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Understanding oral reading fluency among adults with low literacy: Dominance analysis of contributing component skills

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Reading fluency lacks "definitional, theoretical, empirical, or instructional consensus in the research literature" (Kame'enui & Simmons, 2001, p. 204). Yet, the evident connection between fluency and reading comprehension stimulates continued interest in and investigation of the construct (e.g., Adolf, Catts, & Little, 2006; Barth, Catts, & Anthony, 2009; Jenkins, Fuchs, van den Broek, Espin, & Deno, 2003a, 2003b; Katzir, Kim, Wolf, O'Brien, Kennedy, Lovett, & Morris, 2006; Pikulski & Chard, 2005; Samuels & Farstrup, 2006). To bring some coherence to the discussion, Katzir and colleagues (2006) called for an exploration of the "component structure of reading fluency and the differential role of each component within that structure for different readers at different points in their development" (p. 52). The implication is that a component analysis of fluency could inform assessment, curriculum, instruction, and intervention.

Insufficient research exists on the role of fluency for adults with low literacy skills and interventions that might help them become fluent readers. A national prevalence of low literacy (Kutner, Greenberg, & Baer, 2005), the correlation between passage reading rate and literacy level (Baer, Kutner, Sabatini, & White, 2009), the high rates of learning disability among adult literacy learners (Patterson, 2008), and the suggestion that fluency's structure and roles may differ by developmental stage (Katzir et al., 2006) collectively highlight the need for more study of adult literacy learners' fluency. Such research could have an impact on many of the 93 million U.S. adults who read at or below a basic level (Kutner et al., 2005). The strong positive relationships of literacy with employment (e.g., median weekly earnings, full time employment), civic involvement (e.g., voting, volunteering), and parenting (e.g., reading to and with children) demonstrate the broad impact that may result from research that contributes to increasing literacy among adults with low literacy (Kutner, Greenberg, Jin, Boyle, Hsu, & Dunleavy, 2007). Specifically, the 1.4 million adults who annually enroll in adult literacy programs (U.S. Department of Education, 2006) funded by Title II of the Workforce Investment Act (P.L.105–220) could benefit from improved instruction in reading fluency. Therefore, this study extends the literature by identifying the unique and shared contributions of reading component skills to oral reading fluency of adult learners.

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Fluency Construct and Research

Wolf and Katzir-Cohen (2001) defined fluent oral reading as “a level of accuracy and rate where decoding is relatively effortless; where oral reading is smooth and accurate with correct prosody; and where attention can be allocated to comprehension” (p. 218). The complexity of the fluency construct is evident in the multiple elements contained in this definition—accuracy, rate, decoding, speech, prosody, attention, and comprehension. Deficits or inefficiencies in any one or more of these components have the potential to disrupt fluency (Kame’enui & Simmons 2001; Wolf & Katzir-Cohen, 2001), making instructional intervention a complex problem for educators.

Although multifaceted, oral reading fluency is frequently described in the literature as having three major components: (a) word reading accuracy, (b) automaticity or word reading rate, and (c) prosody or the appropriate use of phrasing and expression to convey meaning (Rasinski, 2010). Some reading theories and research focus on accuracy and automaticity or efficient word recognition processes as the key to fluent reading, particularly among developing readers (e.g., Ehri, 1995; LaBerge & Samuels, 1974; Nathan & Stanovich, 1991; Samuels & Farstrup, 2006; Torgesen, Rashotte, & Alexander, 2001). From this perspective, the number of words correctly read per minute has proven to be “an elegant and reliable way to characterize expert reading” (Fuchs, Fuchs, Hosp, & Jenkins, 2001, p. 240) because it reflects a reader’s ability to quickly coordinate multiple reading skills. Others theories emphasize prosody as the bridge to comprehension (e.g., Allington, 1983; Dowhower, 1991; Pikulski & Chard, 2005; Pinnell, Pikulski, Wixon, Campbell, Gough, & Beatty, 1995; Rasinski, 2010; Schreiber, 1991). Proper phrasing and expression are seen as the reader attempts to comprehend the meaning of a text; such behaviors may begin after a reader has established some degree of automaticity (Rasinski, 2010).

Recently, researchers have identified models that explain variance in fluency among developing readers (e.g., Berninger, Abbott, Billingsley, & Nagy, 2001; Joshi & Aaron, 2000; Katzir et al., 2006; Torgesen et al., 2001; Wolf & Bowers, 1999; Wolf & Katzir-Cohen, 2001). Torgesen et al.’s (2001) model of reading fluency includes the reader’s word skills and processing speed in relation to the text read. Their reading fluency model includes five components: (a) proportion of words in text that the reader recognizes as orthographic units, (b) variations in speed with which sight words are processed, (c) speed of processes used to identify novel words, (d) use of context to speed word identification, and (e) speed with which word meanings are identified. Wolf and Katzir-Cohen’s (2001) fluency model includes accuracy and automaticity in lexical and sublexical processes (i.e., perceptual, phonological, orthographic, morphological) and their integration in semantic and syntactic processes at word and connected text levels. Berninger et al.’s (2001) systems approach describes oral reading fluency as a function of input (e.g., text), processes (e.g., word analysis), and output (e.g., speech-articulation), with the processes being subject to constraints (e.g., working memory, word learning layers, strategies, speed/automaticity, and executive functioning to coordinate processes and components).

Given these many ways of understanding fluency, Kame’enui and Simmons (2001) asserted that fluency’s cognitive mechanisms and processes are theoretically and experimentally unsettled. One reason for this ambiguity is that most studies have not comprehensively assessed the roles of all relevant component skills because they were limited to just a few predictor variables. Another possible reason for this uncertainty stems from the statistical methods used to analyze the relative importance of component skills that contribute to oral reading fluency. Specifically, most extant studies used multiple regression, which maximizes prediction of an outcome variable through the assignment of weights to predictor variables. However, several factors influence the regression weights in such a way that the relative importance of predictors cannot be reliably sorted and ranked. For example, intercorrelations among predictor variables, suppression effects, and elimination or addition of predictor variables in models can each influence the weights assigned to a given predictor. In summary, some prior studies of oral reading fluency may have excluded important component skills as predictors and other studies may have erroneously ordered the relative importance of component skills because of statistical oversights. The effect of these methodological issues is that previous fluency models may have underemphasized the roles of some component skills and overemphasized the roles of other component skills.

Dominance analysis (Azen & Budescu, 2003; Budescu, 1993) is one way to overcome some of the statistical shortcomings of simple multiple regression analysis. Dominance analysis is an extension of multiple regression in that it tests not only the full regression model that includes all predictors but it also tests all possible submodels that are comprised of every possible combination of predictors. Dominance analysis then calculates the unique contributions of each predictor variable under all of these contexts. In other words, dominance analysis determines the unique contribution of each predictor variable to the total variance (R^2) by calculating the semi-partial coefficients (*sr*) of a given predictor variable in the context of all possible combinations of remaining predictor variables. The *sr* numerically represents the unique information that the variable provides to understanding the criterion of interest, which in this case was oral reading fluency. Finally, the relative importance of predictors is determined based on pair-wise comparisons of variables' average contributions in models of different sizes (e.g., models with two predictors, models with three predictors, etc.).

Using this method, three levels of dominance between pairs of predictors can be achieved: complete dominance, conditional dominance, and general dominance. One predictor is said to completely dominate another predictor if its unique contribution is larger than the other predictors' unique contribution in the full regression model and in all possible submodels. However, if one predictor's unique contribution is larger for some submodels but not for all submodels, then complete dominance is undetermined, but weaker levels of dominance may still be achieved. If a predictor's unique contributions that have been averaged within every model are larger than those averaged unique contributions of another predictor at every model, then the first predictor is said to conditionally dominate the other. However, if a predictor's averaged unique contributions are larger for some models but not for all models, then conditional dominance between the two variables is undetermined. Nonetheless, general dominance can still be achieved if the average of a predictor's unique contributions across all possible models is larger than that of another predictor. Note that complete dominance implies conditional dominance, and conditional dominance implies general dominance.

The call to better understand the component structure of oral reading fluency at different points in reader development (Katzir et al., 2006) prompted us to pose the following research questions:

1. What is the relative importance of each reading component skill to the oral reading fluency of this population?

2. Which reading component skills demonstrate complete dominance, conditional dominance, and general dominance over other reading component skills?

The answers to these questions may help researchers, curriculum and intervention developers, and educators to prioritize their efforts and become more effective in helping adults with low literacy become more fluent readers.

Methodology

We present two dominance analyses (Azen & Budescu, 2003) that assess the unique contribution and relative importance of seven predictor variables that represent reading component skills associated with two ways of measuring oral reading fluency among 272 adult literacy learners. One oral reading fluency measure had a constant text difficulty across participants while the other measure had variable text difficulty that depended on readers' comprehension levels.

Sample

Research staff collected data from adults enrolled in 13 Midwestern Adult Education and Family Literacy Act programs (P.L.105–220), excluding participants involved in English as a Second Language (ESL) services. Subjects had to be at least 16 years old; withdrawn from secondary education without earning a secondary credential or attaining basic reading, writing, or math skills; have U.S. citizenship or authorization to work in the U.S. as a foreign national in order to receive a nominal participation payment; and volunteer to participate in the study.

Selection—In order to create a heterogeneous sample that spans the full range of low literacy, as required by dominance analysis, we drew a stratified sample based on the six educational functional reading levels as defined by the U.S. Department of Education's National Reporting System (NRS; USDE, 2001) and determined by Comprehensive Adult Student Assessment System reading diagnostic scores (CASAS, 2001). The NRS levels are: Level 1 Adult Basic Education (ABE) Beginning Literacy, Level 2 Beginning ABE, Level 3 Low Intermediate ABE, Level 4 High Intermediate ABE, Level 5 Low Adult Secondary Education (ASE), and Level 6 High ASE. In general, an NRS level approximates about two grade levels in school (e.g., NRS Level 2 represents about Grade 4 ability levels).

We randomly selected for a stratified sample of volunteers who were rated NRS Levels 4, 5, and 6 at each study site, with a goal of 60 learners per level. Due to a low number of volunteers from Levels 1, 2, and 3, we conveniently used all eligible volunteers from these three levels. From a total of 319 individuals assessed for this study, the sample size was reduced to 272 cases because 13 cases had at least one invalid test score and 34 cases had at least one missing test score. These 47 cases were excluded because dominance analysis requires that all cases have complete data for the sake of comparability of predictors' semi-partial coefficients across models. The final sample of 272 adult literacy learners were distributed by NRS level as follows: Level 1, $n = 25$; Level 2, $n = 40$; Level 3, $n = 51$; Level 4, $n = 49$; Level 5, $n = 53$; and Level 6, $n = 54$.

Demographics and literacy levels—The sample was comprised of men (41%) and women (59%) between ages 16 and 73 ($M = 31$, $SD = 15$). Race and ethnicity of the sample were representative of the study region's non-ESL ABE and ASE participants: 40% White, 33% African American, 10% Hispanic American, 8% Multiracial/multiethnic, and 6% Asian American.

The literacy levels of our sample are described by NRS level in Table 1. As a whole, the sample is defined by low literacy skills; however, within the sample the heterogeneity needed for dominance analysis exists. Our sample's Level 6 readers, who average 155 words correct per minute (wcpm) on the QRI passages, performed between the National Assessment of Adult Literacy (NAAL) fluency study's Basic (143 wcpm) and Intermediate (166 wcpm) passage reading rates (Baer et al. 2009). The other five reading level groups in our sample averaged fewer words correct per minute than the NAAL Basic rate, ranging from 22 to 130 wcpm.

Dependent Variables

Given the various theories and models of oral reading fluency, we chose to operationalize fluency in two ways in this analysis. To represent fluency definitions that emphasize efficient word reading, we measured oral reading rate and accuracy with connected texts at a standard level of difficulty, as would happen with authentic tasks like reading newspaper or medical directions. The literature suggests that decoding measures would have greater predictive utility as readers with varied skill levels attempt to read the same sets of words. In the second assessment, we computed a fluency score based on several passages that matched readers' abilities and text demands, as might occur in an instructional setting when the assessment begins with a basal passage and ends at the upper limit of each reader's comprehension. This approach represents fluency definitions that emphasize the importance of fluency as it relates to making meaning from text. When operationalized in this way, the literature would suggest language comprehension measures would have greater predictive utility.

QRI passages—We chose to index oral reading fluency by the number of words correctly read per minute because this score reflects a reader's ability to quickly coordinate multiple reading skills and it is highly correlated with reading competence (Fuchs, Fuchs, & Maxwell, 1988; Jenkins et al., 2003a, 2003b). Reading rate and accuracy are more reliably measured than is prosody (Rasinski, 2010), are norm-referenced (Fuchs, Fuchs, Hamlett, Walz, & Germann, 1993; Hasbrouck & Tindal, 1992); and are considered an adequate index of fluency by the National Reading Panel (National Institute for Child Health and Human Development, 2000). Furthermore, the number of words correct per minute was the metric used for passage reading fluency in the NAAL supplemental fluency study (Baer et al., 2009).

We used two passages and the error scoring procedures from the Qualitative Reading Inventory-3 (QRI; Leslie & Caldwell, 2001) for this measure. Although the QRI is typically administered up to a reader's comprehension ceiling, we chose sixth grade passages for all subjects because they approximate the difficulty level of a typical adult reading task (e.g., reading the daily newspaper) and the expected median reading level for the sample.

Subjects read aloud each passage for one minute while examiners counted word errors and total words just as in a curriculum-based measure (Fuchs et al., 2001) and the NAAL (Baer et al., 2009) passage reading assessment. Although individuals read different amounts of text during the allotted time, differences in decoding demands were limited by the consistent level of difficulty throughout the two texts. From the two passages, we calculated an average words correct per minute for our QRI variable.

GORT fluency—For our second measure of oral reading fluency, we slightly modified administration procedures of the Gray Oral Reading Tests-4 (GORT; Wiederholt & Bryant, 2001). We required subjects to orally read and respond to five comprehension questions for a varying number of increasingly difficult passages starting at a basal and ending at individualized comprehension ceilings. Because of the low literacy levels of our study population, we lowered our discontinuation criteria or comprehension ceiling to two rather than three correct answers to the five comprehension questions as specified in the GORT procedures. We did, however, follow GORT deviation from print (or error) scoring and computation methods to create a reading rate score. Our adaptations of GORT procedures nullify any claims to the calculated reliability or validity evidence from standardized administrations. The modifications, however, suited our research purpose of operationalizing fluency as having a comprehension element.

Independent Variables

Processing speed—Oral reading fluency among children is strongly influenced by temporal processes (Wolf, Bowers, & Biddle, 2000). Therefore, we selected the Comprehensive Test of Phonological Processing (CTOPP) Rapid Letter Naming subtest (Wagner, Torgesen, & Rashotte, 1999), which measures how much time a subject requires to quickly name randomly arranged letters on a printed page. The variable was transformed in this analysis to a metric reflecting average letters correct per minute.

Phonemic awareness—Phonemic awareness is widely accepted as a critical factor in reading ability. Thus, we included CTOPP Blending Non-Words subtest (Wagner et al., 1999), which assesses a subject's ability to combine sounds to say non-words after listening to separately spoken sounds. The number of correctly combined non-words was the phonemic awareness variable.

Phonemic decoding—The ability to use phonetic and structural skills to pronounce unfamiliar or non-words is also widely considered an essential reading component skill. We used the Woodcock Reading Mastery Test-Revised (WRMT-R) Word Attack subtest (Woodcock, 1998) to represent this skill. The assessment requires subjects to read in order of difficulty 45 nonsense words or words with a low occurrence rate in English.

Word reading efficiency—Oral reading fluency is influenced by the combination of word reading skills and processing speed, or the efficiency of word reading. Therefore, we also included the Test of Word Reading Efficiency (TOWRE) Sight Word Efficiency subtest (Torgesen, Wagner, & Rashotte, 1999). This assessment measures the number of real words that an individual can accurately identify in 45 seconds. The variable was transformed in this analysis to number of words read correctly per minute.

Vocabulary—Vocabulary knowledge may contribute to word reading and reading comprehension, each of which relate to oral reading fluency. Thus, we included the Vocabulary subtest of the Wechsler Adult Intelligence Scale III (WAIS; Wechsler, 1997). This test assesses expressive vocabulary by requiring oral definitions for 33 words.

Nonverbal IQ—To represent nonverbal intellectual ability (IQ), we chose the Wechsler Adult Intelligence Scale III (WAIS-III) Block Design subtest (Wechsler, 1997). This instrument required subjects to replicate designs made with bicolor blocks. The block designs progressed in difficulty from designs made with two blocks to designs made with nine blocks within time limits. The number of correctly replicated designs within the time limit was the raw score used in analyses.

Auditory working memory—A number of theories posit that working memory affects reading ability (e.g., Bell & Perfetti, 1994; Sabatini, 2002). We chose a measure that would represent both storage and manipulation of data, each of which are potentially involved in a phonological loop for decoding, which may indirectly influence oral reading fluency. Unsworth and Engle (2007) assert that simple and complex span tasks largely measure the same basic subcomponent processes, therefore we opted to use the Woodcock –Johnson-III Auditory Working Memory subtest (Mather & Woodcock, 2001), which employs a storage and processing task. This test required participants to listen to a list of scrambled words and numbers and to then state the words in sequential order followed by the numbers in sequential order.

Data Analysis Plan

Prior to performing any analyses, we examined data for accuracy of data entry, identified invalid and missing values, and verified appropriateness of variables' distributions in accord with the assumptions of dominance analysis. We then conducted two dominance analyses to determine the relative contributions of seven reading component skills to oral reading fluency. The first dominance analysis involved performing 127 regression models of the prediction of QRI fluency scores. The second dominance analysis involved 127 regression models of the prediction of GORT fluency scores.

Results

What is the relative importance of each reading component skill to the oral reading fluency of this population?

All seven reading components suggested by the literature as involved in oral reading fluency indeed correlated with the QRI measure of oral reading fluency (*r*s = .37 to .91; see Table 2). The QRI measure of fluency was most highly correlated with the TOWRE word reading efficiency measure (r = .91). Processing speed measured by the CTOPP rapid letter naming subtest ranked second among zero-order correlations with QRI fluency (r = .70). Auditory working memory (r = .59), vocabulary (r = .57), phonemic decoding (r = .57), and phonemic awareness (r = .57) were moderately correlated with QRI fluency, and non-verbal IQ was least correlated with QRI fluency (r = .37).

Similarly all seven reading components were significantly correlated with GORT reading rate (*r*s = .42 to .77; see Table 2). The GORT rate measure was also most highly correlated with word reading efficiency (r = .77). WAIS vocabulary ranked second most highly correlated with GORT fluency (r = .66), followed closely by measures of auditory working memory (r = .61), phonemic awareness (r = .57), processing speed (r = .56), and phonemic decoding (r = .50). GORT fluency was least correlated with non-verbal IQ (r = .42).

When these reading components' relative importance to our fluency measures (GORT and QRI) is operationalized as the average of a variable's semi-partial coefficients obtained from all submodels, the reading components' relative importance vary only slightly from results of the correlation analyses. These overall average unique contributions are reported in the last columns of Tables 3 and 4 for QRI fluency models and GORT fluency models, respectively, from greatest to least predictive utility. Average unique contributions form the basis upon which relations of general dominance will later be asserted.

Regarding the prediction of QRI fluency (see Table 3), word reading efficiency made the largest average unique contribution (*avg.* sr^2 = .373). Processing speed made the second highest average unique contribution to the prediction of QRI fluency (*avg.* sr^2 = .153). Vocabulary (*avg.* sr^2 = .088), phonemic decoding (*avg.* sr^2 = .080), auditory working memory (*avg.* sr^2 = .079), and phonemic awareness (*avg.* sr^2 = .073) made similar sized average unique contributions. Finally, nonverbal IQ made a very small average unique contribution to prediction of QRI fluency (*avg.* sr^2 = .024). The full model accounted for an impressive 86% of the variance in QRI fluency scores.

Regarding the prediction of GORT fluency (see Table 4), word reading efficiency made the largest average unique contribution (*avg.* sr^2 = .220). Vocabulary made the second highest average unique contribution to the prediction of GORT fluency (*avg.* sr^2 = .164), followed by auditory working memory (*avg.* sr^2 = .094), processing speed (*avg.* sr^2 = .084), phonemic awareness (*avg.* sr^2 = .075), phonemic decoding (*avg.* sr^2 = .056) and nonverbal IQ (*avg.* sr^2 = .036). The eighth columns in Tables 3 and 4 report the unique contributions of each variable to the prediction of QRI fluency or GORT fluency when all seven predictors were included in the full regression models. The full model accounted for 73% of the variance in GORT fluency scores.

If predictors' relative importance were judged from the QRI full model with the seven independent variables, then word reading efficiency (sr^2 = .154) and vocabulary (sr^2 = .017) would be deemed the best unique predictors of QRI fluency scores. However, only word reading efficiency is considered a practically important unique predictor, given that vocabulary yielded such a small a semi-partial coefficient. Moreover, all remaining predictors are deemed equally unimportant predictors of QRI fluency, given that each remaining predictor yielded a semi-partial coefficient of essentially zero.

Perhaps more noteworthy are results from the full model predicting GORT fluency. If predictors' relative importance are judged from the GORT full model, then word reading efficiency (sr^2 = .069) and vocabulary (sr^2 = .068) would be deemed equally important predictors of fluency based on their semi-partial coefficients. All remaining predictors are deemed equally unimportant predictors given that each yielded a semi-partial coefficient of less than .01.

Which reading component skills demonstrate complete dominance, conditional dominance, and general dominance over other reading component skills?

Table 5 reports the complete, conditional, and general dominance relations among all pairs of predictors when predicting QRI fluency. Semi-partial coefficients for word reading efficiency were larger than those for all other predictors in every submodel. In other words, word reading efficient completely dominated processing speed, vocabulary, phonemic decoding, auditory working memory, phonemic awareness, and non-verbal IQ. Similarly, vocabulary and auditory working memory completely dominated non-verbal IQ.

Columns 2 through 8 of Table 3 report the average unique contributions of each predictor at each model size in the prediction of QRI fluency. These results are also illustrated in Figure 1. With a model size of one independent variable, the values are equivalent to the squared correlation coefficient. Figure 1 nicely illustrates how the average unique contributions to the prediction of QRI fluency decreased as a function of increasing the number of predictors in the regression models. The average unique contributions at each model size were compared to establish conditional dominance among pairs of variables whose complete dominance was undetermined. Because processing speed had larger average unique contributions at each model size relative to auditory working memory, phonemic decoding, phonemic awareness, and non-verbal IQ (see columns 2 through 8 in Table 3), processing speed is said to conditionally dominate these four reading components. Auditory working memory likewise demonstrated conditional dominance over phonemic awareness.

Finally, to establish yet a weaker level of dominance among predictors of QRI fluency whose conditional dominance was undetermined, we compared semi-partial coefficients averaged across all submodels without consideration of model size (see last column of Table 3). Processing speed had a larger overall average semi-partial coefficient than vocabulary, and as such, processing speed is said to generally dominate vocabulary in the prediction of QRI fluency. Vocabulary likewise generally dominated phonemic decoding, auditory working memory, and phonemic awareness. Phonemic decoding generally dominated auditory working memory and phonemic awareness. Lastly, phonemic awareness generally dominated non-verbal IQ.

Table 6 reports the complete, conditional, and general dominance relations among all pairs of predictors when predicting GORT fluency. In every regression model, the semi-partial coefficients for word reading efficiency were larger than those for processing speed, auditory working memory, non-verbal IQ, phonemic awareness, and phonemic decoding. Therefore, word reading efficiency completely dominated these five reading components. Vocabulary also completely dominated these same five reading components in the prediction of GORT fluency. Auditory working memory completely dominated non-verbal IQ.

Columns 2 through 8 of Table 4 report the average unique contributions of each predictor at each model size in the prediction of GORT fluency. These values were used to establish conditional dominance among pairs of predictors whose complete dominance was undetermined. Word reading efficiency had higher average semi-partial coefficients at every model size than vocabulary. Thus, word reading efficiency conditionally dominated vocabulary. Auditory working memory demonstrated conditional dominance over phonemic awareness and phonemic decoding. Phonemic awareness conditionally dominated phonemic decoding and non-verbal IQ. Phonemic decoding conditionally dominated non-verbal IQ. Although average unique contributions generally decreased as the number of predictors increased, this effect was less apparent on vocabulary (see Figure 2). These results indicate smaller amounts of shared predictive variance in the vocabulary measure. In fact, vocabulary increased in rank order of importance as more correlated predictors were added to the regression models predicting GORT Fluency.

Finally, we compared semi-partial coefficients averaged across all submodels (see last column of Table 4) to establish general dominance among predictors of GORT fluency whose conditional dominance was undetermined. The overall average semi-partial coefficient of working memory was larger than that for processing speed. Thus, auditory working memory generally dominated processing speed. In the same manner, processing speed generally dominated phonemic awareness, phonemic decoding, and non-verbal IQ in prediction of GORT fluency.

Discussion

The purpose of this study was to identify the reading-related component skills that are most important for fluent oral reading among adults with low literacy. Correlation and regression analyses yielded results consistent with the research and theory that emphasize efficient word recognition processes as key to fluent reading (e.g., Nathan & Stanovich, 1991; Torgesen et al., 2001). Our dominance analyses using two approaches to fluency measurement, however, added new dimensions to our understanding of this adult population’s oral reading fluency. The differences between findings with the QRI and the GORT highlight how choices in operationalizing and assessing fluency affect how you understand its relation to other reading component skills.

Word reading efficiency was clearly the strongest predictor of oral reading fluency in both of our dominance analyses, which measured oral reading fluency at a fixed text difficulty with the QRI and at readers’ comprehension ceilings with the GORT. In the fixed text difficulty dominance analysis (i.e., the QRI), word reading efficiency demonstrated complete dominance over all six of the other reading components (i.e., processing speed, vocabulary, auditory working memory, non-verbal IQ, phonemic awareness, and phonemic decoding). In the comprehension ceiling text dominance analysis (i.e., the GORT) word reading efficiency completely dominated five of the six other reading components, and conditionally dominated vocabulary. Word reading efficiency’s overall importance as demonstrated in these analyses is consistent with prior research that points to word reading skills as essential for fluent oral reading (Nathan & Stanovich, 1991; Torgesen et al., 2001).

When oral reading fluency is operationalized without comprehension, processing speed is the second most important predictor of oral reading fluency, as shown by its conditional dominance over auditory working memory, phonemic decoding, phonemic awareness and nonverbal IQ; and general dominance over vocabulary. Vocabulary, which is regarded as one of the reading components, appears as the third leading predictor. Given the relatively low reading levels of our sample of adult learners and the importance of decoding to reading acquisition, we were somewhat surprised that phonemic decoding was not a strong predictor of oral reading fluency in this analysis.

When oral reading fluency is measured at comprehension level with the GORT, vocabulary is the second most important predictor, demonstrating complete dominance over all the other reading components except word reading efficiency (i.e., processing speed, auditory working memory, non-verbal IQ, phonemic awareness, and phonemic decoding). Perhaps reading for comprehension invokes more language processing than simply reading for speed, as reflected by the larger contribution of vocabulary to GORT fluency scores than to QRI fluency scores. Auditory working memory seems to be the third best predictor of oral reading fluency with comprehension level texts. While auditory working memory is most often viewed as important for reading comprehension, this ability is infrequently discussed in the context of oral reading fluency. Our finding supports the assertion of Berninger et al. (2001) that working memory may serve as a constraint to oral reading fluency.

If we had used only statistical methods that include just a few components (i.e., zero-order correlation and regression), we might have overlooked the importance of vocabulary and auditory working memory in oral reading fluency for adults with low literacy. Conventional fluency interventions (e.g., guided and repeated readings) emphasize accuracy and efficiency to the exclusion of these skills. However, for adults with low literacy, increased vocabulary and perhaps improved memory strategies (e.g., Scruggs & Mastropieri, 2000) may be the missing links to fluent reading.

In fact, our examination of oral reading fluency using not only more robust statistical methods, but two outcome measures based on single and comprehension level texts, affirmed aspects of the Berninger et al. (2001) and Torgesen et al. (2001) models. These models emphasize the relation between oral reading fluency and the text. Vocabulary—knowing the meaning of words—clearly plays a role in oral reading fluency at a reader's comprehension level. Authentic adult oral reading tasks (e.g., children's stories, assembly instructions, technical documents, group study materials, etc.) typically require comprehension. Thus, we suspect that interventions that simply help free attentional resources for comprehension through faster word reading may be insufficient for adults with low literacy. Rather, interventions that increase the fluency of the readers' vocabulary knowledge may free attention as well as improve fluency by helping the reader construct meaning from the text. We suspect that improved vocabulary would also help learners connect the textual information with the background knowledge and further support their fluency.

Limitations

Even though we operationalized fluency in two ways, neither assessment directly measured prosody, which is a limitation of our analysis. As such, the current study cannot speak to the relative importance of various component skills in the acquisition of prosodic reading. Further, the study design only permitted description of the sample's current abilities.

Future research

On the basis of these descriptive findings, we and other adult literacy researchers may form and test hypotheses for interventions that improve oral reading fluency among adults with low literacy. More studies are needed to explain the relations among vocabulary, auditory working memory, and oral reading fluency for adults with low literacy.

Subgroup analyses may also be important for more fully understanding the learning needs of individuals with different literacy levels. However, one could conceivably create subgroups of individuals from within this population based on individuals' literacy ability and find that the relative importance of particular component skills may vary by these subgroups (Mellard, Fall, & Mark, 2009; Mellard, Woods, & Fall, 2011). Such an inquiry may require a larger sample of adult learners than that in the present study; however, the analysis may yield important findings concerning which reading components and psychological mechanisms are most critical for developing reading fluency at different stages of literacy development

Conclusion

When we examined the oral reading fluency of 272 adults with low literacy using zero-order correlation and simple multiple regression techniques, we generally reproduced the findings of extant literacy research. However, our dominance analyses added new dimensions to our understanding of this population's oral reading fluency in relation to the texts they read.

The strongest predictor of oral reading fluency, regardless of how we operationalized fluency, was word reading efficiency. However, when oral reading fluency is measured at a readers' comprehension ceiling, vocabulary and auditory working memory become important predictors as well. Although with K-12 readers such interventions as guided and repeated readings are the remedy for poor oral reading fluency, our findings suggest the merit of investigations into whether adults with low literacy may also need vocabulary and auditory working memory strategy interventions to improve their reading fluency.

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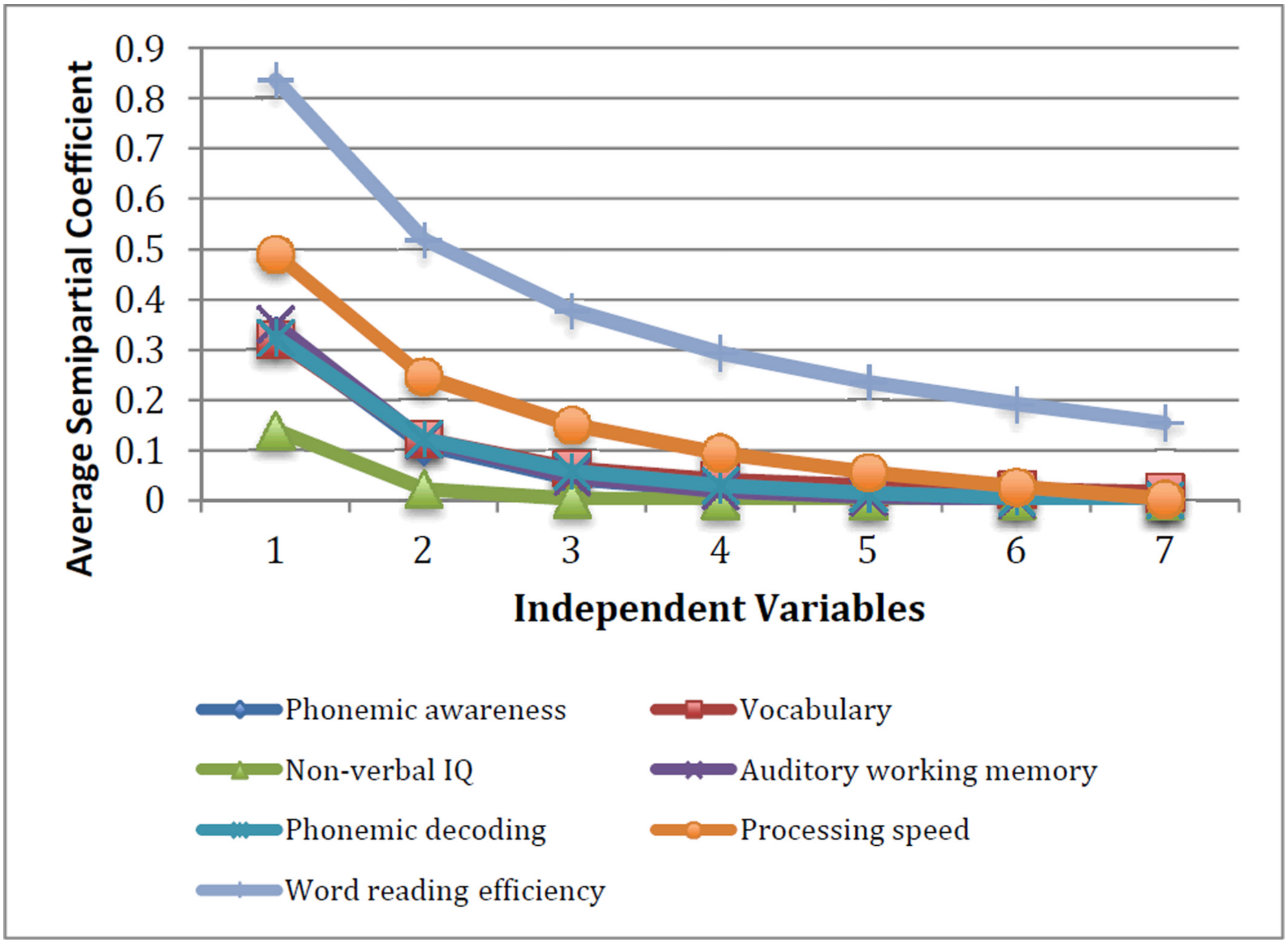

Figure 1.
Unique Contributions of Predictor Variables to QRI Passage Reading Rate Models

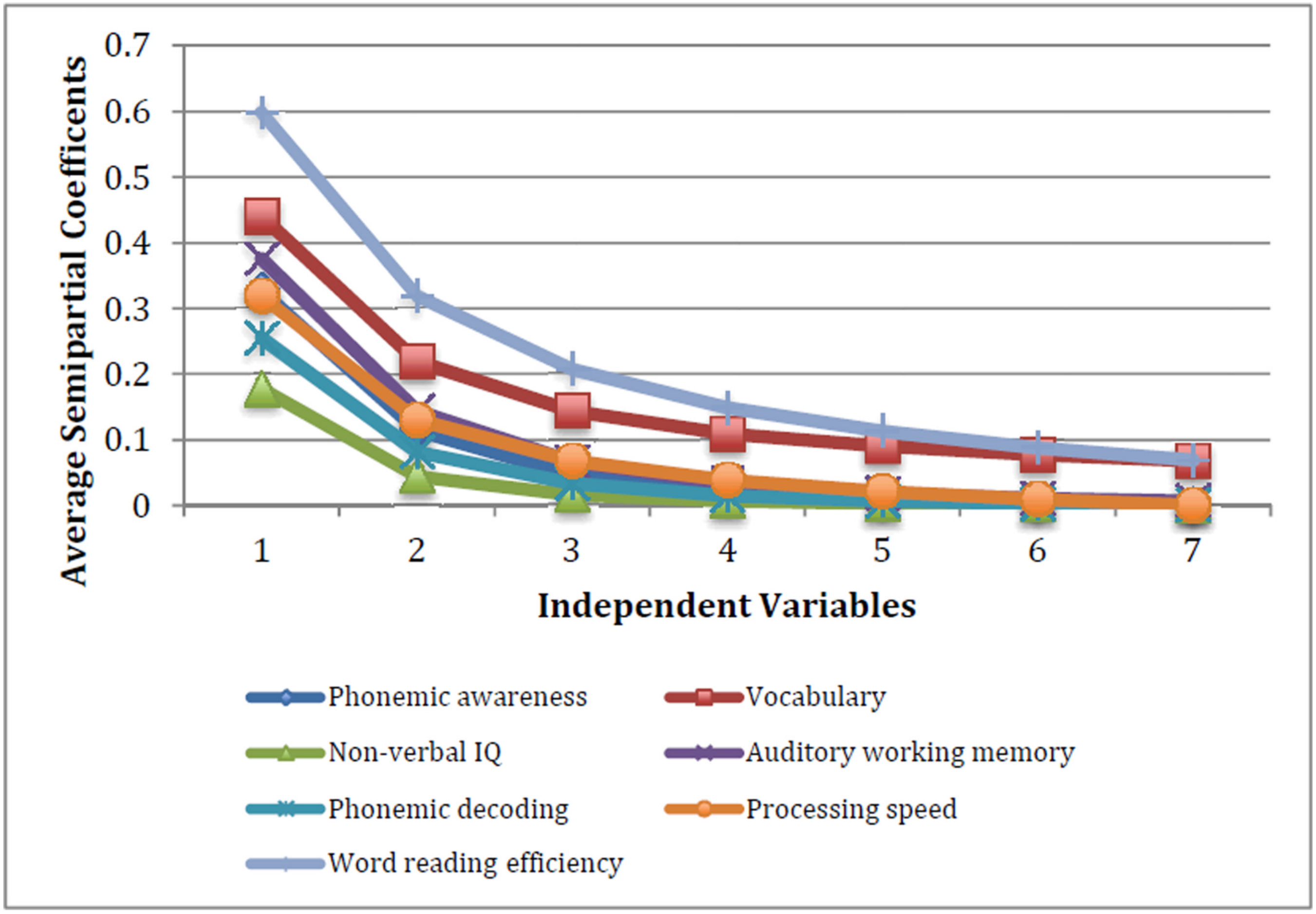

Figure 2.
Unique Contributions of Predictor Variables to GORT Reading Rate Models

Table 1

Mean and Standard Deviation QRI Passage Reading Rate (Words Correct Per Minute) And GORT Reading Rate Scores By Functional Reading Level

Functional reading level	*N*	QRI passage reading rate	GORT reading rate score
Level 1	25	22.0 (24.9)	7.8 (8.1)
Level 2	40	67.4 (34.8)	16.8 (10.2)
Level 3	51	91.1 (38.1)	25.2 (10.7)
Level 4	49	113.7 (27.6)	32.8 (6.2)
Level 5	53	130.3 (30.0)	37.5 (7.9)
Level 6	54	155.7 (28.8)	44.1 (9.7)

Table 2

Correlations And Descriptive Statistics.

	1	2	3	4	5	6	7	8	9
1. QRI passage reading rate	---								
2. GORT reading rate score	.84	---							
3. Vocabulary	.57	.66	---						
4. Auditory working memory	.59	.61	.51	---					
5. Non-verbal IQ	.37	.42	.44	.42	---				
6. Phonemic awareness	.57	.57	.45	.56	.42	---			
7. Processing speed	.70	.56	.28	.48	.26	.36	---		
8. Word reading efficiency	.91	.77	.47	.55	.35	.58	.73	---	
9. Phonemic decoding	.57	.50	.35	.38	.36	.46	.39	.58	---
Mean	105.8	29.9	23.6	22.8	27.5	6.1	139.8	86.1	494.6
Standard deviation	49.9	14.4	10.6	7.7	12.7	3.9	35.4	27.5	26.8
Minimum	1	0	3	0	3	0	60	13.3	440
Maximum	227.5	68	56	41	64	14	240	138.6	777

Note. $N = 272$. All correlations significant at $p < .0001$.

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Table 3

Dominance Analysis of QRI Passage Reading Rate

Predictor variable	R^2	Squared semi-partial correlations 2 IVs	3 IVs	4 IVs	5 IVs	6 IVs	7 IVs	Average
Word reading efficiency	.837	.519	.378	.294	.236	.191	.154	.373
Processing speed	.490	.247	.150	.095	.057	.027	.003	.153
Vocabulary	.320	.122	.023	.040	.029	.022	.017	.088
Phonemic decoding	.324	.123	.059	.030	.015	.006	.001	.080
Auditory working memory	.351	.121	.047	.019	.007	.003	.002	.079
Phonemic awareness	.327	.110	.043	.018	.007	.002	< .001	.073
Non-verbal IQ	.140	.023	.004	.001	< .001	< .001	< .001	.024

Notes. The full model with 7 IVs (independent variables) explained 86% of variance in QRI oral reading fluency. Predictor variables are ordered in the table according to their average unique contribution to QRI oral reading fluency.

Table 4

Dominance Analysis of GORT Reading Rate Score

Predictor variable	R^2	Squared semi-partial correlations						
		2 IVs	3 IVs	4 IVs	5 IVs	6 IVs	7 IVs	Average
Word reading efficiency	.598	.319	.207	.149	.113	.088	.069	.220
Vocabulary	.440	.219	.144	.110	.090	.077	.068	.164
Auditory working memory	.375	.144	.066	.034	.019	.011	.007	.094
Processing speed	.319	.130	.068	.039	.021	.010	< .001	.084
Phonemic awareness	.328	.114	.047	.021	.009	.004	.001	.075
Phonemic decoding	.255	.081	.033	.015	.007	.002	< .001	.056
Non-verbal IQ	.178	.044	.016	.007	.003	.001	< .001	.036

Notes. The full model with 7 IVs (independent variables) explained 73% of variance in GORT oral reading fluency. Predictor variables are ordered in the table according to their average unique contribution to GORT oral reading fluency.

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Table 5

Dominance Relations in the Prediction of QRI Passage Reading Rate

Dominant variable	Complete dominance	Conditional dominance	General dominance
Word reading efficiency	Processing speed Vocabulary Phonemic decoding Auditory working memory Phonemic awareness Non-verbal IQ	--	--
Vocabulary	Non-verbal IQ	--	Phonemic decoding Auditory working memory Phonemic awareness
Auditory working memory	Non-verbal IQ	Phonemic awareness	--
Processing speed	--	Auditory working memory Phonemic decoding Phonemic awareness Non-verbal IQ	Vocabulary
Phonemic decoding	--	--	Auditory working memory Phonemic awareness
Phonemic awareness	--	--	Non-verbal IQ
Non-verbal IQ	--	--	--

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Table 6

Dominance Relations in the Prediction of GORT Reading Rate Score

Dominant variable	Complete dominance	Conditional dominance	General dominance
Word reading efficiency	Processing speed Auditory working memory Non-verbal IQ Phonemic awareness Phonemic decoding	Vocabulary	--
Vocabulary	Processing speed Auditory working memory Non-verbal IQ Phonemic awareness Phonemic decoding	--	--
Auditory working memory	Non-verbal IQ	Phonemic awareness Phonemic decoding	Processing speed
Processing speed	--	--	Phonemic awareness Phonemic decoding Non-verbal IQ
Phonemic awareness	--	Phonemic decoding Non-verbal IQ	--
Phonemic decoding	--	Non-verbal IQ	
Non-verbal IQ --	--	--	