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Morphological awareness and vocabulary predict reading resilience in adults

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Abstract
Resilient readers comprehend written language despite word reading deficits. The reading resiliency framework specifies candidate protective factors hypothesized to mitigate adverse effects on reading comprehension arising from phonological decoding deficiencies and, consequently, illuminates how some individuals exhibit relative reading resiliency. A focus on relative reading resiliency involves an examination of individual strengths and weaknesses because areas of relative strength can bolster one's abilities. The ability for morphological awareness and vocabulary to be strengths or protective factors contributing to reading resiliency was explored in a sample of university students. Morphological awareness is predicted to be a particularly important skill for university students due to the complexity of texts encountered in their coursework. A measure of word-level morphological awareness was positively associated with relative reading resiliency. Furthermore, across norm-referenced and standardized high-stakes testing measures of reading comprehension, vocabulary mediated the impact of morphological awareness on comprehension after controlling for phonological decoding ability. These findings suggest that morphological awareness and vocabulary skills are important contributing factors to reading comprehension and reading resilience.

Keywords Morphological awareness · Reading resilience · University students · Vocabulary

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Introduction

Reading ability varies considerably across individuals along multiple domains of word reading and comprehension skills. The reading resiliency framework outlines candidate domain-general cognitive factors, aspects of language, and socioemotional factors that contribute to this heterogeneity in reading ability with a focus on identifying factors that serve to buffer against reading comprehension deficits that can emerge when individuals struggle to read words (Haft et al., 2016). It highlights the multidimensionality inherent to reading and the continuum of reading ability and, by doing so, specifies candidate factors that can be levered to improve the overall reading outcomes for students who struggle to read words. In this way, the reading resilience framework is similar to theories that discuss the multiple or cumulative risk and protective factors that may emerge in individuals with dyslexia (Catts et al., 2017; Pennington et al., 2012). However, the focus is on conceptualizing reading resilience as an index that encompasses an individual's ability to comprehend text while accounting for potential deficits in word recognition.

In particular, the concept of a resilient reader has evolved from the notion of a compensated dyslexic (Cavalli et al., 2017b; Lefly & Pennington, 1991; Scarborough, 1984), and the reading resiliency index was designed to identify individuals for whom reading comprehension is relative strength in relation to phonological decoding. Moreover, the reading resiliency index and overall reading resilience framework fit within and borrows from more expansive process models of reading comprehension (Perfetti & Stafura, 2014; Vellutino et al., 2007). However, the reading resilience framework focuses on a specific subset of readers—those individuals falling along the continuum of struggling readers who would be labeled with characteristics of dyslexia. The resiliency framework specifies candidate factors that may promote resiliency in these individuals in an effort to identify factors that can be leveraged through prevention and intervention efforts to reduce the overall severity of dyslexia across the lifespan. Towards this end, the current study explored the relative contribution of vocabulary and morphological awareness in predicting a reading resiliency index in a sample of university students with a diverse range of reading abilities.

Reading resiliency and other theories of reading comprehension

The reading resiliency framework emerges from well-established component process models of reading, such as the simple view of reading (Gough & Tunmer, 1986), the convergent skills model (Vellutino et al., 2007), and the lexical quality hypothesis with its related reading systems framework (Perfetti, 2007; Perfetti & Stafura, 2014). The motivation for this study focused specifically on both vocabulary and morphological awareness emerged directly from these larger perspectives. For example, the lexical quality hypothesis specifies text comprehension as being supported by a mental lexicon, which provides an interface for connections between word identification (i.e., orthographic and phonological representations) and comprehension of the word's meaning (i.e., semantic knowledge; Perfetti & Stafura, 2014; Perfetti, 2007). Lexical level semantic knowledge is comprised of the related components of word meaning (i.e., vocabulary) and the meaning of discrete units within a word (i.e., morphological knowledge).

Moreover, for morphologically complex words, the similarity in the lexical representations (i.e., orthographic, phonological, and semantic properties) of a base word and related polymorphemic words impacts the extent to which exposure to each word influences a person's ease of identifying the other word (Reichle & Perfetti, 2003). Lexical level semantic knowledge influences language comprehension, word reading ability, and the learning of new words. The reading resiliency framework also predicts a relative strength in lexical level semantic knowledge, broken down as vocabulary and morphological awareness (MA) for the current study. Strengths in these skills may allow an individual to compensate for struggles with word pronunciation (i.e., poor phonological representations).

Furthermore, empirical studies illustrate that although phonological decoding is especially crucial for reading comprehension early in development, oral language comprehension plays a growing role as text complexity increases (Foorman et al., 2018; Holahan et al., 2018; Nation, 2019). Estimates suggest that by third grade, more than half of the words students encounter have multiple morphemes (Nagy et al., 2013; Nagy & Anderson, 1984). As students progress to college, they are expected to begin to master general and discipline-specific academic language to convey abstract and technical ideas characterized by using a high proportion of lengthy and morphologically complex words (Nagy & Townsend, 2012). Therefore, both morphological awareness and vocabulary seem to be prime candidates to aid individuals who have decoding weaknesses with comprehending text motivating their selection for use in the current study.

Vocabulary and morphological awareness as strengths

Prior studies have shown that vocabulary knowledge can, but may not always, uniquely contribute to interactions between word recognition and reading comprehension abilities (Braze et al., 2016; Perfetti & Stafura, 2014). Although vocabulary knowledge involves knowledge of the meanings of words and MA involves a conscious awareness of the meaning units (i.e., roots and affixes) within words, these two constructs are distinct, at least in adults (Tighe & Schatschneider, 2015). Across adult and child populations, studies have observed direct and indirect relationships between MA and comprehension abilities (Cavalli et al., 2016; Gilbert et al., 2013; Guo et al., 2011; Law et al., 2015; Nagy et al., 2013; Wilson-Fowler & Apel, 2015).

In particular, using a sample of English-speaking young adult public university students, Guo et al. (2011) observed a model with direct paths from MA and syntactic awareness to reading comprehension as well as an indirect path for syntactic awareness to comprehension through vocabulary to be the best fit to their data. These authors included norm-referenced standardized measures of receptive and expressive vocabulary. However, their experimental measure of MA primarily examined knowledge of appropriate morphological inflections within sentence frames. Similarly, Wilson-Fowler and Apel (2015) administered three measures of MA to university students and used data-driven item response theory analyses to obtain the final items. Their MA measure presented participants with sentence frames and either a base word from which a correct response could be derived or four pseudowords with real suffixes. MA performance was positively associated with spelling, word reading, and sentence comprehension scores, and indirect effects of MA on sentence comprehension were observed when either spelling or word reading were entered into the model as mediators. Both of these studies measured MA using tasks that provided participants with contextual cues. MA measures that do and do not involve cues from sentence frames appear to be measuring the same underlying construct (Tighe & Schatschneider, 2015). However, measures may vary in test item complexity—such as the number of morphemes and the presence of orthographic and phonological shifts found in a derivation form of a word. Thus, the current study included both word and sentence-level MA measures.

Why study reading resiliency in university students?

Extending these studies, the current study also recruited university student participants while focusing on reading resilience. While the word resilience is used, it is essentially looking at individual differences in strengths and weaknesses with attention focused on the strengths which may be allowing some individuals to compensate for their weaknesses in other areas. Moreover, it is used within the context of the largest documented profile of struggling readers—those whose struggles include word reading deficits that first emerged as the result of deficits in phonological decoding. The college-age population is vital to study not only because these individuals regularly interact with complex texts, but also because only 37% of US 12th graders in 2015 performed at or above a proficient level in reading (National Association for Educational Progress [NAEP], 2017). Chen (2016) indicates 11% of students who entered public 4-year universities in 2003–2004 took a remedial English or Reading course between 2003 and 2009. Among college students who completed remedial courses, those who were rated as weak in their college preparation (academic preparedness was based on high school grade point average, college admission test scores, and the highest level math course taken in college) were more likely to graduate college than weakly prepared students who did not take remedial courses. Furthermore, the National Center for Education Statistics (2019) indicated the graduation rate for first-time, full-time bachelor's degree-seeking students at 4-year postsecondary institutions was 38.8%, and 64% finished within 6 years. This number drops to 48.2% for post-secondary students (2012 cohort) in the state of Tennessee (Tennessee Higher Education Commission, 2019), where the current sample was obtained. Such findings indicate a significant proportion of individuals entering universities do not finish, likely due to a host of contributing factors, including many outside the scope of this paper.

Importantly, taken together, the data summarized above suggest many university students are at risk of not having sufficient mastery of the knowledge and skills in reading needed to succeed academically. In other words, many university students likely struggle to read. However, to matriculate as university students in the USA, they demonstrated basic skills on a college entrance exam and had a minimum grade point average leaving high school. These realities suggest this population of individuals should be well suited for our purposes because it is possible to obtain a heterogeneous sample of individuals varying in the extent of their strengths and weaknesses across reading skills. We focus on strengths as relative reading resiliency rather than absolute resiliency. In other words, we examined individual differences across literacy skills suggestive of protective factors even if overall performance on any individual measure may not cross the threshold from below average into the average range. Moreover, when recruiting students from a public regional university, the resulting sample will likely include some individuals who are compensated dyslexics, and other individuals who also have a reading disability but may not have ever been formally identified as such during their schooling. Understanding what factors give rise to relative strengths in reading is important to consider as we strive to retain and matriculate all students through their university experience.

Limited research has explored strengths such as reading resiliency in college-age students and the role that vocabulary and MA may have in fostering it (Cavalli et al., 2016, 2017a, b; Law et al., 2015). The studies in this area suggest MA skills may contribute to an individual's reading comprehension abilities. However, they were conducted by comparing performance between adult individuals who had and had not been previously identified with dyslexia, the word level variant of reading disability, in primary school. Although such group comparisons through quasi-experimental designs provide a wealth of information and the ability to test theories, they have limitations. In particular, when individuals are separated into groups based on differences in an attribute, a decision must be made about the cut-points used to determine if a given individual does or does not exhibit that attribute. Here the attribute of interest is reading ability, and it has proven to be very challenging to determine meaningful and stable cut-points to create groups of individuals differing in their reading ability (Francis et al., 2005; Miciak & Fletcher, 2020; Stuebing et al., 2002).

Alternatively, reading ability can be explored as the continuous construct that it is. In this regard, Patael et al. (2018) developed and used two conceptually parallel continuous measures of relative reading resiliency, a discrepancy index calculated by subtracting phonological decoding scores from reading comprehension scores, and a standardized residual score for reading comprehension that partials out the shared variance from phonological decoding. These researchers observed both continuous measures of reading resiliency to be positively correlated with gray matter volumes in the left dorsolateral prefrontal cortex, areas associated with working memory and cognitive control. Furthermore, a magnetoencephalography study observed morphological priming to be associated with greater left inferior frontal activity in adults with than without dyslexia (Cavalli et al., 2017a). Although vocabulary and MA are also proposed to play protective roles in promoting reading resilience (Haft et al., 2016), the metrics developed by Patael et al. (2018) have not yet been used to investigate the impact of those linguistic factors.

Current study

The current study addresses this gap in the literature by examining the performance of college students who completed a battery of reading and literacy tasks. The student's data obtained in the lab was supplemented with their college entrance exam scores. The college entrance exam was a high-stakes testing situation that provided scores for reading comprehension and understanding science-based texts, which required the student to summarize or interpret data. These high-stake general and domain-specific reading comprehension scores were based on performance on multiple-choice questions. They were examined along with scores from a norm-referenced reading comprehension test that used a cloze-type procedure. Importantly, in line with previous calculations (Patael et al., 2018), the participant's phonological decoding scores were partialled out using linear regression from each of their three reading comprehension scores to obtain continuous measures of relative reading resiliency for each participant. Additionally, we examined versions of the relative reading resiliency metrics that used either an untimed or a timed measure of phonological decoding. Our sample contained English speakers. This makes performance on untimed word and non-word reading tasks potentially more informative than they are in languages with a more transparent orthography where timed measures are primarily used to show deficits in individuals with dyslexia. In all, there were six variations of the relative reading resiliency metric that could be explored with the data we had available to us. Furthermore, the alternate version of the relative reading resiliency metric that used subtraction of phonological decoding from comprehension to obtain a discrepancy measure was also examined and is reported in the supplemental material.

The reading resiliency framework and related work by others (e.g., Cavalli, et al., 2017a, b; Elbro & Arnbak, 1996; Law et al., 2015; Law et al., 2018; van Viersen et al., 2019) lead to the hypothesis that relative strength in MA could allow an individual to compensate for weak decoding skills. Furthermore, we hypothesized that among university students, targeted measures of vocabulary and MA might be more strongly associated with relative reading resiliency than a broad measure of oral language ability, such as a listening comprehension score. Thus, the goal of the study was to understand better the role of MA in a sample of college students using the reading resiliency model as the metric under investigation. Two research questions were explored. First, can MA, vocabulary, and listening comprehension skills serve as protective factors predicting relative reading resiliency for a college student population? To address this question, we conducted a set of multiple regression analyses to examine the ability to predict relative reading resiliency from these potential protective factors. Second, do vocabulary skills mediate the relationship between MA and reading comprehension? To address this question, we conducted a series of mediation analyses.

Method

Participants

Eighty-four undergraduate students (54 female) at a public regional university in the Southeastern United States with an undergraduate population of approximately 20,000 students participated in the current study for course credit and had complete reading test data. The participants were native English speakers and between 18 and 45 years old (M = 20.51, SD = 3.92) at the time of testing, which occurred over three separate semesters. The participant's relative standing at the university was collected as follow-up information one to two years post data collection to characterize the sample, but not included in the primary analyses given the differences in time elapsed from data collection to follow-up across individuals. The follow-up information revealed participants had completed 0–213 course credits (M = 72.81, SD = 38.62) and had grade point averages (GPAs) ranging from 1.54–4.00 (M = 3.02, SD = 0.62). GPA information was not obtained from three participants who were in their first semester at the university and two participants who completed study tasks but declined to allow researchers access to their academic records.

Materials

Listening comprehension Listening comprehension was assessed using the listening comprehension subtest from the Woodcock Reading Mastery Test (WRMT-III; Woodcock, 2011). Each participant listened to passages played on an audio CD and responded aloud to orally presented questions about the passage contents. Reported split-half reliability ranges from .70 to .93 across test forms within the age range of the participants in this study (Woodcock, 2011).

Vocabulary Vocabulary skills were measured using the word comprehension subtest from the WRMT-III (Woodcock, 2011). Reported split-half reliability ranges from .91 to .95 across test forms within the age range of the participants in this study (Woodcock, 2011). This subtest has three sections and results in a single score. Participants were asked to provide antonyms, or synonyms, to target words, or to provide a word to complete an analogy based on a provided word-pair relationship. Joshi (2005) suggested such recall-based tasks may provide more reliable measures of vocabulary knowledge than recognition-based tasks using a multiple-choice format.

Real word reading The participant's real word reading ability was measured using the word identification subtest from the WRMT-III (Woodcock, 2011). The task was untimed and contained a list of words presented in a stimulus book for the participant to read aloud. The sight word efficiency subtest from the Test of Word Reading Efficiency (TOWRE-2; Torgesen et al., 2012) provided a timed measure of isolated real word reading.

Phonological decoding The participant's phonological decoding ability was measured using the word attack subtest from the WRMT-III (Woodcock, 2011). In this untimed task, the participant pronounced aloud a list of pseudowords. The phonemic decode efficiency subtest from the TOWRE-2 (Torgesen et al., 2012) provided a timed measure of phonological decoding ability.

Composite word recognition Composite scores that combine the real word reading and pseudoword decoding measures from the WRMT-III and TOWRE-2 were obtained and are also reported in Table 1. These composite scores provide an untimed (WRMT-III Basic Skills) and timed (TOWRE-2 Total Word Reading) measure of word recognition abilities that incorporates both the real word and pseudoword measures from their respective instruments. The reported split-half reliability for the individual subtests (real word reading and phonological decoding) and associated composite (basic skills) for the WRMT-III range from .71 to .92 across test forms within the age range of the participants in this study (Woodcock, 2011). Reported test-retest reliability from the TOWRE-2 manual for the individual subtests (sight word efficiency and phonemic decode efficiency) and associated composite (total word reading) range from .90 to .93 (Torgesen et al., 2012).

Morphological awareness The participants completed three tasks to measure their morphological awareness, a *morpheme counting task*, a *derivation task*, and a *decomposition task*. The scores used for these tasks are the total number of correct responses, whereas scores for other measures collected in this study are the standard scores obtained from those norm-referenced instruments. The *morpheme counting task* is a computerized task in which participants saw a

Table 1 Descriptive statistics for literacy tasks

Measures	*M*	*SD*	Skew	Kurtosis	Range
Listening comprehension (SS)	92.5	13.2	−0.41	−0.28	55–115
Word comprehension (SS)	93.9	13.7	−0.40	−0.63	62–118
Real word reading (SS)	94.2	12.6	−0.06	0.45	55–129
Phonological decoding (SS)	90.8	16.5	−0.04	−0.58	55–123
Basic skills composite (SS)	91.98	13.9	−0.05	−0.19	55–123
Sight word efficiency (SS)	99.5	11.2	0.50	0.44	75–130
Phonemic decode efficiency (SS)	98.5	11.9	−0.61	1.20	60–125
Total word reading composite (SS)	99.0	10.9	0.19	0.92	67 - 127
Derivation (no. correct)	9.2	2.3	−0.93	1.84	0–13
Decomposition (no. correct)	12.9	2.9	−0.98	1.21	2–17
Morpheme counting (no. correct)	18.6	5.6	−0.48	−0.51	6–28
Passage comprehension (SS)	97.2	13.5	−0.26	−0.81	70–128
ACT Read	22.9	5.3	0.49	−0.50	15–36
ACT Science	22.2	3.9	0.18	−0.40	12–33

Note. SS, standard score. Scores from the three MA measures (derivation, decomposition, and morpheme counting) are the number of correct responses word on a screen and identified the number of morphemes present. Following 10 practice items that included corrective feedback, there were 60 task trials presented in random order. The words varied in whether they contained 1–4 morphemes with 15 words presented at each length across the trials. Scores were obtained by summing the number of correct responses across all 60 task trials. The reliability of this measure in the current sample of $N = 84$ college students was $\alpha = .82$. For a full description of the task, a list of the items, and full validity information, see Bernstein et al. (2020).

The Test of Morphological Structure – revised (TMS-R) is a 30-item measure developed from Carlisle's Test of Morphological Structure (Carlisle, 2000; Cooper, 2017) with lower frequency words suitable for older students. The reliability of this measure for a sample of high school students was $\alpha = .83$–$.85$ (Cooper et al., 2015). The test measures knowledge of base and derived forms with two tasks: *derivation* and *decomposition*. Participants were instructed to add (derive) or remove (decompose) a suffix from a word to make it fit the sentence. Individual items were scored as correct (1) or incorrect (0), and the number of correct responses was calculated for each task.

Reading comprehension Reading comprehension was also assessed in three ways. In the lab, participants completed the passage comprehension subtest from the WRMT-III that required them to read a passage and identify the missing word in the passage (cloze format). The reported split-half reliability for this subtest is .83 to .91 (Woodcock, 2011). Additionally, participants granted consent to research personnel to access their most recent American College Test (ACT, 2018) reading and science scores from their college admission records. Both ACT subtests reported in this study involve the participant being given 35 minutes to respond to 40 items. Cronbach's alpha inter-item reliability coefficients for the ACT subtests administered in the 2018–2019 academic year ranged from .84 to .89 (ACT, 2020).

The *ACT reading* subtest measures reading comprehension through the ability to get meaning from texts explicitly and implicitly (ACT, 2018). Students read a series of four passages that are roughly 700–900 words long and respond to multiple-choice questions after each passage. Some passages are fiction or nonfiction narratives, and others present informational text. The *ACT science* subtest measures a person's ability to analyze, reason, and problem-solve (ACT, 2018). Students read passages relating to science topics that may be covered in freshman-level college courses. The passages are often accompanied by a graphic, such as a chart or a table. For each passage, they respond to multiple-choice questions that require the student to synthesize the information read. These ACT scores are reported as scaled scores for each area and range from 1 to 36, with high scores reflecting better performance. Information reported on the university's office of institutional effectiveness webpage indicates that the average ACT Reading and Science scores for new incoming freshman were 22.7 and 22.0 in the academic year in which the study data were obtained. Table 1 illustrates that the mean ACT scores obtained in our sample of participants were similar to the mean ACT scores obtained by all students entering the university.

Procedures

Participants were recruited through the psychology department participant pool which primarily relies on students within introductory psychology courses open to all majors. After providing informed consent, participants completed a battery of individually administered tasks in a single session. Standard scores utilizing age-based norms, or the number of correct responses were obtained for each measure. Table 1 provides the performance for this sample on each measure using the original scales, whereas analyses addressing the research questions used z-scores to allow for an easier comparison across scores obtained on different scales.

Data analysis

Table 1 provides the performance for the full sample for whom there was complete data (N = 84) across all measures. There was somewhat of a negative skew observed for some scores; however, this is not entirely unexpected for a college-age sample from a regional public institution. Individual participants who scored outside of three standard deviations of the mean on multiple measures were identified as potential outliers. This resulted in the identification of two participants. One participant received extremely low scores for both the real word reading and phonological decoding untimed measures, and another participant received extremely low scores for all three morphological awareness measures (i.e., derivation, decomposition, and morpheme counting). Analyses reported in the "Results" section were repeated excluding these two individuals and there was no change in the pattern of results. The purpose of this study is to examine relationships amongst individual literacy skills within a sample with a diverse range of reading abilities. The interest, in particular, is whether some individuals will exhibit strengths or resiliency in the form of relatively preserved abilities in some areas despite evidence of weaknesses in other areas; thus, all 84 individuals were included in the analytic sample. Scores from each MA task were converted to Z scores to put them on the same scale, as were the standard scores from the norm-referenced measures, and the scaled scores from the ACT. These Z scores were used in the calculation of relative reading resiliency metrics, and when individual scores were used as predictors in statistical analyses to address the research questions.

Relative reading resiliency metrics The metrics for relative reading resiliency were based on the operational definition from Patael et al. (2018). The term *relative reading resiliency* is used to clarify that discussions and analyses are not restricted to only individuals who have obtained at least average range scores on standardized instruments. Rather, the focus is on how all individuals can exhibit strengths indicative of relative reading resiliency. Given three measures of reading comprehension were available, three sets of relative reading resiliency metrics were calculated and later analyzed in separate models addressing both research questions. Patael et al. (2018) operationally defined reading resiliency in two ways using a measure of comprehension and a measure of phonological decoding. They calculated the standardized residual scores for the reading comprehension measure that were obtained for each participant from a bivariate linear regression with phonological decoding as the sole predictor, a more statistically sophisticated metric, and they subtracted phonological decoding from reading comprehension to obtain a discrepancy or difference score.

For each of our three reading comprehension measures (i.e., Passage Comp, ACT Read, and ACT Science), we created a relative reading resiliency metric using residual scores from a series of bivariate linear regression models in SPSS v. 26. Furthermore, we calculated separate relative reading resiliency metrics using the untimed and timed measures of pseudoword reading (i.e., phonological decoding, and phonemic decode efficiency). Thus, for each research question, separate analyses were conducted with each reading comprehension measure used in the creation of the relative reading resiliency metric. Then, for each of these metrics, we examined both versions (i.e., the residual score with untimed phonological decoding, and the residual score with timed phonemic decode efficiency). Table 2 reports the descriptive statistics and inter-correlations for each of these six total relative reading resiliency metrics. The scores for each metric ranged from −2.60 to 3.19 and had a mean skew of 0.22 and a kurtosis value of −0.14. The supplemental material reports analyses using the alternate calculation of the reading resiliency metrics created using the discrepancy scores obtained via subtraction, whereas the results in the main text below used the residual scores.

These resiliency metrics may be considered somewhat limited because they focus only on the phonological decoding aspect of word recognition. The normative instruments used in this study provide composite scores for word recognition that combine information from the individual subtests that used pseudowords or real words (i.e., the Basic Skills score from the WRMT-III and the Total Word Reading score from the TOWRE-2). These composite scores are provided in Table 1. As anticipated based on their construction, in Tables 3 and 4, there are positive bivariate correlations amongst the individual subtests measuring word reading abilities using real and pseudowords and their associated composite scores. Furthermore, looking across the timed and untimed measures of word recognition (i.e., the four individual subtests and the two composite scores), the bivariate correlations between any pair of word recognition scores are significant at $p < .01$ and range from .45 to .93. The analyses addressing the research questions that are described below were repeated using these composite measures of word recognition. Overall, the pattern of results did not change when the overlapping variance in decoding and real word reading is allowed to be part of the relative reading resiliency metric itself.

Research question 1 The first research question examines whether morphological awareness and vocabulary serve as protective factors predicting relative reading resilience. This question was addressed using a separate multiple linear regression model in SPSS v. 26 when each of the relative reading resiliency metrics served as the outcome variable. When the relative reading resiliency metric used the untimed measure of phonological decoding, the untimed measure of real word reading was included as a predictor, whereas when the relative reading resiliency metric used the timed measure of phonemic decode efficiency, the timed measure of sight word efficiency was included as a predictor. All other predictors were the same across all models and included word comprehension (representing vocabulary), listening comprehension, and MA as assessed with the morpheme counting, derivation, and decomposition tasks. We expected all tests of MA, vocabulary, and listening comprehension to be significant predictors of relative reading resilience. Tables 3 and 4 provide the initial correlation matrices amongst these sets of variables. The overwhelming majority of these bivariate correlations are positive. Given that each regression model has six predictors, a Bonferroni correction for

Table 2 Descriptive statistics and correlations for the relative reading resiliency measures

Variable	*M*	*SD*	1	2	3	4	5	6
1. Passage comp residual phonological decoding	0.0	1.0	—					
2. ACT read residual phonological decoding	0.0	1.0	.54	—				
3. ACT science residual phonological decoding	0.0	1.0	.50	.72	—			
4. Passage comp residual phonemic decode efficiency	0.0	1.0	.97	.53	.48	—		
5. ACT read residual phonemic decode efficiency	0.0	1.0	.52	.97	.69	.56	—	
6. ACT science residual phonemic decode efficiency	0.0	1.0	.48	.70	.98	.51	.73	—

Note. All relative reading resiliency measures were calculated using Z scores. All correlations are significant at $p < .01$

Table 3 Correlation matrix using Z scores for all variables when relative reading resiliency residual measures use phonological decoding

Variable	1	2	3	4	5	6	7	8	9	10	11
1. Reading resiliency (passage comp)	—										
2. Reading resiliency (ACT read)	.54**	—									
3. Reading resiliency (ACT science)	.50**	.72**	—								
4. Listening comp	.47**	.40**	.41**	—							
5. Word comp (vocabulary)	.60**	.50**	.50**	.63**	—						
6. Real word reading	.39**	.32**	.26*	.43**	.65**	—					
7. Derivation	.45**	.36**	.41**	.50**	.64**	.56**	—				
8. Decomposition	.43**	.30**	.38**	.50**	.67**	.45**	.67**	—			
9. Morpheme counting	.57**	.32**	.40**	.54**	.63**	.42**	.47**	.51**	—		
10. Phonological decoding	.00	.00	.00	.15	.35**	.66**	.28*	.27*	.17	—	
11. Basic skills composite	.18	.16	.12	.29**	.52**	.88**	.43**	.38**	.30**	.93**	—

Note. Resiliency metrics calculated using untimed phonological decoding scores. The results using the residual scores are shown below the diagonal

**p* < .05, ***p* < .01

multiple comparisons indicates that a given predictor would need an alpha less than .008 to be considered significant.

Research question 2 To address the second research question, mediation analyses were conducted using the JSmediation package in R (Yzerbyt et al., 2018) with the indirect effects examined through joint significance testing and a Monte Carlo simulation using 5000 samples to obtain 95% confidence intervals. This approach is suggested to provide a good balance between statistical power and control of type I error rates (Yzerbyt et al., 2018). Similar to the analyses conducted to address the first research question, separate mediation models were

Table 4 Correlation matrix using Z scores for all variables when relative reading resiliency residual measures use phonemic decode efficiency

Variable	1	2	3	4	5	6	7	8	9	10	11
1. Reading resiliency (passage comp)	—										
2. Reading resiliency (ACT read)	.56**	—									
3. Reading resiliency (ACT science)	.51**	.73**	—								
4. Listening comp	.48**	.41**	.42**	—							
5. Word comp (vocabulary)	.63**	.54**	.53**	.63**	—						
6. Sight word efficiency	.05	.14	.06	.13	.35**	—					
7. Derivation	.47**	.40**	.44**	.50**	.64**	.22*	—				
8. Decomposition	.47**	.34**	.42**	.50**	.67**	.13	.67**	—			
9. Morpheme counting	.59**	.34**	.42**	.54**	.63**	.01	.47**	.51**	—		
10. Phonemic decode efficiency	.00	.00	.00	.13	.26*	.61**	.21M	.14	.07	—	
11. Total word reading composite	.03	.08	.04	.14	.34**	.89**	.24*	.15	.05	.90**	—

Note. Resiliency metrics calculated using timed phonemic decode efficiency scores. The results using the residual scores are shown below the diagonal

**p* < .05, ***p* < .01

conducted for each of the 6 relative reading resiliency metrics. In each model, the outcome variable was the relative reading resiliency metric using the residual operationalization; the independent variable was MA, represented by the Z score for morpheme counting; and the mediator was vocabulary, represented by the Z score for word comprehension.

Due to the relatively small sample size, a Monte Carlo power analysis simulation for the indirect effect with 5000 replications and 95% confidence intervals was conducted using the mc_power_med application in R (Schoemann et al., 2017). These post hoc power analyses estimated the power of our mediation models with 84 participants to be .91–.99 when the relative reading resiliency metric used residual scores regardless of which comprehension measure (i.e., Passage Comprehension, ACT Read, or ACT Science) and decoding measure (i.e., untimed phonological decoding or timed phonemic decode efficiency) were used in the calculation. This is in line with estimates from Fritz and MacKinnon (2007) (Table 3) for mediation models using bias-corrected bootstrapped samples. Their estimates indicate that when the coefficients for both the a and b paths (i.e., from the predictor to the mediator, and from the mediator to the outcome) are medium to large, as they are in our models, power of .80 may be obtained with a sample size of 54 people. Thus, given the size of the effects obtained, our models using the residual scores appear to be sufficiently powered.

Results

Presence of protective factors

The first research question addressed whether morphological awareness and vocabulary serve as protective factors predicting relative reading resilience. All regression models were significant ($p < .001$) and are summarized in Table 5.

Relative reading resiliency residual with phonological decoding Three models examined relative reading resiliency using a residual score that partialled out the relationship of the untimed measure of phonological decoding to each of the measures of reading comprehension. Relative reading resiliency calculated with passage comprehension scores was significantly predicted by the morpheme counting and word comprehension tasks. Both predictors were positive indicating that higher scores on morpheme counting and word comprehension were associated with greater reading resiliency. For both the models using ACT Read and the model using ACT Science, word comprehension was the single significant and positive predictor. However, across all three models, if a Bonferroni correction is applied to evaluate the significance of individual predictors (i.e., $p < .008$), then the ability for morpheme counting performance to positively predict relative reading resiliency with passage comprehension is the only marginally significant predictor ($p = .01$). Alternate models dropped the real word reading measure from the group of predictors and used the composite word recognition scores in the calculation of the relative reading resiliency residual metrics. The same pattern of results was observed in this set of models where the overlapping variance in decoding and real word reading was included in the calculation of the relative reading resiliency metric itself.

Relative reading resiliency residual with phonemic decode efficiency Three models examined relative reading resiliency using a residual score that partialled out the relationship of

Table 5 Summary of regression analyses predicting relative reading resiliency

Variable	Reading resiliency passage comp			Reading resiliency ACT read			Reading resiliency ACT science		
	B	*SE*	*t*	*B*	*SE*	*t*	*B*	*SE*	*t*
Residual phonological decoding									
Listening comp	0.08	0.12	0.69	0.15	0.13	1.15	0.11	0.13	0.87
Word comp	0.34*	0.16	2.19	0.45*	0.18	2.58	0.37*	0.17	2.10
Real word reading	−0.02	0.12	−0.19	−0.03	0.13	−0.24	−0.16	0.13	−1.21
Derivation	0.09	0.13	0.67	0.12	0.14	0.81	0.18	0.14	1.24
Decomposition	−0.05	0.13	−0.34	−0.13	0.15	−0.89	−0.02	0.14	−0.15
Morpheme counting	0.31**	0.12	2.65	−0.03	0.13	−0.20	0.10	0.13	0.80
Adjusted R^2	.38			.22			.24		
Residual phonemic decode efficiency									
Listening comp	0.04	0.11	0.39	0.12	0.13	0.91	0.08	0.13	0.62
Word comp	0.44**	0.15	2.94	0.50**	0.17	2.93	0.38*	0.17	2.23
Sight word efficiency	−0.13	0.09	−1.39	−0.06	0.11	−0.54	−0.12	0.11	−1.11
Derivation	0.09	0.12	0.79	0.12	0.14	0.84	0.14	0.14	1.06
Decomposition	−0.03	0.12	−0.24	−0.10	0.14	−0.70	0.01	0.14	0.03
Morpheme counting	0.27*	0.13	2.34	−0.04	0.13	−0.29	0.07	0.13	0.55
Adjusted R^2	.44			.25			.27		

Note. All models were significant at $p \leq .001$

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

the timed measure of phonemic decode efficiency to each of the measures of reading comprehension. After multiple comparison corrections, word comprehension was a positive predictor of relative reading resiliency using passage comprehension ($p = .004$) and ACT Read ($p = .005$). As observed with the models using untimed measures of word reading abilities, alternate models dropped the sight word efficiency measure from the group of predictors and used the composite total word reading score in the calculation of the relative reading resiliency residual metrics. Again, the same pattern of results was observed across these models. The models with the composite score allowed shared variance in pseudoword and real word reading efficiency to be part of the relative reading resiliency metric itself, rather than having one aspect of word recognition be part of the resiliency outcome variable and another aspect be represented as a predictor variable.

Mediation analyses

Relative reading resiliency residual with phonological decoding The model using the residual score for passage comprehension after accounting for untimed phonological decoding as the dependent variable is in Fig. 1A. The direct effect of MA on relative reading resiliency was significant ($\beta = 0.57$, $p < .001$, 95% confidence intervals CI [0.42, 0.74]). There was a partial mediation because the relationship between MA and relative reading resiliency was decreased but still significantly different from zero when the effect of MA on relative reading resiliency through vocabulary was controlled. The *a path* (MA to vocabulary) and *b path* (vocabulary to relative reading resiliency), as well as the indirect effect (*ab path*), were significant (all *p's* < .001), and the confidence interval for the indirect effect did not include zero. Thus, the relationship between a college student's MA and relative reading resiliency,

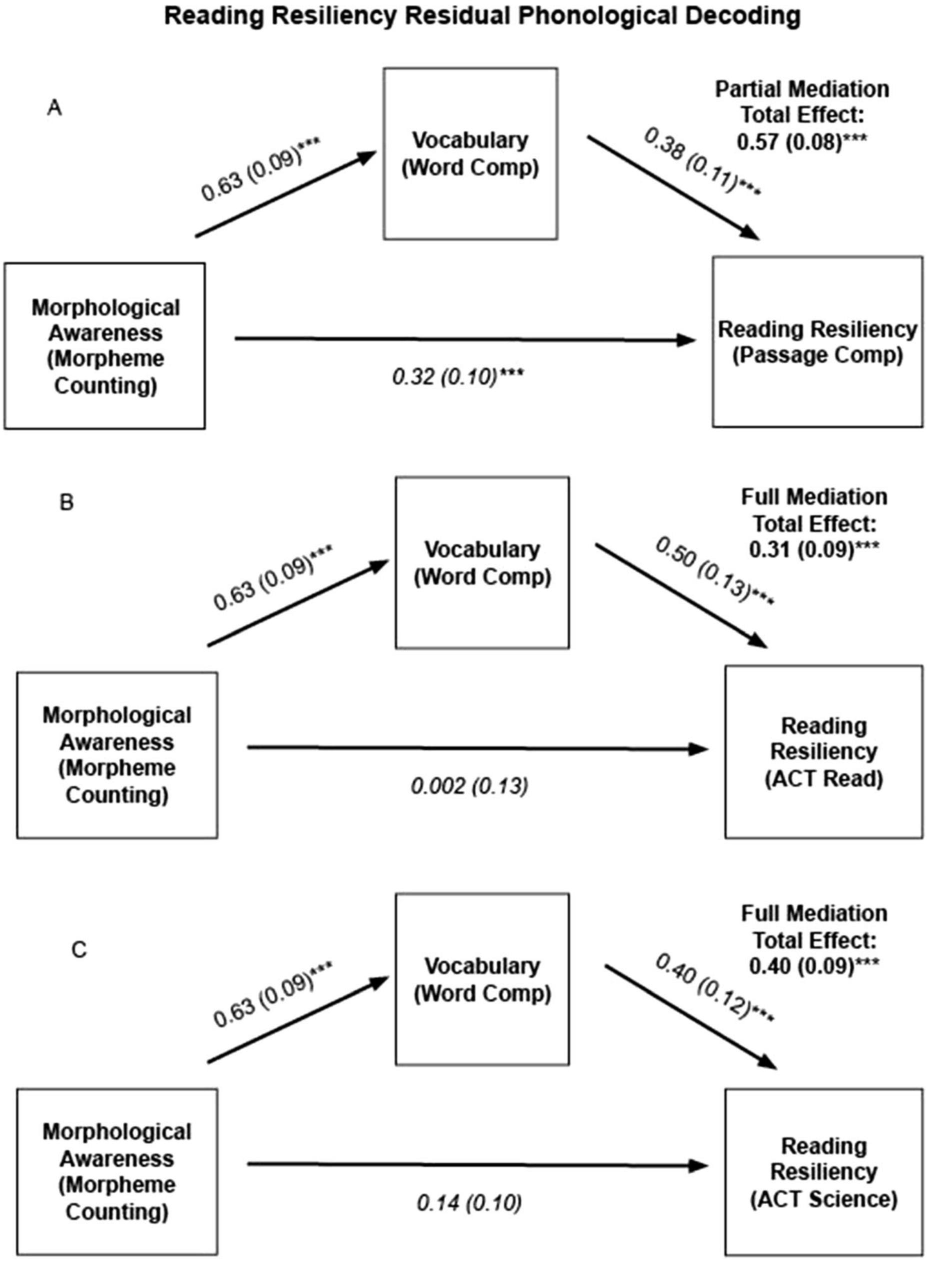

Fig. 1 Mediation analyses examining relative reading resiliency using residual scores controlling for phonological decoding. *Note*. Panel **A**: Passage Comp model has an indirect effect of 0.24, 95% CI [0.10, 0.40]. Panel **B**: ACT Read model has an indirect effect of 0.31, 95% CI [0.15, 0.50]. Panel **C**: ACT Science model has an indirect effect of 0.25, 95% CI [0.10, 0.44].*$p \leq .05$. **$p \leq .01$. ***$p \leq .001$

where the comprehension aspect of resiliency was assessed with a norm-referenced test utilizing a cloze procedure, depends on their vocabulary skills.

The second set of mediation analyses used the residual score for ACT Read after accounting for untimed phonological decoding as the dependent variable representing relative reading resiliency. The direct effect of MA on relative reading resiliency from ACT Read was significant ($\beta = 0.31$, $p < .01$, 95% CI [0.12, 0.54]). There was evidence for a full mediation because the relationship between MA and relative reading resiliency was no longer significant when the indirect effect was incorporated into the model (see Fig. 1B). Again, the a and b paths were significant (all p's < .001) and the confidence interval for the indirect effect did not include zero.

The same pattern of results was observed in the mediation analysis that used the residual score for ACT Science after accounting for untimed phonological decoding as the dependent variable representing relative reading resiliency (see Fig. 1C). The direct effect of MA on relative reading resiliency from ACT Science was significant ($\beta = 0.40$, $p < .001$, 95% CI [0.22, 0.57]). The confidence interval for the indirect effect did not include zero, and the inclusion of the indirect effect in the model reduced the size of the direct relationship between MA and relative reading resiliency, making it no longer significant. This suggests a full mediation was present.

The pattern of results across these three sets of models held when the relative reading resiliency residual metric calculated using the basic skills composite score was used. Thus, even when the resiliency metric incorporates both pseudoword and real word reading aspects of word recognition skills, performance on the word comprehension subtest from the WRMT-III accounted for much of the relationship observed between MA and reading resiliency.

Relative reading resiliency residual with phonemic decode efficiency The next series of mediation analyses used the relative reading resiliency metrics that were the residual scores controlling for timed phonemic decode efficiency (see Figure 2). The pattern of results here mirrored the pattern obtained with the other relative reading resiliency metrics using residual scores (see Fig. 1 and text above). The direct effect of MA on relative reading resiliency with passage comprehension was significant ($\beta = 0.59$, $p < .001$, 95% CI [0.45, 0.74]). The direct effect of MA on relative reading resiliency with ACT Read was significant ($\beta = 0.34$, $p = .001$, 95% CI [0.15, 0.55]). The direct effect of MA on relative reading resiliency with ACT Science was significant ($\beta = 0.42$, $p < .001$, 95% CI [0.25, 0.59]). Each of these direct effects decreased when the indirect effect was included in their respective models, suggesting there is a mediating impact of vocabulary on MA. Furthermore, for the analyses with ACT Read and ACT Science, there was evidence of full mediation because the direct path between the independent and dependent variables was no longer significantly different from zero (Fig. 2). Similar to the results above with untimed measures, the pattern of results was the same when the composite score of total word reading efficiency was used to create the relative reading resiliency residual metric.

Discussion

Within the reading resiliency framework, resilient readers include compensated dyslexics as well as other people who may have or continue to struggle with some aspects of reading but have never been formally identified as having a reading disability. Although these individuals may continue to exhibit weaknesses in some skills, such as in phonological decoding or

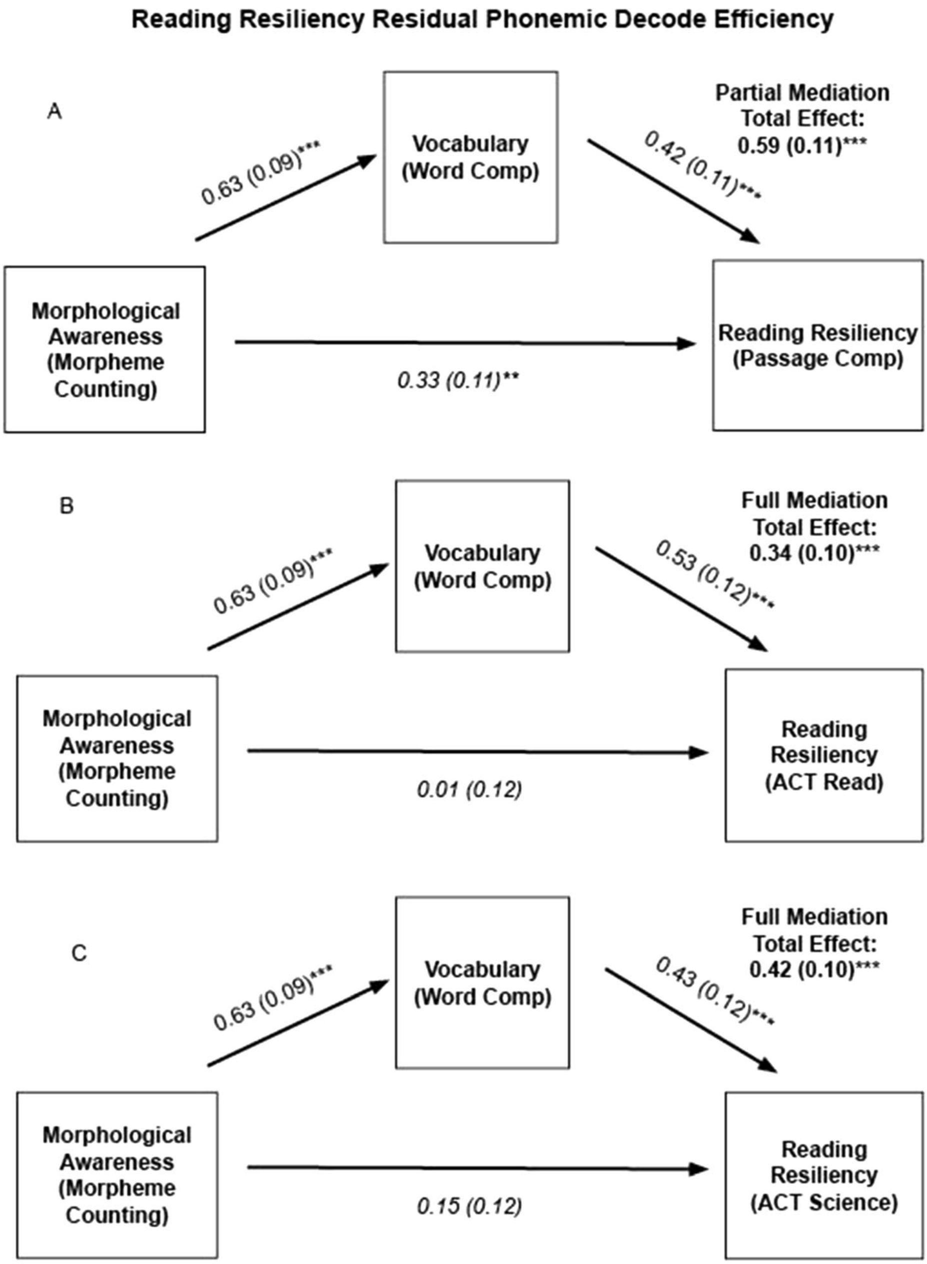

Fig. 2 Mediation analyses examining relative reading resiliency using residual scores controlling for phonemic decode efficiency. *Note.* Panel **A**: Passage Comp model has an indirect effect of 0.26, 95% CI [0.13, 0.43]. Panel **B**: ACT Read model has an indirect effect of 0.33, 95% CI [0.18, 0.53]. Panel **C**: ACT Science model has an indirect effect of 0.27, 95% CI [0.12, 0.45]. $^*p \leq .05$. $^{**}p \leq .01$. $^{***}p \leq .001$

spelling, they may perform well on measures of reading comprehension. This study investigated cognitive-linguistic factors that represent potential strengths in university students. In our sample, the university students' word reading, phonological decoding, vocabulary, listening, and reading comprehension scores ranged from below to above average for their age based on norm-referenced instruments. Our study extends prior research exploring factors related to reading comprehension by using a relative reading resiliency metric which accounts for the impact phonological decoding has on comprehension as a way to capture some of the multidimensional aspects of reading. This allowed our analyses to focus on other literacy skills that contribute to an individual's ability to understand written text. Analyses included individuals who did and did not exhibit average range reading comprehension performance; thus, we use the term *relative* reading resiliency to look at the presence of areas of relative strength (i.e., protective factors). Specifically, in this study, relative reading resiliency was calculated using the operational definition from past research (Patael et al., 2018), and separate measures were used to correspond with the different ways reading comprehension was assessed in our sample. Some shared variance across the potential predictors is to be expected, given how the literacy constructs are interrelated as outlined by the guiding theoretical model of the reading systems framework (Perfetti & Stafura, 2014). Thus, significant effects may be related to subtle differences between tasks that help us to tease apart what aspects of these multifaceted skills are most crucial for promoting reading comprehension.

Word-level vocabulary and morphological awareness measures

Vocabulary was a significant positive predictor of all six measures of relative reading resiliency based on residual scores. Although it only survived multiple comparison corrections in models for passage comprehension and ACT Read that used a timed measure of phonemic decode efficiency in the relative reading resiliency metric calculation. However, a broad measure of oral language skills obtained from the listening comprehension subtest was not significant in any model. These findings suggest that it is not the case that individuals with better language skills are better able to overcome phonological decoding difficulties as often argued based on the simple view of reading (Gough & Tunmer, 1986). Instead, some language skills are more beneficial than others. In the current study, the construct of vocabulary was represented by scores from the word comprehension subtest from the WRMT-III (Woodcock, 2011). This vocabulary measure required individuals to use their knowledge of word meanings to provide synonyms or antonyms, or complete analogical statements based on word-pair relationships. Thus, at the very least, the participant must recall the meaning of the word in the item prompt and access a word with a similar or opposite meaning from their mental lexicon. This task may require more precision than other expressive vocabulary tasks where individuals are asked to define a word. Such precision is required when university students need to understand subtle distinctions between constructs within the academic language they encounter in their coursework. For example, it is beneficial when learning the distinction between phonological and phonemic awareness when covering language in cognitive psychology courses. MA measures are another way to ascertain if an individual has a precise understanding of words.

Across the regression models addressing the first research question, the morpheme counting task was the only significant MA predictor, and this relationship only held in the model where the comprehension aspect of the relative reading resiliency with untimed phonological decoding outcome measure used a cloze-type procedure (i.e., the passage comprehension subtest from the WRMT-III). Furthermore, the bivariate correlations between relative reading resiliency and morpheme counting were small to large across the resiliency metrics (*r's* = .32–.59). Both the morpheme counting task and passage comprehension subtest require a focus on a single word, whether by indicating the number of morphemes in a supplied word or generating a word fitting the prompt. It is possible that because the ACT Read and Science items focus more on the ability to synthesize concepts within the provided material, they may be representing other facets of reading comprehension. So it is when the measure of reading comprehension that focuses more on semantic knowledge at the single word level is used to create the relative reading resiliency metric that vocabulary and MA measures are significant predictors. Interestingly, the unstandardized coefficients for these positive predictors of relative reading resiliency were quite similar (i.e., B = .31 and B = .34, respectively in the relative reading resiliency using passage comprehension with untimed phonological decoding model). Both vocabulary and MA represent aspects of semantic knowledge, and the measures used here focus on the lexical level.

In contrast to the other MA tasks used, the morpheme counting task does not include sentence frames. Arguably the need to use syntactic-level information to process the sentence frames in the derive and decompose MA tasks requires a higher cognitive load. A focus on the lexical level may make the morpheme counting task less cognitively demanding than other MA tasks. On the other hand, since the constraints of developing and standardizing sentence frames across test items are removed, the morpheme counting task items can vary more in their complexity than the items in the other MA tasks. Such item complexity is important given our population of interest is university students who need to be able to engage with complex written materials. Thus, the morpheme counting scores were carried forward as the measure of MA in the mediation analyses.

Similar to the procedures used to address the first research question, separate mediation models were constructed for each measure of relative reading resiliency. The models that used a discrepancy calculation for the relative reading resiliency metric are provided in the supplemental material. These supplemental models were not significant and appear to be underpowered in our sample. Yet, there was evidence for mediation in all six models where relative reading resiliency calculations used residual scores. These differences across models varying in the operationalization of the resiliency metric may be related to how the residual score calculation pools variance within the investigated sample, whereas the discrepancy scores rely on each individual's score, which of course have their own error variance in practice. Discrepancy scores are appealing on the surface because they seem conceptually easier to understand and calculate. Our findings further indicate that much more statistical power, likely obtained with much larger sample sizes, is needed to support analyses with discrepancy scores. However, the residual score metrics of relative reading resiliency capitalize on the ability to estimate an individual's comprehension ability using a model run on a group of people. There do appear to be boundary conditions that may impact the utility of either type of metric. Prior work related to dyslexia has examined similar differences in calculations used to examine change over time with longitudinal designs (see Stuebing et al., 2015 for a meta-analysis, or Petscher & Schatschneider, 2011 for a simulation study) and are likely applicable to such discussions.

Our findings revealed that vocabulary skills impact the observed relationships between MA and relative reading resiliency, regardless of how the comprehension aspect of reading resiliency was assessed. Furthermore, the results suggest that there was full mediation in the models using the ACT Read and Science scores and partial mediation in the other models with the passage comprehension score. These findings held whether the phonological decoding component of the relative reading resiliency metric was a timed or untimed measure, or if a composite score that incorporates both real word and pseudoword reading was used. Such results may be more likely to occur because our study involved the opaque orthography of English. We would hypothesize that studies using a more transparent orthography may primarily observe significant effects with timed measures of non-word reading. Our pattern of findings replicates our results for research question one investigating which constructs serve as protective factors, as suggested by the reading resiliency framework (Haft et al., 2016). Vocabulary and MA make unique contributions to reading resiliency when the passage comprehension subtest is used to create the relative reading resiliency metric.

In contrast, vocabulary, as measured by the WRMT-III word comprehension subtest, fully accounted for the association between MA, as measured by the morpheme counting task, and resiliency when either ACT Reading or Science is used to create the relative reading resiliency metric. These scores from the high-stakes testing environment of college entrance exams focus on comprehension for different types of passages with the science scores using passages from a particular academic domain. Although they are very general assessments used to gauge academic potential or preparedness, they use materials that may be more similar to a university student's coursework than other standardized reading comprehension instruments. One direction for future studies is to investigate the extent to which these findings are replicated with an assessment of a student's understanding of actual course materials.

Reading resiliency findings compared to past studies

Our hypotheses were partially supported. Although MA did not always stand out as a positive predictor of relative reading resiliency, the mediation analyses reveal that this may be because vocabulary skills drive much of the findings. The overall take-home message of the importance of vocabulary knowledge for university students is the same as past research, yet our study design and results differ in several ways.

First, we used a continuous measure of relative reading resiliency unlike other studies which examined group differences often based on past or current word reading deficits existing or not (Cavalli et al., 2016, 2017a, b; Elbro & Arnbak, 1996; Law et al., 2015; van Viersen et al., 2019). Our findings are consistent with the results of these studies. For example, another recent cross-sectional study compared Dutch adolescents with dyslexia who were sub-grouped as exhibiting resolving or persistent deficits in word reading and spelling and who all were considered intellectually gifted (van Viersen et al., 2019). In this study, a set of phonological processing and language-based skills were categorized as risk or protective factors using the core-deficit view (Stanovich & Siegel, 1994), and studies of compensatory factors such as examinations of twice-exceptionality (Foley Nicpon et al., 2011) and the reading resiliency framework (Haft et al., 2016). The authors found that the resolving group exhibited higher performance in grammar, receptive vocabulary, verbal working memory, and rapid naming (van Viersen et al., 2019).

Furthermore, the individuals in the resolving and persistent groups had similar performance on measures of phonological awareness. These authors suggested their results supported the more compensatory focused theories because the participant groups exhibited few differences in risk factors reflecting underlying deficits in phonological processing. However, differences were observed in literacy-based protective factors of grammar and vocabulary. Although longitudinal studies are needed to know when in development, the protective factors begin to have their impact.

Second, our outcome measure was relative reading resiliency. Prior studies have used reading or sentence comprehension as the outcome measure when exploring relationships with vocabulary and MA, but they have not always included a measure of phonological decoding

(Guo et al., 2011; Wilson-Fowler & Apel, 2015), meaning that the relative reading resiliency metric cannot be calculated. Thus, our findings extend these past studies investigating factors impacting comprehension in university students by accounting for individual differences in phonological decoding since relative reading resiliency was our outcome variable.

Third, we included a lexical level measure of MA, the morpheme counting task, from Bernstein et al. (2020). Awareness of root words and affixes was assessed by presenting a series of individual words in isolation and participants indicated the number of morphemes in each item. This was unlike the MA tasks in the prior studies, where participants added or subtracted affixes to fit items into sentences. Measurements of MA with carrier sentences focused on either inflectional knowledge, which preserves the part of speech and meaning of a word stem while conveying grammatical information (Guo et al., 2011), or derivational knowledge, where affixes are used to change the part of speech and meanings of words (Wilson-Fowler & Apel, 2015). Both studies found direct relationships between MA and comprehension in university students and examined potential mediators of that relationship. The indirect relationship of MA to comprehension through vocabulary was not significant for Guo et al. (2011), which is in direct contrast to our findings. However, in addition to the MA task differences, these studies also did not account for word-level reading differences within their sample, and we were able to do so. In contrast, although Wilson-Fowler and Apel (2015) did not assess vocabulary itself, they did find significant indirect effects for MA to sentence comprehension through spelling and word reading.

This distinction between inflectional and derivational morphological knowledge may be more informative when assessing individuals with low reading abilities than stronger readers because typical reading adults are likely to be proficient in their knowledge of inflectional morphology (Tighe & Schnatschneider, 2015). Yet, there were differences in findings from mediation models, including the findings of the current study, suggesting there may be more to explore. On the one hand, there is a motivation for an extensive study that incorporates multiple measures of each part of the reading systems framework. Relative strengths and weaknesses in lexical knowledge could be more precisely assessed by systematically varying the morpho-semantic transparency of items since shifts in phonology and orthography make MA tasks more difficult (e.g., Carlisle, 2000) and make morphologically complex words harder to read (e.g., Carlisle & Stone, 2005). Furthermore, one could also include separate tasks to assess implicit morphological processing and explicit morphological awareness as described by Law et al. (2018). These researchers observed preserved morphological processing benefits in a priming task among university students with dyslexia who had age-appropriate reading comprehension abilities. However, this preserved morphological processing ability occurred alongside low performance on morphological awareness tasks using sentence frames to examine derivational morphological knowledge. This finding raises questions as to whether or not these dyslexic participants would also exhibit low performance on our morpheme counting task. The undertaking of such an extensive study with nuanced measures of morphological awareness and processing and the systematic variation of items within the tasks may be philosophically appealing. Yet, on the other hand, it is more practical to allow the existing findings to motivate intervention-focused work to address the needs of students who struggle with reading. The reading resiliency framework focuses on examinations of the multidimensional aspects of reading in support of future intervention and prevention-focused efforts. MA and vocabulary knowledge are interrelated aspects of semantic knowledge, and our results support thinking of them as protective factors promoting reading resiliency and, consequently, potential areas of focus for interventions to ultimately improve reading comprehension.

In this regard, meta-analyses of intervention studies in school-aged children suggest morphological instruction, especially as part of comprehensive reading interventions, has a positive impact on reading outcomes (Bowers et al., 2010; Goodwin & Ahn, 2010, 2013). Furthermore, such interventions may be more likely to increase reading comprehension for students who exhibit reading difficulties. Specifically, the meta-analyses revealed a moderately sized effect such that participating in a morphological intervention was associated with increased reading comprehension scores in samples of individuals who struggled with reading, but this effect was not significant across a broad school-age population (Goodwin & Ahn, 2010, 2013). Few intervention studies have explicitly focused on morphological interventions in adults. For example, Gray et al. (2018) delivered 8 hours of vocabulary tutoring to adult students seeking alternative high school diplomas that either focused on a morpho-phonemic analysis (e.g., identify the suffix, and read and write morphologically related words sharing the same base word) or whole word analysis (e.g., no focus on the word's internal meaning or sound structure). Participants in both groups exhibited gains in their knowledge of the words targeted during the tutoring sessions. Yet, those whose tutoring emphasized morpho-phonemic analysis exhibited larger gains in standardized measures of real and pseudoword reading. Additional studies are needed to further explore the impact of morphological interventions in adult readers. It would also be prudent to examine aspects of morpho-semantic transparency within words, especially as they relate to the focus of instruction or intervention and in examining lingering difficulties or resilient and compensatory factors in individuals with reading difficulties.

Limitations

As true for any research study, our conclusions must be considered in the context of methodological limitations. Our study was cross-sectional, so we are unable to describe how the participant's reading and language skills developed in tandem. Some participants may have always exhibited underlying strengths in vocabulary, or their vocabulary skills may have improved much later in development. Furthermore, there was a broad range of scores across our participants. However, only two participants appeared to have extreme scores on multiple measures. When analyses were repeated without these two potential outliers, the pattern of results did not change. Multiple measures were obtained for some of our constructs. Still, due in part to the small sample size, we did not build latent variables to represent these multifaceted constructs and subsequently use path analytic or structure equation modeling techniques. However, keeping the individual measures of each construct in separate models or as separate predictors allowed for an exploration of how differences across measures of reading comprehension impacted our observed patterns of results. We were also able to examine potential differences across calculations of the relative reading resiliency metric. Such strategies are beneficial given that the contributions of component processes such as word recognition, decoding, and oral language skills vary across reading comprehension measures (Cutting & Scarborough, 2006). Furthermore, we only had a single measure of vocabulary, which limits our ability to test how different aspects of vocabulary knowledge directly influence reading comprehension. Also, our vocabulary measure relied on knowledge of synonyms, antonyms, and some analogical reasoning as opposed to other perhaps more commonly seen receptive and expressive vocabulary measures employed in other studies. Yet, an important contribution of our study is that word-level reading skills were assessed. Doing so allowed us to test the predictions of the reading resiliency framework (Haft et al., 2016) using the continuous relative reading resiliency index (Patael et al., 2018), thereby expanding past research. Furthermore, our study focused on phonological decoding as an area of weakness because it is frequently observed to be deficient in individuals with dyslexia. Yet, deficits in word recognition can be conceptualized in many nuanced ways to examine lexical and sub-lexical difficulties, which include not only phonological decoding, but also reading irregular words, recognizing affixes, or even fluency skills. Our study was also limited to English speakers and stimuli using the English orthography. Future work to extend our findings, especially in more transparent orthographies is warranted.

Conclusions and future directions

In line with both the reading resiliency (Haft et al., 2016) and reading systems frameworks (Perfetti & Stafura, 2014), in the current study, positive relationships were observed between MA abilities, vocabulary, and reading comprehension. Additionally, a student's vocabulary knowledge impacts the strength of the relationship between measures of their MA abilities and relative reading resilience. This finding indicates that vocabulary knowledge is a protective factor or relative strength amongst university students. Strengths in vocabulary could be what allows some individuals with dyslexia to compensate for their word reading difficulties as they encounter complex texts in the university setting. We were unable to directly examine that idea in the current sample because we did not have sufficient information about our participant's prior reading history. Yet, the range of standard scores obtained on the reading measures in our sample and reports of low NAEP scores in reading and low college completion rates discussed in our introduction highlight that reading struggles are a pressing issue even amongst university students. The protective factors could serve as targets for intervention in individuals with reading struggles. Furthermore, future work could also continue to disentangle the chicken-or-egg question of the relationship between vocabulary and MA, a question that we are not able to examine to its full extent within the limits of measures available in our dataset.

It is crucial to continue to expand our knowledge of how to foster or otherwise enhance these protective factors in individuals who have weaknesses, and especially in individuals who struggle in multiple areas. For example, Goodwin et al. (2012) suggest elementary and middle school teachers can support students in becoming "word detectives" by explicitly teaching students to (1) segment and build words with morphemes, (2) use the meanings of affixes and roots, (3) use morphemes to aid spelling, (4) use morphemes to learn compound words, and (5) identify cognates that share historical roots. Yet, there is a continued need to develop and empirically validate techniques to integrate how vocabulary and morphology are taught, especially how to enhance these skills in university students using direct instruction of morphological components of words.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11881-021-00236-y.

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