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Subgroups of Adult Basic Education Learners with Different Profiles of Reading Skills

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Abstract

The purpose of this study was to identify subgroups of adult basic education (ABE) learners with different profiles of skills in the core reading components of decoding, word recognition, spelling, fluency, and comprehension. The analysis uses factor scores of those 5 reading components from on a prior investigation of the reliability and construct validity of measures of reading component skills (MacArthur, Konold, Glutting, & Alamprese, 2010). In that investigation, confirmatory factor analysis found that a model with those 5 factors fit the data best and fit equally well for native and non-native English speakers. The study included 486 students, 334 born or educated in the United States (native) and 152 not born nor educated in the US (non-native) but who spoke English well enough to participate in English reading classes. The cluster analysis found an 8-cluster solution with good internal cohesion, external isolation, and replicability across subsamples. Of the 8 subgroups, 4 had relatively flat profiles (range of mean scores across factors < 0.5 *SD*), 2 had higher comprehension than decoding, and 2 had higher decoding than comprehension. Profiles were consistent with expectations regarding demographic factors. Non-native speakers were overrepresented in subgroups with relatively higher decoding and underrepresented in subgroups with relatively higher comprehension. Adults with self-reported learning disabilities were overrepresented in the lowest performing subgroup. Older adults and men were overrepresented in subgroups with lower performance. The study adds to the limited research on the reading skills of ABE learners and, from the perspective of practice, supports the importance of assessing component skills to plan instruction.

According to the 2003 National Assessment of Adult Literacy (NAAL, Kutner, Greenberg, & Baer, 2005), substantial numbers of adults in the United States have difficulty with basic literacy. About 14% of the adult population, or 30 million adults, perform below the Basic level, defined as the skills necessary to perform simple and everyday literacy activities. An additional 29% read at the Basic level. Higher percentages of adults from racial and ethnic minorities have difficulty; 24% of African Americans and 44% of Hispanics perform below the Basic level. Limited literacy skills have serious practical consequences across many areas of life including employment, health care, civic participation, and education of children (Miller, McCardle, & Hernandez, 2010). Adults with lower literacy levels are less

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likely to be employed, earn less when they do work, are less likely to vote, and have difficulty reading to their young children (Kutner, et al., 2007). To address this problem, the U.S. Department of Education funds adult basic education (ABE) programs that serve over two million adults annually (U.S. Department of Education, 2006).

Despite the scope and importance of the problem, little research has been conducted on the reading skills of low literacy adults (Comings & Soricone, 2007; Miller et al., 2010). A large body of literacy research on children and adolescents has provided a theoretical and practical foundation for the design of instruction and the development of assessment measures (e.g., National Reading Panel, 2000). In contrast, the National Institute for Literacy commissioned a review of research on adults with low literacy that resulted in the identification of only 70 appropriate studies (Kruidenier, 2002). Consequently, the review was expanded to include research on reading problems and instruction with adolescents in order to provide a foundation for recommendations for instruction and assessment for adults (e.g., Berkovitz & Curtis, 2004).

Existing research on adults with reading problems has found evidence of variability in reading skills and related cognitive processes that may be relevant for assessment and instruction. Greenberg, Ehri, and Perin (1997 Greenberg, Ehri, and Perin (2002) compared adults in ABE programs with children in grades three to five matched for reading level. Adults performed worse on phonological tasks but better on some orthographic tasks including sight word recognition. Further analysis of errors on word recognition, decoding, and spelling showed that adults relied more on orthographic processes and less on phonological analysis than children. Consistent with this finding of weak phonological skills, three recent large studies of ABE learners (Mellard, Fall, & Woods, 2010; MacArthur, Konold, Glutting, & Alamprese, 2010; Sabatini, Sawaki, Shore, & Scarborough, 2010) found relatively lower performance on pseudoword decoding tests than on word recognition. In addition, Binder and Borecki (2009) compared ABE learners to normal college readers on a homophone reading task and found that the ABE learners were less efficient in using phonological information and relied more on context.

The pattern of weak phonological skills is consistent with findings for adults and children with reading problems or dyslexia. However, children and adults with dyslexia would be expected to have weak word recognition as well and to have relatively better comprehension. For example, Bruck (1990; 1992) compared adults with dyslexia with age-matched and reading-matched controls. She found poor phonemic awareness, word recognition, decoding, and fluency among the adults with dyslexia, but relatively good comprehension. In contrast, studies of ABE learners have found comprehension generally consistent with word recognition (Mellard et al., 2010; Sabatini et al., 2010; Nanda, Greenberg, & Morris, 2010). Other weaknesses have also been found among low literacy adults. Worthy and Viise (1996) analyzed the spelling errors of ABE learners and reading-matched children and found greater numbers of morphological errors for the adults.

Description of the literacy skills of ABE learners is complicated by the fact that ABE programs include ESL (English as a Second Language) classes and substantial numbers of students in English reading classes who are not native English speakers. Patterns of performance on reading component skills differ depending on proficiency in English. Strucker, Yamamoto, and Kirsch (2007) reported a cluster analysis of a large sample (N = 1,034) of adult education students including ESL students. Of five subgroups, two included primarily native speakers and had relatively high vocabulary, and two were primarily non-native speakers with low vocabulary scores. The fifth subgroup included both native and non-native speakers and had low performance in all areas. Differences are evident even among students with sufficient English proficiency to participate in non-ESL reading classes. Davidson and Strucker (2002) compared native and non-native speakers, omitting ESL students, with word recognition skills in the grade 4 to 6 range and found that the native speakers scored higher on oral vocabulary, as well as silent reading comprehension, despite similar word recognition and decoding skills. A sub-sample was matched on decoding (pseudoword reading), and decoding errors were analyzed. The native group made more real-word substitutions, while the non-native group made more phonetically plausible errors. It appears that the non-native group relied more on phonological decoding and the native group on visual memory and vocabulary knowledge. Interestingly, non-native speakers who learned English before the age of 12 performed, in general, more like native speakers than like non-native speakers who learned English later.

There is evidence that native and non-native speakers also make differential progress in ABE programs. Alamprese (2009) studied 643 low-literate adults from 130 ABE reading classes in 35 ABE programs, testing their reading skills before and after nine months of participation. All participants had sufficient English proficiency to participate in regular reading classes; no ESL learners were included. For the study, native speakers were defined to include those who were born or educated from the primary grades in the US. As expected, compared to native speakers, adults who were not native English speakers had higher scores at pretest on word recognition and decoding and lower scores on vocabulary and comprehension. Non-native speakers made significantly greater gains on decoding and word recognition and significantly lower gains on vocabulary than native speakers.

Four recent studies have begun to develop models of reading processes among ABE learners (MacArthur et al., 2010; Mellard et al., 2010; Sabatini et al., 2010; Nanda et al., 2010). MacArthur et al. (2010) investigated the reliability and construct validity of measures of reading component skills with a sample of 486 adult basic education (ABE) learners placed in classes for low intermediate readers (approximately fourth to seventh-grade comprehension level), including both native English speakers and non-native speakers with sufficient English proficiency to participate in reading classes. The confirmatory factor analysis (CFA) found a better fit for a model with five reading components -- decoding, word recognition, spelling, fluency, and comprehension – than a two-factor model with word-level and comprehension factors or a three-factor model that separated out a fluency factor. The model fit both native and non-native groups equally well, providing support for the constructs and the measures.

Sabatini et al. modeled relationships among reading and oral language skills in a sample of 476 adult learners with at least intermediate English proficiency and word recognition below the seventh-grade level. A confirmatory factor analysis (CFA) found separate factors for word recognition, language comprehension, oral vocabulary, and reading fluency. Models that included vocabulary and fluency as separate components fit the data better than models with vocabulary included as part of language comprehension and fluency as part of word recognition. However, consistent with the simple view of reading (Hoover & Gough, 1980) and previous research with children and adolescents (Catts, Adlof, & Weismer, 2006; Cutting & Scarborough, 2006), word recognition and language comprehension accounted for a substantial amount of the variance in reading comprehension (64%). Though vocabulary and fluency were separate factors, they did not add unique variance.

Mellard et al. (2010) used path analysis to model the contribution of reading and language skills to reading comprehension in a sample of 174 adults in adult basic education and adult secondary education programs (i.e., ranging from beginning reading to high school level). Using single measures of each construct, they found that word recognition made the largest contribution to reading comprehension. Reading fluency, oral expressive vocabulary, and listening comprehension made significant but relatively modest contributions. The reasons

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for the different findings of Mellard et al. and Sabatini et al. regarding the contribution of oral language to reading comprehension are not clear. The results are sensitive to the variance in the sample, and Mellard et al. (2010) included a sample with a much wider range of reading skill. Mellard et al. also used single measures of each construct whereas Sabatini et al. used factors composed of multiple measures. Both studies did find that word recognition is a major predictor of reading comprehension for low literate adults.

Nanda et al. (2010) also used CFA to explore adult reading processes based on models of children's reading component skills and core reading sub-skills. Their sample included 371 adults reading between the third and fifth-grade levels, about equally divided between native and non-native English speakers. In contrast to Sabatini et al. (2010) and MacArthur et al. (2010), they had considerable difficulty fitting the data to models that had been validated for children and raised questions about whether child-based measurement models will work for low literacy adults.

Researchers have begun the process of describing the reading skills and processes of low literacy adults and exploring how well measures and theoretical models developed with children and adolescents apply to this older population of struggling readers. In most studies, measures of reading skills and related processes were found to have adequate reliability and validity, though questions remain as demonstrated by the Nanda et al. (2010) study. The limited research points fairly consistently to difficulties in phonological processes, decoding, and word recognition, which are consistent with findings for children. Oral language abilities are also generally low, though studies vary in findings about the importance of limited oral language to comprehension. Reading fluency may also be an important factor limiting reading comprehension. MacArthur et al. (2010) and Sabatini et al. (2010) both found separate factors for fluency. Mellard et al. (2010) found that fluency had a modest effect on reading comprehension though Sabatini et al. did not find that fluency contributed unique variance to predicting comprehension. Previous research on fluency with children has been mixed. Some studies have found no additional contribution of fluency to comprehension beyond word recognition and oral language (Adlof, Catts, Little, 2006). Other studies have reported that fluency does contribute unique variance to predictions of comprehension (Cutting & Scarborough, 2006; Aaron, Joshi, Gooden, & Bentum, 2008).

For the most part, the research has investigated the reading skills of ABE students as a whole or divided into subgroups by demographic categories (e.g., native English speakers versus non-native speakers). The great diversity of the ABE population in race/ethnicity, culture, native language, economic status, and schooling background is reflected in different patterns of reading skills. Yet, there has been little research investigating skill profiles of adult poor readers. Individual adults, or subgroups, may have quite different patterns of reading skills, and those patterns may be relevant for instruction. Learners need instruction that develops areas of weakness and builds on areas of strength. Diagnostic assessment as a basis for planning instruction is standard practice in working with younger struggling readers (McKenna & Stahl, 2003). Aaron and colleagues (Aaron et al., 2008) demonstrated the effectiveness, for children with reading disabilities, of gearing instruction to word skills or comprehension based on diagnostic assessment. A line of research by Connor and her colleagues (e.g., Connor, Morrison, & Katch, 2004) has demonstrated aptitude by treatment interactions for reading instruction in primary grade classrooms. They found that students with different patterns of skills in word reading and vocabulary benefited from different types of instruction. More recently, diagnostic assessment has been advocated as a critical component of reading instruction in adult literacy as well (Kruidenier, 2002).

The current study uses cluster analysis to identify subgroups of ABE learners with different profiles of skills in the core reading components of decoding, word recognition, spelling, fluency, and comprehension. Cluster analysis has been used to identify subgroups of students with learning disabilities (Speece, 1987; Feagans & Appelbaum, 1986) and reading disabilities (Konold, Juel, McKinnon, & Deffes, 2003; Morris, Stuebing, Fletcher, Shaywitz, Lyon, & Shankweiler, 1998; Pierce, Katzir, Wolf, & Noam, 2007). For example, Morris et al. (1998) found seven subtypes of reading disability; most of the subtypes displayed impairments in phonological awareness with variable performance on other measures involving fluency, language, and cognitive skills. The only prior studies using cluster analysis to explore the profiles of ABE learners were conducted by Strucker and his colleagues. One of the studies (Strucker et al., 2007) was discussed earlier. In addition, Strucker and Davidson (2003) provided a brief report of another cluster analysis of 676 native-English-speaking ABE students. Using tests of phonological awareness, rapid naming, word recognition, oral reading, spelling, vocabulary, and background knowledge, they found 10 subgroups of readers, 3 at the high school level, 5 at an intermediate level, and 2 at a beginning level. At the intermediate level, the subgroups were differentially weak on decoding and fluency, vocabulary and background knowledge, and fluency. A full, published report is not available.

The analysis reported in the current paper builds on a prior investigation of the reliability and construct validity of measures of reading component skills (MacArthur et al., 2010). That study included 11 measures covering 5 hypothesized components: decoding, word recognition, spelling, fluency, and comprehension. One important limitation of that study and the current one is that the data included only measures of reading because they came from a large intervention study. There were no separate measures of oral language (e.g., comprehension, vocabulary) or cognitive processes underlying reading (e.g., phonemic awareness). Nonetheless, given the limited research on adult literacy learners, the results are of value.

Three of the reading components -- word recognition, decoding, and spelling -- focus on individual words and are generally highly correlated. All three skills draw on phonological, orthographic, and morphological knowledge but to varying degrees (Richards, et al., 2006; Venezky, 1970; 1999). Decoding, assessed with pseudoword reading tasks, draws most heavily on phonological processes (Share & Stanovich, 1995; Vellutino, Tunmer, Jaccard, & Chen, 2007) though as the pseudowords get more difficult, they require knowledge of orthographic patterns (e.g., vowel digraphs, syllables). Word recognition draws on phonological processes but also on orthographic processes for recognition of common sight words and word parts; morphological knowledge becomes more important with multisyllabic words (Ehri & McCormick, 1998). Spelling draws on the same base of phonological, orthographic, and morphological knowledge as word recognition, but spelling is harder because it requires production rather than recognition and, thus, requires a more complete mental representation of the word (Berninger, Abbott, Abbott, Graham, & Richards, 2002; Ehri, 2000; Templeton & Morris, 2000).

One question raised in our previous work (MacArthur et al., 2010) was whether these three components should be treated as separate constructs or as one combined construct for low literacy adults. The research on adults mentioned above (Greenburg, et al., 1997; 2002) found that low-literacy adults in ABE programs, in comparison to children, tended to have weaker decoding skills in relation to their sight word recognition. In addition, many adults with dyslexia who have developed adequate accuracy in reading continue to have substantial difficulties with spelling (Lefly & Pennington, 1991).

Another question considered was whether to consider fluency as a separate construct. A number of studies have found that fluency contributes to prediction of reading comprehension beyond accurate word recognition and language comprehension (Cutting and

Scarborough, 2006; Aaron et al., 2008) while others have found no contribution of fluency to comprehension (Adlof et al., 2006). Adults with reading problems are often characterized by limited fluency (Bristow & Leslie, 1988; Lefly & Pennington, 1991). Sabatini et al. (2010) found a separate factor for fluency although they did not find that it added unique variance to predictions of comprehension. Mellard et al. (2010) did find that fluency contributed to prediction of reading comprehension though modestly.

In our previous study (MacArthur et al., 2010), CFA was used to contrast 3 models based on the 11 measured variables: A 2-factor model with word-level and comprehension factors; a 3-factor model that separated out a fluency factor; and a 5-factor model incorporating all 5 aforementioned hypothesized constructs – decoding, word recognition, spelling, fluency, and comprehension. The 5-factor model fit best. In addition, the CFA model fit both native-English-speaking and non-native populations equally well without modification, indicating that the tests measure the same constructs with the same accuracy for both groups.

In the current analysis, the five factors from the prior CFA were used in a cluster analysis to identify subgroups of adult learners with different profiles of skills. Two main questions with sub-questions guided the research: First, what subgroups of learners can be identified based on the assessment of reading components? In particular, would there be subgroups with substantially higher or lower reading comprehension relative to word-level skills (i.e., decoding, word recognition, spelling)? Also, would there be subgroups with different profiles among the three word-level factors (e.g., spelling lower than word recognition)?

Second, how do these subgroups differ in demographic and background factors? Predictable differences in demographic factors would help to validate the subgroups. Demographic variables that were examined included age, gender, birthplace (native/non-native), and learning disabilities (LD). We compared the numbers of native and non-native adults in the subgroups because previous research suggested strongly that they had different patterns of skills. We anticipated that non-native adults would be in subgroups with relatively higher word skills and relatively lower comprehension skills due to lower language comprehension. We also compared adults with and without self-reported LD because LD has been proposed as one explanation for the reading problems of many adults. Definitions of LD are controversial, but the most common explanation of LDs in reading is that they are characterized by difficulties with fluent decoding based on phonological problems. Research with adults with dyslexia from college-educated samples has found higher comprehension than decoding, spelling, and fluency (e.g., Bruck 1990; 1992). This pattern suggests that adults with LD would be in subgroups with relatively lower word skills and higher comprehension skills. However, our data on LD was based on self-report, and ABE learners have low literacy skills in general and might not exhibit the same pattern. Thus, we made no specific predictions about subgroup membership by LD. Gender was included as a factor because it is often related to literacy performance with women performing better (e.g., Lee, Grigg, & Donahue, 2007). Age was similarly of interest because performance on many cognitive skills is known to change with age during adulthood. Skills related to memory and rapid performance are thought to be more susceptible to declines with age than skills based on knowledge. In addition, age may be related to performance because older people went to school in a different time period when educational opportunities may have been different. Our measures were not based on standard scores normed on adults, so age was not already factored into the scores.

Methods

Participants

The study included 486 adult learners from 23 ABE programs, representing 12 states. Programs were selected based on the following criteria: a) provided class-based reading instruction to English-speaking adults whose reading level in comprehension was at the Low Intermediate level (roughly between the fourth- and seventh-grade equivalence level, as defined by the U.S. Department of Education (2007)), b) met certain basic standards for learner recruitment and assessment, program management, and support services (Alamprese, 1993), and c) had instructors who were trained or experienced in teaching reading. These programs and adults participated in an intervention study. The data used in this analysis were collected as pretest data.

The majority of participants were female (67%). Average age was 35 (*SD* = 14, range 16 to 71). The racial and ethnic breakdown was as follows: White 32%, Hispanic 28%, Black 22%, Asian 12%, and other 6%. All participants were sufficiently fluent in English to participate in English reading classes. The majority (69%, *n* = 334) had been born in the U.S. or educated in the U.S. from the primary grades (native); the remaining 31% (*n* = 152) were born and educated outside of the U.S. (non-native). We used place of birth and early education (hereinafter referred to as birthplace) to represent whether participants were native speakers of English because it was deemed more reliable than self-reports of primary language as an indicator of native English proficiency. We included in the native group individuals who received their education in the U.S. beginning in the primary grades because previous research indicated that individuals who immigrated to the U.S. before the age of 12 performed more like native-born residents than like immigrants who came after the age of 12 (Davidson & Strucker, 2002). A majority of all participants (66%) spoke English at home. A minority spoke Spanish at home (10%), while 24% spoke some other language. Education ranged widely; 7% had less than a sixth-grade education; 49% had completed some secondary education; 14% had a high school diploma or GED; and 30% had some education but not in the U.S. Just less than half (43%) were currently employed although another 47% had been employed previously; 8% had never worked; and 2% were retired. Of the native learners, 48% self-reported that they had had a learning disability when they were young. Almost none of the non-native learners reported a learning disability.

Measures

All participants were assessed with 11 measures covering five reading constructs: decoding, word recognition, spelling, comprehension, and fluency.

Decoding was assessed with the Word Attack subtest of the Woodcock-Johnson Tests of Achievement, Revised (Woodcock & Johnson, 1989), the Phonemic Decoding Efficiency subtest of the Test of Word Reading Efficiency (TOWRE, Torgeson, Wagner, Rashotte, 1999), and an experimenter-designed test, the Letter-Sound Survey (Venezky, 2003). All three tests assess ability to pronounce pseudowords; the TOWRE test is timed.

Word recognition was assessed with the Letter-Word Identification subtest of the Woodcock-Johnson and the Reading subtest of the Wide Range Achievement Test, Revision 3 (WRAT3, Wilkinson, 1993). Both measures require reading lists of increasingly difficult words without time limits.

Spelling was assessed with the Spelling subtest of the WRAT3 and an experimenter-designed test, the Developmental Spelling test, which consists of 20 words of increasing difficulty that represent common phonological, orthographic, and morphological patterns in English.

Comprehension was assessed with two subtests of the Nelson Reading Test (Hanna, Schell, & Schreiner, 1977). The Nelson Word Meaning subtest assesses vocabulary with items that present a term in a sentence and a choice of meanings. The Nelson Reading Comprehension subtest presents short passages followed by multiple-choice questions.

Fluency was assessed with two measures requiring timed reading of words and passages. The Sight Word Efficiency subtest of the TOWRE presents words of increasing difficulty and tests how many a person can read in 45 seconds. The Passage Reading test uses a 161-word passage developed for the fluency test in the National Assessment of Adult Literacy (NAAL, Kutner et al., 2005); it is scored for correct words per minute. Fluency of word reading and passage reading were combined in one fluency factor based on prior research and the correlations among measures in this study. In a study of whether fluency contributes to reading comprehension, Adlof et al. (2006) combined measures of word and passage fluency in the fluency factor. More directly relevant to the current study, Sabatini et al. (2010) used CFA to model reading skills of low literate adults; they contrasted models that included word and passage fluency as separate factors versus as a combined factor and found a better fit with the combined factor. As reported in the earlier CFA study (MacArthur et al., 2010), the sight word fluency measure correlated more highly with Passage Reading (.78) than with either untimed word recognition measure (.56 and .54).

In addition, a Learner Background Interview was administered to gather information on demographics, education, employment, health and disabilities, goals for participating in the program, and literacy activities at home and work.

Table 1 provides scores for the full sample on the 11 measures. Further information on the measures, administration procedures, and reliability and validity with this sample can be found in MacArthur et al. (2010).

Clustering Strategy

The five factor scores representing the five reading constructs were used to identify normative profiles through cluster analysis. The factor scores were standardized (*M* = 0, *SD* = 1) within the total sample prior to analysis. The clustering strategy we adopted was similar to one used elsewhere for identifying normative profiles (Glutting & McDermott, 1990; Glutting, McDermott, & Konold, 1997; Konold, Glutting, & McDermott, 1997), as described in McDermott (1998). This procedure involved three steps. In the first step, Ward's (1963) hierarchical-agglomerative procedure was performed on a Euclidean distance matrix that is sensitive to level, shape, and scatter. Simply put, a Euclidean distance matrix is an array of the sums of the distances (i.e., score differences squared) between each of the five factor scores of every subject with every other subject in the sample. The merging of profiles begins with perfect matches – where the distances sum to zero, at which point, the profiles of two subjects are identical in level, shape, and scatter. Therafter, mergers take place using the smallest sum of the distances (i.e., the smallest amount of error between any two profiles). The merging of profiles and/or groups of profiles (i.e, clusters) repeats itself until there is just one cluster.

Ward's method has been shown to outperform alternative methods in terms of minimizing profile overlap (Bayne, Beauchamp, Begovich, & Kane, 1980) and to be the most efficient means by which to recover known taxonomic structure in a population exhibiting variation (Kuiper & Fisher, 1975). In this first step, the total sample (*N* = 486) was randomly divided into three equal subsamples (*N* = 162) and Ward's hierarchical-agglomerative procedure was conducted on each of the subsamples separately. Decisions regarding the number of clusters to retain within each of the three samples were based on a number of indices: Pseudo-*F* (Calinski & Harabasz, 1985), pseudo t^2 (Duda & Hart, 1973), R^2, inspection of the agglomeration index for each subsample as well as the agglomeration history within each subsample, the coherence of the resulting clusters, and the degree of replicability of clusters across subsamples (Crockett, Moilanen, Raffaelli, & Randall, 2006). This step also utilized a "trim" procedure that removed a maximum of 2% of the outlier cases from consideration in the analysis (McDermott, 1998).

Information from the clusters identified in step one was pooled to form an overall similarity matrix that was used for step two. Thus, step two clustering began with a proximity matrix whose diagonal elements held error sums of squares (ESS) statistic values for respective step one clusters, with off-diagonal elements corresponding to potential ESSs for merging each pair of first-stage clusters. Ward's method was employed on the resulting similarity matrix from step one to assess the extent to which cluster profiles from subsamples of the data matched those found for the total sample (i.e., replication). Each of the aforementioned statistical indices was again considered when determining how many clusters to retain at step two. Steps one and two led to the identification of eight clusters. Clusters one and two yielded replication rates of 66%. The remaining six clusters demonstrated replication rates of 100% (see Table 2). The replication rate of 66% indicates that a profile was also identified in two of the three subsamples, whereas, profiles demonstrating 100% replication rates were found to emerge in all three subsamples of step one.

Group centroids from the step two solution served as starting seeds for the stage three iterative partitioning analysis conducted using *K*-means passes. *K*-means cluster analysis makes use of an iterative procedure where individuals are assigned to core subgroup membership based upon their smallest Euclidean distance to each subsequent cluster centroid (Eng, Heimberg, Coles, Schneier, & Liebowitz, 2000; Jones, Laufgraben, & Morris, 2006). This third step was necessary because hierarchical-agglomerative procedures (steps one and two) do not allow subjects to shift clusters after their original assignment, despite the fact that they may fit better in a different profile later in the solution. By contrast, iterative partitioning procedures allow subjects to migrate to neighboring clusters, following identification of the number of suspected clusters (steps one and two), and generally result in tighter solutions.

Comparisons by Demographic Groups

Next we investigated whether the subgroups varied in composition by demographic variables of age, gender, birthplace (native/non-native), and LD. Preliminary analyses explored the relationships among these demographic factors. Analysis of variance was used to explore relationships between subgroups and age with appropriate follow-up tests for individual subgroups. For the categorical factors of birthplace (native/non-native), gender, and LD, the multidimensional χ^2 (simply referred to as χ^2) was used to test whether the subgroups and the demographic variables were independent of one another (Howell, 2002). For follow-up tests of individual subgroups, odds ratios were calculated and chi-square was used to test the odds of being in the subgroup versus not being in the subgroup; Bonferroni adjustments were made for multiple comparisons.

The analysis also identified an alternate set of five clusters that met criteria for internal cohesion, replication, and external isolation. Analyses of associations with demographic variables were run for both sets of subgroups. For reasons of space, and because the goal was to identify multiple profiles of performance, the results for the eight subgroups are presented in this paper. The general profiles of the five subgroups and their relationships with demographic variables are presented briefly following the full discussion of the eight subgroups.

Results

Mean profile configurations for the eight-cluster solution are presented in Table 2. The eight profiles represent the natural variation of reading skills and are typical of what we would expect among adult basic education learners in the general population. Table 2 also provides other psychometric properties for each profile. The final cluster solution from step three was required to retain the dual properties of internal cohesion and external isolation (Aldenderfer & Blashfield, 1984). Both internal cohesion and external isolation address the issue of internal validity. Internal cohesion refers to the tightness of a cluster, or the closeness of objects around the cluster centroid. External isolation refers to the distance between clusters in multivariate space. Thus, subjects within a given cluster should be similar to one another, whereas clusters composed of homogeneous individuals should be distinct from one another. The average *H* coefficient (Tryon & Bailey, 1970) across profiles satisfied a-priori expectations for internal cluster cohesion ≥ .60 (Average *H* = .89), thereby, providing evidence in support of homogeneous within-cluster representation. In addition, the average r_p (Cattell, 1949) across profiles also satisfied a-priori expectation in support of external isolation < .40 (Average r_p = .27).

Subgroup Descriptions

The profiles of the eight subgroups on the five reading factors are presented in Table 2 and Figure 1. Note that the factor scores are derived from sample-based standard scores (i.e., z-scores) and are relative to this sample. Thus, the overall mean is zero and the standard deviation is 1. The subgroups are relatively equal in size (*N* range 47 – 69), and the discrepancy between the total usable sample and that reported in Table 3 is the result of the trim procedure described above. Subgroups are numbered from lowest to highest score on the decoding factor.

Four of the subgroups have relatively flat profiles with scores on the decoding, word recognition, spelling, and comprehension all within 0.5 *SD*. Subgroup 1 is the lowest performing in all areas with factor scores ranging from −1.3 to −1.7 *SD*. Subgroup 8 is the highest performing in all areas except comprehension; factor scores are about 1.3 *SD* except for comprehension which is about 0.9 *SD*. Subgroups 4 and 5 are within 0.5 *SD* of average on nearly all measures. Subgroup 4 shows somewhat lower comprehension than word recognition and decoding (about −0.3 *SD*, which is 0.4 *SD* below word recognition and decoding). Subgroup 5 has somewhat higher performance in fluency than other areas (about 0.8 *SD*, which is 0.6 *SD* higher than word recognition and decoding).

One question was whether there would be subgroups with substantial differences between word-level skills and comprehension. Three subgroups have profiles with about 1 *SD* difference between the three word-level factors and comprehension. Subgroups 2 and 6 have substantially better performance on comprehension than on word-level skills. Subgroup 2 is low average on decoding, word recognition, and spelling (range −0.6 to −1.0 *SD*) but average in comprehension (0.2 *SD*). Subgroup 6 has high average performance on the three word-level skills (range 0.4 to 0.7) but very high performance on comprehension (1.5 *SD*). Thus, subgroups 2 and 6 have parallel profiles about 1.4 *SD* apart (except for fluency where the gap is about 0.6 *SD*). In contrast, subgroup 7 shows the opposite pattern: word-level skills are high average (range 0.3 to 0.8 *SD*) while comprehension is low average (−0.4). In addition, a fourth subgroup, subgroup 3, has a less marked contrast between word skills and comprehension, with a gap of 0.6 *SD* between decoding and comprehension and 0.4 *SD* between word recognition and comprehension.

Another question was whether there would be subgroups with different profiles among the three word measures. Although correlations among the three word-level factors were relatively high, the CFA found a better fit to the data when they were modeled separately (MacArthur et al., 2010). Two of the subgroups have differences of more than 0.5 *SD* among the word measures. Learners in subgroup 4 had higher word recognition than spelling (gap of about 0.5 SD), while those in subgroup 7 had higher spelling than word recognition (gap of about 0.6 SD). Interestingly, these two subgroups had similar scores on word recognition, comprehension, and fluency. At the same time, subgroup 7 was higher in spelling (gap about 1.2 SD) and decoding (gap about 0.4 SD).

Demographic Comparisons

The subgroups were compared on demographic variables to describe them further and to provide external validation of the subgroups. The demographic variables included age, gender, birthplace (native/non-native), and LD.

Preliminary analyses—Preliminary analyses explored the relationships among the demographic factors of birthplace (native/non-native), age, gender, and LD. For the continuous variable, age, separate one-way ANOVAs were run with birthplace, gender, and LD. For the dichotomous variables, birthplace, gender, and LD, chi-square tests were applied to 2 × 2 contingency tables. Only two significant relationships were found. Non-native adults (M = 38.0 years, SD = 10.9) were older than native adults (M = 33.5 years, SD = 14.4); $F(1, 484) = 11.9$, $p = .001$. This age difference was due primarily to a difference in the youngest quartile (16–22 years), which included 110 native adults and only 10 non-native adults. Consequently, birthplace was taken into account when analyzing age differences in subgroups. The other significant finding was that learning disabilities (LD) were almost never (2%) reported among the non-native group. Consequently, our analyses of LD were limited to the native group.

Other relationships among native status, gender, age, and LD were not statistically significant (all *p*s > .15). Mean age was the same for men and women (35 years), and the proportion of women did not differ between the native (65%) and non-native (70%) groups ($p > .3$). Surprisingly, the proportions of women and men reporting a LD did not differ either; in the native group, 47% of women and 49% of men reported a LD. Also somewhat surprising, given the increase in identification of LD in recent years, LD was unrelated to age among native-born adults.

Birthplace—Table 3 presents the proportion of each subgroup that is non-native and the odds ratio, which is the ratio of the odds of being non-native in the subgroup to the odds of being non-native if not in the subgroup. (Taking subgroup 4 as an example, the odds of being non-native in that subgroup are 31:30 or 1.03. The odds of being non-native outside of the subgroup are 121:292 or 0.41. The odds ratio is 1.03/0.41 or 2.49.) Odds ratios over 1 indicate that non-native adults were overrepresented. To analyze whether subgroups differed in proportion of native and non-native adults, we first ran an overall chi-square analysis of the numbers of native and non-native adults in the eight subgroups, which was significant, $\chi^2(7) = 113.2$, $p < .001$. We then tested the odds ratios for individual subgroups using 2×2 contingency tables (native and non-native adults by in and out of the subgroup). Using a Bonferroni correction for 8 separate tests, we set the per comparison significance level at $p = .006$ (.05/8). Non-native adults were significantly overrepresented in subgroup 4 (odds ratio = 2.49; $\chi^2(1) = 11.30$, $p = .001$) and subgroup 7 (odds ratio = 8.53; $\chi^2(1) = 64.91$, $p < .001$). They were significantly underrepresented in subgroup 2 (odds ratio = 0.13; $\chi^2(1) = 20.91$, $p < .001$), subgroup 6 (odds ratio = 0.29; $\chi^2(1) = 9.74$, $p = .002$), and subgroup 8 (odds ratio = 0.40; $\chi^2(1) = 7.52$, $p = .006$). The two subgroups with an overrepresentation of non-native adults had lower comprehension scores than word-level scores. In contrast, non-native adults were significantly underrepresented in both subgroups 2 and 6, that had

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substantially higher comprehension scores than word-level scores, and in the highest overall subgroup, 8.

Age—Mean ages for the subgroups are presented in Table 3. Due to the significant relationship between age and birthplace, an ANOVA for age with subgroup and birthplace as factors was attempted; however, it failed to meet the requirement of homogeneity of variance. Consequently, separate ANOVAs for native and non-native adults were conducted, using the Welch statistic for the overall test and the Games-Howell adjustment for post-hoc comparisons, both of which are robust to violations of the homogeneity assumption (Field, 2009; Wickens & Keppel, 2004). For the non-native adults, the overall ANOVA showed no statistically significant difference (*Welch F statistic* = 1.726, *df* [7, 27], $p = .145$). For the native adults, an overall significant difference was found (*Welch F statistic* = 5.779, *df* [7, 113], $p = .001$).

Post hoc analyses found that subgroups 1 and 2 were each significantly older than subgroups 4, 5 and 7 (all adjusted *p*s < .025). Subgroup 1 is the lowest performing group on all reading components. Subgroup 2 is one of the lowest on the three word-level skills. Subgroups 4 and 5 have generally flat profiles in the average range, while subgroup 7 is average overall but with higher word skills than comprehension. These age differences are consistent with an overall pattern of lower performance by older adults, at least on word skills.

Gender—Table 3 presents the proportions of each subgroup that are male and the related odds ratios. The overall chi-square analysis found significant differences in the proportions of men and women in the subgroups, χ^2 (7) = 19.38, $p = .007$. Men were significantly underrepresented in subgroup 5 (odds ratio = 0.38; χ^2 (1) = 7.99, $p = .005$). This subgroup had flat performance at the average level with slightly better fluency. Men tended to be overrepresented in subgroups 1, 2, and 3, which had the lowest word-level skills, but the differences were not statistically significant.

LD—Table 3 presents the proportions of each subgroup with self-reported LD and the related odds ratios. Only native adults were included in this data. The overall chi-square analysis found significant differences in the proportions of adults with LD in the subgroups, χ^2 (7) = 25.83, $p = .001$. Adults with LD were significantly overrepresented in subgroup 1 (odds ratio = 2.96; χ^2(1) = 8.46, $p = .004$) and underrepresented in subgroup 7 (odds ratio = 0.06; χ^2(1) = 13.58, $p < .001$). They were overrepresented in the lowest subgroup and underrepresented in the subgroup with substantially better word-level skills than comprehension.

Brief Discussion of the Five-Cluster Solution

To avoid confusion, the five subgroups will be referred to by letter, ordered from A to E based on their scores on the decoding factor. Subgroups A, B, and E had relatively flat profiles. Subgroup A was lowest on all 5 factors (range −1.3 to −1.6 SD). It included all of subgroup 1 and a few adults from subgroup 3. Subgroup B was consistently low average (range −0.5 to −0.7 SD). It included most of subgroups 2 and 3 and about half of subgroup 4. Combining subgroups 2 and 3 conceals some variation because subgroup 2 had higher comprehension than word recognition and subgroup 3 had the opposite pattern. Subgroup E was consistently high performing in all areas (range 1.0 to 1.2 SD). It was composed of all adults from subgroup 8 together with some from subgroups 6 and 5. The other two subgroups had substantial differences between word-level skills and comprehension. Subgroup C had average word-level skills (range 0.0 to 0.3 SD) and high comprehension (1.0 SD). It was composed about equally of adults from subgroup 6, which also had high comprehension and average word-level skills, and subgroup 5, which had a flat average profile. Subgroup D had slightly above average word-level skills (range 0.3 to 0.6 SD) and slightly below average comprehension (−0.3 SD). It was composed of all of the adults from subgroup 7, which also had a similar profile of above average word skills and slightly below average comprehension, and moderate numbers from subgroups 4 and 5, which had relatively flat profiles.

Analysis of demographic factors produced similar results to those using the 8 subgroups. Subgroups A and B were significantly older than subgroup C, and subgroup B was significantly older than C, D, and E. As with the 8 subgroups, the lower performing groups tended to be older. Non-native speakers were significantly over-represented in subgroup D with higher word-level skills than comprehension and significantly under-represented in subgroup C, with higher comprehension than word skills, and in subgroup E, the highest performing subgroup. These results are consistent with the patterns observed with 8 subgroups; non-native adults tended to have higher word-level skills than comprehension. Adults with LD were significantly overrepresented in subgroup A, the lowest performing, and significantly underrepresented in subgroup D, which had higher word-level skills than comprehension. These results are consistent with the analysis of the 8 subgroups.

Overall, both the 5-cluster solution and the 8-cluster solution resulted in groups with relatively flat profiles at low, average, and high levels and groups with relatively higher word recognition or relatively higher comprehension. Similar relationships with the demographic factors of age, birthplace, and LD status were found. However, the 8-cluster solution found two groups with relatively higher comprehension, at two different overall levels. It also found two groups with similar word recognition and comprehension scores but substantially different spelling scores. Both of these differentiated patterns are interesting and potentially relevant to instruction.

Discussion

The overall purpose of the current study was to identify subgroups of adult learners with different profiles of skills in the five reading components of decoding, word recognition, spelling, comprehension, and fluency. Two main research questions were addressed: First, what subgroups of learners can be identified based on the assessment of reading components? In particular, would there be subgroups with substantially higher or lower comprehension related to word skills? Also, would there be subgroups with different profiles among the three word-level measures? Second, how do these subgroups differ in demographic and background factors? The cluster analysis found eight subgroups that were cohesive, separate, and replicable across subsamples. The skill profiles of the subgroups varied substantially both on overall level of performance and also on relative performance across reading components. Comparisons of the subgroups on demographic factors were generally consistent with predictions about profiles, providing external confirmation of the validity of the subgroups.

Four of the subgroups had profiles with substantial differences between word skills (decoding, word recognition, and spelling) and comprehension. Two subgroups (2 and 6) had comprehension scores about one *SD* higher than word skills with parallel profiles about 1.4 *SD* apart on word-level and comprehension factors. Two other subgroups (3 and 7) had higher word skills than comprehension. Subgroup 7 had word skills about one *SD* above comprehension skills; subgroup 3 had a smaller difference, but with decoding and word recognition still about a half *SD* higher than comprehension. The remaining subgroups had relatively flat profiles at varying levels: more than a SD below the mean (subgroup 1), slightly below and above the mean (subgroups 4 and 5, respectively), and more than a SD above the mean (subgroup 8).

As predicted, non-native adults were substantially overrepresented in the subgroups with relatively higher word skills and underrepresented in the subgroups with relatively higher comprehension. In fact, 52% of all the non-native adults were in subgroups 3 and 7, and fewer than 10% of them were in the two subgroups with relatively higher comprehension. These findings are consistent with the limited prior research on ABE learners (Alamprese, 2009; Davidson & Strucker, 2002; Strucker et al., 2007). Furthermore, it makes sense that non-native speakers, particularly those who are already literate in their native language, would acquire decoding skills more quickly than vocabulary and comprehension. Comprehension depends on mastery of vocabulary, and vocabulary takes substantial time to develop in a second language. However, the varying profiles of reading component skills cannot be explained fully by differences between native and non-native speakers. Substantial numbers of native speakers were found in 7 of 8 subgroups (with the exception of subgroup 7). Even the three subgroups with relatively higher decoding skills than comprehension included 25% of the native speakers.

Subgroups differed significantly on age. The prediction that older adults would be in lower performing subgroups was partially supported. The two subgroups with significantly older mean ages included the subgroup with the lowest performance in all areas (subgroup 1), but also included subgroup 2 that had among the lowest word skills but substantially higher comprehension. The three subgroups with significantly younger mean ages included two average subgroups (4 and 5), but also subgroup 7 with above average word skills and low average comprehension. Thus, the prediction was confirmed for word skills. The older subgroups had lower word skills than the younger subgroups. However, the prediction was only partially confirmed for comprehension. The subgroup with the lowest comprehension skills was older. However, the other group that was older (subgroup 2) had average comprehension skills. The finding that subgroup 7 was significantly younger should be interpreted with caution because the comparison was based on native adults only and that subgroup had relatively few native adults.

The subgroups also differed significantly on gender in the overall analysis, as anticipated. However, the followup subgroup comparisons were generally not statistically significant. Men tended to be overrepresented in the subgroups with lower word skills, but the only statistically significant finding was an overrepresentation of women in one average subgroup (subgroup 5).

The subgroups also differed on self-reported LD. No specific predictions were made about subgroup membership and LD for two reasons. The self-reported data might not be reliable, and ABE students are unlike other groups of adults with dyslexia that have been studied because their overall level of reading performance is low. However, the findings are interesting. Adults with LD were overrepresented in the lowest subgroup (subgroup 1). Guidelines for identification of students with LD, at least until recently, have required a discrepancy between achievement and intelligence (Swanson, 2000). However, in practice, schools have identified many generally low achieving students as LD (Tomasi & Weinberg, 1999). These low performing adults might also represent a group of students who had LD but did not receive appropriate specialized intervention and did not learn to compensate for their decoding problems. The other significant finding was that adults with LD were underrepresented in the subgroup (subgroup 7) with substantially better word-level skills than comprehension. This finding is consistent with expectations; one would not expect adults with LD to have relatively good word skills. However, it should be interpreted with caution because only six percent of the native sample was in that subgroup.

The study also asked whether there would be subgroups with different profiles of skills at the word level. The confirmatory factor analysis (MacArthur et al., 2010) had found that a model including separate factors for decoding, word recognition, and spelling, as well as fluency and comprehension, provided a better fit to the data than 2-factor and 3-factor models that combined the three word-level factors. Thus, variation in these components across subgroups was anticipated. Word recognition and decoding skills were generally consistent within each subgroup; the largest difference was 0.4 *SD* in subgroup 2. However, two subgroups did have differences of 0.5 *SD* or greater between spelling and word recognition. These two subgroups had very similar scores on word recognition, comprehension, and fluency, but subgroup 4 had higher word recognition than spelling (difference = .5 *SD*) and subgroup 7 had lower word recognition than spelling (difference = .6). Together these subgroups comprised 27% of the sample. Interestingly, non-native English speakers were overrepresented in both of these subgroups. It is possible that some factor related to their first language or education in their home country would help to explain the difference, although our data on amount of education and self-reported home language did not differ across subgroups. Further research should explore the reasons for this differing performance on spelling.

The study has a number of limitations. First, the study was limited to measures of five reading components. There were no separate measures of oral language, oral vocabulary, or cognitive processes underlying reading (e.g., phonemic awareness). Measures of language and cognitive processes might have revealed different profiles or provided better explanations of the existing profiles. Second, the sample, although adequate in size and gathered from 23 programs in 12 states, was not designed to be representative of the population of ABE learners in the United States. The sample was limited primarily to adults reading at the low intermediate level of ABE. Furthermore, the non-native English speakers in the study included a smaller proportion of adults from Spanish-speaking countries than the overall ABE population.

Despite the limitations, the study contributes to research describing the reading skills of ABE learners by identifying subgroups with varying profiles of reading skills and exploring relationships between those profiles and demographic factors. Further research to identify subgroups of ABE learners should include a wider range of measures.

From the perspective of practice, the findings support the importance of assessing multiple reading components to plan appropriate instruction. Research with children has demonstrated the importance of differentiating instruction based on relative strengths in word skills and vocabulary or language skills (Aaron et al., 2008; Connor et al., 2004). In the current study, subgroups of adults were found to have substantially different patterns of component skills and, presumably, different instructional needs. Four of eight subgroups, together comprising 51% of the sample, exhibited differences of more than 0.5 *SD* between decoding and comprehension. Current assessment practice in ABE focuses on broad assessments of reading comprehension using tests specifically developed for use with low-literacy adults, such as the Tests of Adult Basic Education (CTB/McGraw-Hill, 1994) and the Comprehensive Adult Student Assessment System (2005). These measures are used to place students in appropriate level classes and to document the outcomes of instruction for accountability purposes. While such tests are important indicators of overall reading functioning, they are not directly useful in differentiating instruction.

Given the existence of subgroups of adults with different profiles of reading skills, it seems appropriate to recommend assessment of those component skills as a critical part of instructional planning. In addition, instructional research is needed to test the hypotheses about ways that differential instruction can lead to better outcomes for adult learners.

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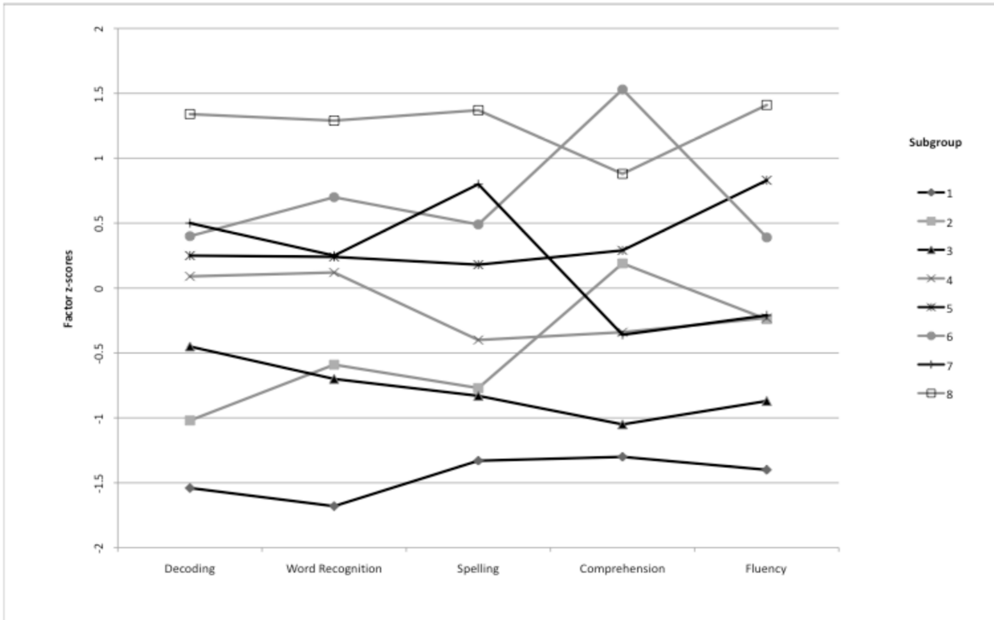

Figure 1. Mean Scores on the Reading Components Factors for the Subgroups

Table 1

Reading Component Descriptive Measures

Test	Mean	SD	Mean Grade Equivalent
Decoding			
Woodcock Johnson Word Attack[a]	488.5	15.6	3.3
TOWRE Phonemic Decoding	26.4	11.7	3.7
Letter Sound Survey[b]	13.1	5.8	NA
Word Recognition			
Woodcock Johnson Letter Word[a]	497.6	22.4	5.1
WRAT Reading[a]	500.8	12.7	4.5
Spelling			
WRAT Spelling[a]	498.8	11.8	4.0
Developmental Spelling [b]	6.9	4.9	NA
Comprehension			
Nelson Word Meaning [b]	19.7	6.5	5.1
Nelson Reading Comprehension [b]	20.9	6.6	5.5
Fluency			
TOWRE Sight Word	61.8	14.7	4.0
Passage Reading – Correct words/min. [b]	111.2	39.7	NA

[a]Absolute or W-scores.

[b]Raw scores.

Table 2

Mean Reading Factor Scores for the Subgroups

	Subgroups							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Factors[a]								
Decoding	−1.54	−1.02	−0.45	0.09	0.25	0.40	0.50	1.34
Word Recognition	−1.68	−0.59	−0.70	0.12	0.24	0.70	0.25	1.29
Spelling	−1.33	−0.77	−0.83	−0.40	0.18	0.49	0.80	1.37
Comprehension	−1.30	0.19	−1.05	−0.34	0.29	1.53	−0.36	0.88
Fluency	−1.40	−0.24	−0.87	−0.23	0.83	0.39	−0.21	1.41
Subgroup statistics								
Prevalence	9.9%	12.9%	12.0%	12.9%	13.1%	11.2%	14.6%	13.5%
Internal Cohesion (H)	0.89	0.88	0.91	0.92	0.89	0.86	0.89	0.85
Internal Replication	100%	100%	66%	66%	100%	100%	100%	100%
External Isolation (rp)	.15	.30	.26	.39	.39	.26	.33	.08

[a]Factor scores are z-scores for the population.

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Table 3

Demographic Data for the Subgroups

	Subgroups								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
N	47	61	57	61	62	53	69	64	474
Mean age (years)	41.41	39.95	32.30	29.43	27.78	32.13	26.28	32.34	33.36
Percent of subgroup:									
Non-native	0.213	0.066	0.474	0.508	0.177	0.132	0.739	0.172	0.321
Male	0.404	0.475	0.439	0.230	0.177	0.302	0.333	0.344	0.335
LD (native only)	0.703	0.544	0.600	0.483	0.392	0.435	0.056	0.415	0.474
Odds Ratios:									
Non-native	0.54	0.13	2.10	2.49	0.41	0.29	8.53	0.40	
Male	1.39	1.97	1.65	0.55	0.38	0.84	0.99	1.04	
LD (native only)	2.96	1.41	1.76	1.04	0.67	0.83	0.06	0.75	