Rate of Stuttering and Factors Associated With Speech Fluency Characteristics in Adult

Abstract

Stuttering is a disorder that affects about 1% of the population and manifests as speech disfluencies. Reading difficulties and disabilities are commonly found in this population. Nonetheless, speech disfluencies have not been explored in adult struggling readers (ASRs). In the current study, we examined the rate of stuttering in ASRs as well as the relationships between their speech fluency and reading skills. A total of 120 participants were interviewed about their experiences with reading and administered standardized reading and reading-related assessments. Speech fluency and the criterion for stuttering were based on the interview. About 18.3% of the sample met the criterion for stuttering. ASRs who stutter (ASRs-S) and ASRs who do not stutter (ASRs-NS) did not differ in their reading and reading-related skills. ASRs-S had higher rates of negative correlations between reading and reading-related skills compared to ASRs-NS. Correlation patterns between performance on standardized assessments point to higher rates of uneven skills or dissociations in ASRs-S. These findings may have implications for the assessment and instruction for ASRs.

Keywords: Adult struggling readers, reading, speech fluency, stuttering

About one in five adults in the United States struggle with reading (U.S. Department of Education National Center for Education Statistics, 2017). There is evidence that adults who struggle with reading (ASRs) exhibit difficulties in core reading components as well as oral language skills (Greenberg et al., 2011; Nanda et al., 2014; National Institute of Child Health and Human Development, 2000). This study focuses on a specific issue related to oral language: speech disfluency. To date, no published studies have examined the correlation between reading and speech fluency in ASRs, although speech disfluency has been found to negatively impact performance on oral reading fluency assessments, and reading difficulties are not uncommon in those who stutter (Blood et al., 2003; Games & Reeves, 2014; Howland & Scaler Scott, 2016). Consequently, understanding the relationship between stuttering and reading skills could inform the profile of ASRs and instructional interventions. Before the study is described, a brief introduction to ASRs, speech disfluency, and the relationship between speech fluency and reading ability is provided.

Adult Struggling Readers

ASRs show weaknesses in all areas of reading and reading-related skills. ASRs read at slower speeds and with lower accuracy compared to skilled readers (e.g., Test of Word Reading Efficiency [TOWRE]–Sight Word Efficiency; Mellard et al., 2012; Sabatini, 2002; Torgesen et al., 1999). Slower reading speeds and lower accuracy are also observed in nonword reading assessments (e.g., TOWRE-Phonemic Decoding; MacArthur et al., 2012; Mellard et al., 2011; Nightingale et al., 2016; Sabatini, 2002; Tighe et al., 2019; Torgesen et al., 1999). ASRs also consistently show poorer performance on comprehension measures relative to skilled readers (e.g., Woodcock-Johnson III Passage Comprehension [WJ-PC]; Binder & Lee, 2012; MacArthur et al., 2012; Woodcock et al., 2007).

There is considerable evidence that oral language skills, including expressive vocabulary and phonological awareness, are linked to word and text reading fluency and comprehension in school-age children (for an overview see Katzir et al., 2006; Wise et al., 2007; however see Melby-Lervag & Lervag, 2011). The literature indicates that this is true for adults as well. It used to be widely believed that the oral language skills of chronological age–matched adults who do and do not struggle with reading were similar as both groups were exposed daily to adult oral language experiences (Hoffman, 1978). However, oral language studies have indicated that the skills of ASRs more closely match their reading age level and not their chronological age level. As an example, Sticht (1982) found that adults and children reading at the fifth-grade level performed similarly on a listening comprehension task that was orally transmitted. Likewise, Gold and Johnson (1982) found that adults who read at the third-grade level exhibited fourth-grade listening comprehension skills, and Sabatini and his colleagues (2010) reported that adults reading on average at the third-grade level performed at third- to fifth-grade levels on different listening comprehension tests. Adults reading at the third- through fifth-grade levels performed similarly to nine-year-old children on a test measuring syntax skills (Taylor et al., 2012).

ASRs have also shown difficulties with expressive vocabulary (Cantwell & Rubin, 1992; Gold & Johnson, 1982; Hall, Greenberg et al., 2014; Sabatini et al., 2010). Cantwell and Rubin (1992) found that their ASR participants' reading levels were highly related to their object naming abilities. Although Gold and Johnson (1982) reported slightly higher antonym production skills (sixth-grade level) in ASRs relative to their reading level (third-grade level), their antonym production skills were clearly below adult level. Hall and colleagues (2014) found that their ASR participants performed extremely below adult norms on a confrontation task and more similar to children reading at or below the adults' reading levels (third- to fifth-grade levels). Similarly, Sabatini and colleagues (2010) found that ASRs who read on average at the third-grade level exhibited expressive vocabulary skills at the fourth-grade level.

The most researched oral language topic in ASRs is in the area of phonological awareness, with all studies reporting extreme deficits in all aspects, including blending, elision, decoding, and rhyming (e.g., Dietrich & Brady, 2001; Greenberg et al., 1997, 2002; Mellard et al., 2011; Nanda et al., 2014). As one example, Greenberg et al. (1997) found that compared to reading-matched children, adults reading at the third- to fifth-grade levels showed extreme difficulty with phonological awareness tasks. As another example, ASRs presented more errors when asked to repeat nonwords, regardless of length, compared to skilled adult readers and school-age children with equivalent lexical competency (Dietrich & Brady, 2001). It should be noted that the construct of phonological awareness includes varying levels of skills, from awareness and identification of phonemes to higher level processes such as rhyming, blending, and elision that require the ability to manipulate phonemes beyond awareness and identification (Stahl & Murray, 1994).

Models of Reading

These deficits in expressive vocabulary and phonological awareness in ASRs are consistent with the Simple View of Reading (SVR; Catts, 2018; Gough & Tunmer, 1986) and the language view of reading (LVR; Catts et al., 2014). According to the SVR, reading comprehension difficulties can be attributed to deficits in oral language and/or word reading skills (Gough & Tunmer, 1986). Indeed, these competencies have accounted for the preponderance of variance in reading comprehension across investigations with children and adults (e.g., Lonigan et al., 2018; Savage & Wolforth, 2007; Talwar et al., 2018). In a similar vein, the underlying assumption of the LVR is that reading impairments are underpinned by language deficits, markedly, linguistic (de)coding deficits (Catts, 2017). Oral language skills such as phonology, semantics, and syntax also support speech fluency (Honig, 2007; Levelt, 1999; however see Melby-Lervag & Lervag, 2011). For example during speech, the speaker must retrieve the phonological segments of a word and build a syllable frame for articulation (Levelt, 1993). This encoding process is similar in reading where phonemes are mapped onto letters (Ehri, 2014). Phonological encoding whether in word or nonword reading is correlated with phonological awareness, that is, the awareness that words and nonwords consist of phonemes and combinations of phonemes (Vellutino & Scanlon, 1987). Not surprisingly, adults and children with stronger phonological awareness have stronger reading skills (Dietrich & Brady, 2001), and greater speech fluency (Pelczarski & Yaruss, 2014). In contrast, deficits in phonological awareness may lead to reading and speech impairments.

Speech and reading also share knowledge domains; for example, both processes access the same mental lexicon (Catts, 2017). This is particularly evident in children learning to read for whom oral vocabulary facilitates reading comprehension (Roth et al., 2002). Conversely, weaker oral language skills including lower conceptual knowledge elevate the risk for speech disfluencies and reading difficulties (Catts, 2017; Gough & Tunmer, 1986; Talwar et al., 2018). Theoretically, understanding the link between oral language components, including those involved in speech and reading ability, could reveal mechanisms that underpin reading skills. A disorder such as stuttering that is correlated with speech disfluency, weaker oral language skills (including phonological encoding), and high rates of reading impairments provides a means to understand this relationship. Such knowledge could promote more effective instructional strategies for less proficient readers including those who stutter.

Reading and Reading-Related Skills of Adults Who Stutter

Based on estimates of clinical samples, about 30% of people who stutter exhibit difficulties with reading and writing (Blood et al., 2003; Blood & Seider, 1981). Studies by Ajdacic-Gross and colleagues (2018, 2010) found that adults who stuttered in childhood were four to five times more likely to report reading difficulties. In a study of Spanish-speaking college students (mean age = 24 years) in Colombia, around 27% of those who stutter also reported dyslexia (Ardila et al., 1994). However, this study did not specifically use the term *stuttering* in their survey; instead, respondents were asked about “syllabic iterations” (Ardila et al., 1994, p. 41). Accordingly, it is plausible that stuttering was over-identified, resulting in higher rates of comorbidity in the study. It should be pointed out that in the Ardila et al. (1994) study, participants were surveyed about dyslexia, whereas in the Ajdacic-Gross et al. studies (2018, 2010) participants were also asked about reading “problems” or “troubles.” As such, these studies may be surveying different types of reading challenges.

Adults who stutter also show deficits in reading-related skills. They have lower accuracy and slower responses during oral language tasks (e.g., in picture naming) compared to those who do not stutter (Newman & Ratner, 2007; Pellowski, 2011). Adults who stutter also show poorer performance in nonword repetition tasks compared to adults who do not stutter, although this difference is most evident in more demanding tasks (e.g., repetitions of longer relative to shorter syllables; Sasisekaran, 2013). They are also slower and less accurate in phoneme selection and matching tasks compared to their typically fluent peers (Sasisekaran et al., 2006). Similarly, often children who stutter show weaker skills in multiple aspects of oral language, including phonology, lexicon, morphology, and semantics, compared to children who do not stutter (Anderson & Conture, 2000; Pellowski & Conture, 2005; for an overview see Ntourou et al., 2011). These findings point to deficits in oral language skills that support both reading and speech in people who stutter. As such, deficits in reading and speech may co-occur.

Reading difficulties (such as dyslexia) and stuttering are reported to share common genetic and biological factors (see Elsherif et al., 2021 for an overview). For example, mutations in three genes, GNPTAB, GNPTG, and NAGPA (lysosomal enzyme-targeting genes), associated with susceptibility to stuttering (Kang et al., 2010) also are implicated in the risk of dyslexia (Chen et al., 2015). Additionally, aberrations in brain structure and function in areas involved in oral language processing reported in adults with reading impairments are also found in adults who stutter. For example, both adults with dyslexia and adults who stutter show lower gray matter volume in the left superior temporal gyrus (Eliez et al., 2000; Lu et al., 2010), and lower activity in the left inferior frontal gyrus during reading compared to skilled readers and typically fluent adults, respectively (Brambati et al., 2006; De Nil et al., 2000). Collectively, these findings suggest a strong etiological overlap between reading impairments and stuttering.

Speech Disfluency

The term *speech disfluency* refers to disruptions in the flow of speech, with certain types being more common in people who stutter (Bloodstein & Ratner, 2008). There are two types of disfluencies: typical disfluencies (TDs) and stuttering-like disfluencies (SLDs; Ambrose & Yairi, 1999). TDs consist of multisyllabic word repetitions, phrase repetitions, word and phrase revisions, and pauses (Ambrose & Yairi, 1999; Ratner & Brundage, 2019). SLDs consist of blocks, prolongations, part-word repetitions, broken words, phonological fragments, and monosyllabic word repetitions (Ambrose & Yairi, 1999; Ratner & Brundage, 2019).

Typical Disfluencies (TDs). There are various TDs but certain ones are more common in the general population. Interjections (e.g., *uhm* and *uh*) are commonly found in spontaneous speech

(Ambrose & Yairi, 1999; Yairi & Clifton, 1972). Other TDs include phrase and word revisions in which speakers attempt to repair their utterance (e.g., *What did …? Where did …*?); multisyllabic word repetitions, which are the unintended repetition of whole multisyllabic words (*curtain … curtain*); and pauses, which are marked by the absence of speech (Bloodstein & Ratner, 2008).

Stuttering-like Disfluencies (SLDs). SLDs are less common in the general population but occur at higher rates in those who stutter (Ambrose & Yairi, 1999). High rates of SLDs (≥ 3%) are indicative of a fluency disorder and increase as a function of stuttering severity (Ambrose & Yairi, 1999). *Blocks* occur when the speaker is unable to initiate or vocalize a sound (e.g., ---*car*), and *prolongations* occur when the speaker holds on to or is unable to move past a sound (e.g., *sssssssssstutter*; Bloodstein & Ratner, 2008). Other SLDs include *part-word repetitions,* where the initial sound of a word is repeated (e.g., *c-c-c-cat*); *broken words,* where the speaker pauses within a word (e.g., *wa-ter*); *phonological fragments,* where the speaker initiates but abandons a word (e.g., *pas---spaghetti*); and *monosyllabic repetitions,* where the speaker repeats a single-syllable word (e.g., *I-I-I-I;* Ambrose & Yairi, 1999; Ratner & Brundage, 2019). SLDs decrease in children who recover within two to three years after stuttering onset; however, an estimated 30% stutter into adulthood, resulting in a prevalence of around 1% in the general population (for an overview, see Yairi & Ambrose, 2013). Although the exact cause of stuttering is unclear, high rates of affected individuals with a family history suggest a hereditary component (Buck et al., 2002).

The Present Study

Studies examining stuttering have mainly focused on those with typical literacy, and/or those in clinical samples. However, given the reports of high rates of co-occurring reading difficulties and stuttering, it is critical to expand our understanding by investigating adults who attend adult literacy programs to further grasp the relationship between speech disfluency and reading in adults with low literacy skills. Understanding the relationship between stuttering and reading in this specialized population could help inform assessment and instruction for ASRs. In this study, we first focused on uncovering the rates and characteristics of adults who exhibit SLDs (i.e., those who stutter). Second, we sought to determine whether ASRs who do and do not stutter show similar reading levels and reading-related skills based on their performance on standardized assessments. Third, we were interested in the interrelationships between reading and reading-related skills in ASRs who do and do not stutter, that is, whether and how different skills were correlated (e.g., positively or negatively). Specifically, we asked the following research questions to address the critical gap in our understanding:

RQ1. What is the rate of stuttering in ASRs?

RQ2. Do ASRs who meet the criterion for stuttering (ASRs-S) show weaker reading and related skills compared to ASRs who do not stutter (ASRs-NS)?

RQ3. Do ASRs-S show similar relationships between reading and reading-related skills compared to ASRs-NS?

Method

Participants

Participants consisted of 120 native English-speaking ASRs (70 females, 50 males) who, based on testing conducted by the adult literacy programs, were enrolled in adult literacy reading classes targeting the third- to eighth-grade levels in a large southeastern metropolitan area in the United States. The age of participants ranged between 17 and 70 years old (*M* = 37.94 years, *SD* = 15.43). They were drawn from a larger federally funded study on adult struggling readers in the United States and Canada (see Author Note). Within this larger study, a sample was selected to study dialect use among the native English speakers who identified as Black or as African American and were part of the United States sample. Researchers of that study noticed heightened disfluencies in their sample, which provided an impetus to this current study. Although all participants in this current study identified as Black or African American, race and ethnicity are not predictors of stuttering, and studies comparing the prevalence of stuttering between African American and European American children have found no significant differences (Proctor et al., 2008). For more demographic information about the participants see Table 1.

Procedure

Participants were recruited to be part of a larger study (see Author Note). After consent was obtained, in a quiet room participants were individually administered a battery of tests and surveys and interviewed about their reading experiences. All assessments, surveys, and interviews were conducted by trained research assistants. Depending on the participant's availability, these were conducted before or after participants attended class, and sometimes on days when they did not have class. In the larger study, the complete testing battery took anywhere from 4 to 6 hours across 2 to 4 multiple sessions.

Standardized Assessments, Survey and Oral Disfluency Speech Sample. Participants were administered tests for oral word and nonword reading, silent reading, reading speed, comprehension, expressive language, and phonological awareness (see Table 2 for a full list of assessments and descriptions). Participants were also asked to report their gender, age, highest level of grade completion, whether they attended any special education classes, whether they were tested for a learning disability or educational problem as a child or adult, whether they had their vision or hearing tested as a child or adult, and whether they ever had a head injury or stroke. Self-reported reading ability was ascertained with the following question: "In general, how well do you understand what you read (in English)?" Possible responses included: "I don't understand anything I read," "I understand some of what I read," "I understand most of what I read," "I understand everything that I read," "Don't know," and "No response."

Based on work conducted by Gorges and Kandler (2012), participants were asked to describe a past negative reading experience and a positive one. Participants were prompted with two questions specifically designed for the present study: "Tell me about a negative or bad experience you had with reading in the past. Pick one that has stuck with you over the years," and "Tell me about a positive or really good experience you have had with reading in the past. Just like the last one, pick one that has stuck with you over the years." Responses from the interview were audio recorded and transcribed. These audiotaped transcriptions served as our measure of speech fluency.

Transcription and Coding of Speech Disfluency. The audio samples were initially transcribed using the Systematic Analysis of Language Transcripts (SALT; J. Miller & Chapman, 2008) but reformatted into CHAT using the Computerized Language Analysis (CLAN; MacWhinney, 2003). Three researchers trained in a commonly used procedure to quantify stuttering frequency (see Yaruss et al., 1998) identified and coded oral disfluencies in the audio samples into two categories: (1) stuttering-like disfluencies (SLDs), and (2) typical disfluencies (TDs). Coding consisted of multiple passes through each transcript. First, SALT codes were removed. Next, transcribers listened to the audio sample and coded SLDs and TDs according to the conventions of CLAN (see Ratner & Brundage, 2019). Transcribers conducted two more passes after the initial coding to review the accuracy and to make any necessary additions or corrections. If there were ambiguities, the original transcriber and another transcriber listened to the samples to reach a consensus. Finally, FLUCALC, a utility under CLAN, was used to determine the frequency of these speech disfluencies (i.e., the number of disfluencies divided by the total number of words; Ratner & Brundage, 2019). Ten percent of the transcripts were randomly selected to evaluate the reliability of the speech disfluency coding. There was strong inter-scorer agreement in the identification of disfluencies (ICC = 0.976).

Criteria for Stuttering. A criterion of ≥ 3% SLDs (three or more SLDs per 100 words), a validated, commonly used method to identify stuttering (Ambrose & Yairi, 1999), was applied to the audio transcripts. ASRs with ≥ 3% SLDs were identified with stuttering (ASRs-S) and ASRs with < 3% SLD (ASRs-NS) were classified as typically fluent, that is, without clinically significant levels of stuttering.

Data Analyses

To address our research question related to the rate of stuttering, we analyzed the number of ASRs who met the criterion for stuttering divided by the total number of ASRs in the sample. Rates of speech disfluencies (i.e., number of speech disfluencies divided by the total number of words) were also determined for each group (ASRs-S vs. ASRs-NS). A MANOVA was used to determine whether there were differences in the speech fluency measures (SLDs and TDs). If the MANOVA result was statistically significant, *t* tests were conducted to evaluate differences across the various types of speech disfluency between the two groups. We compared a series of demographic characteristics and speech disfluencies between the ASRs-S and ASRs-NS. The chi-square tests of association were used to evaluate group differences in sex, learning history, and medical history. Two-sample independent *t* tests were used to evaluate group differences in age, education level, and self-reported reading pattern.

To determine whether ASRs-S show weaker reading and related skills compared to ASRs-NS, we used a MANOVA to determine group differences in performance. If the MANOVA result was statistically significant, *t* tests were conducted to evaluate differences between the two groups in each of their standardized test raw scores. To determine whether ASRs-S show similar relationships between reading and related skills compared to ASRs-NS, Pearson bivariate correlations were conducted to identify relationships between reading, related measures, and speech disfluency (%SLD and %TD). All analyses were conducted with SPSS 25 (IBM Corp., 2017).

Results

Research Question 1

Based on the analysis of the interviews, 22 ASRs or 18.3% of the participants (female = 15) met the criterion for stuttering (ASRs-S), while 98 ASRs (female = 55) were identified as typically fluent (ASRs-NS; see Table 1). The ratio of females to males was higher for ASRs-S (2.14:1) compared to ASRs-NS (1.32:1); however, the chi-square test indicated that there was no significant association between sex and stuttering status. The rate of ASRs-NS (n = 36, 36.73%) who were tested for a learning disability as a child or adult was significantly higher than for ASRs-S (n = 2, 9.09%) $\chi^2(1, N = 116) = 5.683$, $p < .05$. Also, the rate of ASRs-NS (n = 22, 22.45%) who were tested for an educational problem was higher compared to ASRs-S (n = 1, 4.55%), although this difference did not reach statistical significance, $\chi^2(1, N = 115) = 3.728$, $p = .053$. There were no statistically significant group differences in terms of their demographic characteristics.

The skewness and kurtosis of speech disfluencies were in agreement with past findings in the population who do and do not stutter, that is, a symmetric distribution with a slight right skew (Jones et al., 2006). Furthermore, as expected based on our group classification criterion, the MANOVA revealed significant differences in the rates of disfluencies between groups (Wilks' lambda [Λ] = 0.311), *F*(13, 106) = 18.034, $p < .0001$, $\eta 2_p = 0.689$.[1] Thus, two-tailed *t* tests with Bonferroni correction ($p = .05/14 = .004$) were further used to determine between-group differences on each disfluency measure. As expected based on the group classification criteria, the rates of speech disfluencies were higher for ASRs-S compared to ASRs-NS (see Table 3). The overall rate of speech disfluencies for the sample (both SLDs and TDs) was 12.84% (*SD* = 10.39). The % SLDs for ASRs-S was 5.34% (*SD* = 2.09), and 1.10% (*SD* = 0.95) for ASRs-NS, *t*(22.9) = -9.323, $p < .0001$ (see Table 3). The %TDs appeared to be higher for ASRs-S (15.43%, *SD* = 11.62) compared to ASRs-NS (9.96%, *SD* = 8.90) although the difference was no longer significant after the Bonferroni correction, *t*(118) = -2.455 , $p > .004$. For SLDs, phonological fragments (ASRs-S: 2.73%, *SD* = 1.30; ASRs-NS: 0.50%, *SD* = 0.67), *t*(23.6) = -7.781, $p < .0001$; and monosyllabic repetitions (ASRs-S: 2.17%, *SD* = 1.74; ASRs-NS: 0.45%, *SD* = 0.62), *t*(22.2) = -4.564, $p < .0001$; were higher for ASRs-S compared to ASRs-NS. For TDs, phrase revisions (ASRs-S: 2.77%, *SD* = 2.12; ASRs-NS: 1.26%, *SD* = 1.51), *t*(26) = -3.165, $p = .004$; and multisyllabic word repetitions (ASRs-S: 2.23%, *SD* = 1.78; ASRs-NS: 0.48%, *SD* = 0.66), *t*(22.3) = -4.550, $p < .0001$; were more common in ASRs-S compared to ASR-NS (see Table 3).

Research Question 2

There were no significant differences between groups (Wilks' lambda [Λ] = 0.946), *F*(12, 91) = 0.436, $p > .05$, $\eta 2_p = 0.054$[2]; as such, follow-up *t* tests were not required. However, to provide more information to readers, the performance of ASRs-S and ASRs-NS across these assessments, along with the *t* test results with Bonferroni correction ($p = .05/12 = .004$), are presented in Table 4.

Research Question 3

As indicated in Table 5, different correlation patterns were noted for the two different groups. Overall, ASRs-S showed 33 negative correlations compared to ASRs-NS, who had only 15 negative correlations. Further, ASRs-NS and ASRs-S showed significant correlations on 20 identical items. Two items were significant for ASRs-S but not for ASRs-NS. Of note, there was a surprising negative correlation between the WJ-Passage Comprehension and CTOPP-Elision that was significant for ASRs-S ($r = -0.475$, $p < .05$) but not for ASRs-NS ($r = 0.098$, $p > .05$). This means that ASRs-S who demonstrated better reading comprehension showed poorer performance on the elision task. Further comparison of these correlations using the Fisher's *Z* statistic (Fisher, 1921) indicated that they were significantly different from each other ($Z = -2.392$, $p < .05$). Sixteen items were significant for ASRs-NS but not for ASRs-S. Notably, there was a counterintuitive but significant correlation between the WJ-Word Attack and %TDs for ASRs-NS ($r = 0.218$, $p < .05$; i.e., the higher the WJ-Word Attack scores, the higher the rates of speech disfluencies). Generally, better decoding and articulation skills are associated with lower rates of disfluencies (Pelczarski & Yaruss, 2014; Tumanova et al., 2011). For example, children who stutter, who generally show weaker decoding skills than their typically fluent peers, present higher rates of disfluencies (Pelczarski & Yaruss, 2014). Further, weaker articulation skills (as reflected in slower rates) are correlated with higher rates of disfluencies in children who stutter (Tumanova et al., 2011). In the present study, the correlation between the WJ-Word Attack and %TD was as low as 0.021 for ASRs-S ($p > .05$). The magnitude of this correlation appeared to be larger for ASRs-NS compared to ASRs-S; however, further comparison of these correlations using the Fisher's *Z* statistic (Fisher, 1921) indicated that they were not significantly different from each other ($Z = -0.78$, $p > .05$). One potential reason for the lack of a significant difference could be our small sample size; however, we believe that the observed difference is still meaningful and worthy of future investigation.

Discussion

The goals of the present study were to determine the rate of stuttering in a sample of adults who read between the third- and eighth-grade levels and to examine the link between speech disfluencies and reading skills in ASRs. The major finding is the higher rate of stuttering in ASRs compared to the general population. Another somewhat surprising finding is that the frequency of speech disfluency was not associated with reading ability. Of additional interest is that the ASRs-S group was more likely to have negative correlations between reading and related abilities, that is, they showed more dissociated skills compared to the ASRS-NS group.

Stuttering and ASRs

Nearly a fifth of ASRs in the current study met the criterion for stuttering, which is higher than the estimated 1% in the general population. This finding is consistent with past reports of high rates of reading challenges and disabilities in clinical populations who stutter (Blood et al., 2003; Blood & Seider, 1981). This finding also aligns with the LVR, which proposes that reading challenges are a corollary of oral language deficits (Catts et al., 2014) and as such may be more common in those who stutter (Elsherif et al., 2021; however see Nippold & Schwarz, 1990). Reading necessitates the same linguistic and conceptual knowledge as oral language, and weaker skills in these domains would increase the risk of reading difficulties (Catts, 2017). In children who do not stutter, early language impairments increase the risk for reading impairments (for an overview, see Pennington & Bishop, 2009).

Due to the relationship in the general population between stuttering and reading, it is perhaps not surprising that we found a higher rate of stuttering in this ASRs sample. However, it is surprising that there was almost no relationship between speech disfluency and any of the reading/reading-related tests for ASRs-S, although ASRs-NS showed a contradictory correlation between nonword oral reading and %TD ($r = 0.218$; ASRs-S: $r = 0.021$). After all, children who stutter often show weaker oral language skills that are correlated with speech abilities, including in phonology, lexicon, morphology, and semantics, compared to children who do not stutter (Anderson & Conture, 2000; Pellowski & Conture, 2005). Children who stutter on average exhibit expressive language skills below their chronological age, with some showing delays of more than 3 years (K. Byrd & Cooper, 1989; Choo et al., 2016; for an overview see Ntourou et al., 2011), and they have more errors in phoneme identification and manipulation compared to children who do not stutter (Pelczarski & Yaruss, 2014; for an overview see Bloodstein & Ratner, 2008). Similarly, adults who stutter show slower lexical, semantic, syntactic, and phonological processing, and weaker expressive vocabulary relative to adults who do not stutter (Newman & Ratner, 2007; Pellowski, 2011). Further, greater linguistic complexity (e.g., in syntax, grammar, phonology and lexical diversity) is correlated with a higher frequency of stuttering: Stuttering is more likely to occur on longer, more complex sentences than on shorter, less complex sentences (LaSalle & Wolk, 2011; Logan & Conture, 1995; Wagovich & Hall, 2017; Wolk & LaSalle, 2015; however, see Nippold, 2002).

Overall, as expected based on the group classification criteria, rates of SLDs (which are characteristic of stuttering) and TDs (typical disfluencies) were higher for ASRs-S compared to ASRs-NS. Further inspection of the SLDs points to higher rates of phonological fragments and monosyllabic word repetitions for ASRs-S relative to ASRs-NS, which is consistent with expectations based on the group classification criteria. Phonological fragments may reflect word substitution strategies in which the speaker abandons a word and replaces it with another to prevent stuttering (Jackson et al., 2015). In fact, a majority of adults who stutter (≥ 80%) report using word substitution as a strategy to increase fluency (Jackson et al., 2015; Vanryckeghem et al., 2004). Word repetitions, including monosyllabic word repetitions, may be the result of "stalling": A speaker (consciously or unconsciously) reproduces a previous word to increase planning time for an upcoming word (Howell, 2007, p. 732; Howell & Au-Yeung, 2002).

The correlational trend between oral nonword reading and oral disfluency also revealed a surprising finding for the ASRs-NS. Stronger phonological skills were correlated with lower speech fluency for ASRs-NS. Studies examining adults and children who stutter report lower phonological skills compared to their typically fluent peers, suggesting that speech disfluencies may be associated with phonological deficits (Sasisekaran, 2013; Sugathan & Maruthy, 2020; however, see Nippold, 2002). Nonetheless, these studies have not found a direct correlation between the rate of stuttering and phonological ability. Although seemingly counterintuitive, the association between weaker phonological skills and higher speech fluency suggests that phoneme production or reading in ASRs-NS may be influenced by other factors, including the phonological pattern frequency (i.e., the frequency that a sequence of phoneme occurs) and higher-level compensatory processes (e.g., lexical access). Models for speech production that include ones for lexical access and findings in early readers could offer some insights. In classic models of speech production (e.g., Levelt, 1993), speech processing is a sequential process. Messages must be formulated; that is, the phonological code for the word is retrieved from the mental lexicon based on semantic and pragmatic correspondence, and then it is serially mapped into a motor plan for execution (Levelt, 1993; Levelt & Meyer, 2000). The speed and ease at which the phonological plan is retrieved and executed is frequency dependent, that is, it is faster and easier for words that are frequently encountered (Levelt & Meyer, 2000). Without access to lexical information (as in nonword reading compared to word reading), the phonological encoding process would be slower and more challenging, particularly for less-skilled readers.

Findings in early readers are aligned with predictions from speech production models. In the early stages of vocabulary development, phoneme production is highly sensitive to context and frequency (Munson, 2001). Children show greater accuracy and fluency (as measured by the speed of production) in phoneme repetition for words compared to nonwords, and for high-frequency phoneme sequences compared to low-frequency or novel phoneme sequences (Casalini et al., 2007; Edwards et al., 2004; Munson, 2001). Further, children with larger vocabularies showed higher accuracy and greater fluency relative to children with smaller vocabularies, and the difference in accuracy and fluency between the high-frequency and low-frequency or novel phoneme sequences was greater for children with smaller vocabularyies relative to those with larger vocabularies (Edwards et al., 2004; Munson, 2001). These findings suggest that context and access to lexical information (which are present in real words or high-frequency phoneme sequences but absent in nonwords or novel sequences) may facilitate phoneme production, ipso facto, speech production and fluency, particularly for those with smaller vocabulary (Edwards et al., 2004).

Difficulties in lexical access have been found to increase speech disfluencies (Don & Lickley, 2015; Hartsuiker & Notebaert, 2009). For example, speakers produced higher rates of pauses in naming tasks with low picture name agreement where the lexical retrieval is more difficult relative to conditions with high picture name agreement (Hartsuiker & Notebaert, 2009). Likewise, the association between weaker oral nonword reading (where context and lexical knowledge cannot be applied) and greater speech fluency during the interview (where context and lexical information are accessible) suggests that context and lexical information are crucial in facilitating speech fluency in ASRs-NS. However, the present study was unable to determine the degree to which context and lexical information contribute to speech fluency in ASRs-NS. We suggest this as an area of future research.

We would also expect greater difficulty in nonword and low-frequency or novel phoneme reading in ASRs based on models of speech production and the aforementioned findings in children. Studies comparing word and nonword reading in individuals with reading impairments and skilled readers are in agreement with this prediction, that is, weaker nonword relative to word reading in readers with impairments (Gottardo et al., 1999; Paul et al., 2006). Greenberg et al. (1997, 2002) found that when compared to reading age-matched children, their ASRs sample exhibited (a) relative strengths in irregular word reading and spelling and (b) significant weaknesses in phonological tasks (e.g., phoneme deletion and segmentation).

Alternatively, it is also possible that visual word recognition facilitates reading in ASRs-NS, a strategy that is not available for nonword reading. In general, ASRs are stronger in visual word reading and weaker in decoding nonwords (Greenberg et al., 2002; Perin & Greenberg, 1992). Visual word recognition or memory may also facilitate fluent speech. Speech production requires that speakers engage cognitive resources to access and maintain representations (e.g., syntax, lexicon, phonology) of relevant information in memory (Baddeley & Hitch, 1974). Storing and processing information across two modalities (e.g., visual and verbal) could reduce the cognitive load (Sweller et al., 2011) and increase available resources for speech processing, lowering the risk of speech disruptions. In line with this explanation, research points to weaker visual memory for those who stutter compared to their typically fluent peers (Oyoun et al., 2010;

Wagovich et al., 2020). Simply put, ASRs-NS may have stronger visual processing skills, at least in comparison to their phonological skills and peers who stutter, which facilitates speech fluency. Accordingly, determining whether ASRs-S and ASR-NS differ in their visual word recognition skills will be an important area for future research.

Why would there be a lack of a significant correlation between nonword reading and speech fluency in ASRs-S? The literature on speech motor skills in stuttering may shed some light. In nonword repetition tasks with short syllable lengths where the stimuli were presented orally, adults who stutter showed equivalent accuracy to adults who do not stutter (Sasisekaran, 2013; Smith et al., 2010). However, C. T. Byrd et al. (2012) found that for adults who stutter (but not for their typically fluent counterparts), speech accuracy during nonword repetition decreased with increasing nonword length even when the phonotactic complexity did not increase (i.e., similar combination of phonemes). Findings in nonword reading where the stimuli were presented orthographically were similar to the results based on oral stimuli. Sasisekaran (2013) found that adults who stutter showed a negative correlation between nonword reading accuracy and syllable length. Although both adults who do and do not stutter showed comparable accuracy with shorter syllable lengths (e.g., 6 syllables), adults who stutter exhibited lower accuracy relative to adults who do not stutter with longer syllable lengths. These findings may point to the contribution of speech motor ability to speech production in those who stutter. Kinematic data (i.e., analyses of movement of speech-related structures such as lips) during nonword repetition were also consistent with these findings. Adults who stutter had less consistency (i.e., less consistent lip movements) even when there were no observable differences in oral production compared to typically fluent adults, and group differences in motor accuracy widened with increasing syllable length (Smith et al., 2010). Together, these findings on syllable lengths and kinematics suggest that speech motor skills and demands have significant impact on speech fluency in those who stutter, including ASRs-S.

Speech motor skills may also mediate reading comprehension in ASRs-S. In the present study, ASRs-NS, but not ASRs-S, showed a small and positive (but non-significant) correlation between elision and reading comprehension. In terms of magnitude, the weak correlation in ASRs-NS is in agreement with previous reports of a marginal effect of elision on reading comprehension for readers with impairments wherein other reading-related skills such as decoding and word identification modulated the effects of elision (Chen et al., 2016). In terms of correlational direction, the positive correlation in ASRs-NS is consistent with findings pointing to elision as a predictor of early reading comprehension (Foorman et al., 2015; however, see Elhassan et al., 2017). Conversely, there was a large, negative correlation between elision and reading comprehension in ASRs-S: ASRs-S with stronger phonological awareness (at least in comparison to others who stutter) showed weaker reading comprehension.

There is a growing body of research pointing to lower phonological awareness, including in elision, in those who stutter compared to their typically fluent peers (e.g., C. T. Byrd et al., 2015; Pelczarski & Yaruss, 2014). Based on this finding, ASRs-S would be expected to show weaker phonological awareness compared to ASRs-NS, and ASRs-S who utilize a phonological awareness strategy would be predicted to show weaker reading comprehension. In the present study, ASRs-S showed slightly lower performance on the elision task compared to ASRs-NS, although this was not statistically significant, and there were no differences in reading comprehension scores between the two groups. First, it is plausible that phonological awareness may be weaker in ASRs-S compared to ASRs-NS. Nonetheless, the deficits in phonological awareness may only be apparent when task demands are high enough to exceed capacity, and the

CTOPP-Elision task in which phonological awareness is tested in isolation may not be sufficiently taxing. Second, there were no differences in the reading comprehension skills between ASRs-S and ASRs-NS based on the WJ-PC. In fact, ASRs-S had slightly higher scores (albeit not significant) compared to the ASRs-NS. In skilled readers, reading comprehension is correlated with phonological awareness (Melby-Lervåg & Lervåg, 2011). Further, skilled readers show equivalent levels of comprehension with either oral or silent text reading, whereas oral text reading, which requires overt speech and engages the speech motor system to a larger degree, facilitates greater comprehension compared to silent reading for less proficient readers (Holmes, 1985; Huang et al., 2001; S. D. Miller & Smith, 1985; Price et al., 2016; however, see Juel & Holmes, 1981).

Similar to less proficient readers, ASRs-S may also utilize oral word or text reading to a greater degree to facilitate comprehension. In fact, previous findings suggest that adults who stutter show greater reliance on speech motor skills, engaging the motor regions of the brain during silent word reading to a larger extent compared to adults who do not stutter even when speaking is not required (e.g., De Nil et al., 2000). Collectively, these findings suggest that ASRs-S may rely on speech motor skills to a greater degree during both silent and oral text readings compared to phonological awareness skills to promote comprehension. This would be consistent with the negative correlation between phonological awareness and reading comprehension in ASRs-S in the present study. Nonetheless, it is beyond the scope of the present study to determine the link between speech motor ability and reading comprehension in ASRs-S. We suggest this as a future area of research. In summary, the findings that phonological skills (as measured by nonword repetition and elision) were not positively correlated with speech fluency or reading comprehension suggest that ASRs-S may engage speech motor skills to a greater extent, at least in comparison to ASRs-NS, for speech and reading processes.

Dissociated Skills

It was of interest that the ASRs-S showed a higher number of negative correlations and fewer significant correlations between reading and related skills compared to the ASRs-NS. In other words, ASRs-S were more likely to have unequal or “dissociated” skills compared to ASRs-NS. Higher rates of negative correlations and lower rates of significant correlations in ASRs-S suggest that the development of one skill does not necessarily support another; that is, some abilities may be more impaired than others, leading to dissociated skills. Dissociations may result in greater allocation of already limited resources to reconcile these mismatches, depleting resources for speech and lowering speech fluency (Anderson et al., 2005; Choo et al., 2016). The allocation of resources to resolve mismatched skills may also result in fewer resources available for reading processes in ASRs-S. The resolution of dissociations could increase available resources, improving reading skills as well as speech fluency in ASRs-S. Dissociated skills do not necessarily indicate weaker reading ability for ASRs-S compared to ASRs-NS. A modest difference between abilities could result in a dissociation. In fact, in this study, ASRs-S and ASRs-NS showed similar performance on standardized tests.

Dissociations may also result from constrained mastery, whereby skills are narrowly applied and do not translate to other domains. It is possible that deficits associated with stuttering limit the ability of the reader to command and integrate skills within and across tasks, but these challenges only emerge when reading processes are sufficiently taxed. Findings from studies examining skills transfer support this explanation. In both sequenced finger tapping and oral production tasks (e.g., /ta ba pa ta ga pa ga ta pa ba/), adults who stutter show reduced ability to retain and transfer learned skills (Smits-Bandstra & De Nil, 2009). Further, although adults who stutter showed gains in accuracy and speed with practice during these tasks, these gains were more modest compared to improvements in adults who do not stutter (Smits-Bandstra & De Nil, 2009; Smits-Bandstra et al., 2006). Adults who stutter, including ASRs-S, may have difficulty in transferring requisite skills (including those for reading) beyond the immediate domains. Nonetheless, when task demands are low, these abilities may not appear deficient, at least in comparison to ASRs-NS.

Implications

The present findings have implications for assessment and instruction. Speech-language pathologists typically evaluate for speech disfluencies, while adult literacy instructors and researchers do not. The high rate of stuttering in our sample suggests that the adult literacy field may want to consider including assessments for stuttering, and more research is necessary to draw implications for instruction. For ASRs-S, speech disfluencies may camouflage gains achieved in adult literacy classes, particularly if oral word or text reading rate—or speech fluency—are used to gauge improvement. Although the directionality of the stuttering-reading relationship is unclear, the higher rates of dissociation in the ASRs-S group suggest that stuttering may have a profound impact on the integration of skills required for reading. Therefore, a two-pronged strategy targeting stuttering and supporting reading skills may be required for successful instruction.

Limitations and Directions for Future Research

In the current study, the criterion for stuttering was based on audio samples taken during an interview about the participants' past reading experiences. Speech disfluencies could be accompanied by secondary behaviors, such as eye blinking and grimacing, that would indicate severe stuttering but are not detectable in audio samples. Counts for oral disfluencies are 20% lower for audio samples compared to audiovisual ones (Rousseau et al., 2008). Thus, it is plausible that stuttering was undercounted in this study. Further, stuttering severity is variable across speaking situations, increasing the risk of misidentification, particularly for ASRs with mild stuttering or who may be experiencing increased fluency during the interview. Nonetheless, our interview topic, "Tell me about a negative or bad experience you had with reading experiences," may have heightened anxiety in some ASRs, leading to a higher number of speech disfluencies and possibly an over-identification of stuttering.

Participants were not asked about their history of stuttering, treatment for the disorder, or any other speech-language interventions that could have impacted speech fluency. It is possible that some treatments for stuttering could directly or indirectly impact reading and reading-related skills; as such, we propose this as a future area of research. It is also unknown whether stuttering in the present study was developmental or acquired. While acquired stuttering is typically due to neurological trauma (e.g., stroke), the cause of developmental stuttering is unclear. Such distinctions may impact assessments. Finally, it is unclear whether other challenges in addition to stuttering distinguish between the two groups. For example, a higher percentage of ASRs-NS were tested for a learning disability compared to ASRs-S; however, the results of these assessments are not known.

Race and ethnicity are not risk factors for stuttering; the prevalence of stuttering is not higher in the general population of African Americans (Proctor et al., 2008), and the types of disfluency reported in African Americans who stutter do not differ from those observed in their European American counterparts (Olsen et al., 1999; Ratusnik et al., 1979). Nonetheless, future research is warranted to determine whether our findings generalize to other populations. Further, as stuttering is a low prevalence disorder affecting about only 1% of the general population, the present study consisted of a smaller number of participants who stutter compared to participants who do not stutter. However, studies that consist of 10 to 20 participants who stutter are not uncommon (e.g., Howell & Ratner, 2018: 15 adults who stutter and 15 adults who do not stutter; Sasisekaran et al., 2006: 10 adults who stutter and 11 adults who do not stutter). Future studies that include a larger sample of participants who stutter may reveal trends that were not detected and determine whether findings from the present study are robust.

Conclusion

This is the first known study to investigate the rate of stuttering in an ASR sample. A major significance of this study is the high rate of stuttering in ASRs. This finding argues strongly for (a) screening for stuttering in ASRs and (b) interventions that support speech fluency and reading skills for ASRs-S. Nonetheless, more work needs to be done at the basic level to establish assessments for ASRs that do not conflate speech fluency and reading ability to prevent misidentification. Little is known about the profile of ASRs-S; thus, further research is warranted to uncover the relationship between stuttering and reading challenges. Such knowledge will be essential to establishing the best approach to instruction for ASRs who have the added challenge of stuttering.

Notes

[1]We conducted a separate analysis without ASRs who reported a history of head injury and stroke. This result of this analysis was similar to findings with the full dataset analysis, that is, ASRs-S and ASRs-NS differed in the rates of speech disfluencies (Wilk’s lambda [Λ] = 0.331), $F(13, 71) = 11.023$, $p < .0001$, $\eta 2_p = 0.669$.

[2]We conducted a separate analysis without ASRs who reported a history of head injury and stroke. This result of this analysis was similar to findings with the full dataset analysis; that is, ASRs-S and ASRs-NS did not differ in reading and reading-related skills (Wilks' lambda [Λ] = 0.757), $F(12, 62) = 1.657$, $p > .05$, $\eta 2_p = 0.243$.

References

Ajdacic-Gross, V., Bechtiger, L., Rodgers, S., Müller, M., Kawohl, W., von Känel, R., Mutsch, M., Rössler, W., Seifritz, E., Castelao, E., Strippoli, M-P., Vandeleur. C., Preisig, M., &, Howell, P. (2018). Subtypes of stuttering determined by latent class analysis in two Swiss epidemiological surveys. *PloS One, 13*(8), e0198450. http://dx.doi.org/10.1371/journal.pone.0198450

Ajdacic-Gross, V., Vetter, S., Muller, M., Kawohl, W., Frey, F., Lupi, G., Blechschmidt, A., Born, C., Latal, B., & Rössler, W. (2010). Risk factors for stuttering: a secondary analysis of a large data base. *European Archives of Psychiatry and Clinical Neurosciences, 260*(4), 279-286. http://dx.doi.org/10.1007/s00406-009-0075-4

Ambrose, N. G., & Yairi, E. (1999). Normative disfluency data for early childhood stuttering. *Journal of Speech, Language, and Hearing Research, 42*(4), 895-909. http://dx.doi.org/10.1044/jslhr.4204.895

Anderson, J. D., & Conture, E. G. (2000). Language abilities of children who stutter: A preliminary study. *Journal of Fluency Disorders, 25*(4), 283-304. https://doi.org/10.1016/S0094-730X(00)00089-9

Anderson, J. D., Pellowski, M. W., & Conture, E. G. (2005). Childhood stuttering and dissociations across linguistic domains. *Journal of Fluency Disorders*, *30*(3), 219-253. http://dx.doi.org/10.1016/j.jfludis.2005.05.006

Ardila, A., Bateman, J., Niño, C. R., Pulido, E., Rivera, D. B., & Vanegas, C. J. (1994). An epidemiologic study of stuttering. *Journal of Communication Disorders, 27*(1), 37-48. http://dx.doi.org/10.1016/0021-9924(94)90009-4

Baddeley, A.D. and Hitch, G.J. (1974) Working memory. In G. A. Bower (Ed.), *The psychology of learning and motivation* (pp. 47–89). Academic Press.

Binder, K. S., & Lee, C. (2012). Reader profiles for adults with low literacy skills: A quest to find resilient readers. *Journal of Research and Practice for Adult Literacy, Secondary, and Basic Education, 1*(2), 78-90.

Blood, G. W., Ridenour Jr, V. J., Qualls, C. D., & Hammer, C. S. (2003). Co-occurring disorders in children who stutter. *Journal of Communication Disorders, 36*(6), 427-448. http://dx.doi.org/10.1016/S0021-9924(03)00023-6

Blood, G. W., & Seider, R. (1981). The concomitant problems of young stutterers. *Journal of Speech and Hearing Disorders, 46*(1), 31-33. http://dx.doi.org/10.1044/jshd.4601.31

Bloodstein, O., & Ratner, N. (2008). *A handbook on stuttering*. Thomson Delmar Learning.

Brambati, S. M., Termine, C., Ruffino, M., Danna, M., Lanzi, G., Stella, G., Cappa, S., & Perani, D. (2006). Neuropsychological deficits and neural dysfunction in familial dyslexia. *Brain Research, 1113*(1), 174-185. http://dx.doi.org/10.1016/j.brainres.2006.06.099

Buck, S. M., Lees, R., & Cook, F. (2002). The influence of family history of stuttering on the onset of stuttering in young children. *Folia Phoniatrica et Logopaedica, 54*(3), 117-124. http://dx.doi.org/10.1159/000063407

Byrd, C. T., McGill, M., & Usler, E. (2015). Nonword repetition and phoneme elision in adults who do and do not stutter: Vocal versus nonvocal performance differences. *Journal of Fluency Disorders, 44*, 17-31. http://dx.doi.org/10.1016/j.jfludis.2015.01.004

Byrd, C. T., Vallely, M., Anderson, J. D., & Sussman, H. (2012). Nonword repetition and phoneme elision in adults who do and do not stutter. *Journal of Fluency Disorders, 37*(3), 188-201. http://dx.doi.org/10.1016/j.jfludis.2012.03.003

Byrd, K., & Cooper, E. B. (1989). Expressive and receptive language skills in stuttering children. *Journal of Fluency Disorders*, *14*(2), 121-126. http://dx.doi.org/10.1016/0094-730X(89)90005-3

Cantwell, A., & Rubin, H. (1992). Object naming ability of adults with written language difficulties. *Annals of Dyslexia, 42*(1), 179-195. http://dx.doi.org/10.1007/BF02654945

Casalini, C., Brizzolara, D., Chilosi, A., Cipriani, P., Marcolini, S., Pecini, C., & Burani, C. (2007). Non-word repetition in children with specific language impairment: A deficit in phonological working memory or in long-term verbal knowledge? *Cortex, 43,* 769–776. http://dx.doi.org/10.1016/s0010-9452(08)70505-7

Catts, H. W., Fey, M. E., Weismer, S. E., Bridges, M. S., Tomblin, J., & Nippold, M. (2014). The relationship between language and reading abilities. In J. B. Tomblin & M. A. Nippold (Eds.), *Understanding individual differences in language development across the school years* (pp. 144-165). Psychology Press.

Catts, H. W. (2017). Early identification of reading disabilities. In K. Cain, D. Compton, & R. Parrila (Eds.), *Theories of reading development* (pp. 311-332). John Benjamins Publishing.

Catts, H. W. (2018). The simple view of reading: Advancements and false impressions. *Remedial and Special Education, 39*(5), 317-323. https://doi.org/10.1177%2F0741932518767563

Chen, H., Xu, J., Zhou, Y., Gao, Y., Wang, G., Xia, J., Huen, M., Siok, W., Tan, L. H., & Sun, Y. (2015). Association study of stuttering candidate genes GNPTAB, GNPTG and NAGPA with dyslexia in Chinese population. *BMC Genetics, 16*(1), 7. http://dx.doi.org/10.1186/s12863-015-0172-5

Chen, C., Schneps, M. H., Masyn, K. E., & Thomson, J. M. (2016). The effects of visual attention span and phonological decoding in reading comprehension in dyslexia: a path analysis. *Dyslexia, 22*(4), 322-344. http://dx.doi.org/10.1002/dys.1543

Choo, A. L., Burnham, E., Hicks, K., & Chang, S. E. (2016). Dissociations among linguistic, cognitive, and auditory-motor neuroanatomical domains in children who stutter. *Journal of Communication Disorders*, *61*, 29-47. http://dx.doi.org/10.1016/j.jcomdis.2016.03.003

De Nil, L. F., Kroll, R. M., Kapur, S., & Houle, S. (2000). A positron emission tomography study of silent and oral single word reading in stuttering and nonstuttering adults. *Journal of Speech, Language, and Hearing Research, 43*(4), 1038-1053. https://doi.org/10.1044/jslhr.4304.1038

Dietrich, J. A., & Brady, S. A. (2001). Phonological representations of adult poor readers: An investigation of specificity and stability. *Applied Psycholinguistics, 22*(3), 383-418. http://dx.doi.org/10.1017/S014271640100306X

Don, S., & Lickley, R. (2015, August). *Uh–I forgot what I was going to say: How memory affects fluency* [Paper presentation]. 7th Workshop on Disfluency in Spontaneous Speech, Edinburgh, Scotland. http://diss2019.elte.hu/wp-content/uploads/2018/09/DiSS2015_Papers.pdf#page=19

Edwards, J., Beckman, M. E., & Munson, B. (2004). The interaction between vocabulary size and phototactic probability effects on children’s production accuracy and fluency in nonword repetition. *Journal of Speech, Language and Hearing Research, 47*, 421-436. http://dx.doi.org/10.1044/1092-4388(2004/034)

Ehri, L. C. (2014). Orthographic mapping in the acquisition of sight word reading, spelling memory, and vocabulary learning. *Scientific Studies of Reading, 18*(1), 5-21. http://dx.doi.org/10.1080/10888438.2013.819356

Eliez, S., Rumsey, J. M., Giedd, J. N., Schmitt, J. E., Patwardhan, A. J., & Reiss, A. L. (2000). Morphological alteration of temporal lobe gray matter in dyslexia: An MRI study. *Journal of Child Psychology and Psychiatry, 41*(5), 637-644. http://dx.doi.org/10.1111/1469-7610.00650

Elhassan, Z., Crewther, S. G., & Bavin, E. L. (2017). The contribution of phonological awareness to reading fluency and its individual sub-skills in readers aged 9- to 12-years. *Frontiers in Psychology, 8,* 533-533. http://dx.doi.org/10.3389/fpsyg.2017.00533

Elsherif, M. M., Wheeldon, L. R., & Frisson, S. (2021). Do dyslexia and stuttering share a processing deficit? *Journal of Fluency Disorders, 67,* 105827. https://doi.org/10.1016/j.jfludis.2020.105827

Fisher, R. A. (1921). On the "probable error" of a coefficient of correlation deduced from a small sample. *Metron, 1*, 3–32.

Foorman, B. R., Herrera, S., Petscher, Y., Mitchell, A., & Truckenmiller, A. (2015). The structure of oral language and reading and their relation to comprehension in kindergarten through Grade 2. *Reading and Writing, 28*(5), 655-681. http://dx.doi.org/10.1007/s11145-015-9544-5

Games, D., Paul, D., & Reeves, N. (2014). Oral reading fluency measures and accommodations for school-age students who stutter. *Perspectives on Fluency and Fluency Disorders, 24*(2), 38-45. http://dx.doi.org/10.1044/ffd24.2.38

Gold, P. C., & Johnson, J. A. (1982). Prediction of achievement in reading, self-esteem, auding, and verbal language by adult illiterates in a psychoeducational tutorial program. *Journal of Clinical Psychology, 38*(3), 513-522. http://dx.doi.org/10.1002/1097-4679(198207)38:3%3C513::AID-JCLP2270380308%3E3.0.CO;2-7

Gottardo, A., Chiappe, P., Siegel, L. S., & Stanovich, K. E. (1999). Patterns of word and nonword processing in skilled and less-skilled readers. *Reading and Writing, 11*(5-6), 465-487. https://doi.org/10.1023/A:1008034802088

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

Greenberg, D., Ehri, L. C., & Perin, D. (1997). Are word-reading processes the same or different in adult literacy students and third–fifth graders matched for reading level? *Journal of Educational Psychology, 89*(2), 262-275. http://dx.doi.org/10.1037/0022-0663.89.2.262

Greenberg, D., Ehri, L. C., & Perin, D. (2002). Do adult literacy students make the same word-reading and spelling errors as children matched for word-reading age? *Scientific Studies of Reading, 6*(3), 221-243. http://dx.doi.org/10.1207/S1532799XSSR0603_2

Greenberg, D., Wise, J. C., Morris, R., Fredrick, L. D., Rodrigo, V., Nanda, A. O., & Pae, H. K. (2011). A randomized control study of instructional approaches for struggling adult readers. *Journal of Research on Educational Effectiveness, 4*(2), 101-117. http://dx.doi.org/10.1080/19345747.2011.555288

Gorges, J., & Kandler, C. (2012). Adults' learning motivation: Expectancy of success, value, and the role of affective memories. *Learning and Individual Differences, 22*(5), 610-617. http://dx.doi.org/10.1016/j.lindif.2011.09.016

Hall, R., Greenberg, D., Laures-Gore, J., & Pae, H. K. (2014). The relationship between expressive vocabulary knowledge and reading skills for adult struggling readers. *Journal of Research in Reading, 37*(S1), S87-S100. http://dx.doi.org/10.1111/j.1467-9817.2012.01537.x

Hammill, D. D., Widerholt, J. L., & Allen, E. A. (2006). *Test of Silent Contextual Reading Fluency*. Pro-Ed.

Hartsuiker, R. J., & Notebaert, L. (2009). Lexical access problems lead to disfluencies in speech. *Experimental Psychology*, *57*(3), 169-177. https://doi.org/10.1027/1618-3169/a000021

Hoffman, L. M. (1978). Reading errors among skilled and unskilled adult readers. *Community Junior College Research Quarterly, 2*(2), 151-162. http://dx.doi.org/10.1080/03616975.1978.10588107

Holmes, B. C. (1985). The effect of four different modes of reading on comprehension. *Reading Research Quarterly*, 575-585. http://dx.doi.org/10.2307/747944

Honig, A. S. (2007). Oral language development. *Early Child Development and Care, 177*(6-7), 581-613. http://dx.doi.org/10.1080/03004430701377482

Howell, P. (2007). A model of serial order problems in fluent, stuttered and agrammatic speech. *Human Movement Science*, *26*(5), 728-741. https://doi.org/10.1016/j.humov.2007.07.004

Howell, P., & Au-Yeung, J. (2002). The EXPLAN theory of fluency control and the diagnosis of stuttering. In E. Fava (Ed.), *Pathology and therapy of speech disorders* (pp. 75–94). John Benjamins Publishing.

Howell, T. A., & Ratner, N. B. (2018). Use of a phoneme monitoring task to examine lexical access in adults who do and do not stutter. *Journal of Fluency Disorders*, *57*, 65-73. http://dx.doi.org/10.1016/j.jfludis.2018.01.001

Howland, K., & Scaler Scott, K. (2016). Oral reading fluency testing. *The Reading Teacher, 69*(6), 653-658. http://dx.doi.org/10.1002/trtr.1441

Huang, J., Carr, T. H., & Cao, Y. (2001). Comparing cortical activations for silent and overt speech using event-related fMRI. *Human Brain Mapping, 15,* 39-53. https://doi.org/10.1002/hbm.1060

IBM Corp. (2017). IBM SPSS Statistics for Windows, Version 25.0 (computer software). IBM Corp.

Jackson, E. S., Yaruss, J. S., Quesal, R. W., Terranova, V., & Whalen, D. H. (2015). Responses of adults who stutter to the anticipation of stuttering. *Journal of Fluency Disorders, 45*, 38-51. https://doi.org/10.1016/j.jfludis.2015.05.002

Jones, M., Onslow, M., Packman, A., & Gebski, V. (2006). Guidelines for statistical analysis of percentage of syllables stuttered data. *Journal of Speech, Language, and Hearing Research, 49,* 867-878. http://dx.doi.org/10.1044/1092-4388(2006/062)

Juel, C., & Holmes, B. (1981). Oral and silent reading of sentences. *Reading Research Quarterly*, 545-568. http://dx.doi.org/10.2307/747315

Kang, C., Riazuddin, S., Mundorff, J., Krasnewich, D., Friedman, P., Mullikin, J. C., & Drayna, D. (2010). Mutations in the lysosomal enzyme–targeting pathway and persistent stuttering. *New England Journal of Medicine, 362*(8), 677-685. http://dx.doi.org/10.1056/NEJMoa0902630

Katzir, T., Kim, Y., Wolf, M., O’Brien, B., Kennedy, B., Lovett, M., & Morris, R. (2006). Reading fluency: The whole is more than the parts. *Annals of Dyslexia, 56*(1), 51-82. http://dx.doi.org/10.1007/s11881-006-0003-5

LaSalle, L. R., & Wolk, L. (2011). Stuttering, cluttering, and phonological complexity: Case studies. *Journal of Fluency Disorders, 36*(4), 285-289. https://doi.org/10.1016/j.jfludis.2011.04.003

Levelt, W. J. (1993). *Speaking: From intention to articulation* (Vol. 1): MIT press.

Levelt, W. J., & Meyer, A. S. (2000). Word for word: Multiple lexical access in speech production. *European Journal of Cognitive Psychology, 12*(4), 433-452. https://doi.org/10.1080/095414400750050178

Levelt, W. J., Roelofs, A., & Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences, 22*, 1-38. http://dx.doi.org/10.1017/S0140525X99001776

Logan, K. J., & Conture, E. G. (1995). Length, grammatical complexity, and rate differences in stuttered and fluent conversational utterances of children who stutter. *Journal of Fluency Disorders, 20*(1), 35-61. https://doi.org/10.1016/0094-730X(94)00008-H

Lonigan, C. J., Burgess, S. R., & Schatschneider, C. (2018). Examining the simple view of reading with elementary school children: Still simple after all these years. *Remedial and Special Education, 39*(5), 260-273. http://dx.doi.org/10.1177/0741932518764833

Lu, C., Peng, D., Chen, C., Ning, N., Ding, G., Li, K., Yang., Y., & Lin, C. (2010). Altered effective connectivity and anomalous anatomy in the basal ganglia-thalamocortical circuit of stuttering speakers. *Cortex, 46*(1), 49-67. http://dx.doi.org/10.1016/j.cortex.2009.02.017

MacArthur, C. A., Konold, T. R., Glutting, J. J., & Alamprese, J. A. (2012). Subgroups of adult basic education learners with different profiles of reading skills. *Reading and Writing, 25*(2), 587-609. http://dx.doi.org/10.1007/s11145-010-9287-2

MacWhinney, B. (2003). *The CHILDES Project: Tools for analyzing talk*. Lawrence Erlbaum Associates. http://childes.psy.cmu.edu/clan/

Mather, N., Hammill, D. D., Allen, E. A., & Roberts, R. (2004). *Test of Silent Word Reading Fluency*. Pro-Ed.

Mellard, D., Anthony, J. L., & Woods, K. L. (2012). Understanding oral reading fluency among adults with low literacy: dominance analysis of contributing component skills. *Reading and Writing, 25*(6), 1345-1364. http://dx.doi.org/10.1007/s11145-011-9322-y

Mellard, D., Woods, K., & Fall, E. (2011). Assessment and instruction of oral reading fluency among adults with low literacy. *Adult Basic Education and Literacy Journal, 5*(1), 3-14.

Melby-Lervåg, M., & Lervåg, A. (2011). Cross-linguistic transfer of oral language, decoding, phonological awareness and reading comprehension: A meta-analysis of the correlational evidence. *Journal of Research in Reading, 34*(1), 114-135. http://dx.doi.org/10.1111/j.1467-9817.2010.01477.x

Miller, J., & Chapman, R. (2008). Systematic analysis of language transcripts (SALT software). University of Wisconsin Language Analysis Laboratory.

Miller, S. D., & Smith, D. E. (1985). Differences in literal and inferential comprehension after reading orally and silently. *Journal of Educational Psychology, 77*(3), 341-348. http://dx.doi.org/10.1037/0022-0663.77.3.341

Munson, B. (2001). Phonological pattern frequency and speech production in adults and children. *Journal of Speech, Language, and Hearing Research, 44*, 778-792. https://doi.org/10.1044/1092-4388(2001/061)

Nanda, A. O., Greenberg, D., & Morris, R. D. (2014). Reliability and validity of the CTOPP Elision and Blending Words subtests for struggling adult readers. *Reading and Writing, 27*(9), 1603-1618. http://dx.doi.org/10.1007/s11145-014-9509-0

National Institute of Child Health and Human Development. (2000). *Report of the National Reading Panel: Teaching children to read: An evidence-based assessment of the scientific research literature on reading and its implications for reading instruction: Reports of the subgroups*. https://www.nichd.nih.gov/publications/pubs/nrp/smallbook

Newman, R. S., & Ratner, N. (2007). The role of selected lexical factors on confrontation naming accuracy, speed, and fluency in adults who do and do not stutter. *Journal of Speech, Language, and Hearing Research, 50*(1), 196-213. http://dx.doi.org/10.1044/1092-4388(2007/016)

Nightingale, E., Greenberg, D., & Branum-Martin, L. (2016). Selecting fluency assessments for adult learners. *Journal of Research and Practice for Adult Literacy, Secondary, and Basic Education, 5,* 18-29.

Nippold, M. A. (2002). Stuttering and phonology. *American Journal of Speech-Language Pathology, 11*, 99-110. https://doi.org/10.1044/1058-0360(2002/011

Nippold, M. A., & Schwarz, I. E. (1990). Reading disorders in stuttering children. *Journal of Fluency Disorders, 15*(3), 175-189. http://dx.doi.org/10.1016/0094-730X(90)90017-M

Ntourou, K., Conture, E. G., & Lipsey, M. W. (2011). Language abilities of children who stutter: A meta-analytical review. *American Journal of Speech-Language Pathology, 20*(3), 163-179. http://dx.doi.org/10.1044/1058-0360(2011/09-0102)

Olsen, L. T., Steelman, M. L., Buffalo, M. D., & Montague, J. (1999). Preliminary information on stuttering characteristics contrasted between african american and white children.

Journal of Communication Disorders, 32(2), 97-108. http://dx.doi.org/10.1016/S0021-9924(98)00032-X

Oyoun, H. A., El Dessouky, H., Shohdi, S., & Fawzy, A. (2010). Assessment of working memory in normal children and children who stutter. *Journal of American Science, 6*(11), 562-566.

Paul, I., Bott, C., Wienbruch, C., & Elbert, T. R. (2006). Word processing differences between dyslexic and control children. *BMC Psychiatry, 6*(1), 5. http://dx.doi.org/10.1186/1471-244X-6-5

Pelczarski, K. M., & Yaruss, J. S. (2014). Phonological encoding of young children who stutter. *Journal of Fluency Disorders, 39*, 12-24. http://dx.doi.org/10.1016/j.jfludis.2013.10.003

Pellowski, M. W. (2011). Word-finding and vocabulary abilities of adults who do and do not stutter. *Contemporary Issues in Communication Science and Disorders, 38*, 126-134. http://dx.doi.org/10.1044/cicsd_38_F_126

Pellowski, M. W., & Conture, E. G. (2005). Lexical priming in picture naming of young children who do and do not stutter. *Journal of Speech, Language, and Hearing Research, 48*(2), 278-294. http://dx.doi.org/10.1044/1092-4388(2005/019)

Pennington, B. F., & Bishop, D. V. (2009). Relations among speech, language, and reading disorders. *Annual Review of Psychology, 60*, 283-206. http://dx.doi.org/10.1146/annurev.psych.60.110707.163548

Perin, D., & Greenberg, D. (1992). *Retention patterns in an adult basic education program for health care workers preparing for college* [Paper presentation]. Annual meeting of the American Educational Research Association, San Francisco, CA. https://files.eric.ed.gov/fulltext/ED346237.pdf

Price, K. W., Meisinger, E. B., Louwerse, M. M., & D'Mello, S. (2016). The contributions of oral and silent reading fluency to reading comprehension. *Reading Psychology, 37*(2), 167-201. http://dx.doi.org/10.1080/02702711.2015.1025118

Proctor, A., Yairi, E., Duff, M. C., & Zhang, J. (2008). Prevalence of stuttering in African American preschoolers. *Journal of Speech, Language, and Hearing Research, 51*, 1465-1479. http://dx.doi.org/10.1044/1092-4388(2008/07-0057)

Ratner, N., & Brundage, S. (2019). *A clinician's complete guide to CLAN and PRAAT.* https://talkbank.org/manuals/Clin-CLAN.pdf.

Ratusnik, D. L., Kiriluk, E., & Ratusnik, C. M. (1979). Relationship among race, social status, and sex of preschoolers' normal dysfluencies: A cross-cultural investigation. *Language, Speech, and Hearing Services in Schools, 10*(3), 171-177. http://dx.doi.org/10.1044/0161-1461.1003.171

Roth, F. P., Speece, D. L., & Cooper, D. H. (2002). A longitudinal analysis of the connection between oral language and early reading. *The Journal of Educational Research, 95*(5), 259-272. http://dx.doi.org/10.1080/00220670209596600

Rousseau, I., Onslow, M., Packman, A., & Jones, M. (2008). Comparisons of audio and audiovisual measures of stuttering frequency and severity in preschool-age children. *American Journal of Speech-Language Pathology, 17,* 173-178. http://dx.doi.org/10.1044/1058-0360(2008/017)

Sabatini, J. P. (2002). Efficiency in word reading of adults: Ability group comparisons. *Scientific Studies of Reading, 6*(3), 267-298. http://dx.doi.org/10.1207/S1532799XSSR0603_4

Sabatini, J. P., Sawaki, Y., Shore, J. R., & Scarborough, H. S. (2010). Relationships among reading skills of adults with low literacy. *Journal of Learning Disabilities, 43*(2), 122-138. http://dx.doi.org/10.1177/0022219409359343

Sasisekaran, J. (2013). Nonword repetition and nonword reading abilities in adults who do and do not stutter. *Journal of Fluency Disorders, 38*(3), 275-289. http://dx.doi.org/10.1016/j.jfludis.2013.06.001

Sasisekaran, J., De Nil, L. F., Smyth, R., & Johnson, C. (2006). Phonological encoding in the silent speech of persons who stutter. *Journal of Fluency Disorders, 31*(1), 1-21. http://dx.doi.org/10.1016/j.jfludis.2005.11.005

Savage, R., & Wolforth, J. (2007). An additive simple view of reading describes the performance of good and poor readers in higher education. *Exceptionality Education International*, *17*(2), 243-268. https://doi.org/10.5206/eei.v17i2.7606

Smith, A., Sadagopan, N., Walsh, B., & Weber-Fox, C. (2010). Increasing phonological complexity reveals heightened instability in inter-articulatory coordination in adults who stutter. *Journal of Fluency Disorders, 35*(1), 1-18. http://dx.doi.org/10.1016/j.jfludis.2009.12.001

Smits-Bandstra, S., & De Nil, L. (2009). Speech skill learning of persons who stutter and fluent speakers under single and dual task conditions. *Clinical Linguisiscs & Phonetics*, *23*(1), 38-57. http://dx.doi.org/10.1080/02699200802394914

Smits-Bandstra, S., De Nil, L., & Rochon, E. (2006). The transition to increased automaticity during finger sequence learning in adult males who stutter. *Journal of Fluency Disorders, 31*(1), 22-42. http://dx.doi.org/10.1016/j.jfludis.2005.11.004

Stahl, S. A., & Murray, B. A. (1994). Defining phonological awareness and its relationship to early reading. *Journal of Educational Psychology, 86*(2), 221-234.

Sticht, T. G. (1982). *Evaluation of the "Reading Potential" concept for marginally literate adults* (ERIC Document Reproduction Service No. ED 217 168). Alexandria, VA: Human Resources Research Organization. https://apps.dtic.mil/sti/pdfs/ADA115036.pdf

Sugathan, N., & Maruthy, S. (2020). Nonword repetition and identification skills in Kannada speaking school-aged children who do and do not stutter. *Journal of Fluency Disorders, 63*, 105745. https://doi.org/10.1016/j.jfludis.2019.105745

Sweller, J., Ayres, P., & Kalyuga, S. (2011). The modality effect. In J. Sweller, P. Ayres, & S. Kalyuga (Eds). *Cognitive load theory* (pp. 129-140). Springer.

Talwar, A., L. Tighe, E., & Greenberg, D. (2018). Augmenting the simple view of reading for struggling adult readers: A unique role for background knowledge. *Scientific Sstudies of Reading, 22*(5), 351-366. http://dx.doi.org/10.1080/10888438.2018.1450410

Taylor, N. A., Greenberg, D., Laures-Gore, J., & Wise, J. C. (2012). Exploring the syntactic skills of struggling adult readers. *Reading and Writing: An Interdisciplinary Journal, 25*(6), 1385-1402. http://dx.doi.org/10.1007/s11145-011-9324-9

Tighe, E. L., Little, C. W., Arrastia-Chisholm, M. C., Schatschneider, C., Diehm, E., Quinn, J. M., & Edwards, A. A. (2019). Assessing the direct and indirect effects of metalinguistic awareness to the reading comprehension skills of struggling adult readers. *Reading and Writing, 32*(3), 787-818. http://dx.doi.org/10.1007/s11145-018-9881-2

Torgesen, J. K., Wagner, R. K., & Rashotte, C. A. (1999). *TOWRE: Test of Word Reading Efficiency*. Pro-Ed.

Torgesen, J. K., Wagner, R. K., & Rashotte, C. A. (2012). *TOWRE: Test of Word Reading Efficiency II*. Pro-Ed.

Tumanova, V., Zebrowski, P. M., Throneburg, R. N., & Kulak Kayikci, M. E. (2011). Articulation rate and its relationship to disfluency type, duration, and temperament in preschool children who stutter. *Journal of Communication Disorders, 44*(1), 116-129. https://doi.org/10.1016/j.jcomdis.2010.09.001

U.S. Department of Education National Center for Education Statistics. (2017). *Program for the International Assessment of Adult Competencies (PIAAC)* (U.S. PIAAC 2017, U.S. PIAAC 2012/2014). https://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2020224

Vanryckeghem, M., Brutten, G. J., Uddin, N., & Van Borsel, J. (2004). A comparative investigation of the speech-associated coping responses reported by adults who do and do not stutter. *Journal of Fluency Disorders, 29*(3), 237-250. https://doi.org/10.1016/j.jfludis.2004.07.001

Vellutino, F. R., & Scanlon, D. M. (1987). Phonological coding, phonological awareness, and reading ability: Evidence from a longitudinal and experimental study. *Merrill-Palmer Quarterly, 33*(3), 321-363.

Wagner, R. K., Torgesen, J. K., Rashotte, C. A., & Pearson, N. A. (2013). *Comprehensive Test of Phonological Processing II*. Pro-Ed.

Wagovich, S. A., Anderson, J. D., & Hill, M. S. (2020). Visual exogenous and endogenous attention and visual memory in preschool children who stutter. *Journal of Fluency Disorders, 66*, 105792. https://doi.org/10.1016/j.jfludis.2020.105792

Wagovich, S. A., & Hall, N. E. (2017). Stuttering Frequency in Relation to Lexical Diversity, Syntactic Complexity, and Utterance Length. *Communication Disorders Quarterly*, 1525740117702454. http://dx.doi.org/10.1177/1525740117702454

Wise, J. C., Sevcik, R. A., Morris, R. D., Lovett, M. W., & Wolf, M. (2007). The relationship among receptive and expressive vocabulary, listening comprehension, pre-reading skills, word identification skills, and reading comprehension by children with reading disabilities. *Journal of Speech, Language, and Hearing Research, 50*(4), 1093-1109. http://dx.doi.org/10.1044/1092-4388(2007/076)

Wolk, L., & LaSalle, L. R. (2015). Phonological complexity in school-aged children who stutter and exhibit a language disorder. *Journal of Fluency Disorders, 43*, 40-53. doi:10.1016/j.jfludis.2014.11.001

Woodcock, R. W., McGrew, K. S., Schrank, F. A., & Mather, N. (2007). *Woodcock-Johnson III Normative update*. Riverside Publishing.

Yairi, E., & Ambrose, N. G. (2013). Epidemiology of stuttering: 21st century advances. *Journal of Fluency Disorders*, *38*(2), 66-87. http://dx.doi.org/10.1016/j.jfludis.2012.11.002

Yairi, E., & Clifton, N. F. (1972). Disfluent speech behavior of preschool children, high school seniors, and geriatric persons. *Journal of Speech and Hearing Research, 15*(4), 714-719. http://dx.doi.org/10.1044/jshr.1504.714

Yaruss, J. S., Max, M. S., Newman, R., & Campbell, J. H. (1998). Comparing real-time and transcript-based techniques for measuring stuttering. *Journal of Fluency Disorders, 23*(2), 137-151. http://dx.doi.org/10.1016/S0094-730X(98)00003-5

Table 1. *Summary of Demographic Information for Adult Struggling Readers Who Do and Do Not Stutter*

Characteristic	**ASRs-NS**	**ASRs-S**	**Total**	**Group difference**
Sample size	98	22	120	
Mean age in yrs (*SD*)	36.93 (15.67)	42.45 (13.77)	37.94 (15.43)	$t(118) = -1.526$, $p = .130$
Range	17–70	17–62	17–70	
Sex (*n*)				$\chi^2(1, N = 119) = 0.976$, $p = .323$
Female	55 (56.12%)	15 (68.18%)	70 (58.33%)	
Male	42 (42.86%)	7 (31.82%)	49 (40.83%)	
Not reported	1 (1.02%)	—	1 (0.83%)	
Highest completed grade level				$t(109) = 0.599$, $p = .510$
Grades 1–6	1 (1.02%)	0	1 (0.83%)	
Grades 7–9	66 (67.35%)	17 (77.27%)	83 (69.17%)	
High school diploma	16 (16.33%)	1 (4.55%)	17 (14.17%)	
Pre-associate's degree	2 (2.04%)	1 (4.55%)	3 (2.50%)	
College or trade certification	5 (5.10%)	1 (4.55%)	6 (5.00%)	
Professional degree	1 (1.02%)	0	1 (0.83%)	
Not reported	7 (7.14%)	2 (9.09%)	9 (7.50%)	

Self-reported reading patterns				*t*(118) = -0.417 , *p* = .678
Does not understand anything read	0	0	0	
Understands some	23 (23.47%)	4 (18.18%)	27 (22.50%)	
Understands most	54 (55.10%)	13 (59.09%)	67 (55.83%)	
Understands everything	21 (21.43%)	5 (22.73%)	26 (21.67%)	
Not reported	0	0	0	
Response to *"Have you attended any special education classes?"*				$\chi^2(1, N=117) = 0.142, p = .706$
Yes	39 (39.80%)	10 (45.45%)	49 (40.83%)	
No	56 (57.14%)	12 (54.55%)	68 (56.67%)	
Not reported	3 (3.06%)	0	3 (2.50%)	
Response to *"Have you ever been tested for any of the following problems as a child or adult?"*				
Learning disability				**$\chi^2(1, N=116) = 5.683, p = .017$**
Yes	36 (36.73%)	2 (9.09%)	38 (31.67%)	
No	60 (61.22%)	18 (81.82%)	78 (65.00%)	

Not reported	2 (2.04%)	2 (9.09%)	4 (3.33%)	
Educational problem				$\chi^2(1, N=115) = 3.728, p = .053$
Yes	22 (22.45%)	1 (4.54%)	23 (19.17%)	
No	72 (73.47%)	20 (90.91%)	92 (76.67%)	
Not reported	4 (4.08%)	1 (4.55%)	5 (4.17%)	
Eye trouble (not corrected by glasses)				$\chi^2(1, N=120) = 0.595, p = .441$
Yes	49 (50.00%)	13 (59.09%)	62 (51.67%)	
No	49 (50.00%)	9 (40.91%)	58 (48.33%)	
Not reported	0	0	0	
Hearing problems				$\chi^2(1, N=119) = 1.718, p = .190$
Yes	26 (26.53%)	9 (40.91%)	35 (29.17%)	
No	71 (72.45%)	13 (59.09%)	84 (70.00%)	
Not reported	1 (1.02%)	0	1 (0.83%)	
Response to *"Have you ever had ______"*				
Head injury				$\chi^2(1, N=117) = 1.108, p = .293$
Yes	24 (24.49%)	8 (36.36%)	32 (26.67 %)	

No	71 (72.45%)	14 (63.64%)	85 (70.83%)	
Not reported	3 (3.06%)	0	3 (2.50%)	
Stroke				NA[a]
Yes	0	1 (4.55%)	1 (0.83%)	
No	97 (98.98%)	21 (95.45%)	118 (98.33%)	
Not reported	1 (1.02%)	0	1 (0.83%)	

Note. ASRs-NS = adult struggling readers who do not stutter; ASRs-S = adult struggling readers who stutter. In the last column significant group differences are in bold.

[a]Chi-square test was not conducted due to the small sample size in some categories.

Table 2. *List of Administered Assessments, Constructs, and Task Descriptions*

Construct	Assessment	Description
Decoding	WJIII Letter-Word Identification (WJ-LWI)	Read aloud printed words.
	WJIII Word Attack	Read and pronounce phonetically decodable nonwords.
Fluency–(non)word reading	TOWRE–Sight Word Efficiency (TOWRE-SWE)	Read aloud as many words as possible w/in 45 seconds.
	TOWRE – Phonemic Decoding Efficiency (TOWRE-PDE)	Read and pronounce phonetically decodable nonwords w/in 45 seconds.
	Test of Silent Word Reading Fluency (TOSWRF)	Mark boundaries of printed words presented in rows w/in 3 minutes.
Fluency–connected text	WJIII Reading Fluency (WJ-Read-F)	Read a list of simple sentences and answer true or false statements w/in 3 minutes.
	Test of Silent Contextual Reading Fluency (TOSCRF)	Mark boundaries of words presented in short passages w/in 3 minutes.

Reading comprehension	WJIII Passage Comprehension (WJ-PC)	Silently read a passage and identify the missing keywords.
Expressive language	WJIII Picture Vocabulary (WJ-PV)	Name pictured objects.
Phonological awareness	CTOPP Blending Words (CTOPP-BW)	Combine the different orally presented phonemes into words.
	CTOPP Elision (CTOPP-E)	Remove phonemes from orally presented words to form other words.
	CTOPP Phoneme Isolation (CTOPP-PI)	Isolate individual phonemes within the orally presented words.

Note. CTOPP = Comprehensive Test of Phonological Processing subtests (Wagner et al., 2013); TOSCRF = Test of Silent Contextual Reading Fluency (Hammill et al., 2006); TOSWRF = Test of Silent Word Reading Fluency (Mather et al., 2004); TOWRE = Test of Word Reading Efficiency (Torgesen et al., 2012); WJIII = Woodcock-Johnson III Normative Update subtests (Woodcock et al., 2007).

Table 3. *Type and Percentage of Oral Disfluencies for Adult Struggling Readers Who Do and Do Not Stutter*

Type of disfluencies	**ASRs-NS** **% (*SD*)**	**ASRs-S** **% (*SD*)**	***t***	***df***	***p***	**Cohen's *d***
Stuttering-like disfluencies						
Phonological fragments	0.50 (0.67)	2.73 (1.30)	**-7.78**	**23.6[a]**	**< .000**	2.16
Monosyllabic word repetitions	0.45 (0.62)	2.17 (1.74)	**-4.564**	**22.2[a]**	**< .000**	1.32
Part-word repetitions	0.096 (0.31)	0.41 (0.72)	-1.981	22.8[a]	.060	0.57
Blocks	0.021 (0.14)	0.043 (0.14)	-0.685	118	.495	0.16
Prolongations	0.033 (0.18)	0 (0)	0.867	118	.388	
Broken words	0 (0)	0 (0)	—	—	—	
Total	1.10 (0.95)	5.34 (2.09)	**-9.323**	**22.9[a]**	**< .000**	2.61
Typical disfluencies						
Interjections	5.23 (4.22)	9.45 (8.78)	-2.200	23.2[a]	0.038	0.61
Phrase revisions	1.26 (1.51)	2.77 (2.12)	**-3.165**	**26.0[a]**	**.004**	0.82
Multisyllabic word repetitions	0.48 (0.66)	2.23 (1.78)	**-4.550**	**22.3[a]**	**< .000**	1.30
Phrase repetitions	0.37 (1.03)	0.96 (1.18)	-2.183	28.6[a]	.037	0.53

Word revisions	0.53 (1.12)	0.81 (1.27)	-1.045	118	.298	0.23
Pauses	0.51 (1.26)	0.30 (0.53)	0.754	118	.452	0.22
Total	9.96 (8.90)	15.43 (11.62)	-2.455	118	.016	0.53

Note. Type and percentage of oral disfluencies for adult struggling readers who do and do not stutter are presented. Significant group differences based on two-tailed $p < .003$ (with Bonferroni correction) are in bold. ASRs-NS = adult struggling readers who do not stutter; ASRs-S = adult struggling readers who stutter.

[a]The degrees of freedom were based on *t* tests with unequal variances.

Table 4. *Mean Raw Scores on Assessments for Adult Struggling Readers Who Do and Do Not Stutter*

	Maximum	ASRs-NS		ASRs-S					
Measure	**possible score**	***M* (*SD*)**	**Range**	***M* (*SD*)**	**Range**	***t***	***df***	***p***	***Cohen's d***
1. WJ-LWI	76	54.57 (8.74)	33–73	54.48 (8.35)	34–70	0.047	113	.963	0.011
2. WJ-WA	32	16.09 (7.89)	2–30	15.19 (7.26)	6–30	0.482	114	.631	0.120
3. TOWRE-SWE	108	66.57 (14.83)	31–100	66.91 (13.38)	36–91	-0.098	118	.922	0.024
4. TOWRE-PDE	66	20.45 (14.64)	0–55	20.64 (13.60)	0–57	-0.055	116	.956	0.013
5. TOSWRF	220	93.12 (27.84)	2–153	100.32 (25.21)	47–142	-1.114	118	.268	0.271
6. TOSCRF	473	82.87 (28.27)	26–166	86.41 (29.62)	32–158	-0.526	118	.600	0.120
7. WJ-READ-F	98	42.35 (11.74)	19–75	43.95 (11.20)	19–64	-0.585	118	.560	0.140
8. WJ-PC	47	29.21 (4.45)	19–39	30.19 (3.79)	24–38	-0.937	114	.351	0.240
9. WJ-PV	44	25.88 (3.33)	18–35	26.68 (2.88)	20–32	-1.048	118	.297	0.260
10. CTOPP-BW	33	14.09 (5.02)	0–25	13.09 (5.14)	6–24	0.841	118	.402	0.200
11. CTOPP-E	34	16.01 (6.04)	0–33	15.24 (5.82)	1–27	0.535	117	.594	0.130
121. CTOPP-PI	32	13.49 (6.85)	0–28	12.73 (6.66)	1–29	0.474	118	.636	0.110

Note. There were no significant differences between groups based on two-tailed $p < .004$ (with Bonferroni correction) using the raw scores. ASRs-NS = adult struggling readers who do not stutter; ASRs-S = adult struggling readers who stutter; CTOPP-BW = Comprehensive Test of Phonological Processing–Blending Words; CTOPP-E = CTOPP–Elision; CTOPP-PI = CTOPP–Phoneme Isolation; TOSCRF = Test of Silent Contextual Reading Fluency; TOSWRF = Test of Silent Word Reading Fluency; TOWRE-PDE = Test of Word Reading Efficiency–Phonemic Decoding; TOWRE-SWE = TOWRE–Sight Word; WJ-LWI = Woodcock-Johnson III Normative Update–Letter-Word Identification; WJ-PC = WJIII–Passage Comprehension; WJ-PV = WJIII–Picture Vocabulary; WJ-READ-F = WJIII–Reading Fluency; WJ-WA = WJIII–Word Attack.

Table 5. *Correlations Between Standardized Tests for Reading Ability, Expressive Language, Phonological Awareness, and Speech Disfluency*

Measure	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1. WJ-LWI	—	**.813****	**.737****	**.765****	.411	**.436***	**.609****	-.025	.178	.361	**.464***	.086	-.195	-.234
2. WJ-WA	**.691****	—	**.639****	**.871****	.210	.292	***.438****	.072	.077	**.535***	**.570****	.389	.021	.005
3. TOWRE-SWE	**.517****	**.436****	—	**.714****	**.584****	**.731****	**.627****	-.221	.061	.242	.348	.129	-.151	-.185
4. TOWRE-PDE	**.714****	**.781****	**646****	—	.166	.283	.375	.011	.050	.368	.356	.340	*-.004*	*.011*
5. TOSWRF	***.261****	.197	**.467****	***.279*****	—	**.843****	**.549****	-.021	-.039	*-.037*	*.151*	*-.146*	*-.260*	-.157
6. TOSCRF	**.351****	***.291*****	**.553****	***.384*****	**818****	—	**.580****	-.209	.149	-.073	.154	-.262	-.295	-.185
7. WJ-READ-F	**.287****	.193	**.597****	***.346*****	**.518****	**.638****	—	-.165	-.074	-.018	.304	-.238	-.297	-.186
8. WJ-PC	-.002	.065	.148	.036	.036	.147	***.252****	—	-.193	-.085	***-.475****	.052	-.008	.387
9. WJ-PV	***.227****	.156	.115	.097	.014	.185	***.263*****	.025	—	-.001	.264	.042	.040	-.277
10. CTOPP-B	.123	**.389****	.057	***.201****	.014	.091	.040	-.059	.173	—	**.707****	**.527***	.211	-.037
11. CTOPP-E	**.407****	**.522****	***.372*****	***.492*****	.185	***.255****	.050	.098	.157	**.371****	—	**.476***	.187	-.428
12. CTOPP-PI	.212	***.448*****	.122	***.227****	.005	.171	.089	-.026	.168	**.511****	**424****	—	.379	-.028
13. % TD	.142	***.218****	-.084	.159	-.109	-.057	-.109	.113	-.163	-.092	077	-.060	—	.208
14. % SLD	.108	.146	.053	.093	.058	.082	-.018	-.056	-.064	-.012	-.044	***.246****	.140	—

Note. Items on the right of the diagonal are for adult struggling readers who stutter (ASRs-S) while items on the left are for ASRs who do not stutter (ASRs-NS). Values that are italicized in the upper right quadrant denote those that are significant for ASRs-S but not for ASRs-NS, while values that are italicized in the lower left quadrant denote those that are significant for ASRs-NS but not ASRs-S. Significant correlations are in bold. CTOPP-B = Comprehensive Test of Phonological Processing –Blending Words; CTOPP-E = CTOPP–Elision; CTOPP-PI = CTOPP–Phoneme Isolation; TOSCRF = Test of Silent Contextual Reading Fluency; TOSWRF = Test of Silent Word Reading Fluency; TOWRE-PDE = Test of Word Reading Efficiency–Phonemic Decoding; TOWRE-SWE = TOWRE–Sight Word, WJ-LWI = Woodcock-Johnson III Normative Update–Letter-Word Identification; WJ-PC = WJIII–Passage Comprehension, WJ-PV = WJIII–Picture Vocabulary; WJ-READ-F = WJIII Reading–Fluency; WJ-WA = WJIII–Word Attack; % TD = percentage of typical disfluencies; % SLD = percentage of stuttering-like disfluencies.

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