering questions that require recall, understanding, sequencing of events, predictions, and inferences	Test-retest reliability .52 – .91 Concurrent validity for total language scores with WISC-III IQ .75
Reading Fluency	Qualitative Reading Index (QRI) Leslie & Caldwell, 2001	Measures fluency with connected text: by averaging words correctly read from two, one minute oral readings of sixth-grade reading level passages	Study data indicate alternate form reliability of .94, and a .78 correlation with Test of Silent Word Reading Fluency (Mather, Hammill, Allen & Roberts, 2004)
Reading Comprehension	WRMT-R Passage Comprehension subtest Woodcock, 1998	Using a cloze procedure, assesses ability to read and comprehend short passages of two to three sentences of increasing difficulty	Internal reliability .87 – .98 Concurrent validity .79 – .92

Analysis Procedures

We checked variables to ensure they met assumptions of normal distribution, central tendency, and multicollinearity, and plotted all variables with another relevant variable in scatter plots for visual inspection following Tabachnick and Fidell's (2007) recommended data-cleaning procedures.

To test our model we used a tear down procedure (Cohen, Cohen, West, & Aiken, 2003). Beginning with the hypothesized model pictured in Figure 1, we tested goodness of fit with a χ^2 significance test along with other model fit indices. Next, we systematically removed non-significant paths, starting with the one having the smallest numerical path coefficient. With each path deletion, we tested the change in model fit with χ^2 difference tests. The best fitting path model was the last model for which we observed a significant change in χ^2.

Results

Correlations. The eight observed measures of reading component skills, with a few exceptions, were correlated as we expected based on the literature (Table 3). Vocabulary, however, did not strongly correlate with language comprehension (r = .41) or reading fluency (r = .52). Likewise, language comprehension did not strongly correlate with reading fluency (r = .35) or reading comprehension (r = .47). These correlational values were statistically significant and in general reflect a moderate correlation.

Path model. The hypothesized model (Figure 1) contained 21 paths between variables. After testing this model with our data set and systematically removing the non-significant paths, 11 significant paths remained in the best fitting model (Figure 2). This adult low literacy model had a comparative fit index of 0.985, which is considered a good fit; it also had a root mean square error of approximation of 0.073, which is an acceptable level of error (Stage, Carter, & Nora, 2004). The simple interpretation of these statistics is that the resulting path model, regarding reading comprehension, adequately fits the observed data from our sample of AE readers and our selected variables and their respective measures.

Table 5 contains the standardized and unstandardized path coefficients indicating the direct effect of each variable (assumed to be a cause) on another variable (assumed to be the effect). The standardized coefficients indicate the relative importance of paths within this derived model. The unstandardized coefficients reflect the measures we used and cannot be interpreted as indicating the variables' relative importance. On the other hand, the unstandardized coefficients could be used to compare models across different normative samples, whether an entirely different sample or the same sample tested at different points of time (James, Mulaik & Brett, 1982). Because our model is empirically derived, it represents how a low-literacy population achieved its fifth-grade level of reading comprehension. We consider this model *descriptive* of the way reading occurs for adults with low literacy rather than *prescriptive* of how reading should occur.

Table 3. *Model Component Correlations, Raw Scores and Rankings (N = 174)*

	Correlation coefficient								Raw Score		
Variable	1	2	3	4	5	6	7	8	*M*	*SD*	Percentile Rank
1 Rapid automatic naming	1.00								32.9	10.0	--
2 Auditory working memory	-.38	1.00							22.2	7.4	37
3 Phonemic decoding	-.51	.60	1.00						22.4	11.7	7
4 Word reading	-.53	.56	.84	1.00					71.5	16.3	3
5 Vocabulary	-.21	.48	.47	.60	1.00				22.7	9.8	9
6 Language comprehension	-.20	.50	.31	.37	.41	1.00			6.6	3.3	37
7 Reading fluency	-.66	.55	.77	.88	.52	.35	1.00		105.9	46.4	--
8 Reading comprehension	-.44	.59	.70	.84	.64	.47	.79	1.00	37.8	12.8	4

Figure 1. Hypothesized Model

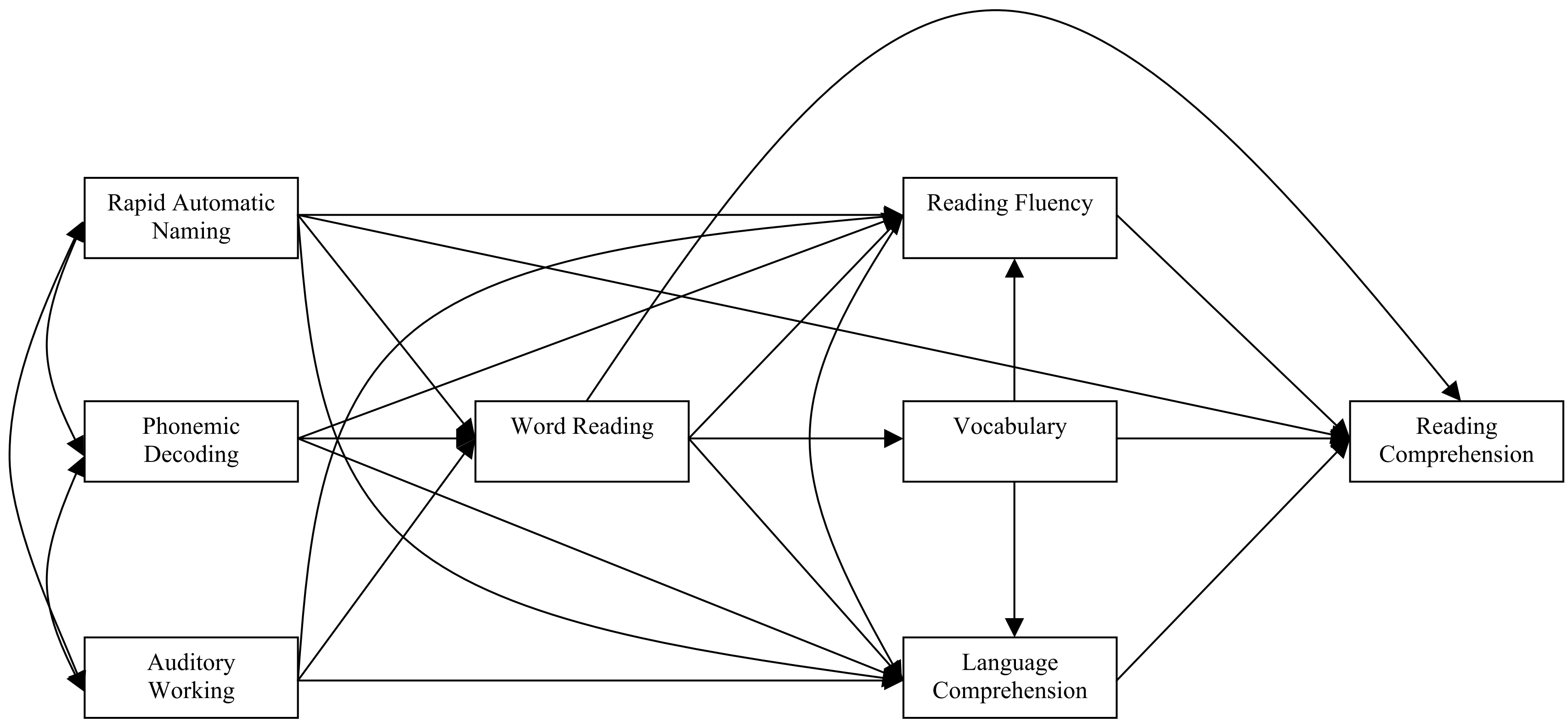
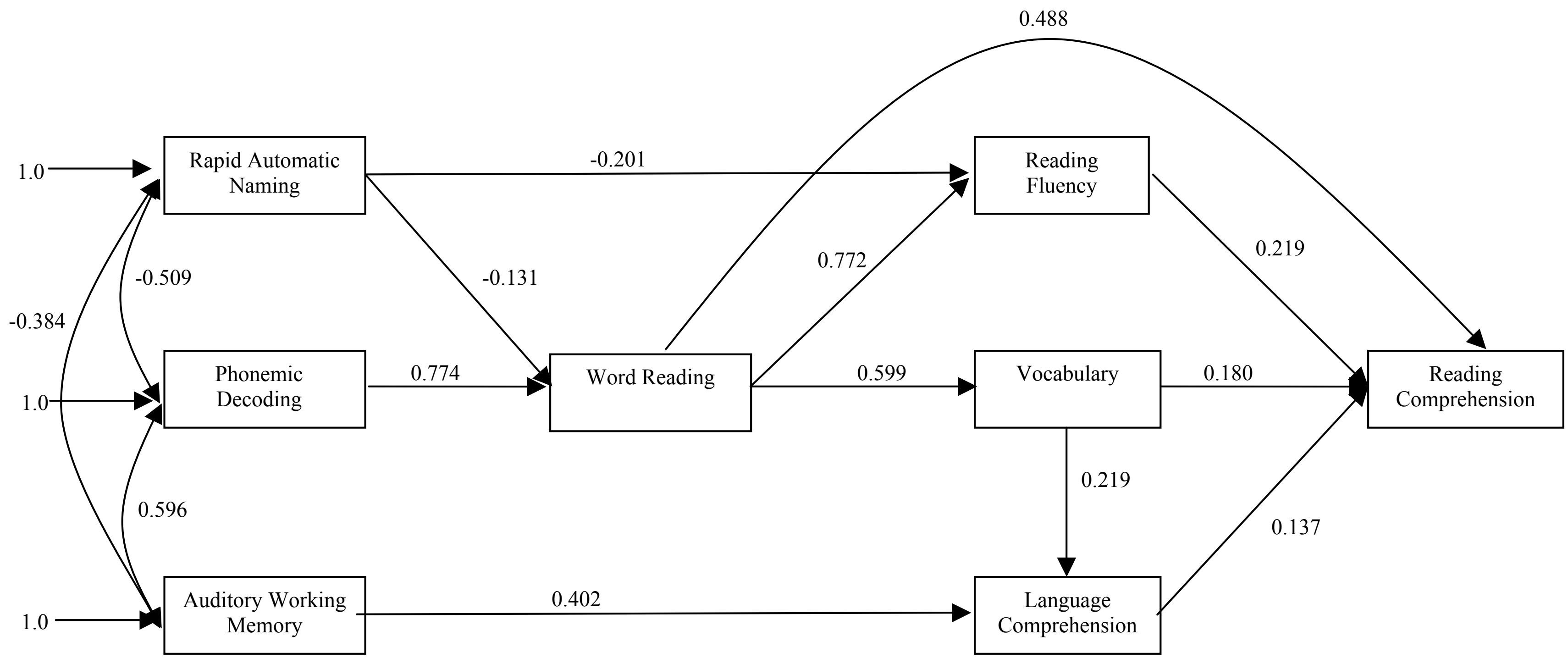


Figure 2. Path Model



CFI = 0.985
RMSEA = 0.073
90 percent C.I. for RMSEA = 0.029 to 0.114
$\chi^2_{df=25} = 907.14$, $p < 0.001$

Table 4. *Model Component Raw Scores by NRS Reading Level*

Variable	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
	M (SD) Range	M (SD) Range	M (SD) Range	M (SD) Range	M (SD) Range	M (SD) Range
Rapid automatic naming	45 (12) 62 – 27	38 (13) 70 – 23	35 (9) 67 – 21	31 (7) 65 – 20	30 (6) 43 – 18	26 (4) 36 – 20
Auditory working memory	16 (4) 10 – 23	17 (6) 0 – 26	20 (7) 2 – 34	23 (6) 8 – 35	25 (3) 20 – 30	30 (5) 10 – 37
Phonemic decoding	5 (6) 0 – 17	12 (9) 0 – 32	21 (10) 1 – 39	24 (9) 1 – 38	31 (8) 13 – 40	34 (6) 16 – 42
Word reading	38 (16) 20 – 72	57 (12) 37 – 81	70 (12) 47 – 93	73 (9) 54 – 95	81 (11) 66 – 94	89 (6) 78 – 102
Vocabulary	16 (6) 7 – 22	16 (6) 3 – 27	20 (8) 5 – 44	22 (7) 11 – 36	26 (8) 13 – 39	34 (10) 17 – 56
Language comprehension	4 (2) 2 – 7	6 (3) 1 – 12	6 (3) 0 – 11	6 (3) 1 – 13	8 (3) 4 – 12	9 (3) 4 – 15
Reading fluency	26 (34) 3 – 113	71 (34) 18 – 155	94 (37) 33 – 172	112 (28) 60 –195	125 (34) 67 – 188	160 (30) 101 – 228
Reading comprehension	15 (11) 3 – 36	25 (11) 6 – 47	35 (10) 13 – 56	41 (7) 27 – 54	45 (8) 28 – 56	52 (5) 42 – 61

Table 5. *Decomposition of Effects from Path Analysis*

Variables	Unstandardized	SE	Standardized
Phonemic decoding — Word reading	1.079	0.065	0.774
Rapid automated naming — Word reading	-0.213	0.076	-0.131
Word reading — Vocabulary	0.359	0.036	0.599
Word reading — Reading fluency	2.201	0.114	0.772
Rapid automated naming — Reading fluency	-0.932	0.185	-0.201
Vocabulary — Language comprehension	0.072	0.023	0.219
Auditory working memory — Language comprehension	0.174	0.030	0.402
Word reading — Reading comprehension	0.380	0.065	0.488
Vocabulary — Reading comprehension	0.233	0.062	0.180
Reading fluency — Reading comprehension	0.060	0.022	0.219
Language comprehension — Reading comprehension	0.540	0.160	0.137

The most important effects found in this model were paths from phonemic decoding (an exogenous variable) to word reading (ß = 0.774) and from word reading to reading fluency (ß = 0.772). Paths from word reading to vocabulary (ß = 0.599) and reading comprehension (ß = 0.488) were also relatively important; and vocabulary, in turn, had an effect on language comprehension (ß = 0.219) and reading comprehension (ß = 0.180). Reading fluency had an effect on reading comprehension (ß = 0.219).

Three significant paths led from the other two exogenous variables in the model to intermediate variables: auditory working memory to language comprehension (ß = 0.402), rapid automatic naming to reading fluency (ß = -0.201) and to word reading (ß = -0.131). Lastly, the model predicted language comprehension made a minimal yet significant contribution to reading comprehension (ß = 0.137).

Limitations. MacCallum and Austin (2000) recommend confirming models such as this with an independent sample. Our sample was not large enough to cross validate using a split-half sample. Thus, we encourage future researchers to test these findings with another sample of adults with low literacy.

We also recognize that path analysis relies on the association of variables as represented in correlational values. Thus, the causal inference does not exist in the data but rather our interpretation of those path coefficients. The path or causal relationship among the variables was based on our reading of the research literature and our choice of instruments based on their psychometric properties. As other research is completed with this adult population, we can begin to further evaluate the magnitude and significance of these relationships. In our future work for example, we will examine the robustness of this model through selecting other measures of the constructs in the model and completing a comparable analysis. For example, we can substitute a receptive vocabulary measure, a more traditional measure of reading comprehension, and rate measures of phonemic processing and word identification. Using these related constructs collected on the same population will provide important evidential validation. Lastly, although of interest to us and perhaps the reader, our sample size was too small to make accurate inferences about the reading component skill differences between those adults who self-reported learning disabilities and those who did not.

Discussion

This path model of low literacy adult reading comprehension demonstrates that these readers have not made the expected shift from reliance on word recognition to language comprehension (Catts, et al., 2005; Cromley & Azevedo, 2007; Gough & Tunmer, 1986). They strongly rely on word reading, with vocabulary and such higher order language comprehension skills as summarization and inference contributing less to their reading comprehension. For these readers, their most direct path to comprehension is through their word recognition skills.

Reliance on word recognition. Our resulting model confirmed the literature that suggests phonemic decoding of nonwords significantly contributes to the ability read whole words (ß = .774) and that reading whole words contributes to fluency (ß = .772), vocabulary (ß =.599), and reading comprehension (ß = .488). However, reliance on these word recognition skills has not advanced these adults with low literacy beyond their average fifth-grade reading comprehension level. We are left to speculate about what factors have limited improvement of skills for these readers. Insufficient prior knowledge, vocabulary, and integration of their skills seem to be reasonable explanations.

We hypothesized that adult learners would differ from younger readers because we expected they would have larger vocabularies stemming from their life experiences. Indeed, recent findings from Cromely and Azevedo's (2007) and Braze et al. (2007) emphasized the importance of vocabulary to reading comprehension among adolescent and young adult readers. Thus, we expected our sample of adult readers to integrate their vocabulary with syntax and context in order to be fluent readers. However, we were surprised to find vocabulary did not correlate higher with reading fluency (r = .52) or language comprehension (r = .41). Moreover, our model did not have a statistically significant path between vocabulary and reading fluency, and the path to language comprehension, while significant, was relatively unimportant (ß = .219). The limited role of vocabulary in our model, however, may reflect the distinction of expressive vocabulary, which we assessed using the *Wechsler Adult Intelligence Scale-III* subtest, from reading vocabulary, which are often used in models of reading (e.g., DIME used Gate-MacGinitie paper-and-pencil, multiple choice vocabulary subtest). Further, we anticipated that the more word reading skills and fluency a reader achieved, the more language comprehension skills he or she would acquire. However, we found no significant contribution from word reading or reading fluency to language comprehension. Missing and weak paths in our model suggest interventions should be explored and tested to determine if they help adults with low literacy efficiently integrate their word reading skills with other reading processes (e.g., the *Wilson Reading System*®, Wilson Language Training, 2002).

Limited contribution of language comprehension. Language comprehension was the least important contributor to reading comprehension for these adults (ß = .137). As indicated by the simple view model, more language comprehension contribution should be expected from more advanced readers; and the DIME suggests that, in addition to vocabulary, the ability to use such strategies as summarization or to draw inferences are important elements leading to comprehension.

Once again, the weak or missing relationships here may lead intervention developers to consider how to help adults with low literacy learn to enact comprehension strategies and draw inferences with both the spoken and written word. Although our model and other models of reading did not measure metacognitive abilities indicating how readers think about their reading, the instruction research (e.g., Swanson, 1999; Swanson & Hoskyn, 2001) leads us to speculate that interventions that encourage improved reflective thinking about one's own reading may help this population, particularly when learning disabilities are present. *The Paraphrasing Strategy* (Schumaker, Denton, & Deshler, 1984) and *The Self-Questioning Strategy* (Schumaker, Deshler, Nolan, & Alley, 1994) are validated examples of such strategy-focused instructional interventions.

Automaticity and fluency. Lastly, we hypothesized that, because of the prevalence of learning disabilities in this population, an exogenous variable representing the rapid automatic naming might shed light on some reading skill deficits. In fact, rapid naming ability made small significant contributions to word reading (ß = -0.131) and reading fluency (ß = -0.201), but no significant direct contribution to language comprehension. Our model also found reading fluency made a significant contribution to reading comprehension (ß = 0.219), giving credence to theories supporting efficient integration of word reading skills freeing limited cognitive capacity for other comprehension tasks.

Conclusion

Adults with low literacy skills by definition have not achieved reading abilities consistent with what extant models of reading predict for mature readers. In fact, the adult basic and secondary education learners in our study have not made the expected shift from reliance on word recognition to language comprehension (Catts, et al., 2005; Cromley & Azevedo, 2007; Gough & Tunmer, 1986). Instead, they function somewhat like young readers, relying on word reading skills to understand connected texts—yet their phonemic decoding ability averages 3.8 grade equivalent and word reading averages 5.0 grade equivalent. Moreover, they have not developed or acquired the ability and strategies required to integrate their word reading skills with vocabulary knowledge and other language comprehension skills for the purpose of reading comprehension. Instructors and curriculum developers targeting this population face the challenge of focusing on improving these readers' word reading skills at the same time helping them learn and integrate language comprehension skills.

Future research. For researchers we pose a question about causal reading models. We speculate that a non-recursive model warrants investigation. In this proposed analysis the model specification would allow for a path between reading comprehension and phonemic decoding and, or word identification. The logic would suggest that improved reading comprehension, that is, making sense of the text, would also improve a reader's familiarity with phonemic decoding and word identification. Thus, a reciprocal causation could be postulated that in common terms might be expressed *as the more you read, the better you get at all of the components of reading*.

References

Adolf, S., Catts, H., & Little, T. (2006). Should the simple view of reading include a fluency component? *Reading and Writing*, *19*, 933–958.

Bell, L., & Perfetti, C. (1994). Reading skill: Some adult comparisons. *Journal of Educational Psychology, 86*(2), 244–55.

Braze, D., Tabor, W., Shankweiler, D., and Mencl, W.E. (2007). Speaking up for vocabulary: Reading skill differences in young adults. *Journal of Learning Disabilities*, *40*(3), 226–243.

Bruck, M. (1990). Word-recognition skills of adults with childhood diagnoses of dyslexia. *Developmental Psychology*, *26*(3), 439–454.

Bruck, M. (1992). Persistence of dyslexics' phonological awareness deficits. *Developmental Psychology*, *28*(5), 874–886.

Bruck, M. (1993). Component spelling skills of college students with childhood diagnoses of dyslexia. *Learning Disabilities Quarterly*, *16*, 171–184.

Cain, K., Oakhill, J., & Bryant, P. (2004). Children's reading comprehension ability: Concurrent prediction by working memory, verbal ability, and component skills. *Journal of Educational Psychology*, *96*(1), 31–42.

Carr, S., & Thompson, B. (1996). The effects of prior knowledge and schema activation strategies on the inferential reading comprehension of children with and without learning disabilities. *Learning Disability Quarterly*, *19*(1), 48–61.

Catts, H., Hogan, T., & Adolf, S. (2005). Developmental changes in reading and reading disabilities. In H. Catts & A. Kamhi (Eds.), pp. 25–40. *Connections between language and reading disabilities*. Mahwah, NJ: Erlbaum.

Catts, H., Hogan, T., & Fey, M. (2003). Subgrouping poor readers on thee basis of individual differences in reading-related abilities. *Journal of Learning Disabilities*, *36*(2), 151–164.

Cohen, J., Cohen P., West, S.G., & Aiken, L.S. (2003). *Applied multiple regression/correlation analysis for the behavioral sciences* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum Associates..

Comings, J. (2003). *Building an evidence-based adult education system* (NCSALL Occasional Paper). Cambridge, MA: National Center for the Study of Adult Learning and Literacy.

Comings, J., & Soricone, L. (2007). *Adult literacy research: Opportunities and challenges* NCSALL Occasional Paper, January 2007. Cambridge, MA: National Center for the Study of Adult Learning and Literacy. Retrieved January 28, 2007, from http://www.ncsall.net/fileadmin/resources/research/op_opps_challenges.pdf

Comprehensive Adult Student Assessment System. (2001). *CASAS technical manual*. San, Diego, CA: Author

Cromley, J., & Azevedo, R. (2007). Testing and refining the Direct and Inferential Mediation Model of reading comprehension. *Journal of Educational Psychology*, *99*(2), 311–325.

Cunningham, A., Stanovich, K., & Wilson, M. (1990). Cognitive variation in adult college students differing in reading ability. In T. Carr & B. Levy (Eds.) *Reading and Its Development: Component Skills Approaches*. San Diego, CA: Academic Press, Inc., 129-159.

Curtis, M., & Kruidenier, J. (2005). *A summary of scientifically based research principles: Teaching adults to read*. Washington, DC: National Institute for Literacy. Retrieved November 19, 2007, from http://www.nifl.gov/partnershipforreading/publications/teach_adults.pdf.

Cutting, L., & Scarborough, H. (2006). Prediction of reading comprehension: Relative contributions of word recognition, language proficiency, and other cognitive skills can depend on how comprehension is measured. *Scientific Studies of Reading*, *10*(3), 277–299.

Davidson, R., & Strucker, J. (2002). Patterns of word-recognition errors among Adult Basic Education native and nonnative speakers of English. *Scientific Studies of Reading*, *6*(3), 299–316.

Dreyer, L. G., & Katz, L. (1992). An examination of the 'simple view of reading'. *Yearbook of the National Reading Conference, 41,* 169–176.

Durgunoglu, A., & Oney, B. (2002). Phonological awareness: It's not only for children. *Scientific Studies of Reading, 6*(3), 245–266.

Glass, D. (2007, January 17). *Kansas adult education FY06 annual report to the Kansas Board of Regents*, January 17, 2007. Topeka, KS: Kansas Board of Regents.

Gough, P., Hoover, W. & Peterson, C. (1996.) Some observations on a Simple View of Reading. In C. Cornoldi, & J. Oakhill (Eds.), *Reading comprehension difficulties*. Mahwah, NJ: Lawrence Erlbaum Associates.

Gough, P., & Tunmer, W. (1986). Decoding, reading, and reading disability. *Remedial and Special Education, 7*(1), 6-10.

Greenberg, D., Ehri, L., & Perin, D. (1997). Are word reading processes the same or different in adult literacy students and third-fifth graders matched for reading level? *Journal of Educational Psychology, 89*(2), 262-275.

Greenberg, D., Ehri, L., & Perin, D. (2002). Do adult literacy students make the same word-reading and spelling errors as children matched for word-reading age? *Scientific Studies of Reading, 6*(3), 221-243.

James, L.R., Mulaik, S.A., & Brett, J.M. (1982). *Causal analysis: Assumptions, models, and data*. Beverly Hills, CA: Sage Publications.

Joshi, R.M., & Aaron, P.G. (2000). The component model of reading: Simple view of reading made a little more complex. *Reading Psychology*, *21*(2), 85–97.

Kruidenier, J. (2002). *Research-based Principles for adult basic education reading instruction.* Washington, DC: National Institute for Literacy.

Kutner, M., Greenberg, E., & Baer, J. (2005). *National Assessment of Adult Literacy (NAAL): A first look at the literacy of America's adults in the 21st century*. (NCES 2006-470). Washington, DC: National Center for Educational Statistics.

Kutner, M., Greenberg, E., Jin, Y., Boyle, B., Hsu, Y., & Dunleavy, E. (2007). *Literacy in Everyday Life: Results From the 2003 National Assessment of Adult Literacy* (NCES 2007–480). Washington, DC: U.S. Department of Education, National Center for Education Statistics.

Leslie, L., & Caldwell, J. (2001). *Qualitative reading inventory, 3*. New York: Addison Wesley Longman, Inc.

Lewis, A., & Smith, D. (1993). Defining higher order thinking. *Theory into Practice*, *32*(3), 131–137.

Long, D., Oppy, B., & Seely, M. (1994). Individual differences in the time course of inferential processing learning, memory, and cognition. *Journal of Experimental Psychology*, *20*(6), 1456–1470.

MacCallum, R., & Austin, J. (2000). Applications of structural equation modeling in psychological research. *Annual Review of Psychology*, *51*, 201–226.

Malicky, G., & Norman, C. (1989). The reading concepts and strategies of adult nonreaders. *Journal of Reading, 33*, 198–202.

Mather, N., Hammill, D., Allen, E., & Roberts, R. (2004). *Test of Silent Reading Word Proficiency*. Austin, TX: PRO-ED.

Mather, N., & Woodcock, R. (2001). Examiner's Manual. *Woodcock Johnson-III Test of Cognitive Abilities*. Itasca, IL: Riverside.

McKane, P, & Greene, B. (1996). The use of theory-based computer-assisted instruction in correctional centers to enhance the reading skills of reading-disadvantaged adults. *Journal of Educational Computing Research, 15*(4), 331-344.

McKown, B., & Barnett, C. (2007). *Improving reading comprehension through higher-order thinking skills*. Chicago, IL: Saint Xavier University.

McShane, S. (2005). *Applying research in reading instruction for adults*. Washington, DC: National Institute for Literacy.

Mellard, D., Fall, E. & Mark, C. (2008). Reading profiles for adults with low-literacy: Cluster analysis with power and speeded measures. *Reading & Writing.* Early online publication at DOI 10.1007/s11145-008-9136-8.

National Reading Panel (U.S.). (2000). *Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction*. Retrieved February 18, 2008, from http://www.nationalreadingpanel.org/Publications/researchread.htm.

Patterson, M.B. (2008). Learning disability prevalence and adult education program characteristics, *Learning Disabilities Research & Practice*, *23*(1), 50-59.

Rapp, D., van den Broek, P., McMaster, K., Kendeou, P., & Espin, C. (2007). Higher-order comprehension processes in struggling readers: A perspective for research and intervention. *Scientific Studies of Reading*, *11*(4), 289–312.

Sabatini, J. (2002). Efficiency in word reading of adults: Ability group comparisons. *Scientific Studies of Reading*, *6*, 267-298.

Sabatini, J., Scarborough, H., Shore, J., Bruce, K., & Sawacki, Y. (2007, April). *Profile and intervention results for adult literacy learners with low decoding and fluency abilities*. Paper presented at American Educational Research Association Conference, Chicago, IL, April 11, 2007.

Schumaker, J., Denton, P., & Deshler, D. (1984). *The paraphrasing strategy*. Lawrence, KS: The University of Kansas, Center for Research on Learning.

Schumaker, J., Deshler, D., Nolan, S., & Alley, G. (1994). *The self-questioning strategy*. Lawrence, KS: The University of Kansas, Center for Research on Learning.

Semel, E., Wiig, E., & Secord, W. (1987). *Clinical Evaluation of Language Fundamentals* (Rev. ed.). San Antonio, TX: The Psychological Corp.

Stage, F., Carter, H., & Nora, A. (2004). Path analysis: An introduction and analysis of a decade of research. *The Journal of Educational Research*, *98*(1), 5–12.

Swanson, H.L. (1999). Instructional components that predict treatment outcomes for students with learning disabilities: Support for a combined strategy and direct instruction model. *Learning Disabilities Research and Practice, 14*(3), 129–140.

Swanson, H.L., & Hoskyn, M. (2001). Instructing adolescents with learning disabilities: A component and composite analysis. *Learning Disabilities Research and Practice, 16*(2), 109–119.

Tabachnick, B., & Fidell, L. (2007). *Using multivariate statistics* (5th ed.). Needham Height, MA: Allyn & Bacon.

Unsworth, N. & Engle, R. (2007). On the divisions of short-term and working memory: An examination of simple and complex span and their relation to higher order abilities. *Psychological Bulletin*, *133*(6), 1038–1066.

U.S. Census Bureau. (2000). *Profile of general demographic characteristics, Census 2000*. Retrieved June 26, 2007, from http://infoplease.com/ipa/A0884102.html.

U.S Department of Education, Office of Vocational and Adult Education. (2005). Enrollment and Participation in the State-Administered Adult Education Program 2004-2005 Tables. Retrieved August 14, 2007, from http://www.ed.gov/about/offices/list/ovae/pi/AdultEd/aedatatables.html.

U.S. Department of Education. Office of Adult and Vocational Education, Division of Adult Education and Literacy. (2001). *Measures and methods for the National Reporting System for adult education: Implementation guidelines*. Washington, DC: Author.

van den Broek, P., Tzeng, Y., Risden, R., Trabasso, T., & Basche, P. (2001). Inferential questioning: Effects on comprehension of narrative texts as a function of grade and timing. *Journal of Educational Psychology*, *93*(3), 521–529.

Vellutino, F., Scanlon, D., & Tanzman, M. (1994). Components of reading ability: Issues and problems in operationalizing word identification, phonological coding, and orthographic coding. In R. Lyon (Ed.), *Frames of Reference for the Assessment of Learning Disabilities: New Views on Measurement Issues*. (pp. 279-332). Baltimore, MD: Paul Brookes.

Vellutino, F., Tunmer, W., Jaccard, J., & Chen, R. (2007). Components of reading ability: Multivariate evidence for a convergent skills model of reading development. *Scientific Studies of Reading, 11*(1), 3-32.
Wagner, R.K., Torgesen, J.T., & Rashotte, C.A. (1999). *The Comprehensive Test of Phonological Processing*. Austin, TX: Pro-ed.
Wechsler, D. (1997). *Manual for the Wechsler Adult Intelligence Scale* (3rd ed.). San Antonio, TX: The Psychological Corporation.
Wilson Language Training. (2002). *Wilson Reading System*. Oxford, MA: Author.
Wolf, M., & Bowers, P. (1999). The "double-deficit hypothesis" for the developmental dyslexias. *Journal of Educational Psychology*, *91*(3), 415-438.
Wolf, M., Bowers, P., & Biddle, K. (2000). Naming-speed processes, timing and reading: A conceptual review. *Journal of Learning Disabilities*, *33*(4), 387–407.
Wolf, M., & Katzir-Cohen, T. (2001). Reading fluency and its intervention. *Scientific Studies of Reading*, *5*(3), 211–239.
Woodcock, R. (1998). *Woodcock Reading Mastery Tests—Revised: Examiner's Manual*. Circle Pines, MN: American Guidance Service.
Workforce Investment Act of 1998, Pub. L. No. 1005-220, 112 Stat. 936 (1998).

About the Authors

Daryl F. Mellard, PhD, is the director of the Center for Research on Learning, Division of Adult Studies, at the University of Kansas, Lawrence, KS, USA, where he conducts research addressing the needs of children and adults, including improving literacy outcomes and accommodating adults with disabilities in adult and postsecondary education, employment, and other services.

Emily Fall, MA, is a graduate research assistant for the Center for Research on learning, Division of Adult Studies, at the University of Kansas, Lawrence, KS, USA, pursuing a doctorate degree in quantitative psychology.

Kari L. Woods, MBA, supports dissemination of research findings for the Center for Research on learning, Division of Adult Studies, at the University of Kansas, Lawrence, KS, USA.