Reading profiles for adults with low-literacy: Cluster analysis with power and speeded measures

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Abstract

The United States' National Institute for Literacy's (NIFL) review of adult literacy instruction research recommended adult education (AE) programs assess underlying reading abilities in order to plan appropriate instruction for low-literacy learners. This study developed adult reading ability groups using measures from power tests and speeded tests of phonemic decoding, word recognition, fluency, and comprehension. A multiple cluster analysis of these reading ability scores from 295 low-literacy AE participants yielded seven reading ability groups. These groups are described in terms of instructional needs relevant to an instructor's planning and activities.

Key Words: adult education, low literacy, reading

Abbreviations:
ABE: Adult Basic Education
AE: adult education
ASE: Adult Secondary Education
CASAS: Comprehensive Adult Student Assessment System
NIFL: National Institute for Literacy
NRS: National Reporting System
QRI: Qualitative Reading Inventory
TABE: Test of Adult Basic Education
TOSWRF: Test of Silent Word Reading Fluency
TOWRE: Test of Word Reading Efficiency
USDE: U.S. Department of Education
WRMT-R: Woodcock Reading Mastery Tests-Revised

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In the United States, adult basic and secondary education (AE) programs annually serve approximately 2.8 million adults with low literacy (National Center for Educational Statistics, 2006). Some of these AE participants read very well and enroll in AE only to earn a high school equivalency credential, while some have less than the necessary literacy skills needed to perform simple and everyday literacy tasks (Kutner, Greenberg & Baer, 2005; Kutner et al., 2007). Between these extremes, many AE learners are able to read well enough to function in their homes or current jobs by using compensating strategies or skills, but lack the literacy skills needed to achieve higher education or employment goals. Given this diversity of learners, AE programs do not simply offer generalized instruction to all learners, nor refer to a learner's age or previous educational attainment to determine their instructional needs (McShane, 2005), as is done in elementary and secondary school settings.

A common practice among AE programs is to use functional assessments, such as Comprehensive Adult Student Assessment System (CASAS, 2001) or TABE: Tests of Adult Basic Education (CTB/McGraw-Hill, 1997), to place learners in leveled instructional programs. CASAS and TABE tests include stimulus material authentic to literacy demands experienced by adults (e.g., newspapers, advertisements, forms, documents), and thus differ from K-12 assessments that emphasize prose and expository text passage comprehension. Although functional assessments provide information about how well adults use literacy in daily life, they do not necessarily correspond with reading instruction needs (McShane, 2005; Strucker & Davidson, 2003). Thus, the National Institute for Literacy's (NIFL) review of adult literacy instruction research recommends AE programs should assess underlying reading abilities in order to plan appropriate instruction for low-literacy learners (Kruidenier, 2002a; McShane, 2005). Research indicating *which* of the many underlying reading abilities AE programs should assess and, therefore, how they might best group learners for instruction, is less clear (Kruidenier, 2002b). Thus, this study explores one scheme for classifying adult literacy learners in groups based on commonalities in phonemic decoding and word recognition accuracy and rate, and fluency and comprehension outcomes.

Reading Components

The Simple View of Reading (Gough & Tunmer, 1986) suggests the end goal of reading, that is, reading comprehension, is the product of two basic abilities: decoding and linguistic comprehension. Studies with developing readers (i.e., children) indicate that the relative contribution of these components shift as the reader progresses, starting with heavier reliance on word reading skills and moving to more reliance on the ability to understand language (Adolf, Catts, & Little, 2006; Catts, Hogan, & Adolf, 2005; Francis, Fletcher, Catts & Tomblin, 2005; Gough, Hoover, & Peterson, 1996).

Joshi and Aaron (2000) found that at about the 4th grade reading level speed of processing emerges as a significant factor in reading ability. The addition of a speed component to the decoding and linguistic comprehension components reflects several long-standing theories that explain the differences between good and poor readers on the basis of word reading speed and efficiency (combined speed and accuracy). For example, the theory of automatic information processing (LaBerge & Samuels, 1974) hypothesized poor readers would benefit from becoming more automatic in surface level processing (visual perception, sounding, phrasing words together, etc.) rather than depleting or exhausting attention, memory, and cognitive capacity that could otherwise be invested in comprehension. The verbal efficiency theory or limited capacity theory of reading (Lesgold & Perfetti, 1978; Perfetti, 1985) posited that word reading skills must reach a high level of efficiency and automaticity in order for the reader to be able to devote cognitive capacity (e.g., attention, memory) to meaning and comprehension. Likewise, Stanovich (1980), hypothesized that the difference between good and poor readers was in the way they processed text, that is, poor readers may be less able to employ automatic, attention-free, bottom-up processes in decoding, and compensate with strategies that require significant cognitive resources.

Some studies, however, do not support the addition of a separate speed or efficiency component of reading; rather Adolf, Catts, and Little (2006) found that “few individuals had problems in fluency separate from word recognition accuracy or listening comprehension” (p. 933). Similarly, Edwards, Walley, and Ball (2003) found that adults with reading disabilities who had attained adequate reading skills “seem to have lingering difficulties with phonological, but not more general, temporal processing.” For some readers, in fact, reading faster in itself may interrupt successful comprehension strategies (e.g., looking back in text to resolve confusion by restoring information to working memory or acquiring overlooked information; Walczyk & Griffith-Ross, 2007).

However, other recent research supports the idea that differentiating adult readers’ abilities on the basis of the speed and efficiency with which they perform component skills is possible. For example, Sabatini (2002) examined the role speed of processing plays in reading among adults with low literacy and found a significant connection to word recognition. Leinonen, Müller, Leppänen, Aro, Ahonen, and Lyytinen (2001) observed that adults with a reading disability who were able to read relatively fast, even with numerous errors, experienced more rewarding everyday reading than those who read slower with more accuracy. Thus, it seems that assessments of word reading accuracy, level of difficulty, and speed may distinguish between adult learners' reading comprehension levels and help identify their instructional needs.

NIFL and the National Center for the Study of Adult Learning and Literacy's Reading Research Working Group—in parallel to the National Reading Panel report on teaching children to read (National Institute of Child Health and Human Development, 2000)—identified four core topics as a conceptual, research-based framework for adult literacy instruction: alphabetics, which includes phonemic awareness and word analysis; fluency; vocabulary; and comprehension (Kruidenier, 2002a). Strucker and Davidson (2003) alternatively classified English-speaking AE learners based on their assessed strengths and weaknesses in word recognition, spelling, vocabulary, and silent reading rate.

We hypothesized that a useful instructional grouping scheme for adults with low literacy could be identified using both power and speeded tests of phonemic decoding and word recognition, along with measures of two reading outcomes, oral reading fluency and reading comprehension. We investigated our hypothesis using a clustering classification research method with 295 AE participants.

Methodology

Research Design

This study draws on primary data collected during our broader study of learners receiving adult literacy services. We selected seven measures from a battery of assessments administered in this study to test our hypothesis. Next, we applied Morris, Stuebing, Fletcher, Shaywitz, Lyon, Shankweiler, et al.'s (1998) classification research methodology using multiple cluster analysis techniques to identify subtypes of low-literacy adult readers. Lastly, we analyzed each subtype's ability patterns using *z*-scores for the seven variables as a common scale for identifying instructional emphasis for each group.

Setting and Subjects

Research staff collected data during a 30-month period beginning in 2003 from adults enrolled in thirteen Midwestern AE programs. In order to participate in the study, subjects had to be at least 16 years old, withdrawn from secondary education, 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. The project design did not call for sampling students in the AE programs' English as a Second Language (ESL) courses, or English language learners (ELL). Graduate research assistants trained to criterion on the instruments assessed participants individually at the AE program sites.

Sampling method. The participating AE programs categorize all non-ELL learners into six educational functional levels defined by the U.S. Department of Education (USDE, 2001) National Reporting System (NRS) using CASAS reading diagnostic scores (CASAS, 2001). The NRS levels are: (a) Level 1, Adult Basic Education [ABE] Beginning Literacy; (b) Level 2, Beginning ABE; (c) Level 3, Low Intermediate ABE; (d) Level 4, High Intermediate ABE; (e) Level 5, Low Adult Secondary Education [ASE]; and (f) Level 6, High ASE. From among the AE learner volunteers, we randomly drew a stratified random sample at each study site for a total of approximately 60 learners per level in Levels 4, 5, and 6. Because of few Level 1, 2, and 3 volunteers, we used a convenience sample that included all eligible volunteers up to a total of 60 per level.

Sample size. Three hundred and thirty eligible learners were selected for the study, 11 of whom subsequently refused participation, mostly due to "lack of time." We eliminated 11 participants' data from our study because of incomplete information, and 13 participants for whose data we had validity concerns (e.g., statistical outliers, cognitive disability such as traumatic brain injury). Therefore, we present analysis on a total sample of 295 learners distributed by NRS educational functional level as follows: Level 1 n = 25; Level 2 n = 46; Level 3 n = 56; Level 4 n = 57; Level 5 n = 55; Level 6 n = 56.

Sample description. The subjects were 60% female (n = 177), which is typical among AE populations (Moore & Stavrianos, 1995). Subjects' median age was 24 years, with a range from 16 to 73. Race and ethnicity of the sample were representative of the study region's non-ELL AE participants with 37% White Non-Hispanic (n = 109), 35% African American (n = 103), 11% White Hispanic (n = 32), and 17% Other or not reported (n = 51). During childhood, 18% of the sample spoke a language other than English in their home; 53% of these individuals (10% of the sample) indicated that they had previously been enrolled in an English as a Second Language course.

Variables and Assessment Instruments

To test our hypothesis, we selected instruments designed to capture individual difference variance in accuracy and rate of phonemic decoding and word recognition, along with instruments that measured fluency and comprehension outcomes. The accuracy instruments are power tests that measure accuracy with items that span a range of difficulty. The speeded test items also span a range of difficulty but have the additional element of a time limit, which can indicate a level of automaticity or efficiency in performing the reading skill. Fluency and comprehension are outcome measures that provide an indication of the degree to which readers are able to integrate their component skills.

Phonemic decoding. To assess power of phonemic decoding skills, we selected the Woodcock Reading Mastery Tests-Revised (WRMT-R) Word Attack subtest (Woodcock, 1998), which tasks a subject with pronouncing increasingly difficult, phonetically decodable non-words. For phonemic decoding speed, we selected the Test of Word Reading Efficiency (TOWRE) Phonemic Decoding subtest, which measures how many phonetically decodable non-words a reader can pronounce within a 45-second time limit (Torgesen, Wagner, & Rashotte, 1999).

Word recognition. As a power test for word recognition, we selected the WRMT-R Word Identification subtest (Woodcock, 1998), which requires a subject to pronounce increasingly difficult, familiar words. We selected both a silent and an oral speeded test of word recognition. The Test of Silent Word Reading Fluency (TOSWRF) gives examinees three minutes to draw lines between increasingly difficult printed words strung together in lines without spaces between words (Mather, Hammill, Allen, & Roberts, 2004). The TOWRE Sight Word Efficiency subtest requires subjects to pronounce increasingly difficult, familiar words in a 45-second time limit (Torgesen et al., 1999).

Outcome measures. Although many definitions of fluency include a measure of comprehension (e.g., Jenkins, Fuchs, van den Broek, Espin, Deno, 2003), for our purposes we limited fluency to accurate and speedy word recognition with correct prosody with connected text (Kruidenier, 2002a). Thus we measured the number of words per minute correctly read from connected prose using the scoring criteria from a widely accepted informal assessment, the *Qualitative Reading Inventory* (QRI; Leslie & Caldwell, 2001). Subjects orally read one minute from each of two QRI sixth-grade reading level passages with lexile scores of 660L and 710L. As a measure of reading comprehension skills, we selected the WRMT-R Passage

Comprehension subtest (Woodcock, 1998). This assessment uses a cloze procedure with short passages of two to three sentences.

Clustering Analysis

Initial clustering. Morris et al.'s (1998) classification methodology employs an exploratory clustering analysis using multiple clustering techniques in order to determine a reasonable number of clusters within a data set (Blashfield & Draguns, 1976; Morris, Blashfield, & Satz, 1981). In our analysis we used three hierarchical clustering techniques: Ward's method, average link, and central link (Everitt, 1980); and we measured distance among clusters with squared Euclidian distance. We used raw scores to calculate z-scores for the seven variables: (a) WRMT-R Word Attack, (b) TOWRE Phonemic Decoding, (c) WRMT-R Word Identification, (d) TOWRE Sight Word Efficiency, (e) TOSWRF, (f) QRI, and (g) WRMT-R Passage Comprehension. The three clustering procedures indicated seven as the appropriate number of clusters for this data set. We assessed reliability for the agglomerative procedures through a cross-tabulation of the results.

Cross-validation analysis. As a confirmatory procedure, Morris et al.'s (1998) method uses a K-means clustering technique. For the purpose of cross-validation, we randomly split our data set in half, with a post hoc ANOVA to demonstrate the similarity between data sets (Table 1). We performed the K-means analysis with each half and made comparison of the means of each variable by cluster to demonstrate the validity of the clusters. For each cluster, the two data sets demonstrated few significant differences, while having significant differences among the seven cluster groups (Table 2).

Table 1

Analysis of Variance Between Initial Sample and Validation Sample by Measure

Source	*df*	*F*	η	*p*
WRMT-R Word Attack	1	0.237	.000	.966
S within-group error	260	(131.193)		
TOWRE Phonemic Decoding	1	0.234	.001	.629
S within-group error	260	(266.133)		
WRMT-R Word Identification	1	0.032	.000	.858
S within-group error	260	(294.010)		
TOWRE Sight Word	1	0.329	.001	.567
S within-group error	260	(369.589)		
TOSWRF	1	0.484	.002	.487
S within-group error	260	(149.228)		
QRI (fluency)	1	0.001	.000	.972
S within-group error	260	(2242.146)		
WRMT-R Passage Comprehension	1	0.104	.000	.747
S within-group error	260	(161.654)		

Note. Values enclosed in parentheses represent mean square errors. *S* = subjects.

Table 2

Absolute Mean Difference between Initial Sample and Validation Sample by Cluster Group

Reading skill measure	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7
Initial sample *n*	15	10	11	28	33	31	6
Validation sample *n*	18	15	10	24	28	27	6
WRMT-R Word Attack							
Mean difference	3.61	1.00	7.56	3.66	0.65	1.58	3.03
p	1.000	1.000	0.009	0.925	1.000	1.000	1.000
TOWRE Phonemic Decoding							
Mean difference	0.87	1.05	15.41	6.26	0.41	7.38	3.27
p	1.000	1.000	0.000	0.004	1.000	0.003	1.000
WRMT-R Word Identification							
Mean difference	7.63	3.75	7.05	5.64	3.22	1.75	4.87
p	0.260	1.000	0.797	0.441	1.000	1.000	1.000
TOWRE Sight Word							
Mean difference	2.63	0.65	11.69	0.05	4.08	11.61	20.03
p	1.000	1.000	0.000	1.000	0.368	0.000	0.000
TOSWRF							
Mean difference	3.40	0.25	3.83	0.56	3.75	5.16	7.30
p	1.000	1.000	1.000	1.000	1.000	0.706	1.000
QRI (fluency)							
Mean difference	10.51	9.10	37.02	6.93	6.44	24.27	25.10
p	1.000	1.000	0.000	1.000	1.000	0.003	0.629
WRMT-R Passage Comprehension							
Mean difference	2.88	3.45	6.78	4.31	2.66	1.79	3.67
p	1.000	1.000	0.418	1.000	1.000	1.000	1.000

Pattern analysis. Using *z*-scores as a standard scale to compare the mean values of the seven variables for each cluster group, we analyzed each group's skill level pattern. Based on these patterns, we discuss the relative strengths and deficits in reading skill exhibited by each subtype of adult learner with low literacy.

Results

Subtypes Description

Table 3 describes the distribution of the seven reading ability subtypes by the participants' NRS levels. Groups 1, 2, 6, and 7 learners were grouped similar to NRS functional levels at both the high and low ability ends of the spectrum. However, Groups 3, 4, and 5 learners were widely distributed among NRS functional levels, indicating their common reading instruction needs are not represented in such functional assessments as TABE and CASAS.

Table 3

National Reporting System Level Distribution by Group

NRS level	Percent of Group 1	Percent of Group 2	Percent of Group 3	Percent of Group 4	Percent of Group 5	Percent of Group 6	Percent of Group 7	Percent of total initial sample
Level 1	54%	0%	9%	3%	0%	0%	0%	8%
Level 2	33%	70%	9%	11%	3%	0%	0%	12%
Level 3	13%	20%	55%	32%	21%	10%	0%	22%
Level 4	0%	10%	9%	43%	37%	3%	0%	20%
Level 5	0%	0%	18%	11%	21%	22%	17%	15%
Level 6	0%	0%	0%	0%	18%	65%	83%	23%
Group as % of total	11%	8%	8%	21%	25%	23%	4%	100%

Table 4 describes the seven subtypes by the raw score mean and standard deviation for each of the measures used to create the groups in the confirmatory K-means analysis (n = 134). Groups 4 (n = 28), 5 (n = 33), and 6 (n = 31) were the largest clusters in the analysis. Groups 1 (n = 15), 2 (n = 10), and 3, (n = 11) were between one-third and one-half the sizes of these large groups. Group 7 (n = 6), the highest performing group, had the fewest number of persons in the cluster groups.

Table 4

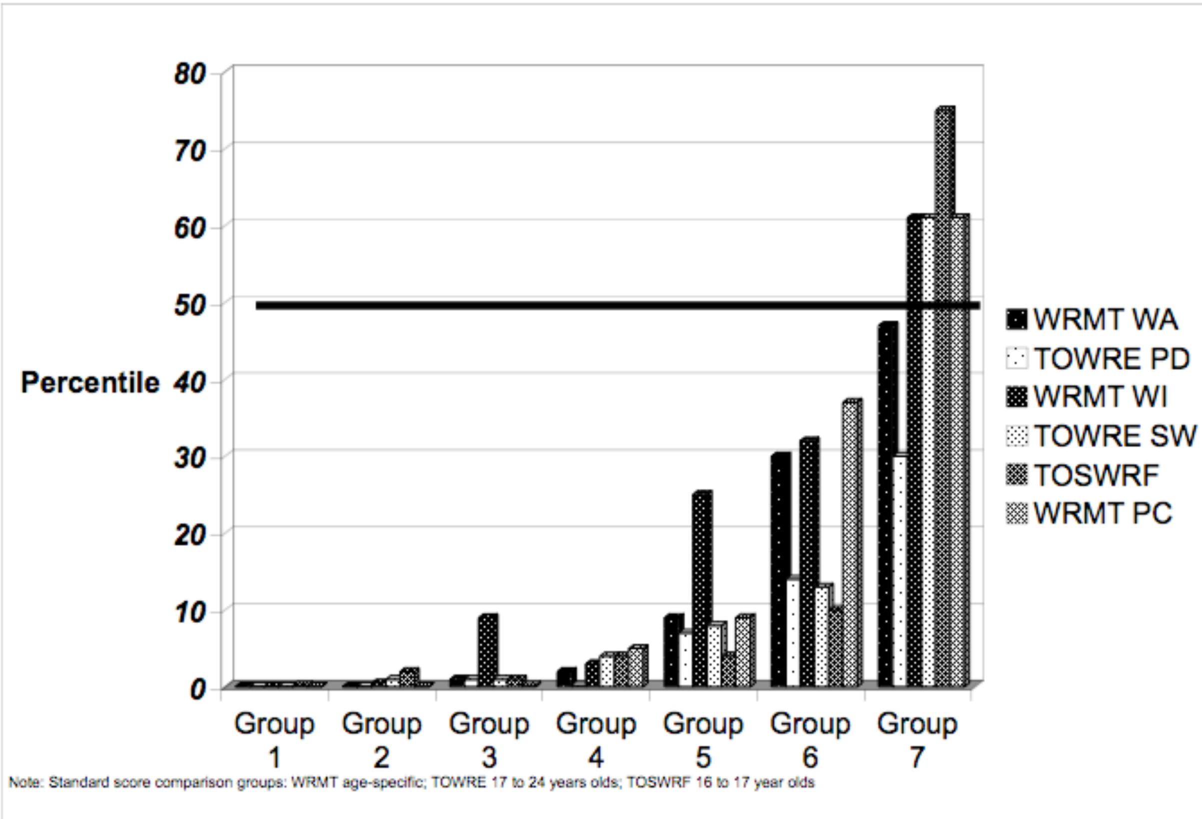
Mean and Standard Deviation Reading Skill Measures by Group

Observed measure	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Total initial sample
n	15	10	11	28	33	31	6	134
WRMT-R Word Attack								
M	4.20	8.60	22.18	18.25	30.12	34.06	37.33	22.99
SD	3.8	3.8	3.9	5.4	5.1	4.3	2.9	12.03
TOWRE Phonemic Decoding								
M	4.20	5.20	18.09	11.36	33.67	40.87	48.83	24.84
SD	4.0	4.4	8.0	4.7	6.4	7.2	3.1	15.9
WRMT-R Word Identification								
M	35.93	55.60	67.03	69.93	78.55	89.32	95.67	71.06
SD	11.2	5.8	8.0	5.8	7.5	4.6	3.4	19.1
TOWRE Sight Word								
M	25.13	51.80	50.91	65.14	74.36	80.23	98.00	63.94
SD	7.7	8.8	5.3	7.2	7.3	9.1	5.6	20.9
TOSWRF								
M	55.53	70.10	64.91	73.96	73.79	81.13	109.5	73.45
SD	2.3	5.3	6.4	6.5	3.2	7.9	9.5	12.3
QRI (fluency)								
M	21.3	65.55	67.45	102.16	126.27	156.87	185.75	106.60
SD	14.3	15.8	15.6	16.3	18.0	19.1	27.6	50.1
WRMT-R Passage Comprehension								
M	15.63	25.30	28.27	39.64	42.30	51.65	56.67	38.49
SD	7.9	10.4	6.6	5.1	6.4	4.2	7.8	13.6

Note: QRI = Qualitative Reading Inventory; TOSWRF = Test of Silent Word Reading Fluency; TOWRE = Test of Word Reading Efficiency; WRMT-R = Woodcock Reading Mastery Tests-Revised

Figure 1 displays how each group ranked compared to the general adult population or the population on which the assessment was normed. Each subtype was well below the 50th percentile on all measures with one exception, Group 7. Even Group 7, however, was below average on phonemic decoding skills. Groups 1, 2, 3, and 4 were below the 10th percentile on all examined reading component skills.

Figure 1
Observed Measure Percentile Ranking by Subtype



Legend: WMRT-R WA = Woodcock Reading Mastery Test Word Attack; TOWRE PD = Test of Word Reading Efficiency Phonemic Decoding; WRMT-R WI = Woodcock Reading Mastery Test Word Identification; TOWRE SW = Test of Word Reading Efficiency Sight Words; TOSWRF = Test of Silent Word Reading Fluency; WRMT-R PC = Woodcock Reading Mastery Test Passage Comprehension

Pattern Analysis

The seven reading ability subtypes of adults with low literacy not only had unique skill patterns, they demonstrated a consistent hierarchy of ability across most measures (see Figure 2). In some cases (i.e., Groups 2 and 4; Groups 5 and 6) the skill patterns were essentially the same with the difference between the subtypes being the level of skills. For Groups 1, 3, and 7 the patterns were unique to each subtype. Three groups consistently scored above the average for the sample (i.e., Groups 5, 6, and 7; see Figure 3), and four groups scored below the average for the sample on virtually all measures (i.e., Groups 1, 2, 3, and 4; see Figure 4). Group 7 was the highest scoring group on every measure with automaticity in sight word recognition as its most outstanding ability. Group 1 was the lowest scoring group on every measure.

Figure 2
Low-literacy Adult Reading Skills Profile: Observed Measure *z*-scores by Subtype

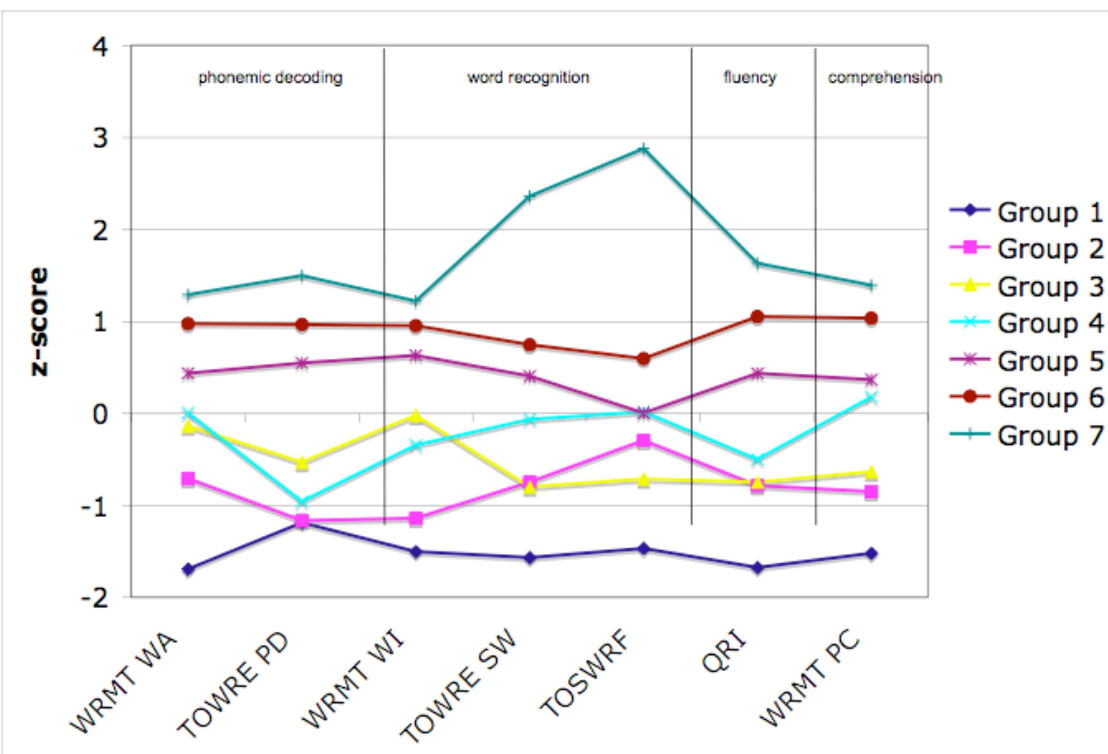


Figure 3
Higher-ability Subtype Reading Skills Profile: Observed Measure *z*-scores by Subtype

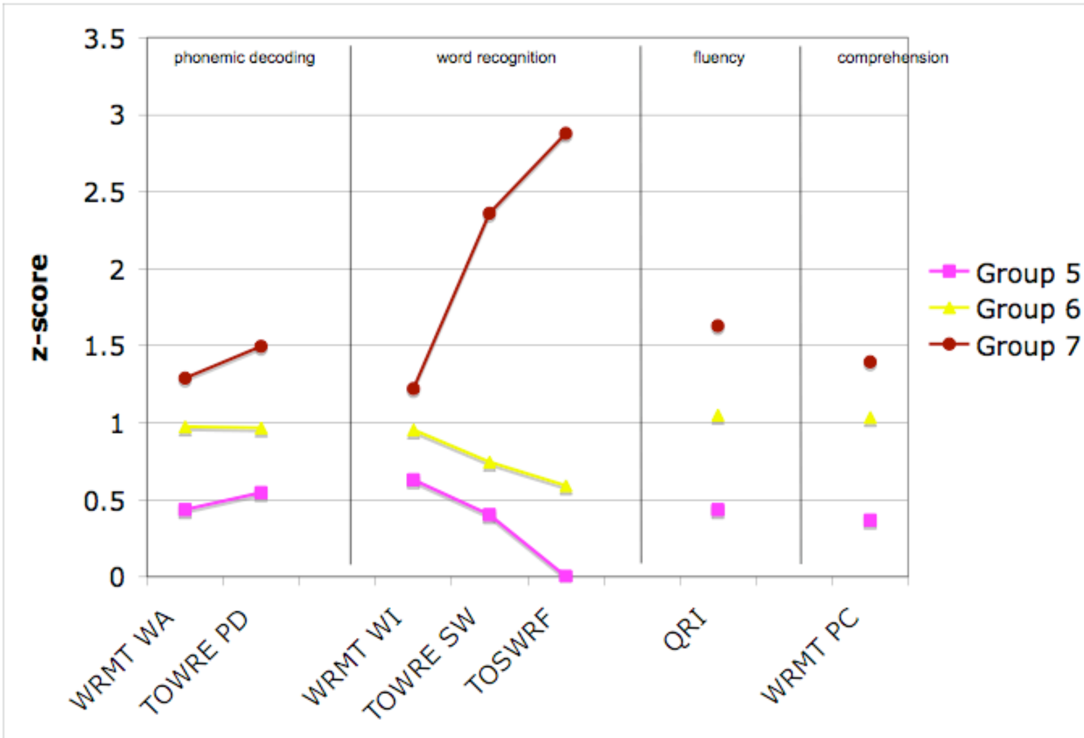
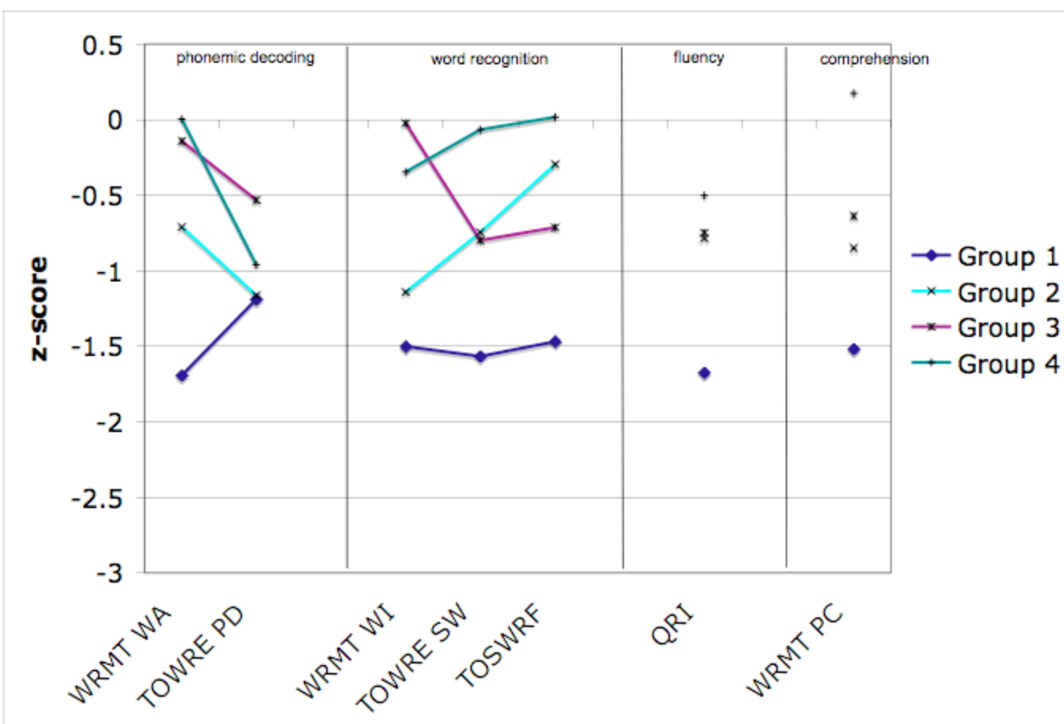


Figure 4
Lower-ability Subtype Reading Skills Profile: Observed Measure *z*-scores by Subtype



Legend: WMRT-R WA = Woodcock Reading Mastery Test Word Attack; TOWRE PD = Test of Word Reading Efficiency Phonemic Decoding; WRMT-R WI = Woodcock Reading Mastery Test Word Identification; TOWRE SW = Test of Word Reading Efficiency Sight Words; TOSWRF = Test of Silent Word Reading Fluency; WRMT-R PC = Woodcock Reading Mastery Test Passage Comprehension; QRI = Qualitative Reading Inventory

Group 7 pattern. As the highest ability group among the sample of low-literacy adults (Figure 3; Table 4), Group 7 demonstrated the most power in phonemic decoding (WRMT-R Word Attack, $M = 37.3$, $SD = 2.9$, $z = 1.29$), and did so with greater speed or better automaticity than the other low-literacy groups (TOWRE Phonemic Decoding, $M = 48.8$, $SD = 3.1$, $z = 1.50$); nevertheless, their standard scores for both measures were below the 50th percentile (Figure 1). In addition, this group displayed the strongest word recognition skills (WRMT-R Word Identification, $M = 95.7$, $SD = 3.4$, $z = 1.22$) and much greater automaticity compared to the other groups (TOWRE Sight Words, $M = 98.0$, $SD = 5.6$, $z = 2.36$; TOSWRF, $M = 109.5$, $SD = 9.5$, $z = 2.88$). Oral fluency with connected prose (QRI, $M = 185.8$, $SD = 27.6$, $z = 1.63$) was also a relative strength for these readers. Group 7 comprehension scores were better than the other groups (WRMT-R Passage Comprehension, $M = 56.7$, $SD = 7.8$, $z = 1.39$).

Groups 5 and 6 pattern. Groups 5 and 6 demonstrated similar relative strengths and weaknesses in component skills (Figure 3; Table 4), with the primary difference between groups being Group 6 had greater power and speed. Although z-scores indicate phonemic decoding power and speed patterns were similar for these groups (Group 5 WRMT-R Word Attack, $M = 30.1$, $SD = 5.1$, $z = 0.44$; TOWRE Phonemic Decoding, $M = 33.7$, $SD = 6.4$, $z = 0.55$; and Group 6 WRMT-R Word Attack, $M = 34.1$, $SD = 4.3$, $z = 0.97$; TOWRE Phonemic Decoding, $M = 40.9$, $SD = 7.2$, $z = 0.97$), Figure 1 demonstrates that compared to norms, Group 5 standard scores were below the 10th percentile for both power and speed; in contrast, Group 6 scores were nearly 30th percentile in power but only a little more than 10th percentile in speed.

For word recognition speeded tests both Groups 5 and 6 appear to have a relative disadvantage compared to measures of their power (Group 5 WRMT-R Word Identification, M = 78.6, SD = 7.5, z = 0.63; TOWRE Sight Words, M = 74.4, SD = 7.3, z = 0.40; TOSWRF, M = 73.8, SD = 3.2, z = 0.00; and Group 6 WRMT-R Word Identification, M = 89.3, SD = 4.6, z = 0.95; TOWRE Sight Words, M = 80.2, SD = 9.1, z = 0.74; TOSWRF, M = 81.1, SD = 7.9, z = 0.59).

Group 6 fluency and comprehension z-scores (Group 6 QRI, M = 156.9, SD = 19.1, z = 1.1; WRMT-R Passage Comprehension, M = 51.7, SD = 4.2, z = 1.0) were similar to the power scores for phonemic decoding and word recognition. For Group 5, fluency z-scores (QRI, M = 126.3, SD = 18.0, z = 0.43) were slightly higher than comprehension z-scores (WRMT-R Passage Comprehension, M = 42.3, SD = 6.4, z = 0.37).

Groups 2 and 4 pattern. Like Groups 5 and 6, Groups 2 and 4 demonstrated similar skill patterns with the difference being the magnitude of their skills (Figure 4; Table 4). Their patterns showed z-scores for phonemic decoding speed were considerably less than for power, even more so for Group 4 than Group 2 (Group 2 WRMT-R Word Attack M = 8.6, SD = 3.8, z = -0.71; TOWRE Phonemic Decoding M = 5.2, SD = 4.4, z = -1.16; and Group 4 WRMT-R Word Attack, M = 18.3, SD = 5.4, z = 0.00 and TOWRE Phonemic Decoding, M = 11.4, SD = 4.7, z = -0.96). Conversely, word recognition speed was a relative strength compared to power for Groups 2 and 4 (Group 2 WRMT-R Word Identification, M = 55.6, SD = 5.8, z = -1.14; TOWRE Sight Words, M = 51.8, SD = 8.8, z = -0.75; TOSWRF, M = 70.1, SD = 5.3, z = -0.30; and Group 4 WRMT-R Word Identification, M = 69.9, SD = 5.8, z = -0.35; TOWRE Sight Words M = 65.1, *SD* = 7.2, *z* = -0.07; TOSWRF, *M* = 74.0, *SD* = 6.5, *z* = 0.02). Standard scores, albeit extremely low for these groups, also indicated these groups had slightly better speed than power scores.

Compared to the other groups, Groups 2 and 4 fluency *z*-scores were relatively low (Group 2 QRI, *M* = 65.6, *SD* = 15.8, *z* = -0.79; and Group 4 QRI, *M* = 102.2, *SD* = 16.3, *z* = -0.50), yet their standard scores were equal to or slightly higher than their word reading speeds (Figure 1). Lastly, Group 2 comprehension z-score showed less relative strength than its fluency z-score (Group 2 WRMT-R Passage Comprehension, *M* = 25.3, *SD* = 10.4, *z* = -0.85). Group 4 comprehension, however, was above the mean for the sample as a whole (i.e., positive z-scores), even as all its other reading skills were below the mean (WRMT-R Passage Comprehension, *M* = 39.6, *SD* = 5.1, *z* = 0.18); all their standard scores were below the 10th percentile.

Group 3 pattern. Measures of Group 3 word analysis skills revealed near the mean levels of power in phonemic decoding and word recognition, but lower automaticity in both component skills (Group 3 WRMT-R Word Attack, *M* = 22.2, *SD* = 3.9, *z* = -0.14; TOWRE Phonemic Decoding, *M* = 18.1, *SD* = 8.0, *z* = -0.53; WRMT-R Word Identification, *M* = 67.0, *SD* = 8.0, *z* = -0.02; TOWRE Sight Words, *M* = 50.9, *SD* = 5.3, *z* = -0.80; TOSWRF, *M* = 64.9, *SD* = 6.4, *z* = -0.71). Fluency as well as comprehension z-scores were approximately the same degree of strength as the speeded measures of word recognition (Group 3 QRI, *M* = 67.5, *SD* = 15.6, *z* = -0.75; WRMT-R Passage Comprehension, *M* = 28.3, *SD* = 6.6, *z* = -0.64). Word recognition for Group 3 was its only standard score that even approached the 10th percentile, with all other scores falling near the bottom of the scale.

Group 1 pattern. As the lowest ability group among the sample of low-literacy adults (Figure 4; Table 4), Group 1 demonstrated such minimal ability to phonemically decode as to effectively make the speeded test not applicable (WRMT-R Word Attack, *M* = 4.2, *SD* = 3.8, *z* =

-1.69; TOWRE Phonemic Decoding, *M* = 4.2, *SD* = 4.0, *z* = 1.19), that is, scores were so low that the measure lacked enough sensitivity at its floor to detect differences in speed. Group 1 readers showed little difference between power and speeded measures of their limited sight word recognition skills (WRMT-R Word Identification, *M* = 35.9, *SD* = 11.2, *z* = -1.50; TOWRE Sight Words, *M* = 25.1, *SD* = 7.7, *z* = -1.57; TOSWRF, *M* = 55.5, *SD* = 2.3, *z* = -1.47). Similarly, for Group 1 low fluency (QRI, *M* = 21.3, *SD* = 14.3, *z* = -1.68) and poor comprehension (WRMT-R Passage Comprehension, *M* = 15.6, *SD* = 7.9, *z* = -1.52) were consistent with its limited word analysis skills.

Discussion

In order for literacy education to be meaningful for the diversity of learners in adult basic and secondary education programs, or any other adult literacy program, the curriculum and instruction need to address the specific needs of each learner. Although nearly all the adults with low literacy in this study displayed comprehension deficits, their most pressing instructional needs varied. These variations in primary instructional needs, however, did not correspond to the functional assessment levels from CASAS and TABE. Table 3 shows this heterogeneity of NRS levels and the empirically derived groupings. The profiles based on assessments of underlying component reading skills—using power and speeded measures of phonemic decoding, word recognition, as well as measures of fluency and reading comprehension—indicated just a few instructional groups are needed for low-literacy adult learners. Three primary instructional needs are present among the seven ability groups: (a) basic decoding skills for Groups 1, 2, 3, and 4, (b) word level reading and fluency for Groups 5 and 6, and (c) comprehension for Group 7.

Basic decoding. Readers who fit the patterns exhibited by Groups 1, 2, 3, and 4 lacked adequate phonemic decoding skills and were not able to rapidly apply the phonics rules that they did seem to know. More intensive instruction in word analysis along with instruction in other aspects of reading may be beneficial for them. However, some of these readers may lack the comparator function component of phonological awareness, which is "an ability to hold a phoneme and/or syllable segments of two phonological structures in mind and compare and represent any variations in the number, identity, or order of their segments" (Lindamood, Bell, & Lindamood, 1992). If this is the case, they may need remedial instruction using procedures that are fundamentally different from typical phonics instruction (e.g., multisensory methods; Ehri & Sweet, 1991).

Word level reading and fluency. Readers who fit the patterns exhibited by Groups 5 and 6 might improve reading comprehension by becoming more automatic in sight word recognition. The limited capacity theory of reading (Perfetti, 1985) maintains inefficient word recognition processes "drain cognitive resources...needed for integrating and constructing meaning from text" (Jenkins, et al., 2003). If these readers can be taught to rapidly recognize a large vocabulary, they may be able to free attentional resources to work on comprehension tasks. Maclay and Askov (1988) demonstrated through computer-aided instruction adult beginning readers could learn to quickly recognize 1,000 high frequency and functional sight words.

These readers may also benefit most from instruction in fluency. As Leinonen et al. (2001) suggested, readers who rely on a slow but accurate reading style experience less rewarding reading than the relatively faster and less accurate readers. The well-supported practice of repeated reading of text or words from texts to increase fluency and overall reading achievement (National Institute of Child Health and Human Development, 2000; Pikulski & Chard, 2005; Samuels, 2006) could benefit these readers—even if they read with a relatively high level of errors.

Comprehension. AE instructors may be tempted to exclude from literacy instruction learners who fit the Group 7 profile because their reading skills were above the 50th percentile for most reading components (Figure 1). They may, in fact, be representative of the readers identified by Edwards et al. (2003) who had attained adequate reading skills while experiencing lingering difficulties with phonological skills. Because Group 7 learners were secondary level readers who were pursuing high school equivalency credentials, they might benefit from reading comprehension strategy instruction for building memory capacity and abilities to summarize, predict, and draw inferences; and perhaps vocabulary instruction in accordance with their educational or vocational pursuits. Samuels and Wu (2003) found higher ability students benefited from reading practice, thus our highest ability group of low-literacy adults might also benefit from reading a wide array of materials to increase knowledge and vocabulary.

Study limitations. We recognize that some caution is warranted in interpreting these data given the small sample sizes in the clusters and validation samples. For Groups 3 and 6, in particular, we make note of the significant differences between the cluster and validation samples for several of the measures (Table 2). Although our exploratory clustering analysis used multiple clustering techniques to determine that seven was a reasonable number of clusters for this data set, one might argue that a five or six cluster solution with Groups 3 and 6 collapsing into adjacent clusters could be a reasonable solution. The cluster analysis procedures are intended to identify clusters. Interpreting the utility of the clusters is left for the researchers and clinicians.

Conclusions

NIFL's review of adult literacy instruction research recommended adult education (AE) programs assess underlying reading abilities in order to plan appropriate instruction for low-literacy learners. Our data support the value of assessing numerous reading-related skills and abilities rather than relying on one placement measure. By using power and speeded tests of reading component skills, this study demonstrated seven reading subtypes exist among diverse low-literacy adults. Our data interpretation further supported that differentiated instruction could be important for improving learner outcomes. Through empirical investigation, researchers can confirm the value of differentiated instruction and determine which instructional methods offer the most benefit for each subtype. This needed research could inform how reader profiles interact with instructional and curricular approaches. Curriculum developers may then be able to offer more efficient and effective materials directed to the unique skill patterns of adult learners. AE and other literacy programs may consider organizing literacy courses based on these subtypes, and using these additional assessments to improve learner placement in instruction. We further speculate that improved learner matches with instructional methods and curriculum would increase retention and program completion.

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