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Adolescent Outcomes of Children With Early Speech Sound Disorders With and Without Language Impairment

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Purpose: In this study, the authors determined adolescent speech, language, and literacy outcomes of individuals with histories of early childhood speech sound disorders (SSD) with and without comorbid language impairment (LI) and examined factors associated with these outcomes.
Method: This study used a prospective longitudinal design. Participants with SSD (*n* = 170), enrolled at early childhood (4–6 years) were followed at adolescence (11–18 years) and were compared to individuals with no histories of speech or language impairment (no SSD; *n* = 146) on measures of speech, language, and literacy. Comparisons were made between adolescents with early childhood histories of no SSD, SSD only, and SSD plus LI as well as between adolescents with no SSD, resolved SSD, and persistent SSD.
Results: Individuals with early childhood SSD with comorbid LI had poorer outcomes than those with histories of SSD only or no SSD. Poorer language and literacy outcomes in adolescence were associated with multiple factors, including persistent speech sound problems, lower nonverbal intelligence, and lower socioeconomic status. Adolescents with persistent SSD had higher rates of comorbid LI and reading disability than the no SSD and resolved SSD groups.
Conclusion: Risk factors for language and literacy problems in adolescence include an early history of LI, persistent SSD, lower nonverbal cognitive ability, and social disadvantage.

Few studies have examined adolescent outcomes of individuals with histories of early childhood speech sound disorders (SSD). Although most adolescents with histories of SSD no longer exhibit overt speech sound errors in conversation, residual weaknesses in phonological processing and/or slow or imprecise articulation may impact language and academic skills, especially if errors are representative of a broader phonological deficit (Preston, Hull, & Edwards, 2013). SSD that fail to resolve by early school age and conditions comorbid with early SSD, such as language impairment (LI) and reading disability (RD), may also increase risks for poorer adolescent outcomes. Additional factors potentially related to adolescent outcomes of early SSD are gender, lower cognitive ability, and socioeconomic disadvantage. The purpose of this study was to examine adolescent outcomes in a large prospective cohort of individuals with histories of early childhood SSD with and without comorbid LI to determine if speech, language, and literacy problems persist at this age and to identify factors associated with poorer outcomes.

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Adolescent Follow-Up Studies of Individuals With Early Childhood SSD

Persistent deficits in speech sound production skills are well documented in adolescents and young adults with histories of SSD. However, it is not known whether these errors are due to poor phonological representations of words or to poor oral motor skills. For example, Johnson, Beitchman, and Brownlie (2010) found that many of their participants with histories of speech and language disorders continued to make articulation errors at 18–20 years of age, although many of these errors were minor distortions that did not impair intelligibility. Distortion errors may be due to impaired motor skills rather than difficulty with phonological representations. Additional support for motor deficits was provided by Flipsen (2002), who found that 12- to 16-year-olds with histories of SSD had a slower articulation rate than their peers, presumably reflecting an effort to

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compensate for speech motor difficulties. Other studies have reported that adults with a history of SSD committed more sequencing errors on multisyllabic and nonword repetition than did adults without a history of SSD and exhibited slow rates on tasks involving sequential alternating compared to repetitive movements (Lewis et al., 2007; Peter, Button, Stoel-Gammon, Chapman, & Raskind, 2013). However, these findings may suggest deficits at several levels of processing, including encoding, memory, and/or translation into motor acts. Deficits in phonological processing abilities may result in persisting speech errors and slowness in articulation and may have negative effects on the development of literacy skills (Edwards & Lahey, 1998).

Factors That Influence Adolescent Outcomes

Impact of comorbid LI on outcomes. The comorbidity of LI with SSD may influence adolescent outcomes, especially literacy skills. Studies that followed children with early childhood SSD to school age have found later academic difficulties in 50%–75% of their samples (Bishop & Adams, 1990; Flax et al., 2003; King, Jones, & Laskey, 1982; Lewis, Freebairn, & Taylor, 2000a). Children with SSD who have comorbid LI, referred to here as "SSD + LI," consistently demonstrate poorer outcomes at school age than individuals with SSD alone and are at higher risk for longer-term reading and spelling problems (Bishop, Price, Dale, & Robert, 2003; Lewis, O'Donnell, Freebairn, & Taylor, 1998). In one of the few studies of adult outcomes of childhood speech-language impairments (Young et al., 2002), participants with LI performed more poorly than control participants in both literacy and mathematics skills. Further, higher rates of learning disabilities were observed in the SSD + LI group than in the SSD-only or control groups. Despite the more pervasive deficits of the children with histories of SSD + LI, those with SSD scored lower than controls only in real-word decoding, indicating that even isolated SSD carried some risk for long-term reading deficits. In another follow-up study of adolescents (Leitao & Fletcher, 2004), individuals whose speech errors were characterized by nondevelopmental error processes (i.e., those not typical of younger children) had weaknesses in phonological awareness, reading, and spelling compared with individuals who had developmental speech sound errors. In the current study, we examined two groups—individuals with histories of early childhood SSD only and individuals with SSD + LI—to test the hypothesis that individuals with histories of comorbid LI will have poorer adolescent outcomes than individuals with histories of SSD only.

Impact of persistent SSD versus resolved SSD on outcomes. Several studies have suggested that children with persistent SSD may have different outcomes than children whose problems resolve by school age. *Persistent SSD* is defined as speech sound errors that persist beyond the age at which typically developing children have acquired the adult speech sound system, usually by 8 and 9 years of age (Shriberg, 2010; Wren, Roulstone, & Miller, 2012). The prevalence of persistent SSD differs on the basis of whether the cohort studied is a population-based sample or a clinical sample, the age and gender of the participants, and the severity of the SSD. Studies of population-based samples indicate a prevalence rate of 3.8% at 6 years of age (Shriberg, Tomblin, & McSweeny, 1999) and 3.6% at 8 years (Wren, Miller, Peters, Emond, & Roulstone, 2014a). One study of a population-based cohort of 8-year-olds revealed that 18% had unresolved speech errors (Roulstone, Miller, Wren, & Peters, 2009). Another study of a clinical sample reported that 27% of 7- to 10-year-olds with speech and language disorders demonstrated linguistic, literacy, and social deficits (Glogowska, Roulstone, Peters, & Enderby, 2006). Rates of persistent SSD decline with age, occurring in only an estimated 1.4% of college freshmen (Culton, 1986).

Bishop and Adams (1990) hypothesized that children whose errors persist past the point at which phonological skills are needed for initial literacy learning are at greatest risk for reading difficulties. In support of this hypothesis, they found that children whose problems had not resolved by age 5½ years did not perform as well on tests of phonological processing and literacy skills as those whose problems had resolved. Further evidence for differences in etiology between persistent and resolved SSD is provided by Bishop et al. (2003), who showed that heritability of LI was higher for children with persistent LI than for those with language delays that normalized early in childhood. However, Bishop and colleagues did not examine persistent SSD independent of LI. Investigators have also hypothesized an association of poor phonological representations with poor literacy outcomes in children with persistent SSD (Bishop & Adams, 1990; Nathan, Stackhouse, Goulandris, & Snowling, 2004). Other researchers have argued that comorbid LI, rather than persistent SSD, is responsible for literacy deficits (Peterson, Pennington, Shriberg, & Boada, 2009). A recent study of children with LI reported that even children whose LI resolved by age 4 years were at risk for later literacy difficulties (Dale, McMillan, Hayiou-Thomas, & Plomin, 2014). However, the risk was the same for children with similar language scores at 4 years. A large and well-characterized sample followed longitudinally that examines both specific speech and language skills is needed to determine the relationship between resolved and persistent SSD and later literacy skills.

A study by Wren et al. (2012) classified children at age 8 years as exhibiting persistent SSD, minor speech errors that did not qualify as persistent SSD, and common clinical distortions only. *Common clinical distortions* are speech errors that are within the correct phoneme category (subphonemic), including dentalization, lateralization, labialization, and derhotacization (Shriberg, 2010). Childhood predictors of persistent SSD included difficulty producing certain sounds and complex syllable sequences, poor nonword repetition, coordination problems, and phonological memory deficits (Schussler & Wren, 2012; Wren, Miller, Peters, Emond, & Roulstone, 2014b). Consistent with these results, Preston et al. (2013) reported that children with atypical errors at preschool had lower phonological awareness and literacy scores at school age. Atypical errors may indicate poor phonological representations, and distortion errors may signal motor learning errors that persisted to school age. In another study Preston and Edwards (2007) compared the phonological processing skills of two groups—10- to 14-year-olds with residual speech sound errors and typically developing children—and found differences in five out of six phonological processing tasks. Tasks included two nonword repetition tasks, multisyllabic word repetition, spoonerisms, phoneme reversals, and an elision task. Participants with residual errors were correctly identified 85% of the time by these tasks. These findings suggest that residual speech sound errors in adolescence may be related in part to poor phonological processing skills and not solely to a motoric deficit.

Impact of SES, Gender, and IQ on Outcomes

Factors other than persistent speech errors and LI may also affect adolescent outcomes. Gender, maternal education, and maternal social class have been associated with persistent SSD (Wren et al., 2012, 2014b). Most studies have found a higher prevalence of SSD in male participants than in female participants. Eleven of the 14 studies reviewed by Harrison and McLeod (2010) found that male gender was a risk factor for speech and/or language impairment, with odds ratios between 1.29 and 1.97 for male gender. Population-based studies have documented male: female ratios of 2:1 to 3:1 at age 3 years and 1.2:1 at age 6 years (Shriberg et al., 1999). When a positive family history for SSD and low maternal education were taken into account, male participants were 7.7 times more likely to have speech delay than were female participants (Campbell et al., 2003). The prevalence rates for persistent SSD are also higher for male participants than female participants, with a range of 1.5–2.5 (Peckham, 1973; Silva, McGee, & Williams, 1982). Further support for a male bias for persistent SSD was provided by a survey by the National Outcomes Measurement System for Pediatric Speech-Language Pathology, which found that 67% of students (n = 14,852) on school-based speech-language pathologists' (SLPs') caseloads in grades K–12 were male (Mullen & Schooling, 2010). Besides gender and SES, low nonverbal cognitive abilities have been associated with poorer outcomes for individuals with SSD, especially in literacy (Bird, Bishop, & Freeman, 1995; Peterson et al., 2009). Wren et al. (2014b) identified other risk factors for persistent SSD, including a weak suck at age 4 weeks, not combining words at age 24 months, and unintelligibility at age 38 months. In the current study, we hypothesized that male gender, lower SES, and lower nonverbal intelligence would be associated with poorer adolescent outcomes.

Study Aims

These research findings suggest that early childhood SSD may have long-term speech-language and academic consequences for some individuals. However, most studies have failed to distinguish long-term outcomes for the subset of children with early SSD only from those for children with early SSD + LI. In addition, few studies have followed samples of these children prospectively from early childhood to adolescence. Much of the research in this area has been based on case studies or assessments of small samples that failed to evaluate multiple speech-language skills or comorbid learning problems. Other limitations of previous research include group comparisons that failed to control for confounding factors, such as cognitive abilities, SES, or gender or that failed to compare adolescents with persistent SSD with those with resolved SSD.

The current study extends the work of previous research in several ways. We report on the adolescent outcomes of a large, well-characterized cohort of individuals with early childhood SSD who were followed to adolescence. Participants were assessed on multiple measures of speech, language, and literacy. Comorbid conditions of LI and RD were considered, and group comparisons were made, controlling for cognitive abilities, gender, and SES. We also compared adolescents with SSD that had resolved to those with persistent SSD on language and literacy outcomes. The research questions addressed were as follows:

1. Do adolescents with histories of early childhood SSD differ from adolescents with no history of speech or language impairment (no SSD) on measures of speech, language, and literacy?
2. Do adolescents with histories of early childhood SSD + LI differ from those with histories of SSD only on speech, language, and literacy measures?
3. How do adolescents with persistent SSD differ from adolescents with resolved SSD or no SSD on speech, language, and literacy measures?
4. Are other factors—such as SES, gender, or nonverbal cognitive abilities—associated with adolescent language and literacy skills?

Method

Participants

All participants were part of an ongoing family study of speech and language disorders (Lewis et al., 2000a, 2006; Lewis, Freebairn, & Taylor, 2000b). Participants were recruited at early childhood (4–6 years of age) from the clinical caseloads of SLPs working in the greater Cleveland area. Efforts were made to test all children in each family regardless of whether they were enrolled in speech-language therapy. Children with SSD (n = 170) met the following criteria at the time of their initial assessment: (a) scored below the 10th percentile on the Goldman Fristoe Test of Articulation–Sounds in Words Subtest (Goldman & Fristoe, 1986, 2000) and (b) exhibited at least three phonological process error types on the Khan-Lewis Phonological Analysis (Khan & Lewis, 1986). These criteria assured that the SSD was not mild. In addition, these children (c) passed a pure-tone hearing screening bilaterally, suggesting normal hearing, and had fewer than six episodes of otitis media prior to 3 years of age; (d) exhibited a normal oral peripheral speech mechanism as determined by a licensed SLP; (e) showed no signs of other neurological or developmental delays per parent report; and (f) demonstrated normal cognitive skills as defined by performance IQ (PIQ) scores >80 on the Wechsler Preschool and Primary Scale of Intelligence–Revised (Wechsler, 1989) or on the Wechsler Intelligence Scale for Children–Third Edition (WISC-III; Wechsler, 1991). Children with early childhood SSD were further divided into groups with SSD only versus SSD + LI, with LI defined as a scaled score of ≤ 8 on two or more subtests of the Clinical Evaluation of Language Fundamentals–Preschool (Wiig, Secord, & Semel, 1992) or the Test of Language Development–Primary: Third Edition (Newcomer & Hammill, 1997) as described by Tomblin et al. (1997). Siblings who had never had an SSD or LI served as the typical control group (n = 146; no SSD group). Participants were followed both at school age (see Lewis, Freebairn, & Taylor, 2000c, for a summary of findings) and again at adolescence (11–18 years). Only outcome data from the latter assessment were considered in this study.

Measures

At the adolescent follow-up, the test battery consisted of both standardized and nonstandardized measures administered in the Family Study of Severe Phonology Disorders (Lewis et al., 2000a, 2000b, 2006). Measures assessed speech and language skills, literacy, nonverbal intelligence (Wechsler PIQ), and SES.

Speech and Language Measures

Speech sound production. The Multisyllabic Word Repetition task (MSW; Catts, 1986) assessed speech sound production. Administration of this task was justified by findings showing that the repetition of multisyllabic real words discriminated parents and older siblings with histories of speech and language disorders who no longer demonstrated overt speech errors in conversational speech from individuals without such histories (Lewis et al., 2007). Participants were asked to repeat multisyllabic words presented by audiotape. The responses were digitally recorded, phonetically transcribed, and analyzed for phonological processes and syllable structure. Age-based norms were derived from the mean scores of unaffected siblings, and z scores were generated based on the means and standard deviations for each age in the unaffected siblings as in our previous work.

Residual speech sound errors were assessed by a 10-min conversational speech sample. Samples were audio recorded and reviewed by a SLP for speech sound errors. Errors were transcribed and coded for omissions, substitutions, distortions, or additions. Phonological process errors were noted, as were dysfluencies and abnormal prosody.

Oral motor skills. Oral motor skills were assessed using the Fletcher Time-by-Count Test (Fletcher, 1977). This test measures the individual's ability to imitate oral motor movements as quickly as possible. The adolescents were asked to produce five monosyllabic syllable repetitions, three two-syllable repetitions, and one multisyllabic repetition. Raw scores were transformed to z scores for analysis based on the test's normative data.

Phonological memory. Nonsense words have been used to assess short-term phonological memory, as these stimuli are novel and thus less likely than real words to be accessed directly from the participant's lexicon. The Nonsense Word Repetition task (NSW; Catts, 1986) involves the repetition of 20 multisyllabic nonsense words presented on a professionally recorded audiotape. All words were derived from real English words employing Snowling's (1981) procedures. Raw scores were standardized for age based on data from unaffected siblings.

Oral language. The Clinical Evaluation of Language Fundamentals–Third Edition Screening Test (CELF-3; Semel, Wiig, & Secord, 1995) comprises the most discriminating items of the CELF-3 and is used to efficiently identify individuals with language impairment. Receptive, expressive, grammatical, and semantic skills are screened. Standard scores for age were used in data analysis.

Vocabulary. The Expressive One Word Picture Vocabulary Test–Second Edition (EOWPVT-2; Gardner, 2000) and the Peabody Picture Vocabulary Test–Fourth Edition (PPVT-4; Dunn, 2006) were used to assess expressive and receptive vocabulary skills. The EOWPVT-2 assesses expressive lexicon. The PPVT-4 was given to all participants to assess lexical comprehension with standard scores for age used in data analysis.

Literacy Measures

Word-level reading. Decoding was assessed by administering the Word Identification (WI) and Word Attack (WA) subtests of the Woodcock Reading Mastery Tests–Revised (WRMT-R; Woodcock, 1987). The WI subtest consists of real words, and the WA subtest consists of nonwords that follow English phoneme–grapheme correspondence rules. Subtest standard scores were used in data analysis.

Reading comprehension. The Reading Comprehension (RC) subtest of the Wechsler Individual Achievement Test (WIAT; Wechsler, 1992) was used to measure comprehension of written passages with standard scores used in data analysis.

Spelling. The Test of Written Spelling–3 (TWS-3; Larsen & Hammill, 1994) was administered to assess spelling skills. The TWS-3 consists of two subtests, one requiring spelling of predictable words or words that conform to rules or generalizations and the other requiring spelling of unpredictable words. The TWS-3 has been extensively normed and demonstrates high reliability and validity. Subtest standard scores were used in data analysis.

Parent report. Parents completed questionnaires that provided information about their children's educational and medical history. Reading disability (RD) was defined as enrollment in special services for reading. Based on parent report, 94 adolescents had received a diagnosis of RD.

Other Measures

PIQ. PIQ was assessed by the WISC-III for participants 11–16 years of age or, for those older than 16 years, the Wechsler Adult Intelligence Scale–Fourth Edition (WAIS-IV; Wechsler, 2008). The WISC-III subtests include Picture Completion, Coding, Picture Arrangement, Block Design, and Object Assembly. These tests measure nonlinguistic cognitive skills, such as problem solving, spatial perception, working memory, and visual-motor coordination. The composite PIQ standard score was used in data analysis.

SES. The family's SES was rated on the Hollingshead Four Factor Index of Social Class (Hollingshead, 1975). The Hollingshead scores were calculated based on the education levels and occupations of both parents or of the caretaker parent whenever data from the other parents were unavailable. Based on these scores, SES was classified into five categories ranging from 1 to 5, with the effect of the two lowest categories (SES 1 and SES 2) assessed in comparison to the highest or reference category (SES 5).

Procedures

Testing was carried out by master's-level SLPs in the language laboratory at Case Western Reserve University. To ensure cooperation and to accommodate families, participants were tested in a quiet room in their homes when necessary. Testing required 3½–4 hr. Tests were administered in counterbalanced order across participants. To avoid test fatigue, participants were given frequent breaks, and, if necessary, testing was performed over 2 days. Sessions were recorded using high-quality digital recorders with matching external microphones monitored in a quiet room at a 15-cm mouth-to-microphone distance. The NSW, MSW, and conversational speech sample were digitally recorded and transcribed phonetically according to procedures outlined by Shriberg and Kent (2003), and consensus transcription was performed by two independent transcribers with prior reliability training. Agreement between transcribers exceeded 85%.

Classification of Participants With SSD

As seen in Figure 1, participants were initially recruited at early childhood and assigned to one of three groups based on test results: No SSD in early childhood (no SSD-EC), SSD only, and SSD + LI. Participants were then reevaluated at adolescence and classified into the following four groups:

1. Low MSW group. Participants with a history of a SSD who scored ≤ −1.5 *SD* from the mean on the repetition of MSW but had no errors in conversational speech were in the low MSW group (n = 33).
2. Persistent SSD group. Participants with a history SSD who scored ≤ −1.5 *SD* from the mean on the repetition of MSW and demonstrated speech errors in conversation were in the persistent SSD group.

   Table 1 summarizes the types of speech errors of the persistent SSD group. The residual speech errors consisted mostly of distortion errors on later-acquired speech sounds known as the "late eight" (Shriberg, 1993). In addition, vowel errors—as well as differences in prosody, voice, and resonance—were noted.
3. Resolved SSD group. Individuals with histories of SSD who scored > −1.5 *SD* from the mean of the MSW task were in the resolved SSD group (n = 105). The conversational speech samples of the resolved SSD group were reviewed for speech errors. Seventeen participants (16%) demonstrated a dentalized or lateralized /s/ and/or /r/ distortion. These errors were infrequent, and often only one occurrence of the error was noted. Similar to Wren et al. (2012), we did not consider these persistent errors because they were rare, are considered common clinical distortion errors (Shriberg, 1993), and did not occur during the more challenging speech task of repetition of multisyllabic words.
4. No SSD-AD group. Siblings who did not have SSD at early childhood or the adolescent follow-up were in the no SSD-AD group.

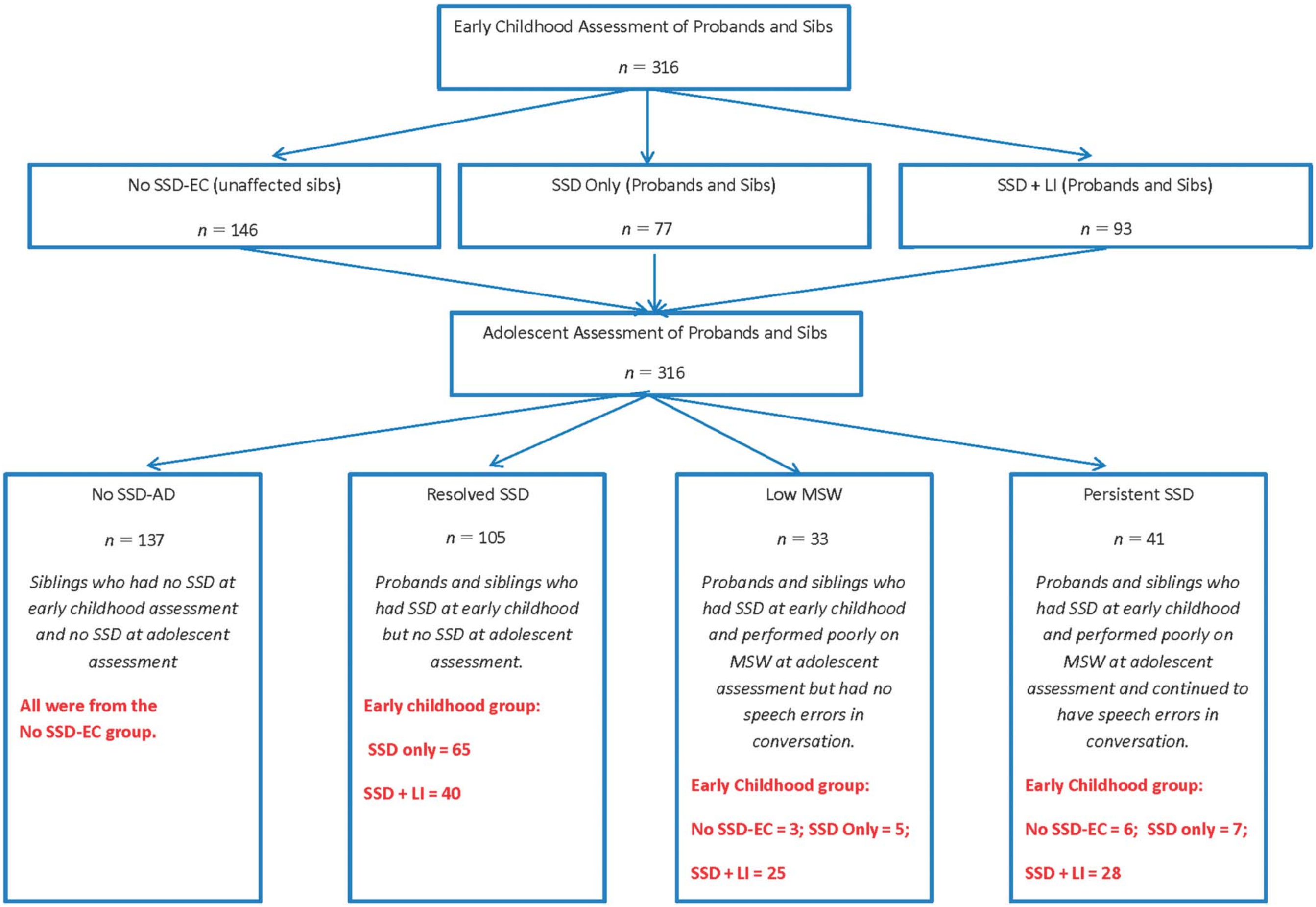
Participants were also coded for comorbid LI, defined as a score ≤ −1.5 *SD* from the mean of the CELF-3 (n = 57), and for low nonverbal intelligence, defined as a PIQ ≤ −1.5 *SD* below the mean of the WISC-III or WAIS-IV (n = 27).

Analyses

Analyses of variance (ANOVAs) were conducted to compare the adolescent groups based on the early childhood classifications of SSD only, SSD + LI, and no SSD-EC. Similar comparisons were made between four groups defined on the basis of adolescent status (no SSD-AD, resolved SSD, low MSW, and persistent SSD). To account for multiple testing, we conservatively corrected for 18 ANOVAs and set the alpha level at .0028 (i.e., α = .05/18). Significant group effects were followed by Tukey's post hoc comparisons to determine how the groups differed from one another. Chi-square analyses were also conducted to determine if parent-reported RD, persistent LI, and low PIQ in adolescence differed across the adolescent SSD groups.

Linear regressions were conducted to examine associations of adolescent predictor variables, including gender, SSD group, low PIQ, age, and SES1 and SES2, with language and literacy outcomes. The regressions were conducted in a forward stepwise fashion, first by identifying the most significant variables within univariate models and then adding variables one by one, starting with the most significant p values. At each iteration, the R^2 values were checked to ensure that the R^2 value improved. The persistent SSD variable described above was treated as a categorical ("dummy") variable, with "no SSD-AD" as the reference category; if the variable as a whole was significant in the model, it was retained even if individual categories were not

Figure 1. Participant groups at the early childhood assessment and adolescent follow-up assessment. Only participants with both early childhood data and adolescent data (AD) were included in the analyses. Sibs = siblings; EC = early childhood assessment; SSD = speech sound disorders; LI = language impairment; MSW = Multisyllabic Word Repetition task.



statistically significant. The final model included only significant variables ($p < .05$).

Results

Comparisons of Adolescents With No SSD-EC to Those With Early Childhood Histories of SSD Only or SSD + LI

Demographics for the early childhood groups of no SSD-EC, SSD only, and SSD + LI at adolescence are presented in Table 2. Both SSD groups had an approximate male:female ratio of 2:1, and the no SSD-EC group had only slightly more male participants than female participants. Although the groups did not differ in age, the SSD + LI group had significantly lower PIQ, $F(2, 264) = 27.71$, $p \leq .001$, and SES, $\chi^2(2, 315) = 17.94$, $p = .022$, than the no SSD-EC and SSD-only groups.

As shown in Table 3, the groups also differed on all descriptive and outcome measures: MSW, $F(2, 315) = 70.48$, $p < .001$; NSW, $F(2, 315) = 70.31$, $p < .001$; Fletcher Time-by-Count, $F(2, 305) = 0.073$, $p < .001$; EOWPVT-2, $F(2, 285) = 25.83$, $p < .001$; PPVT-4, $F(2, 293) = 40.41$, $p < .001$; WA, $F(2, 312) = 40.23$, $p < .001$; WI, $F(2, 213) = 49.29$, $p < .001$; TWS-3, $F(2, 309) = 55.05$, $p < .001$; RC, $F(2, 228) = 45.31$, $p < .001$; and CELF-3, $F(2, 249) = 71.32$, $p < .001$. The SSD + LI group had significantly lower scores on all measures than the no SSD-EC and SSD-only groups, and the SSD-only group performed more poorly than the no SSD-EC group on the MSW. Effect sizes were small, with η^2s ranging from .07 to .03.

Comparisons of Adolescents With No SSD-AD to Those With Resolved SSD, Low MSW, and Persistent SSD

Group comparisons on background factors are presented in Table 4. An ANOVA revealed a group difference on PIQ, $F(3, 264) = 11.94$, $p < .0001$. The low MSW group had lower PIQ than the no SSD-AD group, and the persistent SSD group had lower PIQ than both the no SSD-AD and resolved SSD groups. The low MSW group also had

Table 1. Number and percentage of individuals with persistent speech error types at adolescence.

	Participants			
	Male (n = 29)		Female (n = 12)	
Error type	n	%	n	%
Distortion errors				
/r/ derhotacized	22	76	8	67
/s/ lateralized	10	34	2	17
/z/ lateralized	1	3	0	0
/l/ velarized	6	21	0	0
Substitution errors				
/l/→/w/	9	31	0	0
/ər/ final→/ə/	21	72	8	67
/ʃ/→/s/	3	10	0	0
Phonological processes				
Cluster reduction	4	14	2	17
Vowel nasalization	6	21	2	17
Consonant deletion	9	31	11	92
Deaffrication	3	10	0	0
Depalatization	6	21	3	25
Stopping	6	21	3	25
Voicing errors	1	3	1	8
Abnormal voice, prosody, fluency				
Abnormal prosody	11	38	2	17
Abnormal resonance	7	24	3	25
Harsh voice	10	34	3	25
Dysfluency	9	31	2	17

lower SES than the no SSD-AD and resolved SSD groups, $\chi^2(3, 315) = 34.33$, $p = .0006$. There were no significant group differences in age.

To determine the stability of early childhood groups, early childhood classifications of no SSD-EC, SSD only, and SSD + LI were compared with adolescent classifications of no SSD-AD, resolved SSD, low MSW, and persistent SSD (see Table 5). Significant group differences were found for the adolescent SSD group classifications, $\chi^2(6, 315) = 337.3$, $p < .0001$. Three participants in the early childhood no SSD-EC group fell into the low MSW group, and four fell into the persistent SSD group at the adolescent testing. In the early childhood SSD-only group, 65 participants were classified as resolved SSD, five were classified as low MSW, and seven were classified as persistent SSD in adolescence. In the early childhood SSD + LI group, 40 participants were classified as resolved SSD, 25 were classified as low MSW, and 28 were classified as persistent SSD in adolescence. The effect size for adolescent SSD group membership was medium ($\eta^2 = .74$).

Adolescent group comparisons of the outcome measures are summarized in Table 6. Significant group differences were found for all of the measures: PPVT-4, $F(3, 278) = 17.86$, $p \leq .0001$; EOWPVT-2, $F(3, 270) = 13.62$, $p < .0001$; WA, $F(3, 295) = 42.08$, $p < .0001$; WI, $F(3, 296) = 38.01$, $p < .0001$; RC, $F(3, 217) = 19.03$, $p < .0001$; TWS-3, $F(3, 293) = 40.78$, $p < .001$; NSW, $F(3, 299) = 65.62$, $p < .0001$; Fletcher Time-by-Count, $F(3, 290) = 12.84$, $p < .0001$; and the CELF-3, $F(3, 328) = 32.92$, $p < .0001$. Scores on the PPVT, WA, RC, NSW, and CELF-3 were significantly lower for all three SSD groups than for the no SSD-AD group, although the resolved SSD group and no SSD-AD group were not significantly different on other measures. Scores on the EOWPVT, WI subtest of the WRMT-R, and TWS-3 were also significantly lower for the low MSW and persistent SSD groups than for the no SSD-AD group. Scores on all measures were significantly lower for the low MSW and persistent SSD groups than for the resolved SSD group. However, the low MSW group performed better than the persistent SSD group on the NSW, a measure of phonological memory, and on the Fletcher-Time-By-Count, a measure of oral motor skill. Effect sizes for adolescent outcome measures were small, with η^2s ranging from .13 to .40.

Comorbidity Rates in the No SSD-AD, Resolved, Low MSW, and Low MSW + Persistent SSD Groups

Comparisons of the adolescent groups on rates of comorbid LI, RD, and low PIQ are presented in Table 7. As discussed earlier, RD was determined by parent report, and LI and low PIQ were based on scores < −1.5 *SD* below the mean on standardized measures. Significant group differences were found for all comorbid conditions: LI ($\chi^2 = 58.39$, $p < .0001$), RD ($\chi^2 = 57.49$, $p < .0001$), and low

Table 2. Comparison of early childhood SSD groups on adolescent demographics of gender, age, PIQ, and SES.

	Adolescent demographic							
				SES[c] (%)				
Group	Male:female ratio[a]	Age in years *M (SD)*	PIQ[b,c] *M* (*SD*)	1	2	3	4	5
No SSD-EC (n = 146)	74:72	13.94 (2.07)	109.28 (12.42)	2%	10%	17%	33%	38%
SSD only (n = 77)	50:27	13.86 (1.92)	109.75 (14.18)	0%	7%	13.5%	39%	40.5%
SSD + LI (n = 93)	67:26	13.77 (1.93)	95.68 (15.11)	9%	7%	24%	35%	25%
Total (N = 316)	191:125	13.87 (1.98)	105.45 (15.00)	4%	8%	18%	35%	35%

Note. SSD = speech sound disorders; PIQ = Performance IQ scores from the Wechsler Intelligence Scale for Children–Third Edition (WISC-III) or Wechsler Adult Intelligence Scale–Fourth Edition (WAIS-IV); SES = Ratings on the Hollingshead Four Factor Index of Social Class (1 = *low SES*, 5 = *high SES*); LI = language impairment. For male:female ratio, $\chi^2(2, 315) = 11.70$, $p = .003$. For age in years, $\eta^2 = .001$, $F(2, 315) = 0.20$, $p = .818$. For PIQ, $\eta^2 = .175$, $F(2, 264) = 27.71$, $p < .001$. For SES, $\eta^2 = .035$, $\chi^2(8, 309) = 17.95$, $p = .022$.

[a]No SSD-EC differs from SSD only. [b]No SSD-EC differs from SSD + LI. [c]SSD differs from SSD + LI only.

Table 3. Comparisons of early childhood SSD groups on adolescent descriptive and adolescent outcome measures.

	No SSD-EC			SSD only			SSD + LI					
Measures	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range	*F (df)*	η^2	*p*
Adolescent descriptive measures												
MSW[a,b,c]	90.99	10.20	60 to 100	84.94	18.77	20 to 100	63.51	26.39	0 to 100	70.48 (2, 315)	.310	< .001
NSW[b,c]	77.30	16.07	26 to 100	72.01	17.88	26 to 100	47.94	24.08	6 to 100	70.32 (2, 315)	.310	< .001
Fletcher Time-by-Count[b,c]	–0.37	0.81	–1.93 to 2.51	–0.25	0.76	–0.92 to 3.11	0.20	1.04	–0.76 to 4.25	11.89 (2, 305)	.073	< .001
Adolescent outcome measures												
EOWPVT-2[b,c]	107.48	13.57	73 to 145	107.93	13.07	85 to 145	94.90	16.83	55 to 135	25.83 (2, 285)	.154	< .001
PPVT-4[b,c]	113.36	13.35	85 to 146	112.14	13.47	88 to 159	97.14	14.46	78 to 138	40.41 (2, 293)	.217	< .001
WA[b,c]	104.86	12.03	54 to 135	102.29	9.52	78 to 136	89.53	16.96	44 to 114	40.23 (2, 312)	.206	< .001
WI[b,c]	103.92	13.76	69 to 127	103.19	9.81	82 to 128	86.22	17.38	45 to 117	49.29 (2, 313)	.241	< .001
TWS-3[b,c]	107.51	12.86	80 to 141	106.96	13.03	77 to 141	88.59	17.84	60 to 119	55.05 (2, 309)	.264	< .001
RC[b,c]	109.23	12.72	71 to 137	105.55	13.86	80 to 129	88.70	15.27	64 to 118	45.31 (2, 228)	.286	< .001
CELF-3[b,c]	106.30	12.15	85 to 140	106.33	12.54	77 to 137	82.07	18.72	50 to 123	71.32 (2, 249)	.366	< .001

Note. SSD = speech sound disorders; LI = language impairment; MSW = Multisyllabic Word Repetition task; NSW = Nonsense Word Repetition task; EOWPVT-2 = Expressive One Word Picture Vocabulary Test–Second Edition; PPVT-4 = Peabody Picture Vocabulary Test–Fourth Edition; WA = Word Attack subtest of the Woodcock Reading Mastery Tests–Revised (WRMT-R); WI = Word Identification subtest of the WRMT-R; TWS-3 = Test of Written Spelling–Third Edition; RC = Reading Comprehension subtest of the Wechsler Individual Achievement Test (WIAT); CELF-3 = Clinical Evaluation of Language Fundamentals–Third Edition.

[a]No SSD-EC differs from SSD only. [b]No SSD-EC differs from SSD + LI. [c]SSD only differs from SSD + LI.

Table 4. Comparison of adolescent SSD groups on demographics (gender, age, PIQ, and SES).

	Adolescent demographic							
				SES[b,d] (%)				
Group	Male:female ratio[a]	Age in years *M (SD)*	PIQ[b,c,e] *M* (*SD*)	1	2	3	4	5
No SSD-AD (*n* = 137)	68:69	13.96 (2.09)	110.00 (12.10)	2	10	17	33	38
Resolved SSD (*n* = 105)	72:33	14.02 (1.93)	105.48 (15.33)	2	7	14	42	35
Low MSW (*n* = 33)	22:11	13.53 (1.93)	99.69 (15.00)	19	3	26	23	29
Persistent SSD (*n* = 41)	29:12	13.43 (1.77)	94.80 (16.48)	0	7.5	27.5	35	30
Total (*N* = 316)	191:125	13.87 (1.99)	105.08 (15.75)	4	8	18	35	35

Note. SSD = speech sound disorders; PIQ = Performance IQ scores from the WISC-III or WAIS-IV; SES = Ratings on the Hollingshead Four Factor Index of Social Class (1 = *low SES,* 5 = *high SES*); MSW = Multisyllabic Word Repetition task. For male:female ratio, $\chi^2(3, 315) = 11.94$, p = .0074. For age in years, $\eta^2 = .013$, $F(3, 315) = 1.32$, $p = .2688$. For PIQ, $\eta^2 = .121$, $F(3, 264) = 11.94$, $p < .0001$. For SES, $\eta^2 = .024$, $\chi^2(8, 309) = 34.33$, $p = .0006$.

[a]No SSD-AD group differs from resolved group. [b]No SSD-AD group differs from low MSW group. [c]No SSD-AD group differs from persistent SSD group. [d]Resolved SSD group differs from low MSW group. [e]Resolved SSD group differs from persistent SSD group.

Table 5. Comparison between adolescent SSD groups and early childhood SSD groups.

	Adolescent SSD group			
Early childhood SSD group[a,b,c,d]	No SSD-AD	Resolved SSD	Low MSW	Persistent SSD
No SSD-EC	137	0	3	6
SSD only	0	65	5	7
SSD + LI	0	40	25	28

Note. For the no-SSD-EC group, $\eta^2 = .738$, $\chi^2(6, 315) = 337.3$, p < .0001. SSD = speech sound disorder; MSW = Multisyllabic Word Repetition task; LI = language impairment.

[a]No SSD-AD group differs from resolved group. [b]No SSD-AD group differs from low MSW group. [c]No SSD-AD group differs from persistent SSD group. [d]Resolved SSD group differs from low MSW group.

Table 6. Comparisons of adolescent SSD groups on adolescent outcome measures.

Measure	No SSD-AD *M (SD)*	Resolved SSD *M (SD)*	Low MSW *M (SD)*	Persistent SSD *M (SD)*	η^2	*F(df)*	*p*
	Adolescent SSD group						
PPVT[a,b,c,d,e]	113.61 (13.42)	108.24 (13.57)	98.69 (11.936)	97.03 (19.19)	0.163	17.86 (3, 278)	< .0001
EOWPVT[b,c,d,e]	108.11 (13.54)	104.67 (12.90)	97.39 (18.33)	93.11 (18.10)	0.133	13.62 (3, 270)	< .0001
WA[a,b,c,d,e]	105.66 (11.81)	100.93 (9.05)	84.03 (19.05)	86.72 (14.47)	0.302	42.08 (3, 295)	< .0001
WI[b,c,d,e]	104.60 (13.84)	100.90 (10.17)	81.78 (20.86)	84.77 (13.78)	0.280	38.01 (3, 296)	< .0001
RC[a,b,c,d,e]	109.36 (12.92)	101.51 (14.44)	90.16 (16.07)	90.42 (17.61)	0.211	19.03 (3, 217)	< .0001
TWS-3[b,c,d,e]	108.50 (12.56)	104.17 (14.23)	85.91 (17.48)	85.24 (16.67)	0.297	40.78 (3, 293)	< .0001
NSW[a,b,c,d,e,f]	77.96 (16.27)	71.10 (16.78)	49.36 (19.81)	36.90 (22.63)	0.399	65.62 (3, 299)	< .0001
Fletcher[c,e,f]	−0.36 (0.82)	−0.26 (0.69)	0.04 (0.91)	0.60 (1.21)	0.118	12.84 (3, 290)	< .0001
CELF-3[a,b,c,d,e]	107.14 (11.82)	99.85 (15.55)	82.74 (19.96)	82.57 (19.18)	0.296	32.92 (3, 238)	< .0001

Note. SSD = speech sound disorder; MSW = Multisyllabic Word Repetition task; PPVT = Peabody Picture Vocabulary Test; EOWPVT = Expressive One Word Picture Vocabulary Test; WA = Word Attack subtest of the Woodcock Reading Mastery Tests–Revised (WRMT-R); WI = Word Identification subtest of the WRMT-R; RC = Reading Comprehension subtest of the Wechsler Individual Achievement Test (WIAT); TWS-3 = Test of Written Spelling–Third Edition; NSW = Nonsense Word Repetition; Fletcher = Fletcher Time-by-Count; CELF-3 = Clinical Evaluation of Language Fundamentals–Third Edition.

[a]No SSD-AD group differs from resolved SSD group. [b]No SSD-AD group differs from low MSW group. [c]No SSD-AD group differs from persistent SSD group. [d]Resolved SSD group differs from low MSW group. [e]Resolved SSD group differs from persistent SSD group. [f]Low MSW group differs from persistent SSD group.

PIQ (χ^2 = 16.14, p = .001). All SSD groups had significantly higher rates of RD and LI than the no SSD-AD group. The low MSW and persistent SSD groups also had higher rates of low PIQ than the no SSD-AD group, and the low MSW and persistent SSD groups had higher rates of RD and LI than the resolved SSD group.

Associations of Speech and Language Outcomes With Literacy Outcomes

As summarized in Table 8, several factors were significantly and independently associated with adolescent language and literacy outcomes. Deficits in phonological processing alone (low MSW group) or the combination of these deficits with persisting speech problems (persistent SSD group) predicted lower scores on all of these measures. Low PIQ was also associated with lower scores on all tests. Low SES was associated with lower scores on tests of expressive and receptive vocabulary, word identification, spelling, and language. Finally, male participants had lower expressive vocabulary scores than female participants. In combination these factors accounted for 27%–43% of the variance in scores.

Discussion

This study examined adolescent outcomes of a large cohort of individuals with early childhood SSD who were followed to adolescence and assessed on a battery of speech, language, and literacy measures. Outcomes were considered based on (a) early childhood classifications of SSD only and SSD + LI and (b) adolescent classifications of resolved SSD, difficulty with multisyllabic word repetitions, and persistent SSD. Significant differences were found based on both early childhood SSD groups and adolescent SSD groups. In conclusion, the contribution of other factors, such as SES, gender, and nonverbal IQ, to adolescent outcomes were evaluated. Below, we discuss adolescent

Table 7. Distribution of comorbidities among adolescents with no SSD, resolved SSD, low MSW, and persistent SSD.

Comorbidity	No SSD-AD *n*	No SSD-AD %	Resolved SSD *n*	Resolved SSD %	Low MSW *n*	Low MSW %	Persistent SSD *n*	Persistent SSD %	Total *n*	Total %	χ^2	*p*
	Group											
RD[a,b,c,d,e]	17	12.41	31	29.52	22	66.67	24	58.54	94	29.75	57.49	< .0001
Persistent language impairment[a,b,c,d,e]	5	4.31	21	26.58	15	55.56	16	57.14	57	22.80	58.39	< .0001
Low PIQ[b,c]	3	2.61	11	12.36	5	19.23	8	22.86	27	21.51	16.14	.0011

Note. RD = reading disability; SSD = speech sound disorders; MSW = Multisyllabic Word Repetition task; PIQ = Performance IQ scores from the Wechsler Intelligence Scale for Children–Third Edition (WISC-III) or Wechsler Adult Intelligence Scale–Fourth Edition (WAIS-IV).

[a]No SSD-AD group differs from resolved group. [b]No SSD-AD group differs from low MSW group. [c]No SSD-AD group differs from persistent SSD group. [d]Resolved SSD group differs from low MSW group. [e]Resolved SSD group differs from persistent SSD group.

Table 8. Stepwise multiple regression analyses predicting adolescent vocabulary, reading, spelling, and language outcomes from persistent SSD, PIQ, SES, and gender.

Measure	Predictor	β	*B* (*SE*)	*F(df)*	Overall R^2	Overall *p*
PPVT-4	Intercept	−.691	0.23	10.45 (8, 235)	.269	< .0001
	SSD group					
	Low MSW	−.863***	0.212			
	Resolved SSD	−.349**	0.14			
	Persistent SSD	−.733***	0.192			
	No SSD-AD	REF				
	Low PIQ	−.976***	0.198			
	Low SES 1	−.988**	0.321			
	Low SES 2	−.417*	0.235			
EOWPVT-2	Intercept	−1.095	0.246	8.42 (9, 226)	.259	< .0001
	SSD group					
	Low MSW	−.695**	0.226			
	Resolved SSD	−.255*	0.148			
	Persistent SSD	−.7685***	0.199			
	No SSD-AD	REF				
	Low PIQ	−.995***	0.201			
	Low SES 1	−.691**	0.328			
	Male gender	.464***	0.131			
WA	Intercept	−.879	0.194	34.05 (4, 263)	.345	< .0001
	SSD group					
	Low MSW	−1.315***	0.19			
	Resolved SSD	*ns*	0.123			
	Persistent SSD	−1.078***	0.17			
	No SSD-AD	REF				
	Low PIQ	−1.017***	0.181			
WI	Intercept	−.976	0.233	16.13 (8, 246)	.352	< .0001
	SSD group					
	Low MSW	−1.3565***	0.226			
	Resolved SSD	*ns*	0.141			
	Persistent SSD	−1.069***	0.193			
	No SSD-AD	REF				
	Low PIQ	−1.097***	0.201			
	Low SES 1	−.631*	0.33			
TWS-3	Intercept	−.883	0.228	17.65 (8, 244)	.374	< .0001
	SSD group					
	Low MSW	−1.157***	0.221			
	Resolved SSD	*ns*	0.138			
	Persistent SSD	−1.193***	0.194			
	No SSD-AD	REF				
	Low PIQ	1.163***	0.197			
	Low SES 1	−.790**	0.323			
	Low SES 2	−.478**	0.227			
RC	Intercept	−.917	0.241	19.66 (4, 190)	.297	< .0001
	SSD group					
	Low MSW	−1.074***	0.25			
	Resolved SSD	−0.491**	0.165			
	Persistent SSD	−0.963***	0.239			
	No SSD-AD	REF				
	Low PIQ	−1.207***	0.225			
CELF-3	Intercept	−.945	0.246	17.41 (8, 192)	.431	< .0001
	SSD group					
	Low MSW	−1.282***	0.242			
	Resolved SSD	−.447**	0.153			
	Persistent SSD	−1.138***	0.216			
	No SSD-AD	REF				
	Low PIQ	−1.325***	0.21			
	Low SES 1	−1.036**	0.355			

Note. SSD = speech sound disorders; PIQ = Performance IQ scores from the Wechsler Intelligence Scale for Children–Third Edition (WISC-III) or Wechsler Adult Intelligence Scale–Fourth Edition (WAIS-IV); SES = Ratings on the Hollingshead Four Factor Index of Social Class (1 = *low SES,* 5 = *high SES*); MSW = Multisyllabic Word Repetition task; Low SES 1 = Hollingshead rating of 1; Low SES 2 = Hollingshead rating of 2; PPVT-4 = Peabody Picture Vocabulary Test–Fourth Edition; REF = reference group; EOWPVT-2 = Expressive One Word Picture Vocabulary Test–Second Edition; WA = Word Attack subtest of the Woodcock Reading Mastery Tests–Revised (WRMT-R); *ns* = not significant; WI = Word Identification subtest of the WRMT-R; TWS-3 = Test of Written Spelling–Third Edition; RC = Reading Comprehension subtest of the Wechsler Individual Achievement Test (WIAT); CELF-3 = Clinical Evaluation of Language Fundamentals–Third Edition.

$^{*}p < .10$. $^{**}p < .05$. $^{***}p < .001$.

outcomes in relation to early childhood groups and concurrent adolescent classifications.

Comparisons of Adolescents With Histories of SSD Only, SSD + LI, and No SSD-EC

Adolescents with early childhood histories of SSD + LI continued to have more severe deficits than individuals with histories of SSD only or no SSD-EC on all language and literacy measures. Our studies (Skebo, Lewis, Freebairn, Avrich, & Stein, 2013; Lewis et al., 2000a) and those of others (Nathan et al., 2004; Raitano, Pennington, Tunick, Boada, & Shriberg, 2004) have consistently found that children with SSD + LI are at greatest risk for school-age reading difficulties. However, the mean scores of the SSD + LI group were in the low–average range, suggesting that not all individuals with early SSD + LI have persistent difficulties at adolescence (see Table 3 for ranges of scores). Language skills of the SSD + LI group improved by adolescence, but they did not catch up to those of typical peers.

Adolescents with early histories of SSD only continued to show a weakness in production of multisyllabic words compared to the children without histories of SSD. This finding is in agreement with our previous study on parents of children with SSD, in which we reported that parents with a history of SSD had more difficulty producing multisyllabic words than did parents without a history of SSD (Lewis et al., 2007). Residual effects of an early SSD may be due to (a) poor oral motor skills impacting articulation, especially given coarticulation effects in the production of multisyllablic words; (b) difficulty with encoding processes affecting the sequencing of syllables; (c) weak phonological representations and associated slowness in speed of speech sound processing; and/or (d) poor vocabulary with attendant reduction in exposure to multisyllabic words. Further studies are needed to determine which of these mechanisms underlie poor performance of adolescents with histories of SSD on the MSW and which combinations of these deficits contribute to poor outcomes.

Comparisons of Adolescents With No SSD, Resolved SSD, Low MSW, and Persistent SSD

Adolescents in the no SSD-AD group (siblings of our early SSD group who never had speech or language difficulties) performed better than those in the resolved SSD group (probands with a history of SSD but without current difficulty repeating MSW) on an overall language measure and on tests of receptive vocabulary, reading comprehension, and reading decoding, but they did not differ in PIQ. The differences between the no SSD-AD and resolved SSD groups may be related to overall language skills rather than being specific to articulatory skills. This possibility is supported by the early childhood history of LI in 40 participants of the resolved SSD group (see Table 5) and by LI at adolescence in 21 participants of this group (see Table 7). Difficulty in reading and producing nonwords may also indicate a residual weakness in phonological memory (Preston & Edwards, 2007).

Both the no SSD-AD and the resolved SSD groups performed better than the low MSW and persistent SSD groups on all measures, including overall language, nonword repetition, vocabulary, oral motor skill, and reading and spelling. These results are in agreement with previous research which found that individuals whose SSD resolves have better outcomes than those whose SSD persists past early school age. Results from the regression analyses demonstrated that persistent SSD impacts language, vocabulary, reading, and spelling skills at adolescence. Differences on the nonword repetition task (NWR) suggest that both groups who performed poorly on the NSW repetition (low MSW and persistent SSD groups) had residual weaknesses in phonological memory.

The persistent SSD group scored more poorly than the low MSW group on the NWR, a measure of phonological memory, and on the Fletcher Time-By-Count, an oral motor skills measure. However, the two groups did not differ on measures of language, vocabulary, reading, or spelling. One possibility is that residual effects of early childhood SSD are a continuum of severity, with some individuals presenting difficulties only on challenging tasks, such as the MSW, and others presenting with errors also on less challenging speech production, as in conversational speech. Another explanation is that individuals in the persistent SSD group had both phonologically based errors and articulatory errors. The persistent SSD group had residual speech errors in conversation that were primarily distortion errors. Distortion errors and poor performance on the Fletcher Time-by-Count suggest a motor-based articulatory deficit in addition to the phonological processing deficits implied by poor performance on the MSW.

Most studies of persistent SSD and SSD only examine individuals with overt speech sound errors. These findings indicate that persistent SSD should be broadened to include individuals with errors on difficult-to-articulate multisyllabic words. The findings also speak to the heterogeneity of persistent SSD, with some individuals presenting with overt speech errors and others having difficulties that manifest only on challenging speech tasks designed to elicit errors.

Rates of Comorbidities: Comparisons of the No SSD-AD, Resolved, Low MSW, and Persistent SSD Groups

Individuals with persistent SSD and/or difficulty with the repetition of MSW had higher rates of RD and LI than the no SSD-AD and resolved SSD groups. In addition, the low MSW and persistent SSD groups were more likely to have low PIQs than the no SSD-AD group. These comorbid conditions in combination with residual speech deficits may contribute to the poorer adolescent outcomes observed for the low MSW and persistent SSD groups. In their review of the literature on the overlap of SSD, RD, and LI, Pennington and Bishop (2009) point to diagnostic, cognitive, and etiological overlap among these disorders. These researchers also emphasize the complex and interactive relationships between these disorders. Our findings support the cognitive overlap of these disorders and point to other factors, such as low PIQ and social disadvantage, as additional contributors to poor adolescent language and literacy outcomes.

Associations of Speech and Language Outcomes With Literacy Outcomes

Adolescents in the persistent SSD group, who had difficulty repeating multisyllabic words and made overt speech errors in conversation, had poorer outcomes than the other groups on tests of vocabulary, reading decoding, and spelling. LI was also associated with poor outcomes on vocabulary and reading comprehension and weaknesses in nonverbal cognitive ability and lower SES with lower scores on measures of language and literacy, although male gender was related only to poorer expressive vocabulary. These findings extend previous school-age follow-up studies of children with early SSD + LI by documenting continued language and literacy problems in adolescence and demonstrating the importance of considering cognitive factors and SES in prediction of long-term outcomes (Lewis et al., 2000b, 2000c).

Limitations of the Study

A potential limitation of this work is that unaffected siblings were utilized as the "control" population. An advantage of having siblings serve as controls is that they share a common environment with the probands and thus control for environmental variables, such as maternal education and SES. However, siblings of children with SSD also share some genes and may be more prone to subclinical weaknesses in phonological processing and motor speech than unrelated controls; thus, the use of siblings as controls may have made it more difficult to detect differences between the SSD groups and the no SSD group and resulted in a more conservative approach to hypothesis testing. We also failed to track the participants' developmental trajectory across multiple ages and thus could not identify the ages at which speech sounds were mastered. Examining the trajectory of speech sound errors may provide insight as to why some errors persist and others resolve. As some individuals in the early childhood no SSD group presented with an SSD in adolescence, our early childhood assessments also failed to identify cases of later emerging phonological processing deficits. A further limitation is that articulation errors were not distinguished from phonological errors in early childhood. Some speech errors may be motor based, and other errors may be indicative of weak phonological representations. Finally, we were unable to control for the effects of speech and language therapy on residual speech sound problems and other outcomes and thus could not evaluate the potential effects of therapy on the extent of residual speech sound, language, or literacy deficits.

Summary and Clinical Implications

Early childhood SSD portend difficulties in language and literacy skills that persist to adolescence. SSD are also heterogeneous with those disorders that resolve before adolescence associated with better language and literacy outcomes. However, individuals without overt speech sound errors in conversation may continue to have weakness in speech sound production as observed in their performance on difficult-to-articulate words, such as multisyllabic words. The present findings indicate that difficulties on tasks such as MSW, reflecting weaknesses in underlying phonological representations, are associated with poorer language and literacy outcomes. In fact, residual phonological processing weaknesses appear to pose as high a risk for language and literacy problems as overt speech errors. In contrast, overt speech errors may be related to motor production rather than phonological processing and may have relatively little impact on language and literacy outcomes. Comorbid LI, RD, and SSD may place students at heightened risk for poor long-term outcomes in educational attainment and other areas of adult functioning. Other factors such as nonverbal cognitive abilities, SES, and gender also deserve consideration in predicting the longer-term consequences of early childhood SSD. Identification of adolescents with these comorbidities and risk factors may be critical in targeting school-age interventions to the students most in need of them.

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