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Linguistic Aspects of Stuttering
Research Updates on the Language–Fluency Interface

Shelley B. Brundage and Nan Bernstein Ratner

Purpose: Although commonly defined as a speech disorder, stuttering interacts with the language production system in important ways. Our purpose is to summarize research findings on linguistic variables that influence stuttering assessment and treatment. **Method and Results:** Numerous topics are summarized. First, we review research that has examined linguistic features that increase stuttering frequency and influence where it occurs. Second, we tackle the question of whether or not persons who stutter exhibit subtle language differences or deficits. Next, we explore language factors that appear to influence recovery from early stuttering in children. The final topic discusses the unique challenges inherent in differentially diagnosing stuttering in bilingual children. Clinical implications for each topic are discussed. **Discussion:** The article concludes with a discussion of the unique differences in the integration of language and speech demands by people who stutter, when compared with people who are typically fluent, and their clinical ramifications. **Key words:** *adult*, *child*, *language*, *linguistic factors*, *research*, *stuttering*

IN MANY MAJOR textbooks that group communication disorders into the age-old distinctions of speech, language, and hearing, the chapter on stuttering appears as an example of a speech disorder (see, e.g., Gillam & Marquardt, 2019). But is this characterization accurate? In this article, part of an entire issue of *Topics in Language Disorders*, we suggest that viewing stuttering *purely* as a speech disorder misses some of its features that are important both to understanding what causes stuttering and how to treat it most effectively. In addition, recent linguistic research allows us to estimate the risk that particular children face in predicting whether or not their stuttering is likely to be persistent or resolve spontaneously.

We divide this article into five major conceptual sections. In the first, we explore linguistic features that appear to govern whether spoken utterances are produced fluently or not, as well as locations (loci) of fluency breakdown that tend to characterize stuttering in both children and adults. Both linguistic features and loci have applied ramifications for designing therapy tasks when working with clients who stutter. Loci studies of stuttering have an additional important role to play in trying to understand what causes a speaker to have difficulty with sentence assembly and thus can inform theories about the underlying cause of stuttering.

The second section of this article summarizes an increasingly large literature that finds evidence of subtle, atypical language function in both children and adults who stutter (CWS/AWS). This evidence takes diverse forms but includes both behavioral findings of relatively lower language skills of speakers

Author Affiliations: *Department of Speech, Language, and Hearing Sciences, The George Washington University, Washington, District of Columbia (Dr Brundage); and Department of Hearing and Speech Sciences, University of Maryland, College Park (Dr Bernstein Ratner).*

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Corresponding Author: *Shelley B. Brundage, PhD, CCC, BCS-F, Department of Speech, Language, and Hearing Sciences, The George Washington University, 2115 G st NW, Ste 226, Washington, DC 20052 (brundage@gwu.edu).*

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who stutter and sophisticated brain indices of atypical language processing in both AWS and CWS. Both sets of findings suggest that although, as listeners, we orient primarily toward the fluency features of expressive communication by persons who stutter (PWS), there are measurable differences in language skill between well-matched cohorts of children and adults who do (CWS/AWS) and do not stutter (CWNS/AWNS).

Moreover, an enlarging body of experimental work shows distinct and atypical profiles of grammatical and lexical processing in PWS while listening to language, even when they are not required to produce speech. How these findings may impact both our understanding of what causes stuttering as well as its assessment (particularly in young children) and treatment, will be discussed.

Roughly 80% of children who begin to stutter will recover, apparently without benefit of therapeutic intervention (Bloodstein et al., 2021). Our third topic explores how language skills may predict which CWS will recover without assistance (spontaneous recovery) and those whose stuttering is likely to become persistent. This relatively recent set of research findings may have important ramifications for counseling parents regarding risk factors for persistence, as well as developing treatment programs for our youngest clients who stutter.

Fourth, in light of the fact that stuttering impacts a diverse community of speakers, we address how stuttering manifests itself in speakers who are bi- or multilingual. Bilingualism has been shown to increase the chances that a child may be misdiagnosed as a CWS (Byrd et al., 2015; Byrd, 2018; Choo & Smith, 2020; Howell et al., 2009). In addition, we examine how language attrition, very common among bilingual speakers embedded in majority language communities, can impact fluency. Both concepts are critical to differential diagnosis of stuttering and typical disfluency, which can be exacerbated by language-encoding pressures.

Finally, for those with the interest to follow our research summary, a very reasonable question should arise. Exactly how might involvement of the language system contribute to the symptoms of stuttering? To most observers, stuttering has fairly clear motor symptoms, rather than features of language disorder or even language proficiency. In the last section of this article, we review some evidence of just how language formulation demand apparently impacts the motor systems of AWS and CWS. The fact that we can identify such interactions between motor function and language production supplies a missing link that demonstrates the value of considering human communication disorders such as stuttering from multiple systems perspectives.

LANGUAGE FACTORS THAT INFLUENCE THE FREQUENCY AND LOCATION OF STUTTERING

The study of possible linguistic influences on stuttering is not new. In the 1930s and 1940s, Spencer Brown et al. carried out a series of famous studies on the characteristics of stuttered words and phrases (Brown, 1937; Brown, 1938a, 1938b, 1938c; Brown, 1945). Brown was interested in whether or not the frequency and loci of stuttering were predictable and therefore evidence of anticipatory avoidance in AWS. His methodology was deceptively simple. He had AWS read written passages aloud. Some of these passages were meaningful and others consisted of lists of all types of words that were unrelated to each other. He then calculated the percentage of stuttered words and where they occurred. Brown's studies (Brown, 1937; Brown, 1938a, 1938b, 1938c; Brown, 1945) revealed a number of consistencies regarding which words in a given utterance were most likely to be stuttered. Many of Brown's findings were replicated by other researchers over the years, with the majority of research in this area having been done in English (e.g., Trotter, 1956; Williams et al.,1968) . The influence of Brown's factors on stuttering has been documented in a few other languages, including Kannada (Jayaram, 1983), Arabic (Alqhazo & Al-Dennawi, 2018), and to some extent in Korean (Choi et al., 2020). We start this section with a discussion of "Brown's factors" regarding which words are most likely to be stuttered.

Brown's initial studies on what he termed the "phonetic factors" of words revealed that words beginning with consonants were more likely to be stuttered than were words beginning with vowels (Brown, 1938a; Johnson & Brown, 1935). The particular sounds that led to stuttering were highly idiosyncratic across AWS. Although both studies published lists of phonemes ordered in relative difficulty for maintaining fluency, there was only limited agreement in subsequent studies that such a list exists that pertains to all PWS (Quarrington & Douglass, 1960; Soderberg, 1962; Taylor, 1966a, 1966b). That is, no one speech sound is particularly challenging for all AWS; given that there is much individual variation, the best way for clinicians to assess this aspect is to ask their clients to tell them which sounds they perceive as most challenging to produce fluently.

Brown next turned his attention to the "grammatical factors" of words (Brown, 1937). His analyses revealed that in adults, stuttering was more likely to occur on nouns, verbs, adjectives, and adverbs (sometimes called "content words") and less likely to occur on articles, pronouns, prepositions, and conjunctions ("function words"). These findings have been replicated (Danzger & Halpern, 1973; Griggs & Still, 1979; Hahn, 1942; Quarrington et al., 1962). Content words carry most of the meaning in a given utterance and therefore this finding is perhaps not that surprising. What is surprising is that the relationship is reversed in preschool CWS. Children at this age often stutter on function words, especially pronouns and conjunctions (Au-Yeung et al., 2003; Dworzynski & Howell, 2004; Howell et al., 1999).

Another quite consistent finding is that more stuttering occurs on words that arise earlier, as compared with later in an utterance (Brown, 1938b; Buhr & Zebrowski, 2009; Quarrington, 1965; Taylor, 1966a, 1966b), a finding that suggests a possible problem with motor planning to begin the utterance. This finding manifests itself clinically when we hear the fairly common report from AWS that they would not stutter so much "if they could just get going" with the utterance.

Brown's fourth factor was word length, and his finding that longer words are stuttered more often than shorter words has been replicated by numerous authors (Brown & Moren, 1942; Danzger & Halpern, 1973; Griggs & Still, 1979; Lanyon & Duprez, 1970; Wingate, 1967). There are many possible reasons why this might be. Brown and Moren (1942) believed that longer words were more "prominent" and therefore more likely to be stuttered because the speaker anticipated difficulty due to the prominence of the word. A more motoric/motor planning explanation is that articulatory transitions are more challenging to produce in longer words than shorter ones.

At this point, astute readers will likely have noticed that the factors described previously may not be independent of each other. For example, content words tend to be longer in length than function words, and many function words begin with vowels and occur at the beginning of sentences in English. This possible overlap makes it difficult to "tease out" the relative contributions of word length, word position, content versus function, and phonetic factors (consonants vs. vowels) in the location of stuttering. Brown (1945) thought that each factor contributed relatively equally to the frequency of stuttering. However, Taylor (1966a, 1966b) found that the effect of the phonetic factor was larger than the word length and word position factors, and that these three factors accounted for the majority of the stuttering observed. Max et al. (2019), in their comparison of linguistic features present in neurogenic and developmental stuttering, found that all factors except for word position contributed to stuttering frequency.

There are two additional word-related factors that contribute to the frequency of stuttering. These include word frequency and how predictable the word is in context. The less frequent a word is in a language, the more likely it will be stuttered or disfluent (Anderson, 2007; Palen & Peterson, 1982; Soderberg, 1966), and this effect appears to be independent of word length or grammatical function. The disfluencies of both AWS and CWS, as well as AWNS and CWNS, are influenced by word frequency.

Information value refers to how predictable a word is in a given context. If I say, "Pour me a cup of hot, black ___," the final word is relatively predictable, whereas the final word in the following is not: "Terry's favorite opera is ___." Words that are difficult to guess have a higher information value and therefore are more loaded with information. Thus, a word that is low in predictability is high in information value (Wingate, 1979). Many controlled laboratory studies have shown that words that are less predictable are stuttered more frequently (Quarrington, 1965; Schlesinger et al., 1965; Soderberg, 1967, 1971) but this phenomenon has proved difficult to document in spontaneous speech (Lanyon & Duprez, 1970). In a similar vein, Kaasin and Bjerkan (1982) defined critical words as those that "necessarily had to be pronounced if a listener should be able to understand and act according to the message given" (p. 403), and their results indicated that critical words tended to be stuttered more frequently than words that were less critical to the speaker's message (Kaasin & Bjerkan, 1982).

Utterance-level factors, such as length and complexity, also contribute to the frequency of stuttering in predictable ways (Begić & Babić, 2017; Bernstein Ratner & Sih, 1987; Buhr & Zebrowski, 2009; Melnick & Conture, 2000; Wagovich & Hall, 2018; Yaruss, 1999). Long and complex utterances are stuttered more than short, simple ones. The majority of studies that address utterance length and complexity have been completed with CWS. It is challenging to discover the relative contributions of length versus complexity on stuttering, as most longer sentences are also more linguistically complex. The studies that have attempted to do so are contradictory, with some finding complexity to be a better predictor of stuttering (Bernstein Ratner, 1997), whereas others find that length is the stronger predictor (Yaruss, 1999). Longer and more complex sentences require increased motor formulation and lead to reduced speech motor coordination (Kleinow & Smith, 2000), a fact that has been incorporated into some influential current models of stuttering (Smith & Weber, 2017).

In summary, a large body of literature suggests that there are word-level and utterance-level factors that influence the location and frequency of stuttering. As noted previously, adult speakers are more likely to stutter on words beginning with consonants, on longer words, on content words, and on words occurring early in the utterance. Long and complex utterances also increase stuttering frequency when compared with short, simple utterances. It is important to remember that these are group findings, and the relative influence of these factors on any one person's stuttering may not follow the group trends, as we discussed previously for Brown's phonetic factor. Essentially, any reduction in cognitive and motor planning will likely lead to reductions in stuttering. Clinically, speech–language pathologists can use their knowledge of these linguistic factors to develop hierarchies of linguistic difficulty. They can also develop hierarchies of cognitive/motor planning difficulty by, for example, beginning with reading aloud and progressing to spontaneous conversation.

DO PWS HAVE UNDERLYING LANGUAGE DIFFERENCES OR DEFICITS?

There has long been dispute about the relative level of language skills of speakers who do and do not stutter, in both adults and children (Nippold, 2019; Ntourou et al., 2011; Smith et al., 2012). The body of evidence addressing potential language skill differences and underlying processing strategies derives from two major sources: behavioral studies that appraise language skill in persons who stutter (PWS)/persons who do not stutter (PWNS), and electrophysiological studies that can examine how listeners process the language that they hear. We shall address each of these but in reverse order. We will start with research that has been conducted primarily in research laboratories, then moving to research that relies on language testing or sampling, more accessible to most speech-language pathologists (SLPs), and thus, of higher clinical relevance.

Studies of language processing in AWS and CWS

A large body of research is now accumulating that, even when PWS are listening, rather than speaking, we can observe atypicalities in how language is processed. Early PET and fMRI studies showed high-level, relative overactivation bilaterally during both receptive and expressive language tasks (e.g., single word naming) in AWS (Braun et al., 1997; De Nil et al., 2000; Fox et al., 1996). Using nonmeaningful speech stimuli, other researchers have found relative underactivation (Chang et al., 2009). A more recent major source of data for such research that is applicable to studying both CWS and AWS is the tracking of event-related potentials (ERPs). Specific, named, ERPs can be viewed as cortical signatures marking stages in how the brain decodes language input, from its phonology, to word identification and semantic processing, and finally to grammatical parsing (see the study by Bloodstein et al., 2021, p. 193, for a table of ERP descriptions). Typical ERP studies track listeners' electrophysiological responses to well-formed utterances, followed by test stimuli that contain anomalous elements, such as lexical or grammatical errors (e.g., *She likes to drink tea with sugar/sneakers*; *The boy is/are running*).

Numerous ERP studies of AWS indicate that latency is delayed and amplitude of response is diminished to a variety of stimuli (e.g., Maxfield et al., 2015; Piispala et al., 2017; see Tables 6 and 7 in the study by Bloodstein et al., 2021, for more than two dozen such reports since 2005). Thus, differences between AWS/AWNS are many and varied, as summarized in Chapter 6 of our recent text (Bloodstein et al., 2021). Replicated differences include multiple published findings that identify differences in ERP indices of semantic processing (Maxfield et al., 2012; Murase et al., 2016; Weber-Fox, 2001; Weber-Fox & Hampton, 2008), as well as those that find differences in processing of syntactic features of language (Cuadrado & Weber-Fox, 2003; Usler & Weber-Fox, 2015; Weber-Fox & Hampton, 2008). Similar profiles are seen in CWS as well (Kreidler et al., 2017) and, as we note later, appear to play a statistical role in predicting which children spontaneously recover from stuttering and which become persistent. In addition to generalized differences in amplitude and latency, ERP profiles in both CWS and AWS are often lateralized to the right, rather than left hemisphere (Kreidler et al., 2017; Mohan & Weber, 2015) as seen in typically fluent speakers. Finally, although neurotypical speakers show fairly consistent and different electrophysiological responses to semantic and grammatical errors in heard speech (the so-called N400 and P600 ERPs), both adults and children may show aspects of both ERP responses to both types of spoken language errors (Weber-Fox & Hampton, 2008). Considered together as a body of research, brain function studies of PWS suggest atypical function of areas typically associated with language processing, as well as speech motor processing.

Relative depression of language abilities in CWS

Although little evidence suggests that CWS are frankly language disordered, numerous studies have found subclinical depression of language skills in cohorts of CWS. Two relatively recent community-screening studies, one in Germany (Zaretsky et al., 2017) and one in Japan (Shimada et al., 2018), were able to compare language skills in CWS with much larger cohorts of typically fluent children in the same jurisdiction, all of whom were screened as part of public health projects. Both of these found relative depression of oral language skill in CWS. The German project concluded that CWS performed more poorly across specific tests of articulation, grammar, and overall language skill. The Japanese study used a less detailed screening tool; however, it also found that although CWS performed more poorly, those who achieved scores more typical for their age were more likely to recover from stuttering in the following year. In contrast, an Australian community health project, the Early Language in Victoria Study (ELVS), using very different screening methods, found a slight oral language advantage, rather than disadvantage, for CWS that they tracked, compared with children who were never reported as stuttering (Watts et al., 2015). Such inconsistencies among studies have led some to question whether CWS really do tend to have lower profiles of language skill; the debate thus continues on this topic (Nippold, 2019).

However, a meta-analysis (Ntourou et al., 2011) combined results of numerous studies tracking test performance of CWS relative to fluent peers on language test "batteries" such as the Test of Language Development (e.g., Newcomer & Hamill, 2008) or Clinical Evaluation of Language Fundamentals (Wiig et al., 2013). Analysis suggested that CWS scored significantly lower than CWNS on such measures of overall language (Hedges' $g = -0.48$), as well as receptive (Hedges' $g = -0.52$) and expressive vocabulary (Hedges' $g = -0.41$). Relatively few large studies have been reported since that time that simply contrast CWS and CWNS; most have addressed potential language skill differences between children who recover from stuttering and those who do not (covered in a following section). However, one large-scale study of 100 pairs of CWS and CWNS collected across numerous American laboratories (Luckman et al., 2020) found that CWS scored within 1 standard deviation lower in both expressive and receptive vocabulary, as measured by standardized assessments than did appropriately matched fluent peers. This discrepancy was not observed in spontaneous speech samples, using vocabulary diversity and number of different words.

Nonword repetition (NWR) is a measure that can reflect both linguistic proficiency and executive function; it has been found to be exceptionally sensitive to identification of children with frank language impairment (see the study by Graf-Estes et al., 2007, for meta-analysis) across language communities and in both monolingual and bilingual children (Schwob et al., 2021). Thus, NWR should hold promise for detecting relative weaknesses in language proficiency in CWS. In fact, the majority of studies that have used NWR tasks with stuttering speakers have found relative depression of scores in CWS (see the study by Elsherif et al., 2021, for view). This topic is explored more fully by other authors in this issue of *Topics in Language Disorders*.

Two recent studies have examined ability to repeat sentence-level stimuli by CWS/CWNS (Sitarević et al., 2019; Tiwari et al., 2016). Both found relatively depressed performance by CWS.

Comorbidity of concomitant communication or executive function disorder

Some studies show relatively high comorbidity of articulation and language problems in CWS (Arndt & Healey, 2001; Blood & Seider, 1981), although not all studies agree with this estimation (Clark et al., 2013; Unicomb et al., 2020). A few others find unusually high prevalence of attention deficit hyperactivity disorder (Donaher & Richels, 2012; Druker et al., 2019; Healey & Reid, 2003; Riley & Riley, 2000; Tichenor et al., 2021). "Soft" symptoms of attention deficit disorder are also reported for AWS (Alm & Risberg, 2007; Felsenfeld et al., 2010). A recent meta-analysis (Ofoe et al., 2018) found statistically significant depression of performance of CWS, relative to that of CWNS, on forward memory span, as well as parental reports of inhibition and attention; this pattern may also apply to AWS (Tichenor et al., 2021). This finding serves to emphasize that children who are being evaluated for stuttering should have full-scale evaluations that appraise language skills, as well as aspects of executive function (Anderson & Ofoe, 2019; Brundage et al., 2021).

Although many CWS do have concomitant articulation or phonological delays, research has generally failed to show an association between fluency breakdown and mispronounced target sounds (Gregg & Yairi, 2012). This suggests that attempting to program for a child who shows both stuttering and an articulation/phonological disorder should not create situations in which an articulation task disrupts fluency or vice versa.

In contrast, the literature is quite substantive regarding linguistic influences on fluency and stuttering. The opening section of this article described this phenomenon in detail. As language targets become longer and more developmentally complex, children are much more likely to experience disfluency and stuttering. This relatively well-attested phenomenon has led to numerous suggestions that clinicians proactively explore potential interactions between language skill and fluency in children at multiple levels (Bernstein Ratner, 2018; Hall et al., in press; Kelly et al., in press). These include (1) language sample analysis to ascertain what structures the child appears to be able to use, or are absent from the child's repertoire, and general stage of expressive language development; (2) examination of the sample for possible structures that seem particularly likely to be accompanied by stuttering; (3) general status of language development as informed by standardized testing; (4) programming of fluency goals at lower levels of linguistic complexity (already mastered structures) and moving through planned practice at increasingly more difficult levels of complexity; and (5) accepting that fluency breakdown may accompany the child's attempts to master new language targets during language intervention sessions.

LANGUAGE FACTORS THAT APPEAR TO INFLUENCE RECOVERY FROM EARLY CHILDHOOD STUTTERING

Excellent evidence suggests that many children who begin to stutter stop without professional assistance. Estimates of the likelihood of recovery from early stuttering have come from longitudinal research such as that reported by Yairi and Ambrose in the Illinois Stuttering Research Project (ISRP; Yairi & Ambrose, 2005). In the Yairi cohort, 31% of children (whose mean age at onset was 3 years) had recovered within 2 years, 63% by 3 years postonset, 74% by 4 years, and almost 80% by 5 years after stuttering onset. In a Danish cohort (Månsson, 2000), more than 71% of children had stopped stuttering within 2 years after their initial identification. In another study, Dutch children (Kloth et al., 1999) were being tracked prospectively because at least one of the parents was an AWS. Seventy percent of them were found to have recovered without intervention within 4 years after identification.

When identified that early, recovery rates may even exceed the 80% figure traditionally cited. Data from the British Twins Early Development study (Dworzynski et al., 2007) found that of 1,085 children who met criteria for stuttering between 2 and 4 years of age, 92% were recovered by 7 years of age. When Japanese researchers (Shimada et al., 2018) analyzed results of developmental screening conducted at 3 years of age, 1.41% of the children stuttered, as judged by an SLP; 82.8% of these children were judged to have recovered 6 months later.

The later stuttering is observed, the lower the recovery rate appears to be. Of Australian children living in Victoria who were reported to stutter at the age of 4 years (Kefalianos et al., 2017), 67% were recovered by 7 years of age. In one German sample, children were identified relatively later than in these other studies, at around 5 years of age (Rommel et al., 2000). Three years later, 71% were found to have recovered. Finally, the Purdue Stuttering Project tracked children starting relatively later, at 4 year of age, until 9 years of age. They obtained a recovery rate of approximately 66% in this older age bracket (Walsh et al., 2018).

By itself, this information about high rates of spontaneous recovery is comforting to distressed parents or to SLPs. However, predicting which children will recover still eludes our understanding and is important for obvious reasons. Having said this, numerous factors are now being identified that contribute to risk for stuttering persistence (see the study by Walsh et al., 2021, for the most recent analysis of the Purdue cohort data, discussed in more detail later). These include family history of persistent stuttering and sex (Singer, Hessling, Kelly, Singer, & Jones, 2020). Males are overrepresented among AWS. But this appears to be at least in part a function of an advantage that young girls have in spontaneously recovering.

Two other factors appear interrelated, and we will discuss them in more detail. Children who start stuttering at later ages are less likely to recover than those who start earlier (Yairi & Ambrose, 2005). This fact may be somewhat intertwined with one that we will discuss in detail in this section that children who recover appear to show better language skills (as measured by a number of different metrics) than do children who remain persistent. Thus, children who develop stuttering at a slightly later age are more likely to score less well (function like younger children) on language tasks: both predict less favorable outcomes for spontaneous recovery from stuttering. Put another way, it may be that stuttering does not emerge until a certain level of language proficiency is reached—children who develop language more slowly will reach this stage later in childhood. Data to support the role of language proficiency in recovery from stuttering derive from a number of sources. We cover each of these factors individually later.

Articulation/phonological findings

A number of studies have suggested the possibility that CWS show poorer articulatory or phonological skills than fluent peers, at least when evaluated at onset (Paden, et al., 1999; Rossi et al., 2014; Smith et al., 2012; Walsh et al., 2021), although not all studies are in agreement (Clark et al., 2013; Unicomb et al., 2020). Some of these are behavioral, and easily observed through testing, whereas others are more subtle and have been detected through sophisticated acoustical analysis or results of electrophysiological studies. Although not all agree with this body of research (Nippold, 2019), a few studies have taken such findings to explore whether phonological or related skills in young CWS might predict whether or not they recover.

A number of studies do suggest that this might be the case. Critically, the association, in our view, is strengthened by the fact that positive findings have been reported in studies from different universities, using different paradigms, and nonoverlapping CWS cohorts. For example, lower phonological performance as measured by traditional articulation testing at first visit after onset appeared predictive of persistent stuttering in the Illinois Project children (Ambrose et al., 2015; Paden & Yairi, 1996, 1999), as well as those in the Purdue Project cohort (Spencer & Weber-Fox, 2014; Walsh et al., 2021), and in a smaller study conducted by Ryan (2001).

Phonological awareness and phonological manipulation ability, rather than speech articulation skills, have also been found to be relatively depressed in CWS by a number of studies (Anderson et al., 2019; Ghorbani et al., 2020; Pelczarski & Yaruss, 2014; Sasisekaran & Byrd, 2013; Zohreh Ghaffari et al., 2012). There is also evidence that AWS likewise show relatively lower levels of performance, typically in rapidity of response, when asked to perform a variety of phonological processing tasks (Coalson & Byrd, 2015; Pelczarski et al., 2019; Vincent, 2017). Interestingly, a recent review found overlap in the profiles of AWS and adults with dyslexia (Elsherif et al., 2021).

In laboratory analyses, subtle articulatory differences such as rate of second formant transitions in consonant-vowel syllables were found to differentiate persistent and recovered children from the ISRP when analyzed close to onset (Subramanian et al., 2003). In an experimental task, CWS in the Purdue cohort who remained persistent used strategies in creating rhymes that differed from those of typically fluent and recovered children (Gerwin et al., 2019). Finally, atypicalities in cortical processing of rhyming/nonrhyming words were detected in Purdue cohort persistent CWS (Gerwin & Weber, 2020; Hampton Wray & Spray, 2020; Mohan & Weber, 2015).

Standardized test score achievement as a factor in recovery

Language findings have been a bit more mixed in predicting stuttering prognosis and have utilized a wide range of linguistic measures. Some studies have reported standardized test scores. The ISRP was the first major study to report a possible linguistic predictor of recovery: that lower Preschool Language Scale (PLS; Zimmerman et al., 2011, for most recent edition) scores significantly predicted which children remained persistent (Yairi et al., 1996). This finding surprised a number of fluency researchers, because the PLS is often regarded as a relatively lenient screening device. Since that report, similar performance on screening tests has predicted recovery in very young Japanese CWS (Shimada et al., 2018). Language differences showing higher scores for recovered children have been detected using the Test of Early Language Development receptive scales (Ambrose et al., 2015; Hresko et al., 2017; Singer et al., 2020), as well as expressive scales (Ambrose et al., 2015; Singer et al., 2020). Statistical differences indicating better scores for recovered children were also found for expressive vocabulary by the same teams.

Expressive language analysis

Two different laboratories (the ISRP and a Belgian study) have examined mean length of utterance, a very crude index of language development, and found it not to predict stuttering outcomes (Ambrose et al., 2015; Kloth et al., 1999). Lexical diversity or richness in the child's language sample was repeatedly found not to be a predictive variable in reports from the ISRP (see, e.g., Watkins et al., 1999). Communication skills at 2 years of age (as measured by the Communication and Symbolic Behavior Scales) predicted recovery status by 7 years of age for Australian girls, but not boys, tracked by the ELVS project. At the age of 7 years, Australian-recovered CWS (Kefalianos et al., 2017) had stronger language skills (as measured by the Australian version of the *Clinical Evaluation of Language Fundamentals—4*) than peers who remained persistent. No other variables were predictive of recovery in that cohort.

An important distinction has emerged across four reports covering three different cohorts of CWS (Purdue, Iowa, and ISRP) regarding measurements of expressive language skill taken at a single time point and those tracking language growth profiles. Analysis of the Purdue cohort, using IPSyn analysis of samples gathered from CWS over 3 years, suggested that growth in the variety of grammatical structures seen in children's expressive language, rather than initial presentation, significantly predicted stuttering outcome, with CWS-P showing shallower rates of expressive language growth (Leech et al., 2017, 2019). This work has recently been replicated using 3 years of language samples from children in the ISRP; recovered children show steeper growth in expressive language complexity than do peers who were still stuttering at the conclusion of that project (Hsu et al., in review). Similarly, in a smaller sample tracked at Iowa (Hollister et al., 2017), researchers found that higher levels of expressive grammatical development over an 18-month period were associated with recovery in a sample of preschool CWS between 28 and 43 months of age. In another small sample of Korean recovered and persistent CWS (Lee et al., 2019), persistently stuttering children showed lower language skills at first visit than those who recovered; slower development of accurate case marker use still distinguished these children from peers who recovered over an 18-month period.

Experimental indices of linguistic processing and recovery from early stuttering

Additional linguistic markers of stuttering recovery were also identified for the Purdue cohort (Kreidler et al., 2017). Using ERPs to study brain activity during processing of stories manipulated to contain occasional insertions of semantically anomalous information (e.g., *he ate all his* ***door*** *quickly*), the researchers found that the N400 response typically seen in both children and adults following such violations did not differ appreciably between typically fluent children and those who recovered from stuttering. Strikingly, however, the N400 signal had reduced amplitude in children who remained persistent, a potential marker of weaker semantic processing skill in children who continue to stutter. The same cohort of children was appraised for indices of syntactic processing (Usler & Weber-Fox, 2015). Children who stutter, as a group, did not differ in expected P600 responses to grammatically ill-formed sentences; however, children who remained persistent showed an unusual and unexpected N400 (semantic) response to both semantic and syntactic violations in stimuli.

In summary, although individual studies have reached differing conclusions, results of a recent meta-analysis combining data from a large number of reports (Singer et al., 2020) appear to provide rather clear evidence of some contributions of relative language proficiency relative to age, as well as growth profiles, to recovery from early stuttering. The meta-analysis examined 29 individual sets of data, across multiple measures and research projects, as well as both expressive and receptive language skills. In addition, the analysis examined both results of standardized testing and language sample analysis. The majority of standardized test findings showed a clear statistical advantage for children who recover from stuttering. Findings for receptive vocabulary, all using the Peabody Picture Vocabulary Test (Dunn, 2019), were equivocal. Of the three studies reported, one study found language delay, a second found language advantage, and a third showed no difference for children who do not recover from stuttering. We do note that a study appearing at roughly the same time (Luckman et al., 2020) found significant differences between CWS and CWNS on standardized measures of both expressive and receptive vocabulary across a very large cohort of CWS studied across numerous American study cohorts. Static measures of expressive language do not, as of yet, appear to predict recovery, whereas longitudinal profiling of expressive language growth do appear to factor into models accounting for children's recovery from early stuttering.

LANGUAGE FACTORS IN BILINGUAL CWS

The presence of multiple languages adds complexity

It is important to remember that the findings summarized in this article until now have been obtained with monolingual, and mostly English-speaking, speakers. A potentially unique window to characterize the influence of linguistic factors on stuttering is to study speakers who speak more than one language. Given that over half of the world's population speaks more than one language (Grosjean, 2010), it is reasonable to assume that SLPs will encounter bilingual CWS and AWS on their caseloads. The last decade has seen an increase in research addressing the nature and frequency of disfluencies produced by bilingual children. Some researchers have suggested that differences in stuttering and disfluency rates across languages are due to difference in syntax, phonology, and morphology between the languages spoken (Gkalitsiou et al., 2017; Maruthy et al., 2015), whereas others suggest that relative proficiency with a given language determines the amount of disfluency or stuttering observed (Jankelowitz & Bortz, 1996; Roberts, 2002). A recent systematic review suggests that language dominance and proficiency are significant determinants of disfluency characteristics. The effects of language structure are not as well supported by the accumulated evidence (Chaudhary et al., 2021). The apparent influence of language proficiency on disfluency rates necessitates comprehensive SLP assessment procedures such as those described by Roberts and

Shenker (see protocol described by Roberts & Shenker, 2007). Many variables influence a bilingual child's language proficiency; SLPs need to consider the child's language environment, including history of use, proficiency, functionality, and stability of use in each language spoken (Coalson et al., 2013). The interaction of these factors on a given child's language development (in multiple languages) is interactive and complex.

There do seem to be similarities between monolingual and bilingual speakers who stutter in terms of gender imbalance (more boys than girls stuttering), family history, and recovery profiles (Choo & Smith, 2020). However, a recent review of research on bilingualism and stuttering concluded that there are many gaps in our current knowledge of how the two phenomena interact (Choo & Smith, 2020). In particular, the current research offers only a "fragmented view" (p. 16) of the possible relationships between language factors and stuttering in bilinguals. What is clear is that bilingualism increases a child's risk of being diagnosed as stuttering, even when they are not (Byrd et al., 2015; Eggers et al., 2020). We discuss some of these studies in the next section.

Determining the presence of stuttering in bilingual children

Typical disfluencies, such as revisions, filled pauses, silent pauses, and phrase revisions, are seen in monolingual children during times of rapid language learning (Colburn & Mysak, 1982a, 1982b; Wexler, 1982; Yairi, 1981) and are correlated with language development and language growth in monolingual children (Rispoli et al., 2008; Tumanova et al., 2014). In bilingual children, it can be challenging to discern whether their disfluencies are due to language formulation or due to frank stuttering. Recent research suggests that bilingual children may have increased rates of typical disfluencies (Byrd et al., 2020; Leclercq et al., 2018), perhaps due to the increased challenges of language processing and formulation in two or more languages. There is also an indication that rates of stuttering-like disfluencies are higher in bilingual children even if they are *not* diagnosed with stuttering (Byrd et al., 2015; Eggers et al., 2020). Thus, bilingual children will likely appear to be more disfluent than their monolingual peers, but how does one go about deciding whether the disfluencies are due to language formulation or due to stuttering?

Numerous authors caution against using the monolingual norms for 2%–3% typical disfluencies (Ambrose & Yairi, 1999) to evaluate disfluency rates in bilingual children, as doing so will likely lead to misdiagnosis of stuttering in this group of children (Byrd et al., 2020; Eggers et al., 2020). Instead, observation for other behaviors associated with stuttering, such as tension, arrhythmicity, and sound prolongations, may be more appropriate when making a stuttering diagnosis in bilingual children (Byrd et al., 2020; Eggers et al., 2020).

Just as language learning leads to increased disfluencies, so does language attrition. Language attrition occurs when a speaker does not maintain his or her heritage language. There is evidence that typical disfluency rates increase as speakers experience loss of the heritage language (Schmid & Fägersten, 2010). The effects of language attrition are surprisingly understudied. A recent study revealed several possible profiles of language dominance in 5-year-old Spanish–English bilingual children who had been exposed to Spanish from birth; these profiles capture variations in language balance and total language knowledge (Hoff et al., 2021).

THE INTERFACE BETWEEN LANGUAGE AND MOTOR FACTORS IN STUTTERING

It is beyond the scope of this review article to do full justice to the very sophisticated body of work that has examined how the speech–motor and language systems interact in people who stutter. However, we feel that it is necessary to put the work discussed in this article into some perspective. Any clinician or researcher reading our review might surely wonder how difficulties in processing or retrieving linguistic elements, be they sounds, words, or utterances, could result in the overt symptoms of speaking difficulty that classically describe stuttering. Put more succinctly, why does stuttering look like a speech production disorder, not a language disorder, if evidence suggests potential differences in how children and adults perform basic linguistic tasks?

The answer to this question appears to lie in unique differences in the integration of language and speech demands in people who stutter, when compared with people who are typically fluent. The majority of the relevant research that has examined this question has been conducted by the Purdue project, referenced repeatedly in prior discussion. Anne Smith, in particular, has examined indices of motor stability under language encoding pressures to suggest an avenue by which poorer language skills might play a role in the onset of stuttering and its distributional properties. As an analogy, she compares speech with handwriting. Let us start with that notion and then describe findings from this body of research.

Like any well-practiced motor activity, a person's signature has distinctive form and regularity (much to the dismay of any student who has tried to forge a parent's excuse or permission slip). Repeated trials of one's signature have observable regularity and uniformity. Another way to describe this is to say that there is little variability in the action's temporal and spatial features. Similar properties can be derived for repeated speech sequences, such as saying the same phrase over and over. With that concept in mind, we can now discuss findings of motor skill stability of AWS and CWS across varying task demands.

The first efforts to link speech motor performance to language encoding demand found that although AWS demonstrated slightly more spatial/temporal variability in repeating simple utterances, variability was significantly increased when the AWS attempted to utter the same phrase in a longer, more complicated response (Kleinow & Smith, 2000). Thus, although AWS' production of a phrase such as "buy Bobby a puppy" was not immensely different from that seen in AWNS, embedding the same phrase in a stimulus such as "You buy Sally a kitty, and I'll buy Bobby a puppy" resulted in noticeable loss of stability across repetitions of the target words.

Since then, findings have been extended to CWS (MacPherson & Smith, 2013), and differences have been detected between speech–motor stability in children who recover or persist, using similar tasks (Usler et al., 2017; Usler & Walsh, 2018); the majority of this work was conducted using data from the Purdue University stuttering project. Findings compatible with this conceptualization of the route by which language demand can impact speech motor control have been obtained by additional research groups that study both typical infant/child speech–motor development (Iverson, 2010; Nip et al., 2011) and populations with atypical language proficiency (e.g., children with language impairment: Saletta et al., 2018).

SUMMARY

Across a number of different facets of language knowledge and use, stuttering frequency, distribution, and recovery show measurable distinct mutual influences. Much of this information is of relatively recent emergence (within the last two decades) and may not be familiar to readers of this journal. The interface between speech and language production systems has important ramifications for both research and clinical practice. Clinical ramifications have been explored by numerous reports and range from best practices in assessment to selection of therapy goals, particularly for children (Bloodstein et al., 2021). The remainder of articles in this issue emphasize that more recent conceptualization of stuttering considers it to be influenced, in substantive ways, by requirements imposed by numerous other "systems," such as cognitive and emotional substrates of communication.

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