AJSLP

Research Article

Relationship Between Single Word Reading, Connected Text Reading, and Reading Comprehension in Persons With Aphasia

Kimberly G. Smith[a] and Anna E. Ryan[a]

Purpose: This study examined the relationship between single word reading, connected text reading, and comprehension in persons with aphasia.
Method: Thirteen persons with aphasia read orally from the Arizona Battery for Reading and Spelling real-word and nonword lists and the Gray Oral Reading Tests–Fifth Edition. The comprehension questions following each paragraph of the Gray Oral Reading Tests–Fifth Edition were answered and scored. The Reading Comprehension Battery for Aphasia–Second Edition provided a measure of silent reading comprehension. Descriptive statistics and Spearman correlation were used to examine associations among reading measures.
Results: Persons with aphasia showed associations between single word reading and connected text reading accuracy; however, single word reading ability was not associated with oral or silent reading comprehension.
Conclusions: Although preliminary, the findings provide support for word-level reading abilities underlying connected text reading accuracy but suggest additional cognitive mechanisms are involved in text-level reading comprehension that are not explained by single word reading alone. The findings indicate clinicians should use caution when inferring comprehension abilities from single word reading performance as reading comprehension abilities are likely best assessed using text-level comprehension assessments.

Often, people with aphasia lose or have difficulty with their ability to read and comprehend written material. These acquired impairments of reading following a stroke or other traumatic brain injury are referred to as alexia or acquired dyslexia. In a prevalence study of alexia in persons with aphasia by Wilson (2008), over 80% of the 41 participants with aphasia had concomitant alexia. Alexia may be costly to an individual's quality of life, and a person's participation in various life activities as essential, functional, and pleasurable reading is a difficult task (Knollman-Porter et al., 2015). Single word reading in persons with aphasia has been well studied, but there is limited knowledge of how single word reading abilities relate to connected text reading and comprehension. This is critical given that everyday reading material is seldom presented as single words. In contrast, the developmental reading literature has identified a relationship between single word reading, connected text reading, and reading comprehension abilities (Gough & Tunmer, 1986; Jenkins et al., 2003), which has informed how reading difficulties are assessed and treated in developmental readers. Therefore, the current study examined the relationship between single word reading, connected text reading, and comprehension in adults with aphasia, as evidence of a relationship among these variables may inform how reading difficulties are assessed and treated, in addition to having theoretical implications.

Theories of Reading

Following activation of the visual word form system, the dual route cascaded (DRC; Coltheart et al., 2001) model poses two separate routes for reading single words orally. Coltheart et al. (2001) suggested the nonlexical route with grapheme-to-phoneme conversion explains our ability to read novel words following regular letter–sound spelling rules and nonwords (e.g., *bos, dar, jow*). The nonlexical

[a]Department of Speech Pathology and Audiology, University of South Alabama, Mobile

Correspondence to Kimberly G. Smith: kimberlysmith@southalabama.edu

Editor-in-Chief: Julie Barkmeier-Kraemer
Editor: Anastasia Raymer

Received October 4, 2019
Revision received January 10, 2020
Accepted July 5, 2020
https://doi.org/10.1044/2020_AJSLP-19-00135

Disclosure: *The authors have declared that no competing interests existed at the time of publication.*

route, however, cannot explain how we read words with irregular spellings (e.g., *have, fight, tough*). The lexical route includes stored graphical representations of words (i.e., orthographic input lexicon), which can activate both the meaning of the word in the semantic system and the pronunciation, as represented in the phonological output lexicon. The lexical route can generate pronunciations for both overlearned, frequently accessed regular (e.g., *cave*) and irregular (e.g., *have*) words but fails to generate pronunciations for novel words and nonwords.

The DRC model has been used both to characterize single word reading of persons with aphasia and concomitant alexia and to predict reading errors based on proposed damage to either route. Cherney (2004) provides a summary of the alexia subtypes based on the DRC model. Damage to the nonlexical route causes difficulty sounding words out because grapheme-to-phoneme conversion is no longer available. These deficits are proposed to cause phonological alexia. Persons with phonological alexia have difficulty reading nonwords or low-frequency words; however, since the orthographic and phonological lexicons as well as the semantic system are still accessible, recognizable high-frequency words are less affected. In contrast, damage to the lexical route causes visual errors (e.g., "bank" instead of the target word "blank"), regularization errors (e.g., "pint" as "/pɪnt/"), and difficulty reading words with irregular spellings as in "yacht." These deficits are proposed to cause surface alexia. Persons with surface alexia are able to read regularly spelled real words and nonwords since the grapheme-to-phoneme converter of the nonlexical route is spared. Damage to both the nonlexical and lexical routes causes deep alexia. Deep alexia is characterized by similar difficulties of phonological alexia, but semantic errors are also made. Persons with deep alexia have a reduced vocabulary limited to known, concrete words. Lastly, semantic alexia is associated with impairments in semantic processing. Persons with semantic alexia read without difficulty or hesitation but present with significant comprehension deficits.

Based on the DRC model, we can predict how both real words and nonwords may be associated with text-level reading accuracy and comprehension, depending on factors such as grade level and familiarity with the reading content. Since the nonlexical route is responsible for generating pronunciations of novel words and nonwords via the grapheme-to-phoneme converter, nonword reading ability is more likely to be associated with text-level accuracy and comprehension of novel content and content beyond the reader's proficiency. In contrast, the lexical route generates pronunciations for overlearned, frequently accessed real words. Thus, real-word reading is more likely to be associated with comprehension of familiar content and content matched to an individual's reading proficiency. It is likely that real-word and nonword reading, as often administered as part of a reading assessment, would be differentially associated with reading comprehension, depending on the connected text reading material. This is an important consideration for clinicians selecting stimuli for assessment and intervention.

Although single word reading is a necessary component of connected text reading and comprehension, there are several other processes involved, such as working memory and attention allocation. The verbal efficiency theory of reading (Perfetti, 1985, 1992) includes these cognitive processes and provides a framework for connected text reading, while taking into consideration single word reading ability. The verbal efficiency theory of reading has been used to explain the processes involved in reading for developmental readers but can also be applied to neurotypical adult readers and persons with aphasia and concomitant alexia. This theory proposes that individual variances in reading come from a person's ability to direct adequate attentional resources to reading and comprehension (Jenkins et al., 2003), which shift depending on an individual's reading proficiency (Wolf & Katzir-Cohen, 2001) or reading task. For example, reading automatic, overlearned words would require fewer attentional resources than decoding nonwords. Text comprehension requires working memory skills, and reading nonwords may rely specifically on phonological working memory skills. Individuals who have to direct much of their attention resources to decoding will show deficits in their comprehension. This is because their reading ability is not quick, effortless, and automatic but rather requires effortful concentration that would otherwise be used for processing and comprehending. The verbal efficiency theory is supported by studies of developmental readers that found a relationship between single word reading, connected text reading, and reading comprehension skills (Fuchs et al., 2001; Jenkins et al., 2003; Y. Kim et al., 2011; Nathan & Stanovich, 1991).

Jenkins et al. (2003) concluded single word reading fluency, defined as the number of words orally read in 1 min, was a more significant contributor to reading comprehension in less fluent readers. Additionally, their results indicated that connected text fluency, single word fluency, and text comprehension were all related (Jenkins et al., 2003). They concluded word recognition skill is shared across single word reading, connected text reading, and reading comprehension, while also recognizing these three tasks differ in other dimensions. This interdependent relationship and their conclusion on the influence of single word reading fluency for less proficient readers informed the current study's hypotheses about persons with aphasia. It was expected that single word reading ability would be associated with connected text reading accuracy and comprehension in persons with aphasia as the presence of concomitant alexia makes them less proficient readers.

Reading in Persons With Aphasia and Acquired Alexia

Many studies have investigated single word oral reading abilities of persons with aphasia (Friedman, 1996; Friedman & Kohn, 1990; Gardner & Zurif, 1975) and the effectiveness of reading treatments (Beeson et al., 2005; Cherney, 2010a; 2010b; Cherney et al., 1986; M.Kim & Russo, 2010). Research examining single word reading has been valuable in assessing specific patterns of breakdown related to

neuropsychological models of reading (Coltheart et al., 2001; Seidenberg & McClelland, 1989) and has associated specific word characteristics (e.g., frequency, age of acquisition, concreteness) with reading speed, efficiency, and various errors individuals with aphasia produce during single word oral reading (e.g., semantic, phonological, visual errors). Single word reading ability of persons with aphasia has informed the development of interventions that target underlying impairments, such as deficits in phonology. Treatment for these deficits is often geared toward single word reading, with the goal of improving oral reading abilities and comprehension. Decoding and phonological awareness skills have been examined in particular (Brookshire et al., 2014; Friedman & Lott, 2002; Kendall et al., 2003). Although improvements in reading accuracy have been shown at the single word level, improvement in reading comprehension of persons with aphasia is inconsistent across studies (Brookshire et al., 2014; Kendall et al., 2003). Although this inconsistency may be attributed to varying factors across studies, these findings suggest we might expect single word reading abilities to be associated with connected text reading accuracy in the current study, with possibly weaker associations between single word reading abilities and comprehension.

At the connected text level, persons with phonological alexia may also have difficulty with syntactic processing in addition to the well-documented nonword reading deficits (Friedman, 1996). This finding is particularly relevant to the current study as syntactic processing deficits impact text-level reading accuracy and comprehension. Friedman (1996) identified text-level reading impairments in two individuals with phonological alexia who demonstrated difficulty reading functors and omitted inflectional and derivational markers. Friedman suggested these findings indicate a general phonological processing deficit related to difficulty holding phonological information in verbal short-term memory. These findings informed the hypothesis for the current study, in which it was expected that accuracy of nonword reading and connected text reading would be associated. Thus, these findings would demonstrate phonological abilities and phonological short-term memory have a role in text comprehension.

In summary, despite the wealth of knowledge learned from studies of developmental reading, single word reading in persons with aphasia, and reading treatment approaches for persons with aphasia, it remains unclear how single word reading relates to text reading accuracy and comprehension in persons with aphasia. This is critical because comprehension is the ultimate goal of reading. Associations between single word reading, connected text reading accuracy, and comprehension may also have theoretical and clinical implications. Theoretically, associations among these reading measures would suggest that the mechanisms for single word reading, outlined by the DRC model, should explain text-level reading accuracy to some extent. Furthermore, associations among these reading tasks would provide additional support for the verbal efficiency theory of reading (Perfetti, 1985, 1992). Clinically, it is necessary to bridge the gap between single word reading abilities in persons with aphasia and the functional task of text reading comprehension. If single word reading is associated with connected text reading and comprehension, clinicians may use single word reading tasks to infer text-reading skills. Additionally, clinicians may consider treatment directed toward single word reading, which could potentially generalize to text reading accuracy and comprehension. Based thereon, we sought to answer the following research questions:

1. What is the relationship between the accuracy of real-word and nonword oral reading and the accuracy of orally read paragraphs for persons with aphasia?
2. What is the relationship between the accuracy of real-word and nonword oral reading and oral paragraph reading comprehension for persons with aphasia?
3. What is the relationship between the accuracy of real-word and nonword oral reading and silent reading comprehension for persons with aphasia?

Method

Participants

Thirteen individuals with mild to moderately severe aphasia (M = 59.08 years of age, eight women) were recruited for the study. Data from eight participants have been reported in a previous study (Smith & Clark, 2019). In the study of Smith and Clark (2019), a detailed error analysis of oral paragraph reading was conducted, and associations among connected text reading, error frequency, and reading comprehension scores were examined. Participants were compensated for their participation and gave signed informed consent for study inclusion. Approval for this study was obtained from the institutional review board at the University of South Alabama.

The inclusion criteria included a diagnosis of aphasia as determined by the Western Aphasia Battery–Revised (Kertesz, 2007) cutoff score of 93.8, at least 6 months post-onset, native speaker of English, and between 30 and 80 years of age. Participants were also required to have visual acuity within normal limits as determined by the McDowell Vision Screen Test (McDowell & McDowell, 1998) and the ability to provide written or verbal informed consent for participation. The exclusion criteria included clinically reported history of dementia or other neurological conditions (e.g., Parkinson's disease, traumatic brain injury, psychiatric disorder), habitual misuse of alcohol, history of communication disorder or reading disability prior to stroke, and visual acuity deficits unable to be corrected. Unless otherwise specified, inclusionary and exclusionary criteria were screened by a research questionnaire, self-report, standardized assessments (i.e., Western Aphasia Battery–Revised), cognitive screenings, and vision screenings. Demographic information for each participant is shown in Table 1. Alexia subtype was determined by the first author and a second trained research assistant based on the accuracy of words read on the real-word and nonword lists of the Arizona Battery for Reading and Spelling (ABRS; Beeson & Rising, 2010). Nine of the 13 participants were

Table 1. Demographic information.

Participant	Age	Gender	Ed level (yrs)	WAIS-IV MR[a]	Months postonset	WAB-R AQ[b]	ASRS[c]	Aphasia subtype	Alexia subtype
P1	54	F	12	14	120	60.4	1	Broca's	Surface
P2	71	M	16	12	11	63.8	14	Broca's	Phonological
P3	56	F	20	14	126	86.3	0	Anomic	Phonological
P4	69	M	17	5	17	79.8	13	Broca's	Deep
P5	53	F	12	15	20	65.7	18	Broca's	Deep
P6	68	M	15	19	6	83.3	0	Conduction	Surface
P7	35	M	16	21	36	92.5	1	Anomic	Phonological
P8	55	F	12	10	6	91.1	0	Anomic	Phonological
P9	58	M	16	10	10	70.1	22	Broca's	Deep
P10	70	F	12	6	45	92.8	3	TCM	Phonological
P11	76	F	12	13	23	86.7	4	TCM	Phonological
P12	37	F	16	13	36	92.6	0	TCM	Phonological
P13	66	F	14	17	96	92.8	2	Anomic	Surface

Note. Ed = education; yrs = years; F = female; M = male; TCM = transcortical motor.

[a]WAIS-IV MR = Wechsler Adult Intelligence Scale–Fourth Edition Matrix Reasoning subtest (max score: 26; Wechsler, 2008). [b]WAB-R = Western Aphasia Battery–Revised (max score: 100). [c]ASRS = Apraxia of Speech Rating Scale (sum of ratings for the six items in Section 1: apraxia of speech distinguishing features—0 indicates features of apraxia are not present; a max score of 24 indicates features of apraxia are nearly always evident and marked in severity).

typed the same among the two raters. A consensus was reached for the discrepancies after discussion.

Procedure

Participants completed an assessment battery that took approximately 5 hr depending on aphasia severity. Breaks during testing were provided as needed with the option to complete the assessment battery during another session; however, individual assessments were completed entirely during one session. Table 2 provides a summary of the assessments in the assessment battery. Participants were tested in the Adult Speech and Language Lab at the University of South Alabama unless the participant requested the investigator administer the assessment battery at their place of residence.

Accuracy Coding and Data Preparation

Oral reading of the Gray Oral Reading Tests–Fifth Edition (GORT-5; Wiederholt & Bryant, 2012) paragraphs and the ABRS word lists were video-recorded for later transcription and analysis. For the purpose of this study, accuracy was defined as a person's ability to correctly pronounce words during reading (Wiederholt & Bryant, 2012). Each word from the GORT-5 paragraphs and ABRS were scored as correct or incorrect to gather an overall accuracy score in oral reading of connected text and real words and nonwords. Only words produced accurately were scored as correct. Any production that was not the target was considered a deviation. Errors associated with aphasia such as paraphasias; visual and semantic errors; morphological, phonological, articulatory errors; and whole-word additions and omissions were scored as incorrect. Errors commonly seen in neurotypical adult readers such as self-corrections, revisions, and repetitions were also scored as incorrect.

Few instances of inaccurate productions were not scored as deviations, such as dialectal variations (e.g., *idear* for *idea*). Special consideration was given for filler words and when the person was sounding out a word. Fillers were

Table 2. Assessment battery.

Assessment	Purpose	Administration information
Apraxia of Speech Rating Scale (Strand et al., 2014)	Assess the presence and severity of apraxia of speech	
Arizona Battery for Reading and Spelling (Beeson & Rising, 2010)	Assess single word reading ability	80 real words—40 in List 1 and 40 in List 2; 20 nonwords
Gray Oral Reading Tests–Fifth Edition (Wiederholt & Bryant, 2012)	Assess oral connected text reading ability and comprehension	Paragraphs 1–8 were administered in increasing difficulty; number of words in each paragraph are as follows: 17, 41, 52, 81, 105, 100, 106, 129
McDowell Vision Screen Test (McDowell & McDowell, 1998)	Assess visual acuity and processing	
Reading Comprehension Battery for Aphasia–Second Edition (LaPointe & Horner, 1998)	Assess silent reading comprehension ability	Core Subtests 1–10 were administered
Western Aphasia Battery–Revised (Kertesz, 2007)	Assess the presence and severity of aphasia	

not counted as a deviation if the participant read a word, produced a filler, and then continued on accurately (e.g., *that uh of small* for *that of small*). If the person attempted to sound out a word and arrived at the correct word, it was not counted as a deviation (e.g., */kə/-catastrophe*). Lastly, skipping a line and having to be redirected was not counted as a deviation. These deviations occurred very infrequently, in less than 1% of the reading sample. For example, out of 631 total words, only one deviation was not scored as incorrect for P1 (e.g., "sss-strike"), and five deviations were not scored as incorrect for P3 (e.g., "mmm-major" or "'merican" for "American").

Reliability

Interrater reliability was calculated for transcription and accuracy coding for two participants with aphasia. Reliability was performed by a trained research assistant. An 85% agreement criterion was set for acceptable reliability prior to initiation of this study. An average agreement of 92% was reached for the transcripts, and 98.8% was reached for accuracy coding. A consensus was reached between the two raters for acceptable answers to open-ended comprehension questions of the GORT-5 paragraphs. Since the agreement criterion was met for transcription and accuracy coding between the two raters, scores from the first rater were used for statistical analysis.

Statistical Analysis

Statistical analysis was conducted for Paragraphs 1 through 8 (out of 16) of the GORT-5 as this was the highest number of paragraphs all participants completed due to testing fatigue. The sum was calculated of the first eight paragraphs for accuracy and comprehension. The derived summed values were utilized for data analysis. Total correct scores were used for the real-word and nonword ABRS lists and the Reading Comprehension Battery for Aphasia–Second Edition (RCBA-2). Then, the total scores for each variable and participant were converted to percentage for comparison across measures. The study sample was small, and the assumptions of parametric tests were violated due to nonnormal distributions; therefore, nonparametric tests were used. A Spearman correlation was used to examine associations among variables. Due to the preliminary nature of the study and sample size, Spearman correlations were not corrected for multiple comparisons. Additionally, due to theoretical and clinical interest, post hoc Mann–Whitney *U* tests were used to examine differences between the alexia subtypes represented in the current study sample. Scatter plots were used to examine the associations among the reading tasks.

Results

Table 3 shows the total scores for each variable and participant for each reading measure, as well as the means and standard deviations for the entire group of persons with aphasia. Table 4 summarizes the results of the Spearman correlation. For Research Question 1, a significant positive linear relationship was found between both real-word and nonword reading and GORT-5 text reading accuracy. For Research Question 2, neither real-word or nonword reading accuracy was significantly associated with GORT-5 text reading comprehension. Lastly, for Research Question 3, no significant associations emerged for real-word or nonword reading accuracy and silent text reading comprehension (i.e., RCBA-2).

Since P2, P4, P5, and P9 had significant apraxia of speech as measured by the Apraxia of Speech Rating Scale (Strand et al., 2014) and articulation errors associated with apraxia of speech may have impacted the single word and connected text reading accuracy scores for these participants, Spearman correlations were also conducted excluding these participants. For Research Question 1, associations between real-word and connected text reading accuracy ($r_s = .33$, $p = .39$), and nonword and connected text reading accuracy ($r_s = .33$, $p = .39$) were no longer significant. For Research Question 2, the results remained the same. Neither real-word ($r_s = -.02$, $p = .96$) or nonword ($r_s = .03$, $p = .93$) reading were significantly associated with oral connected text reading comprehension. Lastly, for Research Question 3, there was no change in the results. Nonsignificant relationships remained between real-word reading and silent connected text reading comprehension ($r_s = .50$, $p = .18$) and nonword reading and silent connected text reading comprehension ($r_s = .38$, $p = .31$) abilities.

Post Hoc Alexia Subtype Analyses

Although not initially planned due to the small sample size and the preliminary nature of the current study, it was of theoretical and clinical interest to examine how performance varied based on alexia subtype. Figure 1 shows the mean performance of the participants in each alexia subtype for all reading measures. Based on Figure 1, statistical comparisons were made. Persons with deep alexia had significantly poorer GORT-5 text reading accuracy ($U = 9.00$, $p = .03$) and real-word reading accuracy ($U = 0.00$, $p = .02$) compared to persons with phonological alexia and significantly poorer nonword reading accuracy ($U = 0.00$, $p = .046$) compared to persons with surface alexia. No other comparisons reached the level of statistical significance (all $p_s > .05$).

Figure 2 shows the scatter plots for real-word and nonword reading plotted against GORT-5 accuracy and comprehension scores and RCBA-2 scores for each alexia subtype. A positive association between real-word reading and GORT-5 text reading for persons with deep alexia emerged, whereas no clear pattern emerged for persons with phonological or surface alexia (see Figure 2a), or for nonword reading and GORT-5 text reading accuracy for any of the alexia subtypes (see Figure 2b). A similar pattern emerged for GORT-5 text comprehension. A positive association between real-word reading and GORT-5 text comprehension for persons with deep alexia was evident, whereas no clear pattern emerged for persons with phonological or surface alexia (see Figure 2c),

Table 3. Individual participant scores on assessments.

	ABRS		GORT-5		
	Real word	Nonword	Accuracy	Comprehension	RCBA-2
Participants	*N* = 40	*N* = 40	*N* = 631	*N* = 40	*N* = 100
Deep					
P4	61	0	50	47.50	88
P5	3	0	15	15	96
P9	23	25	23	60	89
Phonological					
P2	76	5	41	45	72
P3	100	40	91	45	75
P7	96	20	86	70	97
P8	95	60	92	62.50	92
P10	99	80	91	10	96
P11	96	5	61	40	82
P12	100	90	89	65	100
Surface					
P1	86	75	89	15	79
P6	70	50	82	65	74
P13	98	100	86	67.50	95
M (*SD*)	82.77 (27.11)	46.15 (36.75)	68.92 (27.82)	46.73 (21.37)	87.31 (9.79)

Note. All scores are in percent correct. ABRS = Arizona Battery for Reading and Spelling; GORT-5 = Gray Oral Reading Tests–Fifth Edition; RCBA-2 = Reading Comprehension Battery for Aphasia–Second Edition.

or for nonword reading and GORT-5 text reading comprehension for any of the alexia subtypes (see Figure 2d). A different pattern emerged for silent reading comprehension (i.e., RCBA-2). Persons with phonological and surface alexia showed a positive association, though weak, for real-word and nonword reading and RCBA-2 scores, whereas no association was evident for persons with deep alexia for real-word or nonword reading (see Figures 2e and 2f).

Discussion

Acquired reading difficulty, or alexia, is common in people with aphasia. When present with aphasia, chronic alexia may impact a person's participation in various life activities such as reading for pleasure or completing work-related reading tasks (Knollman-Porter et al., 2015). Single word reading in persons with aphasia has been studied extensively, but there is limited knowledge of how single word reading abilities relate to connected text reading and comprehension. This is critical since an everyday reading material is rarely presented as single words. The results of this preliminary study showed that the accuracy of real-word and nonword reading was associated with connected text reading accuracy, although this effect was reduced when removing persons with severe apraxia of speech. Additionally, real-word and nonword reading accuracy was not associated with oral or silent reading comprehension. Nonetheless, the findings provide relevant theoretical and clinical insights, despite the apparent effect of apraxia of speech errors on oral reading and the otherwise weak associations among reading measures.

First, these findings serve as a reminder that speech processes are essential for oral reading and speech errors made during word reading will likely predict the speech errors of text-level reading. Motor speech deficits may impact oral reading ability beyond that of linguistic deficits of persons with aphasia. This should be considered during assessment and treatment of reading in persons with aphasia who often have concomitant motor speech impairments. For persons whose life activities involve oral reading, such as

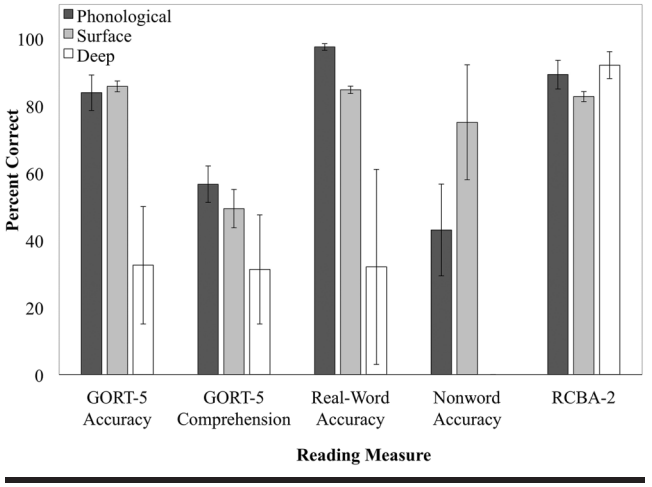
Table 4. Spearman correlation results.

Reading measure	GORT-5 Comprehension	ABRS Real Word	ABRS Nonword	RCBA-2
GORT-5 Accuracy	.07	.80*	.70*	.16
GORT-5 Comprehension		.14	.25	.24
ABRS Real Word			.63*	.27
ABRS Nonword				.27

Note. GORT-5 = Gray Oral Reading Tests–Fifth Edition; ABRS = Arizona Battery for Reading and Spelling; RCBA-2 = Reading Comprehension Battery for Aphasia–Second Edition.

*Indicates significance at the .05 level (two-tailed) uncorrected for multiple comparisons.

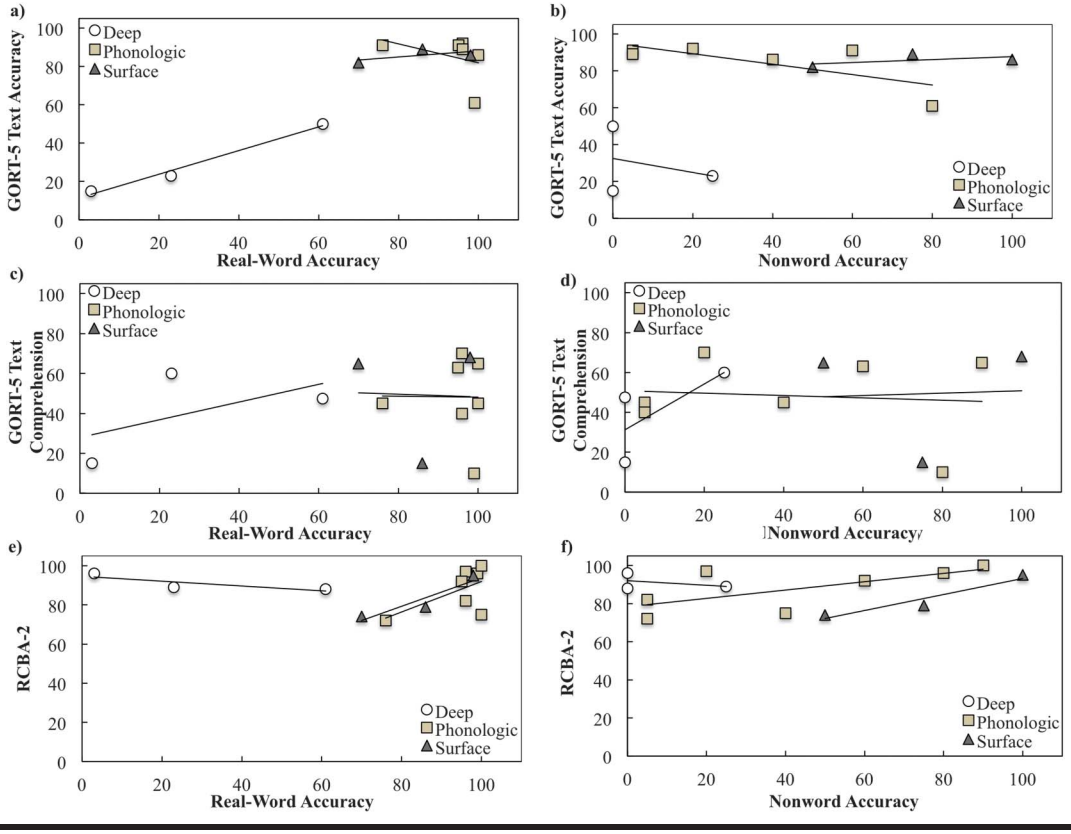
Figure 1. Mean performance of the participants in each alexia subtype for all reading measures. Error bars represent the standard error of the mean. GORT-5 = Gray Oral Reading Tests–Fifth Edition; RCBA-2 = Reading Comprehension Battery for Aphasia–Second Edition.



reading aloud to one's grandchildren or scripture in a bible study, the speech mechanism may be as important to address as the linguistic aspects of reading.

Second, the results imply single word reading alone may not be a good indication of reading comprehension, either oral or silent. Developmental literature generally suggests single word reading, particularly real-word fluency (i.e., measure of accuracy and rate), is predictive of reading comprehension. However, Klauda and Guthrie (2008) suggest comprehension may also depend on processes related to the paragraph, the passage as a whole, or the macrostructure of the text (Kintsch & Kintsch, 2005), especially as the reader develops. In our case, we examined the reading of persons who had well-developed, normal-reading abilities prior to their stroke. It is likely that, although word recognition abilities observed in real-word reading or decoding skills observed in nonword reading have a role in oral paragraph reading and comprehension, additional higher level processes, such as syntax or story grammar, may contribute more significantly. These processes are not currently accounted for in the DRC model. This finding, however, is consistent with intervention studies that have not shown generalization to reading comprehension following treatment

Figure 2. Scatter plots for real-word and nonword reading (*x*-axis) plotted against GORT-5 accuracy (a, b), GORT-5 comprehension scores (c, d), and RCBA-2 scores (e, f) for persons with deep alexia (white circle), phonological alexia (light gray square), and surface alexia (dark gray triangle); all scores are in percent correct. GORT-5 = Gray Oral Reading Tests–Fifth; RCBA-2 = Reading Comprehension Battery for Aphasia–Second Edition.



at the word-level for persons with aphasia (Brookshire et al., 2014).

Additionally, as the verbal efficiency model indicates, cognitive processes such as attention and working memory are required for reading comprehension to occur. These processes come into play once visual word recognition or decoding takes place. Persons with aphasia are known to have deficits in these cognitive processes (Murray, 2012), which may contribute to their reading comprehension deficits. Thus, it is possible single word reading has a role in reading comprehension but is shared with an array of other cognitive processes.

Lastly, while heterogeneity of the study sample is often favorable when examining associations among variables (Goodwin & Leech, 2006), the heterogeneity of the current study participant sample led to no consistent pattern for word reading and reading comprehension. In retrospect, this finding is not surprising as participant samples of persons with aphasia are often heterogeneous because of their varying lesion profiles and associated linguistic symptoms. In the current study, some participants performed well on word reading but poorly on GORT-5 comprehension (e.g., P10), whereas other participants scored poorly on word-reading but with higher accuracy on oral reading comprehension measured by the GORT-5 (e.g., P9) and silent reading comprehension measured by the RCBA-2 (e.g., P5). Though associations among these measures may emerge with a larger participant sample, the results of the current study reflect the variability in word and text-level reading comprehension ability of persons with aphasia. Future research should examine these associations with a larger participant sample to confirm this finding. Additionally, ceiling performance was also observed for some participants and reading measures. For example, for real-word reading and silent reading comprehension, this occurred for five participants who scored above 90% accuracy for both reading measures (e.g., P7, P8, P10, P12, and P13). In a small sample of 13 participants, this likely contributed to the null findings. Ceiling performance results in limited variance and therefore weak correlation coefficients.

Alexia Subtypes

Although it was not decided a priori to examine associations among reading measures for the alexia subtypes, it was of theoretical and clinical interest to do so. Caution should be used when interpreting the findings as alexia subtypes were identified based on the accuracy of the ABRS real-word and nonword reading lists, which included articulation errors associated with apraxia of speech. Nonetheless, persons with deep alexia showed the strongest associations between real-word reading and GORT-5 text reading accuracy and real-word and nonword reading and oral reading comprehension measured by the GORT-5. These results support the verbal efficiency theory of reading, such that persons with deep alexia require effortful concentration and cognitive resources for orally reading at the word level. These resources are then unable to be allocated for processing and comprehension of orally read written material at the text level. Limited associations among reading measures for persons with phonological and surface alexia can likely be attributed to variability of reading abilities even within subtypes. These preliminary findings suggest a need for further study of associations among reading measures particularly with a larger sample that can draw better conclusions about specific alexia subtypes.

Clinical Implications

Results from this study have clinical relevance. The findings suggest clinicians may use single word reading tasks to infer connected text reading accuracy; however, caution should be used when inferring comprehension abilities from single word reading performance. As with other linguistic functions, persons with aphasia are heterogeneous in their word- and text-level reading abilities. Reading comprehension abilities are likely best assessed using text-level, comprehension assessments. Treatment focused at the single word level will likely improve single word and text-level reading accuracy as shown in previous research (Conway et al., 1998; Kendall et al., 2003), but gains in comprehension may remain limited unless comprehension is specifically a treatment target.

Study Limitations

Some limitations of the current study have been discussed in previous sections and include the heterogeneity and ceiling performance of the participant sample. There are a few additional limitations of this study. First, a larger sample size would provide valuable information on the performance of reading, based on individual characteristics of aphasia and concomitant alexia, and allow for a more detailed examination of reading performance among aphasia and alexia subtypes. Second, the RCBA-2 and GORT-5 have limitations that may have contributed to the weak associations between word-level reading and reading comprehension. The RCBA-2 is an assessment composed of subtests that measure comprehension from the single word to paragraph level, and the total score reflects performance on each of these subtests. An assessment that isolates text-level silent reading comprehension could possibly be more associated with oral single word reading than the RCBA-2 total score.

A limitation of using the GORT-5 for the oral paragraph reading stimuli was only the first eight paragraphs were utilized because some participants experienced testing fatigue. This fatigue can likely be attributed to overall aphasia severity of the participants. The GORT-5 paragraphs are formulated with increasing difficulty; thus, the last eight, more complex passages were not analyzed in this study. Additionally, there was a lack of standardization because the GORT-5 is normed on a sample of students between 6 and 23 years of age and is meant to provide scores for accuracy, rate, and comprehension of those within that age range.

Lastly, to better compare this study's findings to the developmental reading research (Fuchs et al., 2001; Jenkins et al., 2003), a time-based fluency measure derived from both accuracy and rate of reading at the single word and text-level should be included in the assessment protocol. This may help reduce the ceiling effects observed particularly for real-word reading. It is also possible word reading would be more associated with text-level reading if fluency was the measure used in the current study rather than accuracy alone. This is a direction of future research.

Conclusions

The aim of this preliminary study was to evaluate the relationship between single word reading, connected text reading, and reading comprehension in persons with aphasia. Persons with aphasia showed associations between single word reading and oral paragraph reading accuracy; however, single word reading ability was not associated with oral or silent reading comprehension. The findings of this study provide support for word-level reading abilities underlying oral paragraph reading accuracy but suggest additional cognitive mechanisms are involved in text-level reading comprehension that are not captured in single word reading alone. Thus, clinicians may consider assessing single word reading both to provide insight into underlying linguistic processing deficits and text-level reading accuracy and to provide intervention focused at the single word level and decoding skills. However, improvements in reading accuracy should be expected with limited improvements in comprehension. Although it is important that these results and suggestions are interpreted with caution, given the preliminary nature of this study, these results still hold relevant implications for clinical practice.

Acknowledgments

Support for this study was provided by the University of South Alabama's Faculty Development Council grant.

References

Beeson, P. M., Magloire, J. G., & Robey, R. R. (2005). Letter-by-letter reading: Natural recovery and response to treatment. *Behavioural Neurology, 16*(4), 191–202. https://doi.org/10.1155/2005/413962

Beeson, P. M. & Rising, K. (2010). *Arizona Battery for Reading and Spelling*. https://aphasia.sites.arizona.edu/content/8

Brookshire, C. E., Conway, T., Pompon, R. H., Oelke, M., & Kendall, D. L. (2014). Effects of intensive phonomotor treatment on reading in eight individuals with aphasia and phonological alexia. *American Journal of Speech-Language Pathology, 23*(2), S300–S311. https://doi.org/10.1044/2014_AJSLP-13-0083

Cherney, L. R. (2004). Aphasia, alexia, and oral reading. *Topics in Stroke Rehabilitation, 11*(1), 22–36. https://doi.org/10.130/VUPX-WDX7-J1EU-00TB

Cherney, L. R. (2010a). Oral Reading for Language in Aphasia (ORLA): Evaluating the efficacy of computer-delivered therapy in chronic nonfluent aphasia. *Topics in Stroke Rehabilitation, 17*(6), 22–36. https://doi.org/10.130/tsr1706-423

Cherney, L. R. (2010b). Oral Reading for Language in Aphasia: Impact of aphasia severity on cross-modal outcomes in chronic nonfluent aphasia. *Seminars in Speech and Language, 31*(1), 42–51. https://doi.org/10/1055/s-0029-1244952

Cherney, L. R., Merbitz, C. T., & Grip, J. C. (1986). Efficacy of oral reading in aphasia treatment outcome. *Rehabilitation Literature, 47*(5–6), 112–118.

Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Zeigler, J. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review, 108*(1), 204–256. https://doi.org/10.1037/0033-295X.108.1.204

Conway, T. W., Heilman, P., Rothi, L. J., Alexander, A. W., Adair, J., Crosson, B. A., & Heilman, K. M. (1998). Treatment of a case of phonological alexia with agraphia using the Auditory Discrimination in Depth (ADD) program. *Journal of the International Neuropsychological Society, 4,* 608–620. https://doi.org/10.1017/S1355617798466104

Friedman, R. B. (1996). Phonological text alexia: Poor pseudoword reading plus difficulty reading functors and affixes in text. *Cognitive Neuropsychology, 13*(6), 869–885. https://doi.org/10.1080/026432996381845

Friedman, R. B., & Kohn, S. E. (1990). Impaired activation of the phonological lexicon: Effects upon oral reading. *Brain and Language, 38*(2), 278–297. https://doi.org/10.1016/0093-934X(90)90115-W

Friedman, R. B., & Lott, S. N. (2002). Successful blending in a phonological reading treatment for deep alexia. *Aphasiology, 16,* 355–372. https://doi.org/0.1080/02687040143000627

Fuchs, L., Fuchs, D., Hosp, M., & Jenkins, J. (2001). Oral reading fluency as an indicator of reading competence: A theoretical, empirical, and historical analysis. *Scientific Studies of Reading, 5*(3), 239–256. https://doi.org/10.1207/S1532799XSSR0503_3

Gardner, H., & Zurif, E. (1975). Bee but not be: Oral reading of single words in aphasia and alexia. *Neuropsychologia, 13*(2), 181–190. https://doi.org/10.1016/0028-3932(75)90027-5

Goodwin, L. D., & Leech, N. L. (2006). Understanding correlation: Factors that affect the size of *r*. *The Journal of Experimental Education, 74*(3), 249–266. https://doi.org/10.3200/JEXE.74.3.249-266

Gough, P. B., & Tunmer, W. E. (1986). Decoding, reading, and reading disability. *Remedial and Special Education, 7*(1), 6–10. https://doi.org/10.1177/074193258600700104

Jenkins, J., Fusch, L., van den Broek, P., Espin, C., & Deno, S. (2003). Sources of individual differences in reading comprehension and reading fluency. *Journal of Educational Psychology, 95*(4), 719–729. https://doi.org/10.1037/0022-0663.95.4.719

Kendall, D., Conway, T., Rosenbek, J., & Gonzalez-Rothi, L. (2003). Phonological rehabilitation of acquired phonologic alexia. *Aphasiology, 17*(11), 1073–1095. https://doi.org/10.1080/02687030344000355

Kertesz, A. (2007). *Western Aphasia Battery: Revised examiner's manual*. Pearson. https://doi.org/10.1037/t15168-000

Kim, M., & Russo, S. (2010). Multiple Oral Rereading (MOR) treatment: Who is it for? *Contemporary Issues in Communication Science and Disorders, 37,* 58–68. https://doi.org/10.1044/cicsd_36_S_58

Kim, Y., Wagner, R., & Foster, E. (2011). Relations among oral reading fluency, silent reading fluency, and reading comprehension: A latent variable study of first grade readers. *Scientific Studies of Reading, 15*(4), 338–362. https://doi.org/10.1080/10888438.2010.493964

Kintsch, W., & Kintsch, E. (2005). Comprehension. In S. G. Paris & S. A. Stahl (Eds.), *Children's reading comprehension and assessment* (pp. 71–92). Erlbaum.

Klauda, S. L., & Guthrie, J. T. (2008). Relationships of three components of reading fluency to reading comprehension. *Journal of Educational Psychology, 100*(2), 310–321. https://doi.org/10.1037/0022-0663.100.2.310

Knollman-Porter, K., Wallace, S., Hux, K., Brown, J., & Long, C. (2015). Reading experiences and use of supports by people with chronic aphasia. *Aphasiology, 29*(12), 1448–1472. https://doi.org/10.1080/02687038.2015.1041093

LaPointe, L. L., & Horner, J. (1998). *Reading Comprehension Battery for Aphasia: Examiner's manual* (2nd ed.). PRO-ED, Inc.

McDowell, P. M., & McDowell, R. L. (1998). *McDowell Vision Screen Kit: A procedure for the assessment of functional vision*. Western Psychological Services.

Murray, L. L. (2012). Attention and other cognitive deficits in aphasia: Presence and relation to language and communication measures. *American Journal of Speech-Language Pathology, 21*(2). https://doi.org/10.1044/1058-0360(2012/11-0067)

Nathan, R. G., & Stanovich, K. E. (1991). The causes and consequences of differences in reading fluency. *Theory Into Practice, 30*(3), 176–184. https://doi.org/10.1080/00405849109543498

Perfetti, C. A. (1985). *Reading ability*. Oxford University Press.

Perfetti, C. A. (1992). The representation problem in reading acquisition. In P. B. Gough, L. C. Ehri, & R. Treiman (Eds.), *Reading acquisition* (pp. 145–174). Erlbaum.

Seidenberg, M. S., & McClelland, J. L. (1989). A distributed, developmental model of word recognition and naming. *Psychological Review, 96*(4), 523–568. https://doi.org/10.1037/0033-295X.96.4.523

Smith, K. G., & Clark, K. F. (2019). Error analysis of oral paragraph reading in individuals with aphasia. *Aphasiology, 33*(2), 234–252. https://doi.org/10.1080/02687038.2018.1545992

Strand, E. A., Duffy, J. R., Clark, H. M., & Josephs, K. (2014). The Apraxia of Speech Rating Scale: A tool for diagnosis and description of apraxia of speech. *Journal of Communicative Disorders, 51,* 43–50. https://doi.org/10.1016/j.jcomdis.2014.06.008

Wechsler, D. (2008). *Wechsler Adult Intelligence Scale–Fourth Edition*. NCS Pearson.

Wiederholt, J. L., & Bryant, B. R. (2012). *Gray Oral Reading Tests–Fifth Edition: Examiner's manual*. Pro-Ed.

Wilson, J. P. (2008). *The nature and prevalence of alexia in aphasia* (Unpublished master's thesis). University of Florida, Gainesville, FL, United States.

Wolf, M., & Katzir-Cohen, T. (2001). Reading fluency and its intervention. *Scientific Studies of Reading, 5*(3), 211–239. https://doi.org/10.1207/S1532799XSSR0503_2