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Laura Vacek
Laura.Vacek@Colorado.EDU

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The relationship between reading skill and a novel phonological awareness matching task in adults with and without compensated dyslexia

Laura Vacek

Undergraduate Honors Thesis
Department of Speech, Language, and Hearing Sciences
University of Colorado at Boulder
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Primary Thesis Advisor:
Christine Brennan, PhD, CCC-SLP | Department of Speech Language and Hearing Science

Honors Council Representative:
Kathryn Arehart, AuD | Department of Speech Language and Hearing Science

Thesis Committee Member:
Tor Wager, PhD | Department of Psychology
Abstract

Phonological awareness (PA) influences the development of reading skill for children learning to read alphabetic orthographies, but less is known about the role of phonological awareness in reading skill in adults. One critical issue readers face is management of granularity, or the scale of the mappings between graphemes and phonemes. Management of granularity involves learning how to map between word segments that may have mismatched grain sizes. In this case, grain size refers to the number of phonemes in a word (i.e., the current study considers one to two phonemes as small grain units and three to four phonemes as large grain units). When grain size is mismatched (e.g., the single grapheme “x” maps to two phonemes /ks/ and the biograph “sh” maps to the single phoneme /ʃ/). The current study directly tested phonological awareness skill in adults using a novel phonological awareness task that manipulates grain size and lexicality in order to determine if (1) accuracy on this task differs for adults with dyslexia (i.e., compensated), (2) if the pattern of skill differs between groups, and (3) if accuracy for any of the grain size and/or lexicality conditions correlates with reading skill. Participants included adults with compensated dyslexia and adults without dyslexia (control group). While no statistical differences between groups were found on the individual phonological awareness matching task conditions, an interaction between lexicality and grain size was found for only the group with compensated dyslexia. Second, the adults with compensated dyslexia did show significant correlations between reading skill and task performance. Finally, the adults with compensated dyslexia also showed a significant positive correlation between reading skill and GPA, whereas this relationship was not significantly correlated for the adults without dyslexia. Future research should explore if use of a phonological awareness matching task that
manipulates grain size can be effective at improving the phonological skills which support reading ability and in turn, promote improved reading overall.

**Introduction**

The relationship between phonological awareness (PA) and reading skill for children learning to read alphabetic orthographies, such as English, is well established (Bradley & Bryant, 1983; Bryant, MacLean, Bradley, & Crossland, 1990; Hoien, Lundberg, Stanovich, & Bjaalid, 1995; Lundberg, Frost, & Petersen, 1988; Schneider, Kuspert, Roth, Vise, & Marx, 1997), yet less is known about how this relationship evolves with experience and skill from childhood to adulthood. PA involves a set of skills that involves identifying and manipulating units of spoken language (i.e., words, syllables, and onsets, and rimes) and being able to isolate and manipulate individual sounds (phonemes) in spoken words. Numerous studies with children have demonstrated that PA predicts reading skills (Bradley & Bryant, 1983; Bryant, MacLean, Bradley, & Crossland, 1990; Hoien, Lundberg, Stanovich, & Bjaalid, 1995; Lundberg, Frost, & Petersen, 1988; Schneider, Kuspert, Roth, Vise, & Marx, 1997) and children with higher PA abilities also have higher reader abilities, whereas children with lower reading abilities demonstrate poorer PA abilities. Interestingly, this relationship is not unidirectional as advancements in PA skill lead to improved reading skill and advancements in reading skill lead to improved PA skill (Ehri, 1989; Morais, 1991; Morais, Alegria, & Content, 1987).

While the relationship between PA and reading skill is reciprocal, pilot data from our lab revealed that this relationship is more nuanced if grain size is considered. In the pilot study (and the current study), small grain size refers to words or word segments with one to two phonemes and large grain size refers to words or word segments with three or more phonemes. Mismatched
grain size refers to instances when the grain size of the graphemic representation does not match the phonological representation (Ziegler & Goswami, 2005). For example, single phonemes can map to combinations of multiple letters (e.g., /ʃ/ maps to “sh” and /ð/ maps to “th”) and single letters may map to combinations of multiple phonemes (e.g., “x” maps to /ks/ and “j” maps to /dʒ/). While the ability to match units with mismatched grain size units is critical to reading acquisition in irregular orthographies, like English, the use of a novel PA matching task involving detection and matching when grain size is manipulated has not been previously used to examine the relationship between PA and reading skill in adults. Using the psycholinguistic grain size theory (Zeigler & Goswami, 2005) as a theoretical framework, this study aimed to test adults with and without dyslexia on a novel PA matching task that manipulated grain size (large and small grain units) and lexicality (real words and nonwords) with the aim of disambiguating the role and nature of PA skill as it relates to reading in adults.

**Grain Size**

The acquisition of reading ability becomes more challenging when the graphic representation does not match the phonological representation, especially when the orthography is inconsistent orthography, like English. According to Ziegler and Goswami (2005), beginning readers encounter three issues with reference to phonological development: availability, consistency, and granularity. Availability refers to the idea that not all phonological units are accessible prior to reading, making the connection of orthography to phonology a challenge. Consistency refers to the regularity or transparency of the mappings. The third issue is granularity (Ziegler and Goswami, 2005). In order to develop proficient reading ability in an irregular orthography, like English, it is crucial that individuals have both availability and
consistency of phonological information but are also able to master management of inconsistent mappings related to mismatched granularity.

In the early stages of literacy acquisition, individuals have more sensitivity to larger grain size units as opposed to smaller units, which develops later (Anthony et al., 2003). As reading skills further develop and strengthen, readers develop greater sensitivity to smaller grain size units (Anthony et al., 2003). In the English orthography, small grain size units are often inconsistent whereas large grain size units are more consistent (Treiman, Mullennix, Bijeljac-Babic, & Richmond-Welty, 1995). According to Ziegler and Goswami (2005), phonological representation favors larger grain size units (whole words), whereas orthographic representation favors smaller grain size units (letters). This theory may explain why readers of inconsistent orthographies develop strategies to recognize multiple grain sizes. Ziegler and Goswami (2005) argue that children use orthographic chunks corresponding to rhymes when developing reading strategies as a way to begin managing inconsistent mappings more easily. Large grain size units are more easily chunked as rhyme/rime patterns while onsets may be variable (e.g., -ing in “sting,” “bring,” and “wing”) (Ziegler & Goswami, 2005). It is important for readers to have sensitivity to both large and small grain size units to successfully decode language, especially in the case of an inconsistent orthography such as English.

Management of granularity directly relates to the ability of readers to map between orthography and phonology. Muneaux and Ziegler (2004) observed that individuals who are able to read produce more orthographic plus phonological rhymes than phonological rhymes alone. For example, the words “ripe” and “wipe” rhyme and they also share a similar orthographic rime pattern (i.e., “-ipe”). Even though the word, “type,” belongs to the same rhyme group, the orthographic rime is different and as a result, this exemplar is less likely to be generated when
readers are asked to produce words that rhyme with -ipe. This effect demonstrates a clear relationship between the understanding and use of orthographic and phonological representations. Muneaux and Ziegler (2004) and because mastery of rhyme/rime patterns requires skill with larger grain units, it also demonstrates a way in which grain size plays a part in reading skill (Mellman, 2017).

**Dyslexia and Compensated Dyslexia**

The International Dyslexia Association defines dyslexia as a specific learning disability that is characterized by difficulties with accurate and/or fluent word recognition by poor spelling and decoding abilities resulting from a deficit in the phonological component (Lyon et al. 2003). Evidence demonstrates that developmental dyslexia persists into adulthood despite developed reading skills, however, adults with dyslexia are still capable of performing on measures of reading in the average range (Kitz & Tarver, 1989). When this happens, the adults are considered to have compensated dyslexia, since their scores on reading measures no longer fall below age expectations. In individuals with a history of reading impairment, intervention or development of compensatory reading skills leads to improved overall reading ability, although PA skill may still fall below average. Understanding how PA skill, specifically how phonological grain size is managed, in adults with and without dyslexia is critical if intervention for adults with dyslexia is to be optimized.

According to Wilson and Lesaux (2001), compensated dyslexia refers to readers who had reading difficulties as children but test within the average range as adults on standardized tests. Their study suggests that “compensated” could refer to those who have developed strategies towards reading. One strategy that individuals with dyslexia may use is an increased focus on
small grain size units needed for letter-by-letter decoding. Because English uses an inconsistent orthography, after mastering small grain size units, there is a tendency among developed readers to pay less attention to small grain size units as the ability to recognize larger units or patterns strengthens (Ziegler & Goswami, 2005). Individuals with stronger skills in recognizing larger patterns may read more efficiently while those focused on smaller units may read less efficiently and make more decoding errors. Individuals with dyslexia may nurture a focus on small grain sensitivity more so than large grain sensitivity. This may in turn create barriers to improvements in accuracy, fluency, and overall reading skill in adults with dyslexia. Wilson and Lesaux’s (2001) found that adults with dyslexia had below average performance with all three areas of processing related to reading tasks. Despite these difficulties as well as persistent deficits in phonological awareness (Snowling, 1980), adults with dyslexia have been found to be capable of demonstrating average range reading abilities (Kitz & Tarver, 1989), suggesting that some adults with dyslexia have developed compensatory strategies to overcome their underlying phonological and processing deficits.

Persisting phonological deficits influence reading skill even with the use of compensatory strategies such as whole-word recognition (focus on large grain patterns). Snowling (1980) found that phonological processing did not improve with reading skill growth in individuals with dyslexia. While phonological processing showed little improvement with age, Snowling (1980) suggested that overall reading skill increased from improved whole-word recognition rather than from improved PA skill. In individuals with reading difficulties, growth in orthographic skills that involve a focus on large grain patterns may compensate for deficits in small grain PA skill.

Word recognition can be used as a strategy to improve overall reading skill and comprehension when phonological decoding using small grain units is less effective. Further
accuracy of word recognition predicts reading comprehension (Cunningham, Stanovich, & Wilson, 1990); however, the relationship between word recognition and reading comprehension is weak (Bruck, 1990). Ransby, Marilyn, and Swanson (2003) found that comprehension was lower in adults with dyslexia versus those without dyslexia. When they examined if either lower level phonological processes (decoding and encoding) or higher order processes (listening comprehension and working memory) played a dominant role in mediating reading comprehension, results demonstrated that neither processes took precedent over the other: both played a role in overall reading comprehension (Ransby, Marilyn, & Swanson, 2003). It is clear that while accuracy and fluency play a role in predicting comprehension, they are not the only factors.

**Pilot Study**

Beginning readers of inconsistent alphabetic orthographies, like English, must manage granularity, (i.e. mapping between written and spoken words with mismatched grain size units, such as “night,” which has five letters but three phonemes). Our pilot study compared reading performance to accuracy on a PA task in ten monolingual, typically developing children. The PA task manipulated grain size and lexicality, with real and nonwords and large and small grain size units. Results were consistent with previous findings regarding the relationship between reading and PA skill, specifically, large grain matching accuracy was better than small grain matching. Further, accuracy for nonwords was positively correlated with timed phonological decoding (TOWRE: PDE) and a measure of PA (CTOPP: blending words). Timed sight word reading (TOWRE: SWE) was positively correlated with accuracy on real word PA matching tasks for both large and small grain units. The pilot study also revealed that children who had higher
scores on measures of timed phonological decoding and timed sight word reading had higher accuracies on the small grain and large grain matching tasks for real words.

The current study aimed to extend the pilot study and determine how the relationship between PA and reading skill changes beyond childhood and how it differs in adults with and without reading difficulties. The results of this study further disambiguate the relationship between PA and reading skill by (1) including tasks related to both large and small grain size matching for real and nonwords and (2) comparing performance on this novel PA matching task to standardized measures of reading in adults with a range of reading skill. These results will be of interest to educators and researchers who study reading development and reading disability. These results may also have important consequences for structuring effective intervention for adults with persistent reading difficulties.

**Research Questions**

1. On a novel PA matching task that manipulates phonological grain size and lexicality, do adults with dyslexia achieve higher or lower accuracies for (a) large versus small grain size and for (b) real words versus nonwords?

2. Do adults with dyslexia show an interaction between grain size and lexicality?

3. Is performance on the novel PA matching task correlated with standardized measures of reading skill or PA?
Methods

Design

The study utilized an experimental design with both a between group comparison and a within groups comparison. Independent measures included standardized tests of reading (Test of Word Reading Efficiency and Gray Oral Reading Test) and of PA skill (Comprehensive Test of Phonological Processing). Dependent variables included accuracy on a novel PA matching task that manipulated grain size (large and small grain units) and lexicality (real and nonwords). Stimuli included words and nonwords with one to two phonemes (small) and three to four phonemes (large).

Participants

Participants included nine typically developing adults and nine adults with compensated dyslexia. The adults with compensated dyslexia all self-reported a history of dyslexia and scored significantly lower on standardized measures of reading and PA. Written consent was obtained from all participants prior to testing. All participants were monolingual and between the ages of 18 and 35 years old. Participants were recruited from the Boulder area through posted fliers.

Experimental Procedure

Informed consent was obtained for all participants. Participants completed standardized testing and the computerized PA matching task (for real words and nonwords). The task was broken up into four segments, allowing for breaks to prevent participant fatigue. Standardized testing and completion of the novel PA matching task were completed on the same day of testing. Participation in standardized testing took approximately 40-100 minutes and completion of the
phonological grain size matching tasks took approximately 25 minutes. Participants were paid for their time by gift cards.

**Standardized Testing**

Standardized testing for PA and reading ability included the following: the *CTOPP-2 (Comprehensive Test of Phonological Processing)*, the *GORT-5 (Gray Oral Reading Test)*, and the *TOWRE-2 (Test of Word Reading Efficiency)*. The *GORT-5* was used to measure reading accuracy, fluency, and comprehension. Participants read multiple short stories with increasing length and difficulty aloud and then answered comprehension questions about the passages read. The *TOWRE-2* examined the participant’s phonemic decoding efficiency (PDE) (i.e., timed measure of nonword decoding) and sight word efficiency (SWE) (i.e., timed measure of sight word recognition). The *CTOPP-2* was used to measure PA skill and included tests of elision (deletion of phoneme/s from one word to produce a new word), blending real words, and blending nonwords.

There was no statistical difference between the groups on age (F(1, 17) = 0.238, p = 0.632), reading comprehension as measured by the GORT-5 (F(1, 17) = 0.731, p = 0.405), or GPA (F(1, 17) = 0.054, p = 0.819). There were statistically significant group differences on all other standardized measures of reading including phonemic decoding efficiency (PDE) (F(1, 17) = 24.622, p < 0.001), sight word efficiency (SWE) (F(1, 17) = 12.525, p = 0.003), GORT-5 reading index (F(1, 17) = 25.134, p < 0.001), the GORT-5 fluency (F(1, 17) = 29.235, p < 0.001), and the GORT-5 accuracy (F(1, 17) = 20.153, p < 0.001). There were statistically significant group differences for two standardized measures of PA: *CTOPP-2* elision (F(1, 17) = 15.371, p = 0.001) and *CTOPP-2* blending nonwords (F(1, 17) = 9.107, p < 0.01). The results of
these standardized tests demonstrate that there are significant group differences in PA and reading skill. Because the actual scores for the adults with a history of dyslexia actually fall in the lower average to borderline average range (see Table 1), these adults more accurately fit the definition of compensated dyslexia rather than dyslexia.

Table 1. Standardized testing results for the control and compensated dyslexia groups. There was no group difference for Age, GORT Comprehension, or GPA, but all other reading measures did have a significant effect of group with the controls having higher scores than the adults with compensated dyslexia.

<table>
<thead>
<tr>
<th>Group</th>
<th>No Dyslexia (Controls)</th>
<th>Compensated Dyslexia</th>
<th>F</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>23 (3.87)</td>
<td>24 (4.76)</td>
<td>0.238</td>
<td>0.632</td>
</tr>
<tr>
<td>TOWRE PDE</td>
<td>113.55 (13.6)</td>
<td>87.2 (8.27)</td>
<td>24.622</td>
<td>0.001</td>
</tr>
<tr>
<td>TOWRE SWE</td>
<td>110.88 (14.95)</td>
<td>90.1 (9.3)</td>
<td>12.525</td>
<td>0.003</td>
</tr>
<tr>
<td>GORT Reading Index</td>
<td>104.55 (5.0)</td>
<td>90.7 (6.55)</td>
<td>25.134</td>
<td>0.001</td>
</tr>
<tr>
<td>GORT Comprehension</td>
<td>9.44 (1.58)</td>
<td>8.7 (1.71)</td>
<td>0.731</td>
<td>0.405</td>
</tr>
<tr>
<td>GORT Fluency</td>
<td>12.44 (1.42)</td>
<td>7.8 (2.08)</td>
<td>29.235</td>
<td>0.001</td>
</tr>
<tr>
<td>GORT Accuracy</td>
<td>13.77 (1.56)</td>
<td>9 (2.78)</td>
<td>20.153</td>
<td>0.001</td>
</tr>
<tr>
<td>CTOPP Elision</td>
<td>0.94 (0.05)</td>
<td>0.75 (0.12)</td>
<td>15.371</td>
<td>0.001</td>
</tr>
<tr>
<td>CTOPP Blending Words</td>
<td>0.89 (0.06)</td>
<td>0.86 (0.08)</td>
<td>0.563</td>
<td>0.464</td>
</tr>
<tr>
<td>CTOPP Blending Nonwords</td>
<td>0.81 (0.07)</td>
<td>0.69 (0.08)</td>
<td>9.107</td>
<td>0.01</td>
</tr>
<tr>
<td>GPA</td>
<td>3.26 (0.35)</td>
<td>3.31 (0.36)</td>
<td>0.054</td>
<td>0.819</td>
</tr>
</tbody>
</table>

Novel PA Matching Task

The novel PA matching task manipulated grain size and lexicality. Participants were presented with an auditory target consisting of one or more phonemes. This was followed by the presentation of a real word or nonword. Participants were asked to determine if the target was in the real word or nonword using a click response (1 for yes, 2 for no) (see Figure 1). In order to manipulate grain size, two conditions were used. For the small grain condition, targets consisted of single phonemes and words or nonwords consisted of two phonemes (i.e., target phoneme /ʃ/...
or “sh” followed by the real word /ʃu/ or “shoe”). For the large grain conditions, targets consisted of three phonemes and words or nonwords consisted of four phonemes (i.e., target phonemes /rɪl/ or “ril” followed by the real word /θrɪl/ or “thrill”). Participants selected the “1” key to indicate if the target was present in the real word or nonword or the “2” key if the phoneme/s was not present. Manipulation of grain size and lexicality resulted in four main conditions: real word large grain, real word small grain, nonword small grain, and nonword large grain. This design allowed for analysis of grain size and lexicality independently and together: Each participant was tested using a computer with high quality headphones in a quiet room with no distractions.

Participants completed a total of 240 trails (60 trials per condition).

**Results**

Figure 1. The Phonological Grain Size Matching Task. For the small grain condition, targets consisted of single phonemes and words or nonwords consisted of two phonemes. For the large grain conditions, targets consisted of three phonemes and words or nonwords consisted of four phonemes. Participants selected the “1” key to indicate if the target was present in the real word or nonword or the “2” key if the phoneme/s was not present.
Statistical Analysis

Statistical analysis was completed using SPSS. GLM (generalized linear model) ANOVAs were used to compare the groups on all conditions. Multivariate GLM correlation analyses were used to compare standardized test results to accuracy on the four conditions of the novel PA matching task. A repeated measures ANOVA was used to compare means within groups for two variables (lexicality and grain size). Each repeated measures ANOVA was done with one group at a time. In order to control for family-wise error rate, we assigned a type I error rate (alpha) of 0.05 and control for family-wise errors using Bonferroni correction for all analyses.

Results

Group comparison for accuracy on the PA matching task conditions

Participants in the control group had slightly higher accuracies on most of the PA task conditions (see Table 2), but there were no significant group effects for any of the PA task conditions; although there was a trend towards significance for the real word small grain condition ($F(1,17) = 3.973, p = 0.064$) with the control group having higher accuracy than the compensated dyslexia group.

<table>
<thead>
<tr>
<th>PA matching task conditions</th>
<th>Group</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No Dyslexia (Controls)</td>
<td>Compensated Dyslexia</td>
</tr>
<tr>
<td>Real word conditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td>0.75 (0.06)</td>
<td>0.69 (0.06)</td>
</tr>
<tr>
<td>Large</td>
<td>0.86 (0.1)</td>
<td>0.83 (0.06)</td>
</tr>
<tr>
<td>Nonword conditions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td>0.75 (0.12)</td>
<td>0.77 (0.09)</td>
</tr>
<tr>
<td>Large</td>
<td>0.84 (0.1)</td>
<td>0.78 (0.09)</td>
</tr>
</tbody>
</table>

Table 2. Results from the four conditions on the novel PA matching task. Results reveal no significant effect of group for any of the conditions.
Interaction between grain size and lexicality

A repeated measures ANOVA that compared means within group for two variables (lexicality and grain size) revealed a significant effect of grain size ($p < 0.005$) and a significant interaction between grain size and lexicality ($p < 0.005$) for the compensated dyslexia group (see Figure 2). The same comparison for the control group only revealed a significant effect of grain size ($p < 0.001$), but not lexicality or an interaction.

![Figure 2. Comparison of grain size and lexicality for the two experimental groups. For the compensated dyslexia group, there was a significant effect of grain size ($p < 0.01$), no significant effect of lexicality, and a significant interaction between grain size and lexicality ($p < 0.005$). For the control group, there was only a significant effect of grain size ($p < 0.001$).](image-url)
Correlations between reading tests and the PA matching task

For the control group, there was one significant negative correlation between standardized reading tests and accuracy on one of the PA matching task conditions, specifically GORT Fluency and real word large grain ($r = -0.726, p < 0.05$) (see Table 3). For the group of adults with compensated dyslexia, however, there were multiple significant positive correlations (see Table 3), including real word small grain and sight word efficiency ($r = 0.816, p < 0.01$), real word small grain and phonemic decoding efficiency ($r = 0.915, p < 0.01$), real word small grain and the GORT-5 reading index ($r = 0.683, p < 0.05$), and real word small grain and the GORT-5 fluency ($r = 0.808, p < 0.01$).

### Table 3

<table>
<thead>
<tr>
<th>Standardized Reading Measure</th>
<th>SWE</th>
<th>PDE</th>
<th>GORT Reading Index</th>
<th>GORT Fluency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No Dyslexia (Controls)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RW Small</td>
<td>-0.273</td>
<td>-0.208</td>
<td>-0.213</td>
<td>-0.607</td>
</tr>
<tr>
<td>RW Large</td>
<td>-0.608</td>
<td>-0.615</td>
<td>-0.342</td>
<td><strong>-0.726</strong></td>
</tr>
<tr>
<td><strong>Compensated Dyslexia</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RW Small</td>
<td><strong>0.816</strong></td>
<td><strong>0.915</strong></td>
<td><strong>0.683</strong></td>
<td><strong>0.808</strong></td>
</tr>
<tr>
<td>RW Large</td>
<td>-0.224</td>
<td>-0.099</td>
<td>0.442</td>
<td>0.211</td>
</tr>
</tbody>
</table>

*p<0.05 corrected, **p<0.01 corrected, ***p<0.001 corrected

Table 3. Results from the correlation analyses for standardized reading measures and PA matching task accuracy. The group of adults with compensated dyslexia had multiple significant positive correlations between reading measures and the real word small grain condition. The control group had one significant negative correlation between reading fluency and the real word large grain condition.
Post Hoc Analysis of GPA, Reading and PA skill, and PA Matching Accuracy

A post hoc analysis was conducted to determine if GPA correlated with any of the standardized measures of reading, PA skill, or accuracy on the PA matching task. For this analysis, statistical testing was run on each group separately. For the control group, none of the standardized tests nor accuracy on any of the PA matching task conditions was significantly correlated with GPA. For the adults with compensated dyslexia, one standardized measure was found to have a significant positive correlation with GPA, specifically, TOWRE SWE ($r = 0.677$, $p < 0.05$). In contrast, the relationship between TOWRE SWE and GPA for the control group was not significant ($r = -0.377$, $p = 0.514$) (see Figure 3).

![Figure 3. Sight Word Efficiency (SWE) and Grade Point Average (GPA). For the control group, the relationship between sight word efficiency (SWE) and grade point average (GPA). Of the eighteen participants, only fifteen provided their grade point average for the study. For the adults with compensated dyslexia, there was a significant positive correlation between SWE and GPA; however there was no correlation for the controls.](image-url)


Discussion

The primary aims of this study was to determine if there were differences between accuracy on the novel PA matching task between adults with and without dyslexia. Because our entire dyslexia group scored in the low average range, this study compared adults with and without compensated dyslexia. Results revealed no significant group differences between the control group and the adults with compensated dyslexia for either grain size or lexicality; however, there were differences when grain size and lexicality effects were compared within groups. Both groups showed a significant effect of grain size, but the adults with compensated dyslexia also showed a significant interaction between grain size and lexicality. The pattern of accuracies suggests that for the adults with compensated dyslexia, real words were more difficult when the target grain size was small, but helped when the target grain size was large. These findings are consistent with what we know about the consistency of large grain sizes in early learners. In early literacy, readers are more sensitive to large grain sizes because they are more consistent and easier to blend (Ziegler & Goswami, 2005). In this case, it is possible that familiarity with real word spelling patterns may have improved accuracy on the PA real word large grain trials, but lack of sensitivity to small grain units could not be improved with knowledge of real words. The lower accuracy on the small grain real word condition observed in the compensated dyslexia group, but not the controls, is consistent with findings that sensitivity to small grain size decoding is a problem in developmental dyslexia (Snowling, 1980).

Our third aim was to determine if performance on the novel PA matching task correlated with standardized measures of reading skill or PA. Interestingly, we found several significant positive correlations between the real word small grain condition and four measures of reading skill, but no such relationship was observed for the adults without dyslexia. There were no
correlations for the control group between the standardized tests and the phonological grain size matching task, however for the compensated dyslexia group there were several significant correlations between PA, reading, and accuracy on the PA task. There were significant correlations between the real word small grain condition and sight word reading (SWE) and phonemic decoding (PDE). We argue that these results show that the ability to manage small grain phonological representations correlates with the ability to recall real word graphemic representations (SWE). While our PA task did not require real word reading, it is likely that the ability to visualize real word representations provided self-cues to perform well on this condition. Visualizing real words may provide an opportunity to forgo decoding words. This correlation between real word small grain size matching and phonemic decoding is also consistent with what is known about the progression of development to small grin units. Increased sensitivity to smaller grain sizes follows the establishment of early reading skills and the ability to phonologically decode words depends on management of small grain units (Anthony et al., 2003). Since the adults with compensated dyslexia have lower PA skills (although some in the low average range), it is logical that performance on small grain PA conditions would be enhanced if phonological decoding is stronger.

There was also correlation for the real word small grain condition and the GORT-5 fluency. In reading, fluency is a measure of reading accuracy and speed. Sensitivity to small grain size decoding relates to multiple areas of reading skill including but not limited to fluency. The ability to decode words using small grain analysis strengthens decoding skills and increases accuracy, in turn increasing fluency.

Our post hoc analysis comparing test scores to GPA revealed an interesting effect for the compensated dyslexia group. While there was no significant difference in GPA between the two
groups, the relationship between reading and phonological measures and GPA was different between groups. The results demonstrated that for the compensated dyslexia group only, speed for accurately reading single words (SWE) did correlate to grade point average. While we expected that GPA might differ between groups and reading skill would correlate with grade point average, it seems that single word recognition may provide an advantage to adults with compensated dyslexia. It is important to note that a student’s grade point average can be influenced by multiple factors other than single word reading; however, these results do suggest that individuals with reading difficulties are capable of achieving average GPA’s potentially due to a reliance on compensatory reading skills. The correlation between SWE and GPA demonstrates that accurate and efficient sight word recognition may be a beneficial strategy for those with lower overall reading ability. While grade point average can be impacted by various factors, accurate single word recognition may play a role in academic achievement.

While not an aim of this study, we found it notable that there was not a significant difference between the control group and the adults with compensated dyslexia on the GORT-5 comprehension measure, but there were significant group differences for the GORT-5 accuracy and fluency measures. This result was unexpected because typically poorer performance on measures of accuracy and fluency would accompany lower comprehension. In other words, if the reader struggles to correctly decode or recognize words, then they should also struggle to derive meaning from the text and in turn, answer comprehension questions correctly. In previous studies, word recognition has been suggested as a strategy to improve comprehension (Ransby, Marilyn, & Swanson, 2003). It is possible that the participants in this study with a history of dyslexia have developed whole word recognition as a strategy to derive meaning from the text. If this is the case, this could partly explain the GORT-5 test results. Lower fluency can reflect
slower reading, but not necessarily less accurate reading. Participants in the compensated dyslexia group read at a slower rate than the controls and this may partly account for how comprehension scores were not significantly different from the control group. More time to decode, comprehend, and store information into working memory may have strengthened reading comprehension performance in the participants with compensated dyslexia despite lower accuracy. Further, lower accuracy could reflect lower overall accuracy, but perhaps enough whole words were correctly recognized such that comprehension is maintained at a higher level than measured by GORT-5 accuracy. We suggest that while lower accuracy and fluency scores on the GORT-5 may influence comprehension, they do not necessarily predict comprehension performance.

Previous research suggests that individuals with dyslexia may nurture small grain size decoding skills more so than readers without dyslexia (Ziegler & Goswami, 2005) and focusing on smaller grain size units has been suggested as a compensatory reading strategy. A focus on smaller grain units may provide adults with dyslexia and/or compensated dyslexia with improved accuracy for single word decoding and recognition. Because the adults with compensated dyslexia in this study achieved similar accuracies on small grain size conditions compared to the controls, it is possible that having higher skill with smaller grain size units does improve reading such that performance on standardized measures can reach the average range even in individuals with a history of dyslexia.

It is worth noting that the original plan for this study was to test adults with dyslexia and when tested, these adults who identified (or were previously tested) as having dyslexia scored in the average to borderline average range, meaning they more closely met the definition for compensated dyslexia. We suggest that testing a group of adults with scores that truly fall in the
range associated with dyslexia might reveal different results. We predict that such a group would show lower scores on all PA matching task conditions.

**Conclusion**

The current study revealed that while adults with compensated dyslexia had lower accuracies on a novel PA matching task, they did not perform significantly lower than the adults without dyslexia. Adults with compensated dyslexia also showed correlations between small grain conditions and standardized measures of reading, whereas the controls did not. This suggests that perhaps there is something fundamentally different in the relationship between PA skill and reading in adults with a history of reading difficulty. This may be due to the use of compensatory strategies, such as a use of whole word recognition, slower reading, or a focus on small grain decoding.

As previously stated, growth in orthographic skills via whole word recognition may compensate for an underlying deficit in phonological decoding. Such strategies impact a reader’s ability to perform well in multiple areas of testing. Future studies should aim to determine if the use of small grain size tasks as practice for strengthening reading skill could improve both speed and accuracy in adults with dyslexia.

Individuals with a history of dyslexia are capable of performing in the average range on standardized tests. Of the participants with lower reading skills, 55% performed in the average range on the GORT-5 standardized tests while the other 40% performed just below the average range. In other words, their reading index (the combination of their fluency and comprehension scores) was in the average range. While scoring in the average range is a positive demonstration of reading skill, it can also prevent a student from receiving academic services. Testing in the
average range does not indicate the individual no longer has dyslexia, only that they are capable of scoring in the same range as their peers. The use of a phonological matching task that manipulates grain size may be an effective tool in strengthening PA and reading skill. Further, such an intervention could provide benefits to adults with dyslexia who are denied intervention or accommodation services despite continuing to struggle. Future studies should determine if practicing a phonological matching task that manipulates grain size provides benefits to adults with persistent reading difficulties. Including adults without dyslexia and with compensated dyslexia illuminated subtle differences in the relationship between grain size skill and reading. These results enhance our understanding of reading skill in adults and further explain the role of PA skill as it relates to reading beyond childhood.
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