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ACADEMIC OUTCOMES IN CHILDREN WITH HISTORIES OF SPEECH SOUND DISORDERS

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Tests of phonology, semantics, and syntax were administered to 52 preschool children (19 girls and 33 boys, age 4–6 years) with moderate to severe speech sound disorders. The children's performance on these tests was used to predict language, reading, and spelling abilities at school age (age 8–11 years). Language impairment at school age was related to poor performance on preschool tests of syntax and nonsense word repetition, while reading impairment was predicted by poor performance in all preschool test domains (phonology, semantics, and syntax). In contrast, spelling impairment was predicted by deficits in preschool tests of phonological processing as measured by the Word Discrimination subtest of the Test of Language Development - Primary 2. Family history for speech and language disorders did not predict language, reading, or spelling impairment at school age. However, family history for reading disorders was a good predictor of school-age spelling difficulties.

Educational Objectives: (1) To examine school-age outcomes of children with early speech sound disorders; (2) to identify early language predictors (syntax, semantics, phonology) of later reading, spelling, and language impairments; and (3) to explore family history for speech/language and reading disorders as a risk factor for later academic difficulties.

KEY WORDS: Phonology; Spelling; Reading; Genetic; Family history; School-age outcomes

INTRODUCTION

Research has demonstrated that children with preschool speech and language disorders are at risk for school-age academic difficulties. Follow-up studies show that 40–100% of children with preschool speech and language disorders have persistent language problems, and 50–100% have academic difficulties (Aram & Hall, 1989; Bishop & Adams, 1990; Felsenfeld, McGue, & Broen,

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1995; King, Jones, & Lasky, 1982; Menyuk, Chesnick, Liebergott, Korngold, D'Agostino, & Belanger, 1991; Shriberg & Kwiatkowski, 1988). In a longitudinal study by Stothard, Snowling, Bishop, Chipchase, and Kaplan (1998), even children whose language had normalized by 5 ½ years of age continued to have difficulty on phonological processing and literacy measures in adolescence. Similarly, Felsenfeld et al. (1995) found that adults with histories of disorders performed more poorly than control subjects on measures of articulation and receptive and expressive language.

Several studies have sought to identify preschool predictors of later language, reading, and spelling skills. Preschool language status has been consistently identified as a predictor of later academic outcomes (Bishop & Adams, 1990; Hall & Tomblin, 1978; Levi, Capozzi, Fabrizi, & Sechi, 1982). In general, preschool children with isolated phonology disorders tend to have better outcomes than do children whose phonology disorders are accompanied by additional language problems (Hall & Tomblin, 1978). Children with isolated phonology disorders, for example, are less likely than children with combined phonology and language disorders to have later reading and writing difficulties (Aram & Hall, 1989; Larrivee & Catts, 1999; Lewis, O'Donnell, Freebairn, & Taylor, 1998). A recent study by Larrivee and Catts (1999) examined the early reading achievement of 30 children with expressive phonological disorders. Children with poor reading outcomes demonstrated more severe expressive phonological disorders, poorer phonological awareness skills, and poorer language skills. The latter finding suggests that the language impairment, rather than the speech sound disorders per se, may be primarily responsible for later emerging academic deficits.

However, not all children with preschool speech and language disorders go on to have problems at school age. Conversely, not all school-age children with reading and spelling difficulties have histories of preschool speech and language problems. Several researchers have attempted to identify specific skills at preschool that predict later problems. These include linguistic awareness (Magnusson & Naucler, 1990a; 1990b; Menyuk, et al., 1991), phonological awareness (Clark-Klein, 1994; Catts, 1993; Webster & Plante, 1992), verbal working memory (Webster, Plante, & Couvillion, 1997), and syntactic abilities (Bishop & Adams, 1990). Global language abilities at preschool are thought to be associated with later reading comprehension, while phoneme awareness is considered a predictor of later reading decoding skills (Catts, 1993).

The association of preschool speech and language disorders with later spelling impairments has not been as extensively studied as have relationships between these disorders and reading problems. However, research has suggested that children with phonological disorders at preschool may be at risk for later spelling difficulties due to poor phonological awareness skills and a weakness in phonological coding in verbal memory (Clark-Klein, 1994; Webster, Plante, & Couvillion, 1997).

Family histories of speech/language and reading disorders have also been examined as predictors of school-age outcomes. Scarborough (1990) found that familial risk for reading disorders accounted for significant proportions of the total variance (19–36%) in reading scores of 66 second-grade children. Studies showing familial aggregation of speech and language disorders offer further support for the possibility of using family history to predict later outcomes of preschool speech and language disorders. Numerous studies, for example, have documented familial aggregation of speech and language disorders (Byrne, Willerman, & Ashmore, 1974; Lahey & Edwards, 1995; Lewis, 1992; Luchsinger, 1970; Neils & Aram, 1986; Tallal, Ross, & Curtiss, 1989; Tomblin, 1989). Family studies of children with speech and language disorders have reported a history of these same disorders in 22.9% to 41.5% of nuclear family members. To our knowledge, however, no study to date has attempted to employ family history of speech and language disorders as a prospective risk factor for school-age academic difficulties.

The goal of this study was to identify preschool predictors of school-age language, reading, and spelling skills in preschool children with identified speech sound disorders. Research questions addressed by this study were:

1. What specific preschool speech/language skills (e.g., phonology, semantics, and syntax) predict language, reading, and spelling abilities and deficiencies at school age?
2. Does family history for speech/language or reading problems predict school-age language, reading, and spelling abilities and deficiencies?

METHOD

Participants

Children were recruited from the clinical caseloads of speech/language pathologists working at community speech and hearing centers or in private practice in the greater Cleveland area. Speech/language pathologists were asked to identify children, ages 4–6 years, enrolled in therapy for a moderate to severe expressive phonology disorder. The therapists discussed the study with the parents, and the parents were asked to return postcards if they were interested in the study. Approximately 100 parents returned postcards and 87 families were subsequently recruited.

At preschool, participants were required to meet the following inclusion criteria: (1) enrolled in speech/language therapy for a moderate to severe speech sound disorder as defined by a score of 1 SD below the mean on a standard test of articulation prior to enrollment into speech/language therapy and based on the therapists' reports; (2) normal hearing acuity as defined by passing a pure tone audiometric screening test at 25 dBHL ISO for 500, 1000, 2000, and 4000 Hz bilaterally and fewer than six reported episodes of otitis

media prior to age three as reported by the parent; (3) normal peripheral speech mechanism documented by the Oral Speech and Motor Control Protocol (Robbins & Klee, 1987) or the Test of Oral Structures and Functions (TOSF) (Vitali, 1986); (4) absence of a history of neurological disorders or developmental delays other than speech and language as reported by the parent; and (5) normal intelligence defined as a Performance IQ of 80 or above on the Wechsler Preschool and Primary Scale of Intelligence—Revised (WPPSI-R) (Wechsler, 1989).

Fifty-two of the 87 children (60%) (19 girls and 33 boys) were followed at school age ($M = 9.34$ yrs; $SD = 1.39$ yrs). The mean performance IQ was 108.8 ($SD = 15.3$). No significant differences were found between children followed and children not followed on measures of SES as measured by the Hollingshead Four Factor Index of Social Class (Hollingshead, 1975) ($\chi^2 = 4.5$; $p = .34$), gender ($\chi^2 = .69$; $p = .41$), or age at preschool testing ($t = .36$; $p = .72$). Children followed were also compared to those not followed in terms of their preschool scores on the Goldman-Fristoe Test of Articulation (GFTA) (Goldman & Fristoe, 1986) to determine if the two groups differed in the severity of their preschool phonology disorders. No significant differences were found between the groups ($t = 1.73$; $p = .087$). Table 1 summarizes sample characteristics.

Preschool Assessments

Phonological processing skills assessed included: phoneme discrimination, phonological encoding, and phonological production. The Word Discrimination Subtest of the Test of Language Development - Primary:2 (TOLD-P:2)

Table 1. Characteristics of Participants at School Age

	Male ($n = 33$)	Female ($n = 19$)	Total ($n = 52$)
Age: M (SD)	9.2 (1.3)	9.5 (1.6)	9.3 (1.4)
SES			
1	2	1	3
2	4	3	7
3	5	5	10
4	12	5	17
5	10	5	15
Speech therapy	15	3	18
Language disorder	16	8	24
Reading disorder	10	5	15
Spelling disorder	17	8	25

Note: SES = socioeconomic status, as measured by the Hollingshead Four Factor Index of Social Class (1975). The levels 1–5 represent categories of SES status from 1 = low to 5 = high.

(Newcomer & Hamill, 1988) was employed to assess the child's ability to distinguish words that differ by only one phoneme in the initial, medial, or final position in words. Pairs of words are presented orally to the child. The child must indicate if the words are the same or different.

The Nonsense Word Repetition Test (Kamhi & Catts, 1986) was included as a measure of phonological encoding. Nonsense words were chosen because they eliminate lexical influences that facilitate speech production. Fifteen nonsense words, such as "spethastope" [spɛəstop] and "batharis" [bəθarIs], were presented via audiotape. Children were asked to repeat the words after hearing them on the recording. Responses were tape recorded and transcribed on-line. The transcriptions were reviewed at a later time for scoring accuracy. Z-scores ($M = 0$; $SD = 1$) on this measure were computed by adjusting raw scores for age and gender using a regression formula derived from the performance of siblings of preschoolers who were not identified as having speech/language disorders.

Phonological production was measured by the Khan-Lewis Phonological Analysis (KLPA) (Khan & Lewis, 1986), based on children's responses on the Goldman-Fristoe Test of Articulation - Sounds in Words Subtest (GFTA) (Goldman & Fristoe, 1986). The KLPA provides an age-adjusted percentile score.

Responses were transcribed on-line as well as audiotape recorded for later review. Ten percent of the samples were transcribed by a second speech/language pathologist to insure reliability of the transcription. The transcribers were in agreement over 95% of the time. When there was a disagreement, the transcribers reviewed the tape until consensus was achieved. Semantics was assessed by the Picture Vocabulary and Oral Vocabulary subtests of TOLD-P:2. A Semantic Quotient was obtained from these two subtests. Syntax was assessed by the Grammatical Understanding, Sentence Imitation, and Grammatical Completion Subtests of the TOLD-P:2. A Syntax Quotient was calculated based on these subtests.

Children were coded as having a preschool disorder of phonology, semantics, or syntax if they obtained a score greater than one standard deviation below the mean on the above measures.

School-Age Assessments

Participants were examined at school age on a test battery assessing articulation, language, reading decoding, reading comprehension, and spelling skills. The Clinical Evaluation of Language Fundamentals—Revised (CELF-R) (Semel, Wiig, & Secord, 1987) provided measures of receptive and expressive language skills. The GFTA was also readministered to determine the presence of residual articulation problems.

The Word Attack and Word Identification subtests of the Woodcock Reading Mastery Tests (WRMT-R) (Woodcock, 1987) were administered as mea-

sures of reading decoding. The Word Attack subtest requires the child to pronounce nonsense words aloud, while the Word Identification subtest requires the reading aloud of real words. The Reading Comprehension subtest of the Wechsler Individual Achievement Test (WIAT) (Wechsler, 1989) was administered to assess comprehension of written text. The Reading Comprehension subtest requires the examinee to read passages of gradually increasing length and difficulty and to answer questions about the passages. Accurate performance requires recognition of details and sequences of events, understanding of cause and effect relationships, and the ability to make predictions or conclusions and to compare and contrast information in the passages. Standard scores were used in data analysis.

The Test of Written Spelling-Third Edition (TWS-3) (Larsen & Hammill, 1994) was selected as a measure of written spelling. The TWS-3 contains both predictable and unpredictable words. Predictable words are those that are spelled as they sound, whereas Unpredictable Words are exceptions to more regular spelling to sound correspondences.

Children were classified as language impaired ($n = 24$) if they met the criteria established by Tomblin, Records, Buckwalter, Zhang, Smith, and O'Brien (1997) for language impairment, including a scaled score of < 7 on two or more subtests of the CELF-R. Children were classified as reading impaired ($n = 15$) if they scored > 1 SD below the mean for age on either the World Identification or Word Attack subtest of the WRMT, and as spelling impaired ($n = 25$) if they scored more the 1 SD below the normative mean for age on either the Unpredictable Words subtest or the Predictable Words subtest of the TWS-3. We chose to define reading impairment based on reading decoding skills rather than comprehension skills as numerous researchers have distinguished between reading disability resulting from phonological difficulties and reading disabilities secondary to other language and cognitive impairments (Morris, Stuebing, Fletcher, Shaywitz, Lyon, Shankweiler, Katz, Francis, & Shaywitz, 1998; Stanovich, 1988; 1991). The children in our sample were identified as having speech sound disorders, and therefore we were interested primarily in their reading decoding skills.

Family History Assessment

As part of the school-age assessment, all parents completed a family history interview and questionnaire pertaining to speech, language, and reading disorders within the nuclear and extended family (Lewis & Freebairn, 1993). Affection status of family members for speech/language and reading disorders was determined either through review of these data (parents) or through review of both interview data and direct testing (siblings). Affection status was not determined for siblings less than three years of age.

A parent was coded as having a speech or language disorder, if by history, he/she had ever been enrolled in speech/language therapy. A reading disorder was coded if the parent reported receiving tutoring or special classes for reading. A sibling was coded as having a speech/language disorder if he/she had ever been enrolled in speech/language therapy, or if he/she performed below age standards on one of the same speech/language tests administered to the probands (defined by a score on a standardized language measure falling > 1 SD below the mean for age). Similarly, a sibling was coded as having reading difficulties if that individual reported receiving tutoring or special classes for reading or if he/she performed below age standards on WRMT-R Word Attack and Word Identification (defined by a score falling > 1 SD below age norms). Affection status was not determined for siblings < 3 years of age.

Family history for disorders was coded as both a dichotomous variable (i.e., positive or negative history) and as a five category ordinal variable (0, 1–25%, 26–50%, 51–75%, 76–100%) indicating the percentage of nuclear family members affected for speech/language disorders and for reading disorders.

Procedures

The subjects were tested individually in two sessions in a speech research laboratory at Case Western Reserve University's Department of Pediatrics or, at the parent's request, in a quiet and adequately lit room in the family's home. Speech productions were recorded using a Sony Professional Tape Recorder (WM-DC6) and an Audio-Technica Omnidirectional Microphone (AT-804). Responses were recorded initially on-line using broad phonetic transcription. Phonology samples were later transcribed in broad transcription using the consensus transcription method described above.

Data Analysis

Multiple regression analysis was employed to determine predictors of school-age language, reading decoding, reading comprehension, and spelling skills.

Risk ratios were calculated to compare the risk of being affected for language, reading, or spelling, for children with a family history of speech/language or reading disorders to those without a family history of disorders. Risk ratios were also used to estimate the risk of school-age impairment given a preschool phonology, semantic, or syntactic disorder. Statistical significance was determined using Fisher's exact test with a one-sided p-value of less than 0.05 being considered significant.

Logistic regression analysis was used to determine if the percentage of nuclear family members affected for speech/language and reading disorders predicted rates of school-age impairments.

RESULTS

Sample Characteristics

Preschool test findings are summarized in Table 2. At preschool, the sample mean for receptive language abilities fell within normal limits (TOLD-P:2 Listening Quotient; $M = 96.0$; $SD = 15.6$), while the sample mean for expressive language abilities fell within the disordered range (TOLD-P Speaking Quotient; $M = 79.3$; $SD = 14.4$). Preschool speech and language disorders included phonology disorders ($n = 27$; 52%), semantic deficits ($n = 16$; 31%), and syntactic deficits ($n = 18$; 35%).

The mean percentage of nuclear family members affected for speech and language disorders was 31.5% ($SD = 28.9\%$). The mean percentage of nuclear family members affected for reading disorders was 12.4% ($SD = 22.7\%$).

At school age, 18 (35%) of the children continued to be enrolled in speech/language therapy. Articulation skills had normalized for the majority of children, with 15 children (28.8%) continuing to fall below the 50th percentile on the GFTA and 9 (17.3%) falling below the 25th percentile on this measure. The sample mean for expressive language abilities as measured by the CELF-R ($M = 86.7$; $SD = 14.3$) continued to lag behind the mean for receptive abilities on the CELF-R ($M = 99.1$; $SD = 18.1$), although both means were within the normal range. Sample means for reading decoding as measured by the WRMT-R ($M = 94.5$; $SD = 16.1$), reading comprehension ($M = 100.3$;

Table 2. Summary of Measures Used to Classify Children at Preschool

	Type of Disorder							
	Phonology Disorder ($n = 27$)		Semantic Disorder ($n = 16$)		Syntactic Disorder ($n = 18$)		Total ($n = 52$)	
Preschool Measures	Mean	SD	Mean	SD	Mean	SD	Mean	SD
KLPA percentiles	5.7	4.5	12.4	10.6	11.5	10.1	21.0	22.5
Nonsense Words z-score	−1.50	.70	−1.1	1.1	−1.1	1.0	−1.0	1.0
TOLD-P:2 Total Score	84.7	15.5	74.4	7.3	74.8	7.6	91.6	17.1
TOLD-P:2 Word Discrimination	8.1	2.6	6.2	1.1	6.5	1.1	8.6	2.9
TOLD-P:2 Semantic Quotient	90.4	15.4	77.0	6.5	80.1	9.1	94.8	17.1
TOLD-P:2 Syntactic Quotient	82.4	15.8	76.9	9.4	75.1	9.0	91.4	18.1

Note: KLPA = Khan-Lewis Phonological Analysis, TOLD-P:2 = Test of Language Development-Primary, 2nd Edition. Standard scores are reported for the TOLD-P:2 and its subscales.

SD = 15.3) and spelling on the TWS-3 (*M* = 87.5; *SD* = 15.1) also fell within normal limits.

Eighteen children (35%) did not demonstrate any impairment at follow-up. Twelve children had isolated disorders (5 language impaired only; 1 reading impaired only; 6 spelling impaired only). The remaining 21 children presented with combinations of disorders, with 12 children demonstrating impairments in all three areas. Table 3 displays the mean test scores of the children classified as language impaired, reading impaired, or spelling impaired at school age. Eight children with reading impairments also fell 1 SD below the mean on reading comprehension; all of these children were in the reading impaired group.

Predictors of School-Age Language, Reading, and Spelling Skills

Predictors of school-age language, reading, and spelling skills used in the regression analyses were preschool scores on the TOLD-P:2, Goldman-Fristoe Test of Articulation, and the Nonsense Word Repetition Test, and the percent of nuclear family members affected for speech/language disorders and for reading disorders. Dependent variables were scores on the CELF-R, WRMT-R, and TWS-3. The multiple correlation coefficients between these five predictor variables and the dependent measures are reported in Table 4. Language abilities were predicted by the TOLD-P:2, Nonsense Word Repetition and family history for reading disorders. Reading ability was predicted by the GFTA, TOLD-P:2, and family history for reading disorders. The Nonsense Word Repetition Task predicted spelling. Family history for speech and language disorders failed to predict significant variance in any of the school-age measures.

Table 3. Performance of Children on the Measures Used for Classification at School Age, According to Type of Disorder/No Disorder

	Type of School-Age Disorder							
	Language Disorder (*n* = 24)		Reading Disorder (*n* = 15)		Spelling Disorder (*n* = 25)		No Disorder (*n* = 18)	
School-Age Measure	Mean	SD	Mean	SD	Mean	SD	Mean	SD
GFTA	58.8	40.2	46.9	44.5	52.4	37.7	84.3	21.8
CELF-R	78.1	11.4	75.9	16.5	84.2	17.3	104.2	10.4
WRMT-R	86.4	15.2	75.0	9.5	84.6	14.7	106.9	9.6
WIAT Read Comp.	89.1	11.3	83.1	9.5	91.5	14.5	110.2	11.4
TWS-3	82.0	12.2	74.8	9.1	76.1	8.0	101.4	11.9

Note: Scores for the GFTA are percentiles; all other scores represent standard scores. GFTA = Goldman Fristoe Test of Articulation, CELF-R = Clinical Evaluation of Language Fundamentals-Revised, WRMT-R = Woodcock Reading Mastery Tests—Revised, WIAT = Reading comprehension subtest of the Wechsler Individual Achievement Test, TWS-3 = Test of Written Spelling—Third Edition

Table 4. Sets of Beta Weights and Multiple Correlations Coefficients for each Criterion Variable

Criterion Variable	Beta Weights for Predictors					
	R square	GFTA	TOLD-P:2	Nonword	Read Hx	Sp/Lang Hx
CELF-R	0.599	−0.411	0.499**	0.578**	−0.298*	0.119
WRMT-R	0.455	−0.358*	0.515*	0.336	−0.331*	0.102
TWS-3	0.332	−0.228	0.252	0.473*	−0.277	0.252

Note: GFTA = Goldman Fristoe Test of Articulation; TOLD-P:2 = Test of Language Development, Primary-2nd Edition; Nonword = Nonsense Word Repetition Task; CELF-R = Clinical Evaluation of Language Fundamentals-Revised; WRMT-R = Woodcock Reading Mastery Tests—Revised; TWS-3 = Test of Written Spelling—Third Edition.

*Significant at $p < .05$.

**Significant at $p < .001$.

Predictors of Language, Reading, and Spelling Impairments

Logistic regression analysis was first employed to determine if the percentage of nuclear family members with speech/language or reading disorders were predictive of school-age impairments. As shown in Table 5, family histories for speech/language disorders failed to predict language impairments at school age. Family history for reading disorders predicted spelling impairment at school age. A trend was noted for family history of reading disorders to predict reading impairment, however this did not reach significance.

Risk ratios were calculated employing family history for disorders as a dichotomous variable (i.e., positive or negative history). In this analysis, family history for speech/language impairment showed a moderate association with reading impairment approaching statistical significance. Family history for reading disorders continued to predict spelling impairment at school age.

Risk ratios also related preschool speech/language deficiencies to school-age language, reading, and spelling impairments as shown in Table 6. As illustrated there, language impairment at school age was predicted with preschool deficiencies in syntax and phonological encoding as measured by the Nonsense Word Repetition Task. Reading impairment, however, was associated with syntactic and semantic deficiencies at preschool, as well as with preschool deficits in phonology as measured by KLPA and phonological encoding as measured by the Nonsense Word Repetition Task. Spelling impairment was associated with preschool phonology impairment as measured by the KLPA and with phoneme discrimination deficits as measured by the Word Discrimination subtest of the TOLD-P:2 as well as the Syntax Quotient.

Discussion

The results of this study are consistent with previous findings showing that school-age children with histories of preschool speech and language disorders

Table 5. Relationship of Family History to Impairments in Language, Reading, and Spelling

A. Family History Reported as Percentage of Nuclear Family Members with Disorders

	Type of School-Age Impairment					
	Language		Reading		Spelling	
Predictor	OR	CI	OR	CI	OR	CI
Family History of Speech/ Language Disorders	1.25	0.79–1.98	1.38	0.83–2.26	1.03	0.65–1.61
Family History of Reading Disorders	1.43	0.78–2.62	1.83	0.97–3.44	2.37*	1.06–5.2

B. Family History as a Dichotomous Variable

	Type of School-Age Impairment					
	Language		Reading		Spelling	
Predictor	RR	CI	RR	CI	RR	CI
Family History of Speech/ Language Disorders	1.59	.77–3.28	3.70	.95–14.54	1.19	.65–2.18
Family History of Reading Disorders	1.13	.61–2.07	1.75	.79–3.87	2.25*	1.37–3.69

Note: OR = Odds Ratio; CI = 95% Confidence Interval; RR = risk ratio. Odds ratios represent the increased risk of a child having a school-age impairment for each additional affected family member based on a nuclear family size of 5. The risk ratio is the risk of a child with a family history of being affected, compared with a child with no family history. No difference is indicated by a RR = 1. No statistically significant difference is indicated by the CI including the value 1.

are at high risk for reading, spelling, and language problems (Aram & Hall, 1989; Bishop & Adams, 1990; Catts, 1991; 1993; Larrivee, & Catts, 1999; Menyuk et al., 1991; Stothard et al., 1998; Tallal, Ross, & Curtiss, 1989). Previous studies have suggested that preschool syntactic/semantic impairments are more predictive of later academic problems than are preschool speech-sound disorders (Bishop & Adams, 1990; Catts, 1991; 1993; Hall & Tomblin, 1978; Levi et al., 1982; Shriberg & Kwiatkowski, 1988). Consistent with these findings, preschool deficits in language skills as measured on the TOLD-P:2 predicted later language and reading disorders.

One noteworthy finding was that language impairment at school age was related to preschool deficits in syntax but not to earlier problems in semantics. This finding suggests that children with persistent language impairment may have particular weaknesses in higher-level linguistic skills (Scarborough, 1990). Tasks requiring semantic processing may tap different cognitive skills than do syntactic tasks. Semantic knowledge may depend on verbal memory skills for word retrieval and on accumulation of general lexical knowledge (Gathercole & Baddeley, 1990). Syntax, on the other hand, may place demands on quite different linguistic capacities such as grammar and metalinguistic

Table 6. Relationship of Preschool Speech/Language Deficiencies to School-Age Language, Reading, and Spelling Impairments

	School-Age Impairment											
	Language				Reading				Spelling			
Preschool Deficiency	Sens.	Spec.	RR	*p*	Sens.	Spec.	RR	*p*	Sens.	Spec.	RR	*p*
Phonology												
Khan-Lewis Phonological Analysis	0.67	0.59	1.78	0.058	0.87	0.61	5.78	0.002*	0.68	0.62	1.89	0.003*
TOLD-P:2 Word Discrimination	0.50	0.60	1.25	0.448	0.71	0.65	3.13	0.110	0.64	0.77	2.25	0.038*
Nonsense Word Repetition	0.65	0.76	2.70	0.010*	5.88	0.80	0.72	0.005*	0.55	0.73	1.80	0.065
Semantics												
TOLD-P:2 Semantic Quotient Syntax	0.50	0.75	1.71	0.073	0.69	0.76	3.84	0.006*	0.46	0.73	1.44	0.159
TOLD-P:2 Syntactic Quotient	0.67	0.79	2.74	0.002*	0.92	0.78	16.4	0.000**	0.61	0.77	2.13	0.010*

Note: RR = relative risk; TOLD-P:2 = Test of Language Development, Primary, 2nd Edition; Sens = Sensitivity, i.e., the proportion of children classified as disordered by preschool testing of those that demonstrated a school-age impairment; Spec = specificity, i.e., the proportion of children classified as within the normal range by preschool testing of those that did not demonstrate a school age impairment.

*$p < .05$; **$p < .001$.

abilities. The findings of this study support theories that attribute specific language impairment (SLI) to deficiencies in innate specialized linguistic mechanisms underlying grammar (Bishop, 1992; Rice & Wexler, 1996). For example, Rice, Haney, and Wexler (1998) demonstrated that children with limitations in a particular feature of grammar (i.e., children with extended optional infinitives) had high rates of family members affected for speech, language, and reading disorders. They suggest that specific grammatical competencies may indicate genetic risk for SLI.

Language impairment at school age was also related to poor performance on the Nonsense Word Repetition Task at preschool. This finding is in agreement with many studies that have documented that children with LI repeat nonsense words less accurately than their normally developing peers (Bishop, North, & Donlan, 1996; Dollaghan & Campbell, 1998; Gathercole & Baddeley, 1990; Montgomery, 1995). However, it is not known whether poor performance on the Nonsense Word Repetition Task is related to phonological processing deficits, reduced verbal memory, or poor articulatory/motor skills. It is unlikely that the semantic deficits account for poor performance on the nonsense word task as nonsense words purportedly eliminate lexical influences.

Reading disorders at school age, in contrast, were predicted by a wider range of preschool linguistic competencies, including syntactic, semantic and phonological skills. This finding is consistent with the literature showing that phonological awareness skills at preschool predict early reading decoding skills, and that general language abilities are associated with reading comprehension (Bird, Bishop, & Freeman, 1995; Catts, 1993; Kamhi & Catts, 1986; Wagner & Torgesen, 1987). Name retrieval abilities have also been associated with fluent reading (Torgesen & Wagner, 1992). Thus, the competent reader draws upon many component skills for decoding, comprehension, and fluency.

The association of early phonological processing skills as measured by the KLPA, Word Discrimination subtest of the TOLD-P:2, and Nonsense Word Repetition Task, with later spelling abilities parallels results from previous studies showing that children with histories of severe speech-sound disorders are at risk for spelling impairment. Clarke-Klein (1994) found that third-grade children with histories of phonology disorders evidenced more phonologically based spelling errors than their normal peers. Similarly, Lewis, O'Donnell, Freebairn, and Taylor (1998) found that children with histories of phonology and language problems, or histories of phonology disorders alone without additional language problems, performed more poorly on measures of dictated spelling (TWS-3) than did their normally developing siblings. Residual metaphonological weaknesses in the children with histories of phonology disorders may be responsible for these differences (Clark-Klein, 1994; Lewis et al., 1998; Treiman, 1991; Webster & Plant, 1992). The trend for family history of reading disorders to predict reading impairment is consistent with research by Scarborough (1990), who found that the incidence of reading problems in

children's families predicted reading ability at Grade 2. Surprisingly, however, family history for speech and language disorders did not predict language impairment at school age. A possible explanation for the differences in predictive validity of the two types of family history is that reading and language impairments have unique etiologies. As suggested in our previous studies, speech/language disorders may differ from reading disorders in terms of both their cognitive determinants and genetic basis. Thus, familial risk for speech/language disorders may be less strongly associated with reading or spelling disorders than is familial risk for reading disorders.

The absence of a relationship between familial risk for speech/language impairment and language impairment at school age is more difficult to explain. A prospective study by Spitz, Tallal, Flax, and Benasich (1997) demonstrated that familial risk for language impairment predicted receptive and expressive language delays in children 16–26 months of age. However, no previous study has attempted to predict language impairment in older school-age children on the basis of family history. One possible explanation for our negative findings is that the phenotype used to identify affected family members was overly broad or poorly specified. Any family member who reported any indication of a history of speech and language therapy was classified as affected regardless of the type of disorder for which therapy was undertaken. A narrower phenotype, such as a history of language impairment that persisted to school age, may have been more closely related to the language phenotype examined in the present study. A second possibility is that parents were under-identified as affected for a speech/language disorder. Older parents may have predated routine diagnosis of language disorders. Determination of family history based on actual test results may also have yielded a more precise measure of family history, although this is unlikely to be a feasible strategy given resolution of many earlier speech and language disorders by adulthood.

Our findings have several clinical implications. First, children with preschool language impairments, especially in syntax, should be followed carefully into elementary school as they are at risk for school-age language impairments and reading disorders. Preschool children with pervasive language impairments in phonology, semantics and syntax, or with a positive family history for reading disorders, are at especially high risk for reading difficulties. Poor phonological skills at preschool may place the child at risk for either reading or spelling disorders, as has been suggested in previous work linking isolated phonology disorders in young children with later spelling difficulties (Lewis et al., 1998). Further investigation is needed to examine the predictive validity of family histories for speech/language and reading disorders in greater detail and to explore the genetic basis of school-age speech/language and learning impairments.

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REFERENCES

Aram, D.M., & Hall, N.C. (1989). Longitudinal follow-up of children with preschool communication disorders: Treatment implications. *School Psychology Review, 18(4)*, 487–501.

Bird, J., Bishop, D.V.M., & Freeman, N.H. (1995). Phonological awareness and literacy development in children with expressive phonological impairments. *Journal of Speech and Hearing Research, 38*, 446–462.

Bishop, D.V.M. (1992). The underlying nature of specific language impairment. *Journal of Child Psychology and Psychiatry, 33*, 3–66.

Bishop, D.V.M., & Adams, C. (1990). A prospective study of the relationship between specific language impairment, phonological disorders, and reading retardation. *Journal of Child Psychology and Psychiatry, 31*, 1027–1057.

Bishop, D.V.M., North, T., & Donlan, C. (1996). Nonword repetition as a behavioral marker for inherited language impairment: Evidence from a twin study. *Journal of Child Psychology and Psychiatry, 36*, 1–13.

Byrne, B.M., Willerman, L., & Ashmore, L.L. (1974). Severe and moderate language impairment: evidence for distinctive etiologies. *Behavior Genetics, 4*, 331–345.

Catts, H.W. (1991). Early identification of dyslexia: Evidence from a follow-up study of speech-language impaired children. *Annals of Dyslexia, 41*, 163–177.

Catts, H.W. (1989). Defining dyslexia as a developmental language disorder. *Annals of Dyslexia, 39*, 50–64.

Catts, H.W. (1993). The relationship between speech-language impairments and reading disabilities. *Journal of Speech and Hearing Research, 36*, 948–958.

Clark-Klein, S.M. (1994). Expressive phonological deficiencies: Impact on spelling development. *Topics in Language Disorders, 14(2)*, 40–55.

Dollaghan, C., & Campbell, T.F. (1998). Nonword repetition and child language impairment. *Journal of Speech and Hearing Research, 41*, 1136–1146.

Felsenfeld, S., McGue, M., & Broen, P.A. (1995). Familial aggregation of phonological disorders: Results from a 28-year follow-up. *Journal of Speech and Hearing Research, 38*, 1091–1107.

Gathercole, S.E., & Baddeley, A.D. (1990). Phonological memory deficits in language disordered children. Is there a causal connection? *Journal of Memory and Language, 29*, 349–367.

Goldman, R., & Fristoe, M. (1986). *The Goldman-Fristoe Test of Articulation*. Circle Pines, MN: American Guidance Service.

Hall, P.K., & Tomblin, J.B. (1978). A follow-up study of children with articulation and language disorders. *Journal of Speech and Hearing Disorders, 43*, 227–241.

Hollingshead, A.B. (1975). *Four Factor Index of Social Class*. New Haven, CT: Yale University.

Kamhi, A., & Catts, H.W. (1986). Toward an understanding of developmental language disorders and reading disorders. *Journal of Speech and Hearing Disorders, 51*, 337–347.

Khan, L., & Lewis, N. (1986). *Khan-Lewis Phonological Analysis*. Circle Pines, MN: American Guidance Service.

King, R.R., Jones, C., & Lasky, E. (1982). In retrospect: A 15 year follow-up report of speech-language disordered children. *Language, Speech, and Hearing in the Schools, 13*, 24–32.

Lahey, M., & Edwards, J. (1995). Specific language impairment: Preliminary investigation of factors associated with family history and patterns of language performance. *Journal of Speech and Hearing Research, 38*, 643–657.

Larrivee, L.S., & Catts, H.W. (1999). Early reading achievement in children with expressive phonological disorders. *American Journal of Speech-Language Pathology, 8*, 118–128.

Larsen, S.C., & Hammill, D.D. (1994). *Test of Written Spelling Third Edition Examiner's Manual*. Austin, TX: Pro-Ed.

Levi, G., Capozzi, F., Fabrizi, A., & Sechi, E. (1982). Language disorders and prognosis for reading disabilities in developmental age. *Perceptual and Motor Skills, 54*, 1119–1122.

Lewis, B.A. (1992). Pedigree analysis of children with phonology disorders. *Journal of Learning Disabilities, 25(9)*, 586–597.

Lewis, B.A., & Freebairn, L. (1993). A clinical tool for evaluating the familial basis of speech and language disorders. *American Journal of Speech-Language Pathology, 2*, 38–43.

Lewis, B.A., O'Donnell, B., Freebairn, L.A., & Taylor, H.G. (1998). Spoken language and written expression- interplay of delays. *American Journal of Speech-Language Pathology, 7*, 77–84.

Luchsinger, R. (1970). Inheritance of speech defects. *Folia Phoniatrica, 22*, 216–230.

Magnusson, E., & Naucler, K. (1990a). Reading and spelling in language disordered children-linguistic and metalinguistic prerequisites, report on a longitudinal study. *Clinical Linguistics and Phonetics, 4(1)*, 49–61.

Magnusson, E., & Naucler, K. (1990b). Can preschool data predict language-disordered children's reading and spelling at school? *Folia Phoniatrica, 42*, 277–282.

Menyuk, P., Chesnick, M., Liebergott, J.W., Korngold, B., D'Agostino, R., & Belanger, A. (1991). Predicting reading problems in at-risk children. *Journal of Speech and Hearing Research, 34*, 893–903.

Montgomery, J.W. (1995). Sentence comprehension in children with SLI: The role of phonolgical working memory. *Journal of Speech and Hearing Research, 38*, 187–199.

Morris, R.D., Stuebing, K.K., Fletcher, J.M., Shaywitz, S.E., Lyon, G.R., Shankweiler, D.P., Katz, L., Francis, D.J., & Shaywitz, B.A. (1998). Subtypes of reading disability: Variability around a phonological core. *Journal of Educational Psychology, 90(3)*, 347–373.

Neils, J., & Aram, D.M. (1986). Family history of children with developmental language disorders. *Perceptual and Motor Skills, 63*, 655–658.

Newcomer, P.L., & Hamill, D.D. (1988). *Test of Language Development-Primary 2*. Austin, TX: Pro-Ed.

Rice, M.L., & Wexler, K. (1996). Toward tense as a clinical marker of specific language impairment in English speaking children. *Journal of Speech and Hearing Research, 39*, 1239–1257.

Rice, M.L., Haney, K.R., & Wexler, K. (1998). Family histories of children with SLI who show extended optional infinitives. *Journal of Speech and Hearing Research, 41*, 419–432.

Robbins, J., & Klee, T. (1987). Clinical assessment of oropharyngeal motor development in young children. *Journal of Speech and Hearing Research, 52*, 271–277.

Scarborough, H.S. (1990). Very early language deficits in dyslexic children. *Child Development, 61*, 1728–1743.

Semel, E., Wiig, E.H., & Secord, W. (1987). *Clinical Evaluation of Lan-*

guage Fundamentals– Revised. San Antonio, TX: The Psychological Corporation.

Shriberg, L.D., & Kwiatkowski, J. (1988). A follow-up of children of phonological disorders of unknown origin. *Journal of Speech and Hearing Research, 53*, 144–155.

Spitz, R.V., Tallal, P., Flax, J., & Benasich, A.A. (1997). Look who's talking: A prospective study of familial transmission of language impairments. *Journal of Speech and Hearing Research, 40*, 990–1001.

Stanovich, K.E. (1988). Explaining the differences between the dyslexic and the garden-variety poor reader: the phonological core variable difference model. *Journal of Learning Disabilities, 21*, 590–604.

Stanovich, K.E. (1991). Discrepancy definitions of reading disability: Has intelligence led us astray? *Reading Research Quarterly, 26*, 1–29.

Stothard, S.E., Snowling, M.J., Bishop, D.V.M., Chipchase, B.B., & Kaplan, C.A. (1998). Language-impaired preschoolers: A follow-up into adolescence. *Journal of Speech and Hearing Research, 41*, 407–418.

Tallal, P., Ross, R., & Curtiss, S. (1989). Familial aggregation in specific language impairment. *Journal of Speech and Hearing Research, 54*, 167–173.

Tomblin, J.B. (1989). Familial concentration of developmental language impairment. *Journal of Speech and Hearing Disorders, 54*, 287–295.

Tomblin, J.B., Records, N.L., Buckwalter, P., Zhang, X., Smith, E., & O'Brien, M. (1997). Prevalence of specific language impairment in kindergarten children. *Journal of Speech and Hearing Research, 40*, 1245–1260.

Torgesen, J.K., & Wagner, R.K. (1992). Language abilities, reading acquisition, and developmental dyslexia: Limitations and alternative views. *Journal of Learning Disabilities, 25*, 577–581.

Treiman, R. (1991). Phonological awareness and its roles in learning to read and spell. In D. Sawyer & B. Fox (Eds.), *Phonological awareness in reading*. New York, NY: Springer-Verlag.

Vitali, G.J. (1986). *Test of Oral Structures and Functions*. East Aurora, NY: Slosson Educational Publications, Inc.

Wagner, R.K., & Torgesen, J.K. (1987). The nature of phonological processing and its causal role in the acquisition of reading skills. *Psychological Bulletin, 101*, 192–212.

Webster, P.E., & Plante, A.S. (1992). Effects of phonological impairment on word, syllable, and phoneme segmentation and reading. *Language, Speech, and Hearing Services in the Schools, 23*, 176–182.

Webster, P.E., Plante, A.S., & Couvillion, L.M. (1997). Phonological impairment and prereading: update on a longitudinal study. *Journal of Learning Disabilities, 30,* 365–375.

Wechsler, D. (1989). *Wechsler Preschool and Primary Intelligence Scale—Revised*. San Antonio, TX: The Psychological Corporation.

Woodcock, R.W. (1987). *Woodcock Reading Mastery Tests—Revised*. Circle Pines, MN: American Guidance Service.

CONTINUING EDUCATION

Academic Outcomes in Children with Histories of Speech Sound Disorders

QUESTIONS

1. Reading disorders have been associated with all of the following EXCEPT:
   a. Phoneme awareness skills
   b. Family history for reading problems
   c. Preschool speech/language disorders
   d. Verbal working memory
   e. Stuttering

2. Studies of familial aggregation of speech/language disorders have shown that:
   a. Speech and language disorders run in some families
   b. There is a gene for phonology disorders
   c. Family history for semantic disorders predict reading decoding
   d. None of the above
   e. All of the above

3. The study in this article demonstrated that:
   a. Children with preschool speech/language disorders are at risk for later reading and spelling disorders
   b. Early syntactic abilities better predicts later language impairment than early semantic abilities
   c. Family history for reading disorders may be used to identify children at risk for reading disability
   d. All of the above
   e. a and c

4. In this study, school age spelling difficulties were *not* associated with:
   a. Early phonological processing skills
   b. Family history for reading disorders
   c. Vocabulary

d. None of the above
e. All of the above

5. The findings of this study suggests that speech/language pathologists should:
   a. Routinely obtain family histories for reading as well as speech/language disorders
   b. Follow children with speech/language disorders to school age as they are at risk for reading, spelling and language impairments
   c. Ignore phonological processing skills until the child can read
   d. a and b
   e. All of the above

ELSEVIER

CULTURAL ANALYSIS OF COMMUNICATION BEHAVIORS AMONG JUVENILES IN A CORRECTIONAL FACILITY

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This study addressed communication behaviors of female juvenile delinquents in a correctional facility. Qualitative methodology was used to study 78 participants ranging in age from 13.1 to 18.9 (years; months), over a five-month period. Data collection consisted of observations, participant observation, interviews, and a review of documents. Additionally, participants were tested on the Clinical Evaluation of Language Fundamentals—3. Listening and following rules, utterance types, topics of conversion, politeness, and conversational management emerged as themes. Findings indicated that as many as 22% of participants were potential candidates for language services. Implications for speech-language pathologists (SLPs) providing communication services will be provided.

Educational Objectives: (1) Readers will understand the communication behaviors of female juvenile delinquents, and (2) why it is difficult to distinguish which female delinquents are language impaired.

KEY WORDS: Interpersonal communications; Pragmatics; Juvenile delinquents

INTRODUCTION

The question of whether juvenile delinquents are deficient in communication skills is not new and, in fact, has been studied for more than 30 years. Studies have confirmed that juvenile delinquents have a higher incidence of speech, language, and hearing problems than non-institutionalized children and youth. According to a review of the literature conducted by Larson & McKinley (1995), as many as 5% of youth in the general population are in need of services. Prevalence figures of communication problems in the delinquent popu-

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lation range from 24% to 84% (Cozad & Rousey, 1966; Falconer & Cochran, 1989; Taylor, 1969). Moreover, recent studies suggest male (Davis, Sanger, & Morris-Friehe, 1991) and female delinquents (Sanger, Hux, & Belau, 1997) with no previous identification of learning or language problems qualify as potential candidates for language intervention.

Although there is sufficient evidence to document the high prevalence of communication problems with delinquent adolescents, there are several concerns about the existing data resulting in unanswered questions about the nature of their language and interactional skills. First, previous research relies primarily on standardized language measures rather than analyses of conversational discourse skills. The limitations inherent in standardized tests limit the findings about conversational interactions. Although two studies attempted to document the conversational language of male (Davis et al., 1991) and female delinquents (Sanger et al., 1997) using a modification of the Damico (1985) Clinical Discourse Analysis, the findings were inconclusive on the pragmatic performance skills of adolescents. Although Sanger and her colleagues (1997) found no significant differences in the discourse behaviors of female delinquent and nondelinquent teenagers, they cautioned readers to interpret the findings on the informal language samples cautiously due to elicitation procedures and the analysis methods performed on the samples. The researchers pointed out that the setting, the high degree of structure inherent in collecting the samples, and the analysis procedure may have minimized the occurrence of pragmatically-based discourse violations. They acknowledged that language challenges might have existed for more delinquents than were apparent from discourse findings.

Second, unanswered questions remain about existing research of pragmatically-based communication behaviors of delinquents. In an attempt to better understand the communication skills of female delinquents (Sanger, Hux, & Ritzman, 1999), the pragmatic awareness of conventions governing conversational interactions of 45 incarcerated female juvenile delinquents was explored through qualitative research. Findings suggested delinquent teenagers could state many conventions governing conversational interactions, however, did not consistently display interactional behaviors consistent with their pragmatic awareness. Though participants were able to state basic rules on how to be a good listener, how to use interpersonal space, use eye contact, take turns in conversations and stay on topics without interrupting their conversational partner, some discrepancies were observed in youths' conversational interactions. Contradictory observations were noted between what subjects knew and how they performed during small-group conversations about communication during multiple class periods. Given that the study was designed to examine what delinquents already knew about rules governing conversations, there was not sufficient data to make firm conclusions about delinquents' pragmatic performance skills. Also, standardized language tests were not administered to

determine the status of the participants' language skills. Therefore, it was not apparent whether a communication skill deficit or other reasons, such as motivation or history of learning accounted for the teenagers' pragmatically-based communication behaviors.

It is difficult to explain the pragmatically-based communications behaviors of juveniles because, in part, previously mentioned language sampling findings suggest they converse much like their peers (Sanger et al., 1997). However, more recent research suggests that delinquent adolescents often display pragmatic performance deficits during conversational interactions (Sanger et al., 1999). Therefore, unanswered questions remain regarding the language patterns of these youth.

A detailed description of juvenile delinquents' patterns of communication is needed to further explore the pragmatic skills of adolescents and help speech-language pathologists (SLPs) plan programs. Understanding the communication behaviors of delinquents may provide clues for SLPs sorting out which individuals need language services. This continues to be a challenge for SLPs because over-qualifying children for language intervention services affects caseload size—a burden that already impacts many clinicians' workloads. Finally, the findings could help SLPs to advocate for delinquents' needs and better define the role of the SLP with this population.

The purpose of this ethnographic study was to describe and interpret the culture-sharing communication behaviors of 78 female juvenile delinquents incarcerated in a correctional facility. Juvenile delinquents will refer to individuals who were determined guilty of violating the law before 18 years of age. This research explored the themes that emerged from observing the communication patterns of juvenile participants. A secondary purpose of the study was to address how individuals performed on the Clinical Evaluation of Language Fundamentals—3 (CELF-3) (Semel, Wiig, & Secord, 1995) to provide SLPs information about delinquents' language skills. The researchers interviewed both participants and staff at a correctional facility to obtain information.

METHOD

Methodology was qualitative and involved ethnographic research (Bogdan & Biklen, 1992; Fetterman, 1998; Patton, 1990). This approach to qualitative research involves a description and interpretation of a cultural or social group (Creswell, 1998). These types of methods are important for studying communication behaviors and are cited in journals of special education (Kliewer, 1998) and communication disorders (Kovarsky, 1992; Kovarsky & Crago, 1990–1991; Maxwell, 1993; Patton & Westby, 1992; Westby & Erickson, 1992). In this study, female juvenile delinquents were studied over a five-month period following the suggestions of previous investigators (Agar, 1980; Creswell, 1998; Harris, 1968; Wolcott, 1980).

Setting

Data were collected from a rehabilitation and treatment center located in a small rural town in the Midwest United States. Both male and female delinquent teenagers resided at the correctional center but were not permitted to interact. Though males were only evaluated at the facility over a 30-day period, females received both evaluation and treatment services throughout their incarceration period. The average length of commitment for females was 4 months and most were committed for one or more misdemeanor or felony offenses. At any given time, approximately 75 to 80 female youth received evaluations, rehabilitation, and treatment for an educational and behavioral assessment. At the center, information was routinely gathered about drug and alcohol usage and background histories to plan treatment programs. Treatment provided by the facility focused on Positive Peer Culture (Leeman, Gibbs, & Fuller, 1993), education, counseling, and behavior management. Positive Peer Culture involved changing the students' behaviors through adult guidance with input from the teenagers. Treatment activities at the facility continued throughout the duration of the present study without changes in students' goals.

A typical daily schedule for females included attending school, group meetings, assisting with assigned duties, and participating in supervised free time. Time spent at the correctional facility was highly structured. For example, individuals had strict rules about when they could talk while going to and from different activities. Young people were not permitted to use profanity and were required to participate in "polite" forms of interactions. Additionally, group discussions followed a strict format but were influenced by student and adult input. Given the structure of the correctional setting and administrative guidelines, there was an attempt to consider the environment of the entire communicative setting in which the participants resided.

Participants

Participants included 78 females ranging in age from 13.1 to 18.9 years (M = 16.20 years; SD = 1.22 years). Records at the facility and self reporting from the teenagers indicated that 46 of the participants were Caucasian, 6 were Native american, 11 were Hispanic, 4 were African American, and the remaining 11 were a combination of two racial/ethnic backgrounds. Most were from poor or working class families according to their parents' current occupations (Stricker, 1988).

The participants had IQ scores between 73 and 125 (M = 95.75; SD = 12.38) as measured either by the Wechsler Intelligence Scale for Children—III, the Test of Nonverbal Intelligence—II, the Slosson Intelligence Test, or the Wechsler Adult Intelligence Scale—Revised. Twenty-eight (35.89%) of the teenagers had received special education services at some point during

their education according to self report and school records. Two had received services for learning disabilities; two for behavioral disorders; and two for attention deficit hyperactive disorder. Twenty-two received multiple services in a resource placement. Of the 28 youth, 3 also received speech services. Two additional participants received only speech and one received language services.

Records of official documentation of maltreatment obtained at the facility indicated that 49 (62.82%) of 78 of the delinquent participants experienced either emotional mistreatment, physical injury, physical neglect and/or sexual abuse. Over 34% experienced a combination of one or more forms of maltreatment. Additionally, 5 other cases emerged but were not officially documented. According to these 5 participants, they had not reported this abuse prior to their placement at the correctional facility. Over half of the participants had experienced maltreatment during their childhood and adolescent years ($n = 54/78$; 69.23%).

Data Collection and Analysis

Criterion and opportunistic sample procedures were used in this research (Miles & Huberman, 1994). Criterion for inclusion was at least 3 months of residence at the center (average was 4 months, 28 days) and willingness to be assessed on the Clinical Evaluation of Language Fundamentals—3. Testing was performed by graduate students majoring in Speech-Language Pathology. Opportunistic sampling allowed the researchers to follow new leads and take advantage of "key informants." Six participants, the librarian, three classroom teachers, and three counselors, were "key informants" and provided information for the study. These individuals were asked to provide their opinions about the juvenile delinquents' communication behaviors.

Field work was conducted for two days weekly over five months (Fetterman, 1998; Wolcott, 1980). Data consisted of field notes based on observations, participants observations, interviews, and a review of documents collected from four settings. Data collected in settings of the library/study hall, in classrooms, and in situations such as group meetings, and during free time. Verbal and nonverbal communication behaviors were the focus of the observations. Researchers recorded observations on hand written field notes or by audiotape recordings, depending on the acceptance of these methods by the participants. Audio-taped conversations were collected through an Audio-Technica PRO 88W/R minature wireless condenser microphone receiver and PRO SSW/T wireless microphone transmitter. A lavalier lapel microphone was placed within 1–3 meters of the speakers and the signal was recorded on a Sony TCM-59V cassette recorder. This system was developed to reduce the visual intrusiveness of the recording equipment. Initially, two of the researchers were "outside" observers who were present in rooms where social activities were conducted but did not actively participate. Eventually, observers joined with the activities as equal participants and could observe as "insiders"

(Jorgensen, 1989). Timing of this transition of passive observation to participant observation was judged by the accepting behaviors of the participants in each activity.

Daily interviews involved one-on-one or small groups of two or three participants. They were conducted by the primary researcher and research assistant and were largely unstructured with open-ended questions. For example, participants would be asked to describe their perceptions of the listening skills of their peers at the center. To help participants focus on a common reference and make judgments, the specific individuals were identified for peer comments. Examples of questions posed to individual participants and their responses are provided in Table 1.

Following transcription of on-line field notes and audio-taped interactions, emerging patterns of communication behaviors were described. Researchers derived procedures based on the work of Fetterman (1998), McCracken (1988), and Spradley (1980). Specific categories of nonverbal and verbal codes, including the emergence of themes are illustrated in Table 2.

Themes were derived from the following procedures: (a) immersion in the setting by reading and rereading field notes and verbatim transcriptions; (b) sorting important and unimportant data; (c) observation of coded patterns of recurrent information in the nonverbal and verbal behaviors; (d) identification of themes; (e) review of the emergent themes for each of the interviews. Themes that emerged included: (a) listening and following rules, (b) utterance types, (c) topics of conversation, (d) politeness, and (e) conversational management. Following the emergence of these themes, additional descriptive information was collected and analyzed on the Checklist of Pragmatic Language (Tattershall, 1988), to compare subgroups of participants who differed on language scores.

Checklist of pragmatic language. The pragmatic checklist included 36 items about topic initiation, topic maintenance, purposes of communication, and nonverbal issues. Seven students who performed below 1.3 SD on the CELF-3 were compared to 7 delinquents who performed within an acceptable range on the CELF-3. The groups were matched for chronological age and intellectual functioning. One counselor familiar with the 14 participants rated the 36 behaviors along a 1 to 4 frequency-of-occurrence continuum on which "1" was a lower rating and corresponded with "never" and "4," a higher rating, corresponded with "frequently." The 36 items were summed to yield a total score and descriptive comments were summarized.

Data Verification Procedures

Validity and verification were used to establish standards of quality (Creswell, 1998; Fetterman, 1998; Hammersley & Atkinson, 1995; Thomas, 1993). Triangulation was established through the use of multiple data sources, investiga-

Table 1. Participants' Opinions on Youths' Communication Skills

Question No.	Participants' (n = 20) Comments	Frequency of Occurrence
1.	How would you describe your peers' listening skills?	
	They may hear things, but don't care	6
	Don't listen much	5
	You can listen if you want, you don't if you don't want to	5
	Not all there	1
	Listen to get out of here (around staff)	1
	Have a hard time hearing things that don't excite them, listen only what they want to	1
	Sometimes they talk and listen very well and at other times they get very irritated.	1
2.	How would you describe your peers' body posture?	
	Slouching/leaning	13
	Restless/fidgeting	2
	Way they sit/stand, shows they don't care	1
	Hands in pockets	1
	Hold head in hands	1
	Lay on tables	1
	Put hands over mouth (when speaking)	1
	Bored/comfortable	1
	Most are appropriate but some show boredom by slouching in chairs, rolling their eyes, or smacking their lips	1
3.	How would you describe the youths' eye contact and facial expressions?	
	Limited/poor eye contact	9
	Inappropriate facials	5
	Some have good eye contact and facial expressions	5
	Facials show true mood/feelings	4
	Girls afraid to use eye contact (because of power issues)	3
	Facials will include rolling eyes and sticking out tongue	2
	Use eye contact/facials to intimidate	2
	Have mean looks	1
	Depends on the situation/person	1
	Don't realize they even make facial expressions	1
	Use eye contact if interested and to show expressions	1
4.	How would you describe the youths' verbal communication (such as questions, statements, expressing feelings, etc.)?	
	Afraid to say what really feel	4
	Depends on the situation/person	4

(*continued*)

Table 1. (Continued)

Question No.	Participants' (n = 20)	Frequency of Occurrence
	Come across rude or say unnecessary things/don't sound serious	3
	Ask questions	3
	Some have good communication	2
	Let out a lot of feelings	2
	Will make negative statements	1
	Say things only they understand	1
5.	How would you describe the youths' types of topics they use in conversation?	
	Drugs	13
	Sex	8
	Boys	6
	The past	5
	Gangs	4
	War stories	4
	Inappropriate conversations	4
	Their problems	4
	Music	3
	Alcohol	3
	Wanting to get out of YRTC/go home	3
	Crimes	1
	Meaningless conversations	1
	Idols	1
	Don't talk about school/familes/futures	1
	"Real life" issues/advanced topics	1
	They discuss everything that ticks us off	1
	Friends	1
	The outside world	1
	Topics depend on who's around (eg. staff)	1
6.	How would you describe the youth's use of politeness and honesty?	
	Honesty is rare/ a lot of bad mouthing occurs	11
	Not much "please" and "thank you" or even general politeness	10
	Polite one minute, rude the next (will depend on who's around, such as staff)	5
	Girls lie so they don't get more problems	3
	Be nice because they have to	1
	Honesty will depend upon the individual person and how much they trust others	1
	Only honest people are close friends	1

(*continued*)

Table 1. continued

Question No.	Participants' (n = 20)	Frequency of Occurrence
7.	How would you describe the youth's behaviors in taking turns and staying on topic during a conversation?	
	Girls interrupt to get what they want or to get attention	10
	Some want control over conversation	4
	They don't like to share (turn-take)	2
	Don't normally interrupt (because of checking system)	1
	Will interrupt in uncomfortable situations or switch topics (always trying to think of what to say next)	1
	Have 3 or 4 different conversations going at a time	1
	Depends on the situation/person	1

tors, and participants (Creswell, 1998; Maxwell, 1996; Patton, 1990). Two researchers established consensus in analyzing field notes. Additionally, discussions were conducted with experienced qualitative researchers on interpretations of field notes, codes, and the emerging themes (Bogdan & Biklen, 1992). The second author had a number of experiences with qualitative research and had published one book on qualitative methodology and research design (Creswell, 1998). To further establish verification, he served as a peer reviewer and debriefer by serving as a "devil's advocate."

Throughout the study, data checks were used to establish reliability and credibility. Individual interviews of participants, classroom teachers, counselors, and cottage parents served as data checks to establish credibility and validity (Glesne & Peshkin, 1992; Lincoln & Guba, 1985). It was important to collect information that reflected the feelings and views of the participants as well as the staff who worked with the young people. Thus, 20 surveys of participants' opinions about their peers' communication skills were collected to establish verification of the researchers' observation (Table 1). This feedback provided members information to supplement and confirm the researchers' observational findings. Finally, collecting the data over a five-month period in the youth center provided opportunities to collect rich, thorough descriptions and address criteria of data trustworthiness (Denzin & Lincoln, 1994; Glesne & Peshkin, 1992).

RESULTS

A review of records established that female juvenile delinquents represented many ethnic backgrounds and had histories of violating the law. Many were

Table 2. Categories of Nonverbal and Verbal Codes

Themes	How Themes Emerged
Nonverbal	
Listening and following rules	Youth repeatedly were reminded not to talk, to sit down, or to complete their assignments
	Youth often needed information repeated
	Youth often acted uninterested in information presented
	Examples:
	"I don't know how to do this. Tell me again."
	Following art teacher's simple explanation of a task several students commented, "What do we do?"
	"We just got told to lower our voices."
	Youth continually talk while teachers present instructions
Verbal	
Utterance types	Youth expressed negative opinions and limited emotions
	Youth asked restricted questions to find out about their conversational partners
	Youth asked few questions to clarify information presented in classrooms
	Youth engaged in limited problem solving
Topics of conversation	Topics centered on violence, drugs, or sex
	Many conversations focused on meeting their own wants and needs
	Issues of friendships and belonging were important
	Youth frequently discussed earned privileges
	Infrequent topics about academics and world knowledge
	Examples:
	"I want girls to like me."
	"I wanted to fit in."
	"I wanted to be with my friends more because I thought trouble was fun."
	"She kicks it with Crips."
	"If you want to be treated with respect, you should not get 'sexed' in."
Politeness	Use of name-calling and profanity
	Nonpolite interactions
	Misleading others
	Examples:
	Students use profanity when they do not get their way.
	"I would throw things at my dad."
	Interruptions while teacher is talking.
Conversational management	Limited topic initiation
	Monopolizing discussions
	Poor turn-talking skills

(*continued*)

Table 2. (Continued)

Themes	How Themes Emerged
Conversational management (continued)	Examples: When talking, several girls in a group often talked over each other and interrupted one another: One girl says, "No cussing you girls." "You guys want to play cards?" says another. "Ya, I know," replies a third. "I don't know," says yet another.

within the average range of intellectual functioning and some presented evidence of language and communication problems. School records suggested many had learning problems and histories of maltreatment. In this study 36% of the subjects had learning problems and 63–69% experienced maltreatment. Additionally, many had histories of troublesome backgrounds. Although not addressed in this study, drugs, alcohol, and belonging to a gang were common issues with this culture-sharing population.

Clinical Evaluation of Language Fundamentals—3

The mean score for 78 participants on the Clinical Evaluation of Language Fundamentals—3 was 89.53 ($SD = 15.36$). Examination of participants' composite (CELF-3) on the measure allowed determination of whether any delinquents were potential candidates for special education services as students with language impairments. Performance of at least 1.3 standard deviations (SDs) below the mean on the CELF-3 was taken as an indication of possible language impairment because it was considered by other researchers as a more conservative measure than the criteria of 1 SD of the mean (Lahey & Edwards, 1996). Using this criterion, 17 (21.79%) of the participants were potential candidates for language services. Of those 17 participants, 11 (14.10%) also met the more stringent criterion of performance at least 1.5 SDs below the mean on the CELF-3 composite performance score. Of the 17 participants showing language impairments, 8 had received services for special education, 2 for speech, and none had received language services.

Communication Patterns: Nonverbal Behaviors

Based on consistent behaviors emerging from the coding activities previously described, several themes were apparent. The primary theme observed in nonverbal behaviors involved listening and following rules.

Listening and following rules. Participants demonstrated acceptable listening skills in some structured contexts, but were more likely to violate rules

of listening and following directions if the settings/contexts were not highly structured. Four settings and situations where listening behaviors were observed included the library/study hall, classrooms, group meetings, and free time. In the library/study hall, participants frequently needed to be reminded not to talk, sit down, and work on their assignments. During seven observations it was estimated that one-third of the students at any given time did not use time in study hall to work on class assignments. Instead, participants talked to their peers, drew pictures, stared into space, wrote letters, read the newspaper, looked at magazines, or read books for pleasure. Observations and comments from participants suggested that more than one-half of the participants were not participating in academic tasks related to school.

Participants were unlikely to follow directions unless the directions were repeated more than one time in some classroom settings. For example, more disruptive behaviors and discipline problems were observed in classrooms that lacked clear rules, procedures, and consequences established by the teachers. In some classrooms, participants asked to have the information restated, others asked for clarification of directions, and other simply did not comply with instructions. During classes some acted uninterested and did not complete their assignments.

A contrast in listening and communication behaviors seemed most apparent in art and music classes. The majority of youth positively participated in the activities presented in these latter classes. Observations indicated that many youth had talents in art and vocal music. In addition to these two classes, many appeared to enjoy home economics. They were proud to demonstrate their cooking and sewing projects and interact about their accomplishments. To some extent, the degree of structure and the nature of the specific activity in the three classes influenced whether participants followed rules and appropriately interacted. Overall, however, the participants appeared to enjoy these classes.

Interviews with several teachers indicated that only one-half of the youth at the facility consistently followed directions during classes. Statements in teachers' interviews indicated that they thought the youth hated the word "no" and did not like being told "no." Another teacher remarked they did not like any type of correction. Still another teacher commented, "Delinquent youth are always pushing the limits and it's hard to like those that push the limits. They have trouble understanding what it is like from the teachers' perspective." When presented information that delinquents do not want to hear, "they turn it off." As indicated from Table 1, this information was not contradictory to the reports of the youth. Some delinquent youth admitted that they wanted to be in charge and did not like to be told what to do.

It appeared that participants were more likely to comply with directions if they were interacting with authority figures who could directly influence their release. However, if authority figures were not considered an influence or

threat to their release, youth were more likely to not listen and engage in distracting behaviors. In general, if the authority figure was firm about enforcing rules, youth ceased their inappropriate talking and disruptive behaviors but then often commented they did not like that person.

Although problems of listening and following directions were the prevailing nonverbal communication behaviors observed, other inappropriate actions were also evident. For example, the participants fidgeted, played with their hair, picked scabs, or bit their nails. They sometimes violated the space of others, slouched, put their heads down on their desks or tables, or displayed inappropriate eye contact. Glaring, giving contentious looks, rolling their eyes, and staring off into space occurred but were observed less often. Likewise, inappropriate facial expressions did not appear to be as interruptive to interactions because they did not stop the conversation. Although staff indicated nonverbal behaviors were frequently used to convert intents, these behaviors were difficult to observe due to the rate at which they occurred.

Communication Patterns: Verbal Behaviors

Utterance types. The participants often expressed opinions and feelings through statements, questions, comments, and expansions of statements. Statements commonly heard included:

- "Like I got in a fight, I did drugs, I was there when people were fighting. We were punching each other, like beating people up."
- "My mother and I got in a fight and I hit her twice, because I didn't like what she was saying."
- "I hate school, I was truant. I don't know why I hate school."
- "I hate this book. I cannot read it because I don't like it."
- "I felt people didn't like me."
- "I felt I didn't get a chance to say anything."
- "Because of peer pressure."
- "My friends have a bad influence on me."

From their point of view people don't care about them or give them a chance. One student said, "Parents think we'll contaminate their kids. They (people) don't stop to think that they might hurt our feelings. They just think we're tough kids from the big city."

In classroom settings, students asked few clarification questions from teachers when it appeared they did not understand the vocabulary being used. Our observations suggested students did not know meanings of words such as "fearful," "inquiry," "web," and "theme." We were unable to determine how often delinquents did not understand the information presented in their classrooms, in part, because of our limited observations.

Participants engaged in limited negotiations during conversations. For example, one participant said she ran away because things did not work out in the way that she wanted. In her case, she didn't like the established smoking rules and solved the problem by running away from home. Another participant used profanity to describe why she did not want to work with her peer on a group project.

Topics of conversation. Participants appeared to enjoy talking to individuals who were willing to recognize their strengths, who took the time to interact, and who did not question their behaviors. Almost all of the topics initiated by the participants centered on their problems with past experiences and family members. They also focused on students' own needs, and their wanting to be accepted by friends. Additionally topics were about greetings, trust, boys, and earned privileges. References to violence were frequently included in the topics of their conversations. Many topics and stories initiated by the participants suggested they came from backgrounds where fighting occurred. In some instances the participants claimed one or both of their parents were mean to them during childhood.

Although participants expressed the desire to change, some teenage subjects seemed to be in need of acceptance from their peer group and simply "wanted to belong." It was common to hear the adolescents remark, "I want girls to like me. I would take the blame for others because I wanted them to like me. I didn't want kids to hate me." During group meetings, the adolescents discussed criminal offenses with group members and stated they wanted to "fit in" and belong with their peer group. Hence, in some situations, regardless of the degree of violence in the criminal act, it appeared that the motivation was to "fit in and belong." It appeared that many group members accepted violent behaviors as "cool."

A common topic was the trust involved in their friendships. A number of participants indicated that they trusted their friends more than they trusted their moms. They indicated they could tell their friends anything. One participant remarked, "I don't trust authority. Most authority hurt me when I was little, so it is hard to trust them now."

Participants' conversational topics at the facility usually did not involve information about world knowledge, academics, or even small talk about weather. However, teenagers talked about their educational goals. One participants with a poor academic record claimed, "I'm going to be psychiatrist when I grow up. I like people. I will have my own files." Though they sometimes initiated topics about food, clothes, and personal appearance, many of their conversations involved violence. Frequently, words describing not liking someone, hatred, and profanity were introduced with their topics. Often, violence was a key component when talking about their past experiences, movies, friends, drugs, or even music. Some participants described how they hurt

members of their family or were involved in harmful behaviors towards others. It was common to hear remarks such as, "It (fighting) is all we know. We've grown up this way. My family was fighting a lot."

Politeness. Findings about politeness were contradictory. For example, participants often initiated polite greetings. However, unobtrusive observations and time in the field setting allowed researchers to often hear the teenagers react to day-to-day incidents with name calling, profanity, or nonpolite interactions. Participants openly admitted that if they did not get it their way, they would use profanity. Use of profanity was commonly overheard by the researchers.

Staff expressed mixed reactions about participants' care and concern of others. They acknowledged that in general, delinquent youth tended to base their judgments and reasoning on whether the delinquent teenagers liked a person and were not challenged. Staff were aware that negative behaviors were particularly evident when the teenagers were required to follow rules and did not get their way.

Conversational management. Many subjects could participate in conversational interactions in structured contexts supervised by an authority figure. In less structured settings with fewer rules and regulations, pragmatic violations were sometimes present in the conversational discourse behaviors of delinquent youth. These violations of conversational rules occurred during interactions with both peers and adults. It should be noted that these violations resembled 20 participants' opinions on youths' communication skills (see Table 1). Several concerns were observed in some of the conversational interactional behaviors of participants.

First, the adolescents primarily limited their choices of topics. Most topics were self serving, rather than reflecting an interest in their conversational partner. Second, although they initiated appropriate greetings and established small talk, some did not stay focused on a topic and use appropriate discourse structure. Problems were also apparent with some in sequencing their ideas when they attempted to explain how to play cards or describe any type of event. Topic maintenance was hindered by their limited content of topics.

Third, participants often interrupted their peers and conversational partner in spontaneous interactions. Some individuals dominated and monopolized discussions. This was also observed during their group meetings despite the degree of structure provided in that setting.

From their reports, violations in conversational interactions often occurred because, "We never get what we want, so we do what we want to do. If we run away, we can do whatever we want." One indicated after she was continuously maltreated, put down, unsuccessful in school, and always faced with being told "can't, don't, not, no" she had to take charge. She said it's hard when you think, "Nothing is ever good enough."

Listening to the Participants with Language Problems

Seven of the 17 participants who performed below 1.3 on the CELF-3 were studied more thoroughly. From listening to the participants and analyzing the interviews, a common history of learning and language problems emerged. A review of official school documents at the facility and participants' self reports revealed that none of the 7 teenagers with language problems had been previously identified nor received language services during previous schooling. Additionally, the interviews with 4 of the 7 participants indicated they were two or more years behind in their grade placements. Remarks commonly heard from tape recorded interviews included, "I had memory problems, I could not understand directions unless repeated over and over, information did not make sense, I had trouble understanding some vocabulary, or I couldn't understand what I had read." Five of the 7 young people thought they were slow and could not learn as quickly as their friends. Often we heard comments such as, "I started not liking school in the seventh grade. It got harder to understand. School was frustrating and I just gave up."

One participant remarked,

> I remember telling mom that I was dumb. I didn't do well in subjects like social studies, math, English, or history. My mom had me tested but I did not have any special learning problems. I thought I had a listening problem. I thought I needed information explained to me in different ways. I tried to ask the teacher what she meant by things and sometimes I got in trouble.

This participant started getting in trouble with the law for trespassing by sixth grade.

Comparison of Two Subgroups on Pragmatic Skills

Following extended observations of the young people in which the researchers immersed themselves in the day-to-day lives of the teenage girls (participant observation), questions emerged about the pragmatic skills of study participants. Preliminary research on a small subsample of participants was collected to provide additional information about the teenagers' pragmatic skills. One councilor very familiar with all 14 participants completed the Checklist of Pragmatic Language on each female. Findings indicated there was considerable overlap of the scores and the descriptive comments of the two subgroups. Although the 7 students who performed below 1.3 SD on the CELF-3 scored lower on the 36-item checklists ($M = 109.86$, $SD = 16.04$) than the comparison group ($M = 121.57$, $SD = 17.11$), the sample size was small. Typical observational comments from the councilor about the 7 language impaired youth were: "Very quiet, doesn't speak up, has trouble with words, interrupts, very blunt, immature, and appears scared." Remarks about the 7 controls included:

"Interrupts, doesn't talk much, quite blunt, immature, does not revise messages when misunderstood, does not express feelings appropriately, impatient."

INTERPRETATION OF FINDINGS

Although a high incidence of communication problems has been documented among juvenile delinquents, their communication patterns are not clearly understood. This is particularly evident in their pragmatically-based conversational interactions (Sanger et al., 1999). Clearly, issues involving communication and violence are complicated and involve a number of interwoven factors (American Speech-Language-Hearing Association, 1995). The present findings from on-going observations, interviews, reviews of records at the correctional facility, and the CELF-3 support the claims documented in the technical report published by the American Speech-Language-Hearing Association. Findings also indicate participants expressed two contradictory styles of conversational interactions throughout the study. We propose that these contradictory patterns contribute to the dilemma in understanding the communication behaviors of incarcerated teenagers. Furthermore, these behaviors relate to challenges of determining who is language impaired in this population.

Two Contradictory Patterns of Communication

Although many participants were capable of communicating in an appropriate manner that conformed to societal dictates, the teenagers also engaged in conversations that tended to violate pragmatic rules that govern conversations. For example, in controlled and structured settings, study participants tended to communicate in a manner that appeared to be similar to conversations of adolescents in the general population. The notion that participants' conversational skills did not appear obviously different from peer counterparts (nondelinquents) in the general population was a finding similar to previously reported research from analyzing language samples (Sanger et al., 1997). In that study, there were no differences between the results of language sampling findings between female delinquent and nondelinquent teenagers on pragmatically-based discourse errors when age, culture, and socioeconomic variables were controlled. Researchers in that study suggested that the conversations of the two groups could have been similar due to the structure inherent in the elicitation procedures used in collecting the samples. Findings from the present study support those explanations of the language sample results. In the present study, participants' pragmatically-based communication behaviors tended to be appropriate in structured situations. They also seemed to use acceptable styles of communication when interacting with authority figures.

In structured contexts, the teenagers followed directions, expressed their opinions about their hurtful feelings, asked questions of others, initiated topics

about wanting to "fit in and belong," and participated in conversational interactions. They also enjoyed classes such as art, music, and home economics and tended to have positive communicative interactions in these settings. Norris (1995) points out how the demands of a setting, the participants, and the topics can affect pragmatic interactions. Perhaps these types of classrooms offered a positive learning context that included interesting activities and conversational topics. Hence, in these settings the teenagers interacted in a positive manner.

Alternatively, however, findings from recent research (Sanger et al., 1999), and the present findings provide evidence that delinquents do not consistently engage in best practices of communication deemed appropriate by society. Hence, they often do not listen, follow directions, negotiate, or appropriately interact in conversations. Three data sources including participant observations by researchers, the participants' opinions of their peers' communication skills as noted in Table 1, and interview remarks from staff at the facility, support this conclusion. Although it is important to explore the participants' inappropriate communication patterns, we caution readers that our explanations represent only a few of the possible factors and/or motives that may explain the adolescents' behaviors.

Explanations of Youths' Inappropriate Communication Patterns

A language-based problem. Findings suggest that some, but certainly not all, adolescent delinquents are potential candidates for language services. It is concerning that 22% ($n = 17/78$) of the young people in this study performed 1.3 SDs below the mean on the CELF-3. Language-based problems may represent one explanation and factor that contributes to the inappropriate communication patterns of some participants.

The interviews of seven teenagers who performed below 1.3 SD on the CELF-3, also suggest that some young people experienced a history plagued by language and learning problems. Participants' frustrations with understanding and following classroom directions, vocabulary, and their problems with reading led us to speculate that some adolescents were dealing with the consequences of language problems as well as their criminal offenses. A number of researchers have described the struggle children encounter if they have a history of pervasive language and learning problems (Bashir & Scavuzzo, 1992; Gordon, 1993). Researchers including Cantwell, Baker, and Mattison (1979), point out how children who have language problems that persist throughout school years, continue to experience frustration with school. Other researchers have indicated that children whose language and learning problems are not severe enough to permit them to qualify for special services often experience frustration (Nelson, 1993).

More recently, Simon (1998), illustrated the need for contextual classroom modifications if students experienced problems with language and learning. She described the importance of at-risk students learning metaskills to become more successful learners. In the present research, we questioned whether the learning environments and tasks addressed in classes such as art, music, and home economics offered participants opportunities of success. It appeared that, in these classrooms, students were able to express their talents and accomplishments. Many of the young people appeared to communicate similarly to other adolescents their age when they were in these types of contexts.

The possibility that three times the number of adolescents ($n = 17$) were more likely to be candidates for language services compared to the statistics reported by Larson & McKinley (1995) for youth in the general population presents concerns for SLPs as well as for correctional educators. None had received prior language services. We speculated that some participants were tested but did not qualify for services. Others might have masked their communication problems at school and thus were not provided services. Alternatively, adolescents who performed below 1.3 SD on the CELF-3 could have been seen for services other than language therapy. Recall that 8 of the 17 (47.05%) participants had received special education services and only 3 received services for speech rather than language. Language problems might have been secondary to problems such as psychiatric and behavioral disorders. Ishii-Jordan and Maag (1999) cited a number of publications documenting the co-existence of emotional or behavioral disorders and language disorders among many children. It is possible many participants were only seen for behavioral concerns due to the magnitude of problems their behavior presented in schools.

A final comment is warranted about the young people who experienced language-based problems. Eleven of the 17 participants (64.7%) performing low on the CELF-3 also had documented histories of maltreatment. According to researchers, the harmful effects of maltreatment on communication development can contribute to lack of success adjusting to school, feelings of low self-esteem, and heightened risk for behavior problems (Cicchetti, Toth, & Hennessy, 1989; Coster & Cicchetti, 1993; Culp, Watkins, Lawrence, Letts, Kelly, & Rice, 1991). Although additional findings on maltreatment and communication will be reported in a separate study, it is important to understand the web of complicating factors that contribute to the communication patterns of the participants as well as for many other young teenagers residing in correctional facilities.

Choosing to communicate. A second explanation about the nature of the participants' communication patterns suggests that some were choosing and intending to use inappropriate conversational conventions in their interactions. Even participants' opinions on their peers' communication skills (Table 1), suggests that many could listen, use appropriate body posture, use appropriate

eye contact, be polite, and appropriately participate in conversations if they would and if they wanted to. After prolonged observations of participants at the youth correctional facility, it became apparent that many were choosing when to not listen, follow directions, follow rules, glare at their conversational partner, talk about violence, and use profanity. It was common to observe the young people to not take turns, to interrupt, and to monopolize conversations. This finding is similar to previously reported research conducted by Sanger, Hux, and Ritzman (1999). In that study, the researchers reported that female juvenile delinquents could state many conventions governing conversational interactions and that some of the 45 delinquents in their study openly chose to violate conventions governing conversations.

Interviews with teachers, participants, and the researchers use of participant observation, confirmed that as a culture-sharing group, delinquents "do not like to be told what to do." Teenagers often remarked that they felt the need to be in charge and in control. Perhaps their desire to control and dominate was a reason related to their patterns of interruptions and monopoly of conversations. It was apparent that the participants were keenly aware of authority figures who had influence and power over their release from the facility. Thus, it appeared that youth consistently chose to interact in acceptable styles with these individuals.

Though many subjects to present pragmatically-based communication problems, an alternative explanation is also warranted. The participants could have been displaying behaviors acceptable in dialects of English other than General American English. Researchers address the importance of understanding culture and its relationship to learning and communication (Crawford, 1993). Hence, the present findings must be cautiously interpreted.

In conclusion, it is not always clear whether a language-based problem or another underlying reason or motive unrelated to a language impairment contributes to delinquents' inappropriate communication behaviors. This is an important distinction for SLPs to consider given their existing large caseloads. Hence, issues concerning, assessment, identification, and decisions about who will benefit from language services will continue to present challenges for SLPs and educators. These challenges are exemplified in the overlap of findings of the seven participants who performed low on the CELF-3 and a comparison of seven other teenagers who scored within an acceptable range on this measure. The overlap suggests it is difficult to distinguish which delinquents are in need of language services. Many delinquent teenagers appear to present pragmatically-based performance problems, but that a much smaller number are likely to be language impaired and are potential candidates for language services.

Limitations

Five limitations are related to methodological and sampling issues and limit the findings of the study. First, although the average length of stay of the par-

ticipants was three months, seven days, we had no control over how long they spent at the correctional facility. Hence, some observations of participants were limited. Second, 78 youth volunteered to be in the study and permitted many opportunities for data collection. However, the size of the sample restricted the amount of time we could spend with each participant. Despite this limitation, the number of teenagers in the study allowed us to observe a pattern of communication behaviors over time. Third, data collection was obtained primarily from four contexts (e.g., library/study hall, in classrooms, group meetings, and during free time) within the correctional facility. Whether these findings resemble the participants' communication patterns in community-based settings is not known and hence, generalization of results are restricted. Fourth, data collection on the language skills of these youth was limited by use of a standardized language measure, review of documents, observations, and interviews of the participants. Additional information about the adolescents' language skills from other measures and past school records would have permitted us to draw better conclusions on their histories of speech and language services. Fifth, firm conclusions about the influence of culture on the communication patterns of the participants in this study can not be determined due to the data collected.

IMPLICATIONS AND CONCLUSIONS

Although we wish to be cautious about proposing definitive statements about best practices for juvenile delinquents, our findings suggest that these young people are at-risk for language and communication problems. The percent of teenagers who had undetected language and communication problems presents warning signals for SLPs and educators who deal with these individuals. Despite the fact that this research was conducted in a correctional facility with delinquent youth, many participants were planning to return to their community-based schools following their release. Thus, many SLPs in schools will encounter individuals such as these in their caseloads. The following suggestions point out that SLPs will continue to play an important role with this population.

Identification of which individuals are language impaired and will benefit from services might be complicated. Ideally, we recommended early identification and use of a variety of assessment measures similar to those proposed by Wiig (1995). Curriculum-based assessment measures and language information that relates to vocational skills might also be helpful for many adolescents. A number of researchers have found that self-assessments are useful to plan programs for young people (Reif, 1990; Thomas, 1993; Way, 1995; Wiig, 1995). We also recommend interviewing individuals about their communication, academic performance, and friendships.

Simon (1998) discusses contextual modifications and intervention strategies that are likely to be useful with individuals. Additionally, many other excellent suggestions are available in sources by Nelson (1993), as well as by

other professionals that address the language needs of those who are at-risk but don't quite qualify for language services. Larson and McKinely (1995) present a number of ideas for language intervention with older students that also might be appropriate. Moreover, the present findings suggest one could consider addressing listening skills, following rules and directions, asking questions of others, showing an interest in others, presupposition skills, choosing topics for conversations, and being polite during communicative interactions. Other conversational management skills could include control of interruptions, not monopolizing the conversation, turn taking, and maintaining a topic. Additionally, it might be helpful to address nonverbal communication behaviors. However, it is important to consider that if conversational types of skills are implemented with delinquents, practitioners should consider the students' pragmatic knowledge of rules governing conversational interactions in order that their efforts in intervention result in useful gains rather than information individuals already know (Sanger et al., 1999).

Collaborating with professionals and considering the web of issues connected with communication and violence will be useful for developing a comprehensive intervention program. Providing in-services to teachers or correctional educators on topics of communication and how it affects learning, socialization, behavior, problem solving, and basic life skills might also be useful. Young people involved in violence need to be aware of how communication impacts academics, social interactions, and vocational skills. They need to be aware of the implications of making "smart" choices. Language intervention services could contribute to adolescents attaining their goals of finishing school, establishing friendships, and seeking successful employment.

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REFERENCES

Agar, M.H. (1980). *The professional stranger: An informal introduction to ethnography*. San Diego, CA: Academic Press.

American Speech-Language-Hearing Association (1995). *Communication disorders and violence*. Technical report.

Bashir, A.S., & Scavuzzo, A. (1992). Children with language disorders: Natural history and academic success. *Journal of Learning Disabilities, 25*, 53–65.

Bogdan, R.C., & Biklen, S.K. (1992). *Qualitative research for education: An introduction to theory and methods*. Boston, MA: Allyn & Bacon.

Cantwell, D.P., Baker, L. & Mattison, R.E. (1979). The prevalence of psychi-

atric disorder in children with speech and language disorder: An epidemiological study. *Journal of the American Academy of Child Psychiatry, 18*, 450–461.

Cicchetti, D., Toth, S.L., & Hennessy, K. (1989). Research on the consequences of child maltreatment and its application to educational settings. *Topics in Early Childhood Special Education, 9(2)*, 33–55.

Coster, W., & Cicchetti, D. (1993). Research on the communicative development of maltreated children: Clinical implications. *Topics in Language Disorders, 13*, 25–38.

Cozad, R., & Rousey, C. (1966). Hearing and speech disorders among delinquent children. *Corrective Psychiatry and Journal of Social Therapy, 12*, 250–255.

Crawford, L.W., (1993). *Language and literacy learning in muticultural classrooms*. Boston, MA: Allyn & Bacon.

Creswell, J.W. (1998). *Qualitative inquiry and research design: Choosing among five traditions*. Thousand Oaks, CA: SAGE.

Culp, R.E., Watkins, R.V., Lawrence, H., Letts, D., Kelly, D.J., & Rice, M.L. (1991). Maltreated childrens' language and speech development: Abused, neglected, and abused and neglected. *First Language, 11*, 377–389.

Damico, J.C. (1985). Clinical discourse analysis: A functional approach to language assessment. In C.S. Simon (Ed.), *Communication and classroom success* (pp. 165–203). San Diego, CA: College-Hill.

Davis, A.D., Sanger, D.D., & Morris-Friehe, M. (1991). Language skills of delinquent and nondelinquent adolescent males. *Journal of Communication Disorders, 24*, 251–266.

Denzin, N.K., & Lincoln, Y.S. (Eds.). (1994). *Handbook of qualitative research*. Thousand Oaks: Sage.

Falconer, K.O., & Cochran, J.R. (1989). Communication skills in male institutionalized juvenile offenders. *Rocky Mountain Journal of Communication Disorders, 5*, 45–54.

Fetterman, D.M. (1998). *Ethnography: Step by step* (2nd ed.) Thousand Oaks, CA: Sage.

Glesne, C., & Peshkin, A. (1992). *Becoming qualitative researchers: An introduction*. White Plains, NY: Longman.

Gordon, N. (1993). Learning disorders and delinquency. *Brain and Development, 15*, 169–172.

Hammersley, M., & Atkinson, P. (1995). *Ethnography: Principles in practice* (2nd ed.). New York, NY: Routledge.

Harris, M. (1968). *The rise of anthropological theory: A history of theories of culture*. New York, NY: T.Y. Crowell.

Ishii-Jordan, S.R., & Maag, J.W. (1999). Therapeutic implications for children with emotional or behavioral disorders and concomitant language disorders. In D. Rogers-Adkinson & P. Griffith (Eds.), *Communication disorders and children with psychiatric and behavioral disorders* (pp. 343–366). San Diego, CA: Singular.

Jorgensen, D.L. (1989). *Participant observation: A methodology for human studies.* Newbury Park, CA: Sage.

Kliewer, C. (1998). Citizenship in the literate community: An ethnography of children with Down Syndrome and the written word. *Exceptional Children, 64*, 167–180.

Kovarsky, D. (1992). Ethnography and language assessment: Toward the contextualized description and interpretation of communicative behavior. In W.A. Secord (Ed.), *Best practices in school speech-language pathology* (pp. 115–122). The Psychological Corporation.

Kovarsky, D., & Crago, M. (1990–1991). Toward the ethnography of communication disorders. *National Student Speech Language Hearing Association Journal, 18*, 44–55.

Lahey, M., & Edwards, J. (1996). Why do children with specific language impairment name pictures more slowly than their peers? *Journal of Speech and Hearing Research, 39*, 1081–1098.

Larson, V.L., & McKinley, N. (1995). *Language disorders in older students: Preadolescents and adolescents*. Eau Claire, WI: Thinking.

Leeman, L.W., Gibbs, J.C., & Fuller, D. (1993). Evaluation of a multi-component group treatment program for juvenile delinquents. *Aggressive Behavior, 19*, 281–292.

Lincoln, Y.S., & Guba, E.G. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage.

Maxwell, J.A. (1996). *Qualitative research design: An interactive approach*. Thousand Oaks, CA: Sage.

Maxwell, M.M. (1993). Introduction: Linguistic theories and language interaction. *Language Interaction in Clinical and Educational Settings, 30*, 1–9.

McCracken, G. (1988). *The long interview* (Sage University Paper Series on Qualitative Research Methods, Vol. 13). Newbury Park, CA: Sage.

Miles, M.B., & Huberman, A.M. (1994). *Qualitative data analysis: A sourcebook of new methods* (2nd ed.). Thousand Oaks, CA: Sage.

Nelson, N.W. (1993). *Childhood language disorders in context: Infancy through adolescence*. New York, NY: Macmillan.

Norris, J. (1995). Expanding language norms for school-age children and adolescents: Is it pragmatic? *Language, Speech, and Hearing Services in Schools, 26*, 342–352.

Patton, M.Q. (1990). *Qualitative evaluation and research methods*. Newbury Park, CA: Sage.

Patton, M., & Westby, C. (1992). Ethnography and research: A qualitative view. *Topics in Language Disorders, 12*, 1–14.

Reif, L. (1990). Finding the value in evaluation: Self assessment in a middle school classroom. *Educational Leadership, 47*, 2.

Sanger, D.D., Hux, K., & Belau, D. (1997). Oral language skills of female juvenile delinquents. *American Journal of Speech-Language Pathology, 6*, 70–76.

Sanger, D.D., Hux, K., & Ritzman, M. (1999). Female juvenile delinquents' pragmatic awareness of conversational interactions. *Journal of Communication Disorders, 32*, 281–295.

Semel, E., Wiig, E.H., & Secord, W.A. (1995). *Clinical evaluation of language fundamentals—3*. San Antonio, TX: The Psychological Corporation, Harcourt Brace.

Simon, C.S. (1998). When big kids don't learn: Contextual modifications and intervention strategies for age 8–18 at-risk students. *Clinical Linguistics & Phonetics, 12*, 249–280.

Spradley, J.P. (1980). *Participant observation*. New York, NY: Holt, Rinehart & Winston.

Stricker, L.J. (1988). Measuring social status with occupational information: A simple method. *Journal of Applied Social Psychology, 18*, 423–437.

Tattershall, S. (1988). Checklist of pragmatic language. *The Clinical Connection, 2(2)*, 16.

Taylor, J.S. (1969). *The communicative abilities of juvenile delinquents: A descriptive study*. Doctoral dissertation, University of Missouri, Kansas City, MO.

Thomas, S.O. (1993). Rethinking assessment: Teacher and students helping each other through the "sharp curves of life." *Learning Disabilities Quarterly, 16,* 257–279.

Way, N. (1995). "Can't you see the courage, the strength that I have?": Listening to urban adolescent girls speak about their relationships. *Psychology of Women Quarterly, 19(1),* 107–128.

Westby, C., & Erickson, J. (1992). Epilogue. *Topics in Language Disorders, 12,* 85–87.

Wiig, E.H. (1995). Assessments of adolescent language. *Seminars in Speech and Language, 16(1),* 14–31.

Wolcott, H.F. (1980). How to look like an anthropologist without really being one. *Practicing Anthropology, 3,* 56–59.

CONTINUING EDUCATION

Cultural Analysis of Communication Behaviors Among Juveniles in a Correctional Facility

QUESTIONS

1. Common characteristics of communication behaviors among female juvenile delinquents include all but:
   a. Consistent pattern of pragmatically-based communication behaviors
   b. Contradictory communication patterns
   c. High prevalence of language and learning problems
   d. Possible history of pervasive language problems

2. It is complicated to explain the pragmatical-based communication behaviors of female juvenile delinquents because:
   a. They tend to display pragmatic performance problems for different reasons; some have language-based problems while others appear to choose to inappropriately interact
   b. In some contexts, many communicate like their nondelinquent peers
   c. A number of interwoven problems potentially affects their communication behaviors
   d. All of the above are acceptable explanations

3. Which of the following does not describe the communication behaviors of female juvenile delinquents?
   a. Some but not all female juvenile delinquents have language problems
   b. They present consistent patterns of communicating

c. Some appear to choose to inappropriately communicate
d. A high percent of female youth tend to perform low on the CELF-3

4. Female juvenile delinquents appear to display contradictory conversational patterns while:
   a. Participating in conversations
   b. Following directions and rules
   c. Using polite forms of communication
   d. All of the above are acceptable explanations

5. Based on the present research, many female juvenile delinquents:
   a. Enjoy participating in classes where they have opportunities to be successful
   b. Generally do not have to contend with histories of maltreatment and learning problem
   c. Predominantly represent one specific type of racial/ethnicity group
   d. Like to know the rules and be told what to do

ELSEVIER

EFFECT OF VOWEL ENVIRONMENT ON CONSONANT DURATION: AN EXTENSION OF NORMATIVE DATA TO ADULT CONTEXTUAL SPEECH

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In this study, we investigated the effect of vowel environment on consonant duration in contextual speech produced by adults. Previous studies, such as Schwartz's published in 1969 and DiSimoni's in 1974, of vowel influence on consonant duration have supported the notion of anticipatory scanning in which final vowel targets influence the duration of preceding fricative consonants. These studies were based on repetitions of nonsense syllables by children and adults, but no research has been reported that extends these data to contextual speech or examines speaker gender differences. Forty adult normal speakers (20 women and 20 men) recorded palatal and alveolar fricatives produced in four vowel environments in words embedded in contextual sentences. Results indicated significant effects of vowel context on consonant duration in contextual speech and revealed anticipatory scanning effects that are similar to those seen with nonsense syllables in previous studies. These normative data can form the basis for comparison of the effects of temporal alterations produced by speaking conditions such as simultaneous communication.

Educational Objectives: The reader will (1) acquire knowledge and understanding of the influence of vowels on fricative duration in contextual speech; and (2) understand the relationships among anticipatory scanning, vowel position, and fricative duration.

KEY WORDS: Consonant duration; Vowel context; Anticipatory scanning

INTRODUCTION

Numerous investigations have reported on the effect of consonant environment on vowel duration in spoken English (House, 1961; House & Fairbanks,

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1953; Peterson & Lehiste, 1960). As noted by Smith (1978), it appears that the consonant that follows the vowel affects the durational characteristics of the vowel. For example, vowels preceding voiced consonants are substantially longer in duration than those preceding voiceless consonants (House & Fairbanks, 1953; Peterson & Lehiste, 1960) and vowels are longer in duration when occurring before a fricative consonant than when occurring before a plosive (House & Fairbanks, 1953). In addition, Raphael (1972) and Hillenbrand, Ingrisano, Smith, and Flege (1984) noted that the variations in vowel duration in various consonant environments provide information that is used for the perception of the vowel as well as for the perception of the following consonant. Zimmerman and Sapon (1958) and House (1961) have concluded that these differences in vowel durations reflect a part of the timing system of spoken English.

In contrast, however, the effect of vowel environment on the duration of consonants has been studied to only a limited degree. Schwartz (1969) reported that when women uttered the VCV nonsense syllables /isi/, /asi/, /isa/, and /asa/, the fricative durations were significantly lengthened if the final vowel was the high front vowel /i/ when compared with the durations if the final vowel was the low back vowel /a/. Similar results were reported for the consonant /ʃ/. From these data, Schwartz (1969) suggested the possibility of a forward or anticipatory scanning process during the production of speech. That is to say, he hypothesized that the short fricative duration that was associated with the following vowel as /a/ was due to an earlier consonantal release in anticipation of the greater displacement of the tongue when proceeding from the lingual-alveolar /s/ or lingual-palatal /ʃ/ to the low-back tongue position for the vowel /a/. In contrast, he suggested that the fricative consonant durations were longer for the high-front vowel /i/ because of the reduced displacement of the tongue. Similar trends were reported in the speech of children by DiSimoni (1974), however, the differences were not significant. DiSimoni (1974) speculated that the vowel effect on consonant duration might be smaller in children because the scanning effect might be a developmental phenomenon not fully emerged in the children he studied or because the children had smaller orofacial structures leading to smaller displacement differences between vowels in children than in adults.

Recent research has focused on the effects of various clinical and developmental conditions on similar temporal speech characteristics. For example, Picheny, Durlach, and Braida (1986) showed alterations in temporal speech characteristics such as voice onset time when subjects were “speaking clearly for the hearing impaired,” an experimental condition they created by instructing speakers to talk as though they were trying to communicate clearly with a hearing-impaired listener in a noisy environment. In addition, Whitehead, Schiavetti, Whitehead, and Metz (1995) reported rate decreases and vowel elongation during “simultaneous communication,” a condition in which

speakers use sign language, fingerspelling, and speech at the same time. Also, Swanson, Leonard, and Gandour (1992) demonstrated temporal changes such as vowel duration increases in "parentese," a condition in which parents change their speech and language patterns when speaking to young children. These studies have demonstrated temporal effects such as changes in articulation rate or pause time in these clinical and developmental conditions, but have indicated that such slowed speech generally follows the temporal rules of English.

Analysis of anticipatory scanning effects in these clinical and developmental conditions would provide further evidence of the degree to which speakers do or do not follow important temporal rules of spoken English. In addition, such an analysis may have implications for determining the appropriateness of temporally altered speech as developmental models for normal-hearing and hearing-impaired children. Although the work of Schwartz (1969) and DiSimoni (1974) is informative regarding the anticipatory scanning mechanism, there are several methodological issues that need to be addressed before applying the anticipatory scanning paradigm to temporally altered speech production in these clinical and developmental conditions. The foremost concern is that the experimental conditions under which Schwartz (1969) and DiSimoni (1974) collected their data were quite different from the experimental conditions employed to study speaking clearly for the hearing impaired, simultaneous communication, and parentese. For example, the speech stimuli employed by Schwartz (1969) and DiSimoni (1974) consisted of isolated VCV nonsense syllables spoken three times in repetition, only the influence of two final vowels on fricative duration was investigated, and the numbers of subjects used were relatively small in both studies. Also, Schwartz (1969) used only adult female speakers while DiSimoni (1974) studied primarily male children as subjects.

To study the effect of vowel environment on fricative consonant duration in a manner that would provide meaningful comparison data for clinical and developmental conditions, data should be collected on a larger number of adult male and female speakers in conditions that more closely approximate natural contextual speaking conditions. The recording paradigm should include speakers producing fricatives in words embedded in sentences, with vowel nuclei in the experimental words varied so that the four anatomical extremes of vowel space are represented.

The purpose of the present study was to conduct a normative investigation of the effect of vowel environment on fricative consonant duration in the contextual speech of female and male adults. The durations of alveolar and palatal fricatives preceding four different vowels were examined to study the degree to which anticipatory scanning effects conformed to previous data regarding durational patterns seen for repetitions of nonsense syllables by adults. Such information would strengthen the data base on the existence of an anticipatory

scanning mechanism and provide a background against which clinical and developmental conditions that alter speech rate could be compared.

METHOD

Participants

Participants for this investigation were 40 Caucasian adults: 20 women ranging in age from 19 to 60 years (mean age = 33.95) and 20 men ranging in age from 19 to 58 years (mean age = 39.15 years). All participants passed a hearing screening at 20 dB HL (ANSI, 1989) at 0.5, 1, 2, and 4 kHz; spoke English as their first language; and demonstrated no speech or language disorders when screened by an ASHA Certified Speech-Language Pathologist.

Speech Materials

The speech samples consisted of the carrier sentence, "I can say _____ again clearly" and eight experimental words which varied in the initial fricative and following vowel embedded in the blank slot in the carrier sentence. Two fricatives were studied: alveolar /s/ and palatal /ʃ/ preceding each of four vowels: high front /i/, low front /ae/, low back /a/, and high back /u/. The experimental words included seat, sheet, sat, shack, sock, shock, suit, and shoot.

Recording Procedures

The experimental sentences were spoken at a comfortable conversational loudness level as they were presented on flashcards. Audio-Technica AT-816 microphone that was placed 15 cm from each speakers' mouth and was connected to a Tascam 202MKII tape deck. Half of the female and half of the male participants were randomly assigned to speak the eight words in each of two different random orders.

Acoustic Analysis Procedures

For each speech sample, duration measures in milliseconds were determined for the initial fricative consonant in the experimental word. The acoustic signal from the audio recording of each sentence was digitized with 16 bit precision at 20 kHz using Kay Elemetrics Computerized Speech Lab (CSL Model 4300B). When the digitizing process is initiated, CSL applies an appropriate internal low-pass anti-aliasing filter to the raw acoustic signal. At a digitizing rate of 20 kHz the upper frequency cut-off is 8 kHz, the digital results are stored in memory, and the resultant waveform is displayed on a VGA graphics monitor.

Fricative consonant duration was measured by visually isolating the initiation of the aperiodic waveform following the diphthong /eI/ in the word "say" and marking the location with a cursor. The cursor was then moved to the end of the aperiodic waveform and the temporal interval between the two cursors was taken as the value for fricative consonant duration.

As a measure of intraobserver reliability of the measurement procedure, the recordings of two male and two female speakers were selected at random and all the fricative durations were measured a second time by the same person who made the first measurement. The mean difference between the first and second measures was 2.25 msec (SD = 0.66 msec). This low mean difference indicates adequate intraobserver reliability for these measures.

As a measure of intraspeaker reliability, two male and two female speakers (whose recordings were not analyzed for the intraobserver reliability) were selected at random to record all speech materials twice and the second recordings were digitized on the CSL and measured for comparison to the original recordings. For each speaker, the repeated measures for each token were subtracted from the original measure of each token to examine the absolute value of the difference between the two recordings. For the first female speaker the mean difference was 5.12 msec (SD = 2.15 msec) and for the second female speaker the mean difference was 6.87 msec (SD = 2.36 msec). For the first male speaker the mean difference was 7.61 msec (SD = 3.19 msec) and for the second male speaker the mean difference was 9.12 msec (SD = 3.71 msec). These low mean differences generally indicate adequate intraspeaker reliability for these measures.

RESULTS

Table 1 is a list of the means and standard deviations (SDs) of the durations of the two initial fricatives in each of the four vowel environments for both the female and male speakers. Inspection of Table 1 reveals longer fricative durations preceding high vowels than preceding low vowels and longer fricative durations preceding front vowels than preceding back vowels. Female speakers produced longer fricative durations than male speakers in all vowel environments. A three-way ANOVA (gender by fricative place of articulation by vowel environment) with repeated measures on fricative place of articulation and vowel environment revealed that fricative duration was longer for females than males, $F(1,38) = 7.44$, $p = .01$, and that the effect of vowel environment on fricative duration was significant, $F(3,114) = 139.54$, $p = .0001$. No other main effects or interaction effects were significant. Direct means contrast tests comparing the main effect of vowel environments (collapsed across gender and place of articulation) indicated that the durations of the fricatives preceding each vowel were significantly different from the durations of the fricatives preceding each of the other three vowels.

Table 1. Means and Standard Deviations of the Durations in Milliseconds of Initial Fricatives Alveolar /s/ and Palatal /ʃ/ in Each of the Four Vowel Environments for Adult Female and Male Speakers

	Alveolar Fricative				Palatal Fricative			
	High Front	Low Front	Low Back	High Back	High Front	Low Front	Low Back	High Back
Females								
Mean	214.20	189.90	171.25	203.20	214.35	189.20	178.35	203.35
SD	26.53	30.62	27.92	26.34	23.12	24.67	23.23	20.33
Males								
Mean	196.55	171.50	160.65	184.20	189.70	160.15	152.00	180.75
SD	36.95	25.70	25.89	32.74	26.67	23.13	21.66	26.68

DISCUSSION

The results of this study are consistent with those reported by Schwartz (1969) indicating greater fricative duration before a high front than a low back vowel. In addition, our results demonstrated that fricative duration is influenced by both the height and the anterior-posterior placement of the following vowel: fricative duration was longer before front than back vowels and was longer before high than low vowels. Both of these findings are consistent with Schwartz's (1969) speculation that shorter durations represent an earlier release of the consonant constriction in anticipation of the greater spatial distance that must be covered when moving from the fricative to a low or back vowel.

In addition, these results extend Schwartz's 1969 findings with nonsense syllables to include meaningful words in contextual speech that more closely approximates natural conversational speech. Further research with children is needed to determine if the vowel environment effect that was not significant for children speaking nonsense syllables in the DiSimoni (1974) study would be significant for children using contextual speech. In addition, it would be important to follow DiSimoni's suggestion to investigate whether a developmental pattern exists beyond the age groups that he studied, because the emergence of an anticipatory scanning effect may not develop until after the age of the oldest children studied by DiSimoni (nine years). For example, it might be possible that a developmental emergence of anticipatory scanning may not occur until after children have reached a certain maturity level as evidenced by orofacial growth to some size criterion that might not be reached until after the age of nine.

The finding of longer fricative durations in female than in male speech is interesting in light of recent research on acoustical differences between adult male and female speakers. In addition to the obvious male-female differences in fundamental frequency (Kent, 1997), acoustic differences between male and female adult speakers have been reported to include longer voice onset times for voiced and voiceless plosives spoken by Caucasian and African American

adult females (Ryalls, Zipprer, & Baldauff, 1997) and higher spectral first moments of fricatives and stop bursts spoken by adult women (Nittrouer, 1995).

An important area of current and future research concerns the perceptual consequences of gender differences in these acoustical speech characteristics. For example, Avery and Liss (1996) investigated acoustical characteristics of less-masculine-sounding male speech and found that acoustical correlates of the perception of masculinity included fricative spectral moments, fundamental frequency contours, and vowel formant midpoints. They cited various speculations concerning perception of the dimension of speech masculinity-femininity, including the notion that feminine speech might be characterized by clarity of pronunciation. Avery and Liss (1996) suggested that future research on this issue should follow guidelines set by Picheny, Durlach, and Braida (1986) for analyzing the acoustical characteristics of speech produced clearly for the hearing impaired. They speculated on a number of possibilities for differences between male and female speakers that could explain perception of gender differences, including possible speaking rate differences. Among the various explanations that they discussed was the notion that feminine speech might sound "smooth and fast" for several possible reasons, including the possibility that ". . . decreases in interword pause time, coupled with increases in phoneme durations, may give the impression of smooth and fast speech" [(Avery & Liss, 1996), p. 3739]. The present results and those of Ryalls et al. (1997) indicating both plosive VOT and fricative durations that are longer for females than males suggest that such durational characteristics would be interesting candidates as predictor variables in future research on acoustical correlates of the perception of the dimension of speech masculinity-femininity. The importance of studying these gender differences in acoustical and perceptual speech characteristics in highlighted in a statement by Klatt and Klatt (1990) , that "Women and children have been somewhat neglected groups in the history of speech analysis by machine" (p. 82) and the suggestion of Hanson (1997) that it is important to quantify gender differences in voice characteristics in order to set criteria for generating more natural sounding synthetic male and female speech.

An important implication of this study is that these adult contextual speech data can form the basis for future research concerning the effects of temporal alterations produced by speaking conditions such as parentese, speaking clearly for the hearing impaired, or simultaneous communication. Previous research has considered the temporal changes that occur in these conditions, such as vowel duration increases in parentese (Swanson, Leonard, & Gandour, 1992), rate decreases and vowel elongation during simultaneous communication (Whitehead, Schiavetti, Whitehead, & Metz, 1995), and voice onset time elongation while speaking clearly for the hearing impaired (Picheny, Durlach, & Braida, 1986). In general, these studies have demonstrated effects of speech slowing such as changes in articulation rate or pause times in these

conditions, but have not shown speech changes that reflect violations of the temporal rules of English speech. Comparisons of anticipatory scanning results in these temporal altering conditions would provide further evidence of the degree to which speakers either conform to or violate the temporal rules of English speech under clinical and developmental conditions that alter speech rate. Such data would have important implications for considering the appropriateness of these temporally altered forms of speech as developmental models for both normal-hearing and hearing-impaired children.

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REFERENCES

American National Standards Institute (ANSI). *Specifications for audiometers* (ANSI S3.6–1989). New York: ANSI.

Avery, J.D., & Liss, J.M. (1996). Acoustic characteristics of less-masculine-sounding male speech. *Journal of the Acoustical Society of America, 99*, 3738–3748.

DiSimoni, F.G. (1974). Effect of vowel environment on the duration of consonants in the speech of three-, six-, and nine-year-old children. *Journal of the Acoustical Society of America, 55*, 360–361.

Hanson, H.M. (1997). Glottal characteristics of female speakers: Acoustic correlates. *Journal of the Acoustical Society of America, 101*, 466–481.

Hillenbrand, J., Ingrisano, D.R., Smith, B.L., & Flege, J.E. (1984). Perception of the voiced-voiceless contrast in syllable-final stops. *Journal of the Acoustical Society of America, 76*, 18–26.

House, A. (1961). On vowel duration in English. *Journal of the Acoustical Society of America, 33*, 1174–1178.

House, A., & Fairbanks, G. (1953). The influence of consonant environment upon the secondary characteristics of vowels. *Journal of the Acoustical Society of America, 25*, 105–113.

Kent, R.D. (1997). *The speech sciences*. San Diego, CA: Singular.

Klatt, D.H., & Klatt, L.C. (1990). Analysis, synthesis, and perception of voice quality variations among female and male talkers. *Journal of the Acoustical Society of America, 87*, 820–857.

Nittrouer, S. (1995). Children learn separate aspects of speech production at different rates: Evidence from spectral moments. *Journal of the Acoustical Society of America, 97*, 520–530.

Peterson, G., & Lehiste, I. (1960). Duration of syllable nuclei in English. *Journal of the Acoustical Society of America, 32*, 693–703.

Picheny, M.A., Durlach, N.I., & Braida, L.D. (1986). Speaking clearly for the hard of hearing II: Acoustic characteristics of clear and conversational speech. *Journal of Speech and Hearing Research, 29*, 434–446.

Raphael, L.J. (1972). Preceding vowel duration as a cue to the perception of the voicing characteristics of word final consonants. *Journal of the Acoustical Society of America, 51*, 1296–1303.

Ryalls, J., Zipprer, A., & Baldauff, P. (1997). A preliminary investigation of the effects of gender and race on voice onset time. *Journal of Speech, Language, and Hearing Research, 40*, 642–645.

Schwartz, M.F. (1969). Influence of vowel environment upon the duration of /s/ and /ʃ/. *Journal of the Acoustical Society of America, 46*, 480–481.

Smith, B.L. (1978). Temporal aspect of English speech production: A developmental perspective. *Journal of Phonetics, 6*, 37–67.

Swanson, L., Leonard, L., & Gandour, J. (1992). Duration of function-word vowels in mothers' speech to young children. *Journal of Speech and Hearing Research, 35*, 617–625.

Whitehead, R.L., Schiavetti, N., Whitehead, B.H., & Metz, D.E. (1995). Temporal characteristics of speech produced during simultaneous communication. *Journal of Speech and Hearing Research, 38*, 1014–1024.

Zimmerman, S., & Sapon, S. (1958). Note on vowel duration seen cross linguistically. *Journal of the Acoustical Society of America, 30*, 152–153.

CONTINUING EDUCATION

Effect of Vowel Environment on Consonant Duration: An Extension of Normative Data to Adult Contextual Speech

QUESTIONS

1. According to both Schwartz and DiSimoni fricative duration was longer than before:
   a. The vowel /a/ than the vowel /i/
   b. The vowel /i/ than the vowel /a/
   c. The consonant /s/ than the consonant /ʃ/

d. The consonant /ʃ/ than the consonant /s/
e. None of the above

2. Schwartz suggested a mechanism to explain this vowel influence on consonant duration called:
   a. Motor theory of speech perception
   b. Motor theory of speech production
   c. Anticipatory scanning
   d. Forward coarticulation
   e. Backward coarticulation

3. In the present article, fricative duration was:
   a. Longer for males than female
   b. Longer for females than males
   c. The same for both males and females
   d. Absent of any gender effect
   e. None of the above

4. In the present article, fricative duration was
   a. Longer before front vowels
   b. Longer before back vowels
   c. The same before front and back vowels
   d. Absent of any vowel position effect
   e. None of the above

5. In the present article, fricative duration was
   a. Longer before high vowels
   b. Longer before low vowels
   c. The same before high and low vowels
   d. Absent of any vowel height effect
   e. None of the above

ELSEVIER

EFFECTS OF SPEECH THERAPY AND PHARMACOLOGIC AND SURGICAL TREATMENTS ON VOICE AND SPEECH IN PARKINSON'S DISEASE: A REVIEW OF THE LITERATURE

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The purpose of this review was to examine the different treatment approaches for persons with Parkinson's Disease (PD) and to examine the effects of these treatments on speech. Treatment methods reviewed include speech therapy, pharmacological, and surgical. Research from the 1950s through the 1970s had not demonstrated significant improvements following speech therapy. Recent research has shown that speech therapy (when persons with PD are optimally medicated) has proven to be the most efficacious therapeutic method for improving voice and speech function. Pharmacological methods of treatment in isolation do not appear to significantly improve voice and speech function in PD across research studies. Surgical treatment methods including pallidotomy and deep brain stimulation may be significant treatment options which improve voice and speech function in some persons with PD. Possible explanations for the differential responses to treatment are discussed. Future studies should investigate the effects of combined treatment approaches. Perhaps the combination of pharmacological, surgical and speech treatment will prove superior to treatments combining pharmacological and surgical or pharmacological and speech therapy in improving the communication abilities of persons with PD.

Educational Objectives: The reader will be able to (1) describe the major types of treatments for persons with Parkinson's disease, (2) specify the effects of these treatments on voice and speech functions, and (3) specify possible explanations for differential responses to treatment.

KEY WORDS: Parkinson's Disease; Hypokinetic dysarthria; Treatment effects; Voice and speech

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INTRODUCTION

Parkinson's Disease (PD) is a progressive disease resulting from a reduction in the release of dopamine (DA) within the striatum of the basal ganglia. PD affects 1 in 1000 of the world's population, and symptoms usually appear in both men and women after the age of 50 years (Marsden, 1996). Nearly 1.5 million people in the United States are affected by PD each year and approximately 40,000 new patients are diagnosed every year (Krauss & Jankovic, 1996; Tapper, 1997).

The diagnosis of PD is based on symptoms including tremor, rigidity or stiffness, bradykinesia, akinesia, and postural abnormalities (Manyam, 1997; Marsden, 1996; Stern & Lees, 1990; Tanner & Goldman, 1996). There is often difficulty executing simultaneous or sequential motor programs, indicating impaired motor planning (Marsden, 1982). An example of akinesia in PD is the classic masked face, in which the person with PD appears expressionless and unresponsive.

The characteristics of idiopathic PD differ from those of persons with Parkinson plus syndromes (PPS) such as multiple systems atrophy (MSA) and Shy Drager syndrome. For example, vocal fold abductor paresis and phonatory characteristics including laryngeal stridor, glottal fry, and excess hoarseness were found to differentiate persons with Shy-Drager syndrome and PD (Bassich, Ludlow, & Polinsky, 1984; Hanson, Ludlow, & Bassich, 1983). The response to treatment also differs depending upon etiology. Limb symptoms do not improve to the same extent with Levadopa (L-dopa) in MSA as they do in PD (Fetoni, Genitrini, Monza, Soliveri, Testa, Caraceni, & Girotti, 1997). Therefore, this review of the literature on the voice and speech effects of various treatment techniques will concentrate on idiopathic PD unless otherwise stated.

CHARACTERISTICS OF PARKINSONIAN DYSARTHRIA

PD can affect speech output. In a survey of 460 patients with PD or multiple sclerosis, 70% of the persons with PD indicated that their speech was impaired after the onset of PD (Hartelius & Svensson, 1994). The speech production problem resulting from PD is known as Parkinsonian dysarthria, or hypokinetic dysarthria. Characteristics of hypokinetic dysarthria include: monotonous and reduced pitch and loudness, variable rate, short rushes of speech, imprecise consonants, and a breathy and harsh voice (Canter, 1963, 1965a, 1965b; Darley, Aronson, & Brown, 1969a, 1969b). Each of the speech production subsystems, respiration, phonation, articulation, resonance, and prosody may be affected in hypokinetic dysarthria (Swigert, 1997). The particular degree of impairment of each of these speech subsystems has a direct effect on how persons with PD convey their meaning during communication.

The respiratory system is affected in PD. During speech breathing, persons with PD have smaller rib cage volumes and larger abdominal volumes when

initiating breath groups, suggesting inadequate amounts of air reach the vocal tract during speech (Solomon & Hixon, 1993). Some persons with PD have lower oral pressures during CVC productions (Netsell, Daniel, & Celesia, 1975; Solomon & Hixon, 1993). Their ability to sustain prolonged vowel phonation has been reported to be impaired (Boshes, 1966; Canter, 1965a; Mueller, 1971). However, Fox and Ramig (1997) reported that there was no statistically significant difference in the vowel prolongation time of participants with PD and healthy comparison participants.

Persons with PD also have variations in speaking rates compared to control speakers (Boshes, 1966; Canter, 1963). Both faster than control speaking rates and slower than control speaking rates have been observed in individual persons with PD (Canter, 1963; Metter & Hanson, 1986). Such a wide range of speaking rates often makes group comparisons statistically non-significant, another frequent finding (Caligiuri, 1989; Ludlow, Connor, & Bassich, 1987; Pitcairn, Clemie, Gray, & Pentland, 1990).

Some of the discrepancies observed in these studies can be attributed to the particular speech samples used. Several studies have noted differences in the performance of persons with PD dependent upon the type of task used to assess impairments (e.g., Connor & Abbs, 1991; Ho, Bradshaw, Cunnington, Phillips, & Iansek, 1998). There may be a difference in speaking rate for persons with PD based on whether they are reading or whether they have to generate speech as in conversation or picture description (Schulz, Greer, & Friedman, 1998). Furthermore, speaking rate measures may differ depending on whether the measure includes pauses. Several studies have found persons with PD produce fewer words, spend less time producing speech per breath group, have a more rapid speech rate between pauses, and/or have longer and more frequent pauses (Hammen & Yorkston, 1996; Metter & Hanson, 1986; Pitcairn et al., 1990; Solomon & Hixon, 1993). These phenomena, in conjunction with articulatory undershoot, may give rise to the perception of "acceleration of speech" (Netsell et al., 1975). Although most research has demonstrated longer pause durations in persons with PD, some studies have not found a difference in pause durations between persons with PD and control participants (Canter, 1963; Volkmann, Hefter, Lange, & Freund, 1992).

Hypokinetic dysarthria also affects the phonatory system. The majority of persons with PD experience reduced vocal loudness. For example, vocal sound pressure level (SPL) in persons with PD has been shown to be statistically significantly lower (by 2.0–4.0 dB SPL) during speech and voice tasks as compared to age-matched control subjects (Fox & Ramig, 1997). In an analysis of the speech of persons with PD before undergoing surgical intervention, over half had diminished vocal loudness, with voices ranging from weakly to barely audible (Buck & Cooper, 1956). Persons with PD also exhibit difficulty achieving low-intensity phonation without going to the level of a whisper (Boshes, 1966; Canter 1965a), and they have a reduced ability to

produce a loud voice when asked (Canter, 1965a). Interestingly, persons with PD can increase their vocal volume when conversing with persons who are greater distances from them but do so to a lesser degree than persons without PD (Ho, Iansek, & Bradshaw, 1999). This suggests that volume regulation may be reflexively intact in persons with PD but that they are still unable to voluntarily control the "gain" of their speech.

Laryngeal abnormalities in the form of bowed vocal cords and an abnormally large glottic aperture during phonation have been found to accompany those with PD (Hanson, Gerratt, & Ward, 1984; Smith, Ramig, Dromey, Perez, & Samandari, 1995). This results in incomplete approximation of the vocal cords, thus decreasing vocal loudness. Laryngeal dysfunction in the form of breathiness, hoarseness, roughness, and tremulousness often occurs in hypokinetic dysarthria (Logemann, Fisher, Boshes, & Blonsky, 1978). Laryngeal tremor and abnormalities in vocal fold phase closure and phase symmetry were frequently observed in persons with PD (Perez, Ramig, Smith, & Dromey, 1996) which may account for the perceptual findings of Logemann et al. (1978). Reduced amplitude and firing rates of one of the major vocal fold adductor muscles, the thyroartenoid, have been reported (Baker, Ramig, Luschei, & Smith, 1998; Luschei, Ramig, Baker, & Smith, 1999) which may also contribute to reduced vocal loudness frequently accompanying PD.

Buck and Cooper (1956) reported that some patients had equally affected phonation and articulation. Imprecise articulation in hypokinetic dysarthria often affects the stop consonants (Ackermann & Ziegler, 1991; Canter, 1965b; Forrest, Weismer, & Turner, 1989), but it has also been reported that 45% of persons with PD exhibit misarticulations affecting affricates and fricatives (Logemann & Fisher, 1981). One manifestation of the imprecise articulation is the impaired ability of persons with PD to perform diadochokinetic tasks such as rapid movements of the lips, tongue tip, and back of the tongue required for /pa/, /ta/, /ka/, and /pataka/ repetitions (Canter, 1965b; Connor, Ludlow, & Schulz, 1989; Hirose, Kiritani, Ushijima, Yoshioka, & Sawashima, 1981).

The resonatory system may also be affected by hypokinetic dysarthria. For instance, Logemann et al. (1978) reported that some of their subjects exhibited hypernasality. An examination of the resonatory system of persons with PD revealed that some persons with PD are perceived as hypernasal due to inadequate velopharyngeal closure (Hoodin & Gilbert, 1989). Although hypernasality has been perceived in some persons with PD, it is not considered a hallmark of the speech disorder.

Hypokinetic dysarthria also affects the prosodic aspects of speech. Prosody of speech can be defined as " . . . the patterned distribution of stress, intonation, and other phonatory features in speech" [(Scott, Caird, & Williams, 1985), p. 13]. Characteristics of the prosodic aspects of hypokinetic dysarthria include monoloudness, reduction of stress, and monopitch. Canter (1963,

1965a) documented significantly higher pitch levels and reduced pitch range for persons with PD. In a study of the production and perception of speech prosody, persons with PD were found to be poorer than controls in identifying and producing angry and questioning statements (Scott, Caird, & Williams, 1984).

The patterns of hypokinetic dysarthria that exist in persons with PD are highly variable. These variations may be dependent upon disease severity, dysarthria severity, task type, co-existing conditions, and/or specific neurological substrate affected. There is a general belief that hypokinetic dysarthria severity increases with increased duration of PD and/or with increased severity of limb symptoms. However, there appears to be little correspondence between dysarthria severity and duration of PD nor severity of limb symptoms (Gamboa, Jimenez-Jimenez, Nieto, Montojo, Orti-Pareja, Molina, Garcia-Albea, & Cobeta, 1997; Metter & Hanson, 1986; Schulz, Greer, & Friedman, in press).

The existence of other co-occurring symptoms such as dementia and/or depression may also account for the variability observed in the speech of persons with PD. It is now recognized that there is a significant subgroup of persons with PD who may also have dementia and the prevalence of dementia in PD is approximately 15–32% (Brown & Marsden, 1984, Wallin, Jennersjo, & Granerus, 1999). This subgroup may not have been differentiated in some studies and thus could have accounted for variations in patterns of hypokinetic dysarthria. In addition, a significant number of persons with PD also suffer from depression and the degree of depression has not been found to correlate with PD severity (Poewe & Luginger, 1999). The presence of depression and/or dementia has now been recognized as possible confounding factors that may affect speech production measures as evidenced by exclusion criteria in several recent studies [e.g. (Ramig, Countryman, Thompson, & Horii, 1995a; Schulz, Peterson, Sapienza, Greer, & Friedman, 1999)].

Another possible explanation for the hypokinetic dysarthria variations and the lack of correspondence between limb and speech symptoms might be differences in the underlying neuropathophysiology of the disease across individuals and systems. For example, the basal ganglia are somatopically organized into separate “leg,” “arm,” and “face” regions in a similar manner as that of the primary sensory and motor cortices (Alexander, Crutcher, & DeLong, 1990; Alexander, DeLong, & Strick, 1986). These areas could well be differentially affected in individuals with PD and thus give rise to differences observed between limb and speech symptoms. In addition, depletion of DA may be differentially affected across various basal ganglia-thalamus-cortex motor loops thus giving rise to differences observed within limb and speech motor systems.

Clearly, studies employing larger sample sizes with participants who exhibit a wide range of speech and limb symptoms with well-controlled inclu-

sion criteria are needed to aid in defining similarities and differences in the patterns of hypokinetic dysarthria. As will become apparent, there are discrepancies in the literature regarding the efficacy of different forms of treatment for the speech system in persons with PD. Such differences in treatment response may also be attributable to differences such as dysarthria severity, task used to assess treatment, co-occurring conditions, and/or specific neurological substrate affected as discussed above.

TREATMENT APPROACHES FOR PARKINSON'S DISEASE

The purpose of this study was to examine how different treatment approaches affect the voice and speech of persons with PD. Treatment methods include speech therapy, pharmacologic, and/or surgical. Recent speech therapy methods include treatments that utilize various therapeutic devices, treatment that targets prosodic aspects of speech and the Lee Silverman Voice Treatment (LSVT). Pharmacological treatment methods include those that replace DA and DA agonists; surgical treatment methods include thalamotomy, pallidotomy, fetal cell transplantation (FCT), and deep brain stimulation (DBS).

SPEECH THERAPY IN PARKINSON'S DISEASE

Between the 1950s and 1970s, there was not much confidence in the effectiveness of speech therapy for persons with PD. Morley (1955) suggested that the goal of rehabilitating the speech mechanism in dysarthric adults was to regain or obtain effective movements of the articulators used for speaking. However, he felt that this approach did not apply to individuals with paralysis agitans (PD) since it is a progressive and irreversible disease (Morley, 1955). Sarno (1968) also believed that individuals with PD did not improve with treatment. In observing the treatment of over 300 persons with PD who had various speech treatments (controlling intensity, improving articulatory mobility, improving articulation), Sarno concluded that "Often they [the patients] are impressively improved during the treatment session only to revert to the pathologic patterns immediately after" [(Sarno, 1968), p. 274)]. Furthermore, some believed that because persons with PD' speech continually deteriorates, PD patients would always need treatment (Allan, 1970).

Some of the recent research has focused on the use of therapeutic devices for treating those with hypokinetic dysarthria. These devices include a voice amplifier, delayed auditory feedback (DAF), a wearable intensity biofeedback device, and a masking device. Voice amplification increases vocal loudness thus relieving any anxiety a person with PD may have if he or she was previously not audible to others. Another benefit of voice amplification was to increase self-monitoring of speech intensity (Greene & Watson, 1968). Intelligibility was not directly assessed, although the authors stated that intelligibility

was improved. Instead of focusing on one aspect of speech production, the goal of the DAF device was to improve the patients' overall intelligibility (Downie, Low, & Lindsay, 1981). Two out of 11 subjects showed marked improvement in speech intelligibility. These two subjects demonstrated a "festinating speech difficulty" [(Downie et al., 1981), p. 852]. One of these patients continued to wear the DAF device for two years and still showed improved speech intelligibility. In a three-month study of two persons with PD, increases in relative vocal loudness and fundamental frequency as well as a marked reduction in speech rate were reported with use of the DAF device (Hanson & Metter, 1983).

In a case study, a microcomputer-based wearable biofeedback device was used to generalize a patient's vocal loudness outside the clinic (Rubow & Swift, 1985). The device provided the person with PD with information about intensity that was usually only available during treatment in the clinic. Acoustic and perceptual analyses were performed on his voice pre- and post-treatment, showing generalization of clinic improvement to his daily life while wearing the device. This suggests that biofeedback, or behavioral modification, is effective in treating individuals with PD as long as the device is worn.

The masking device has been used to improve persons with PD' vocal loudness (Adams & Lang, 1992). This device is based on a phenomenon known as the "Lombard effect," in which most individuals increase their vocal loudness when speaking in the presence of masking noise. A significant increase in vocal loudness was demonstrated in 10 out of 10 persons with PD under the masking condition compared to speaking without masking noise. There was no report of the results of a follow up evaluation or whether this vocal loudness level generalized outside of the clinical setting. These results further indicate that persons with PD can reflexively increase their vocal intensity, as was demonstrated by Ho et al. (1999) but that under "normal" conditions, they cannot voluntarily control the "gain" in their volume.

Today, many individuals with reduced vocal loudness resulting from PD seek speech therapy from a certified speech-language pathologist. In the 1980s, speech therapy for persons with PD was initially centered on the prosodic aspects of speech, sometimes including other areas of speech (i.e., respiration, articulation, etc.); today it focuses on the voice itself (i.e., vocal loudness). The research on speech therapy during the 1980s and 1990s refutes the pessimism of Morley (1955), Sarno (1968), and Allan (1970).

One early report of successful speech therapy techniques targeted respiratory exercises (Erb, 1973). Three persons with PD were given several breathing exercises along with oral speech and non-speech exercises for 30 minutes three times per week. All three were subjectively said to improve in intelligibility but improvement was noted to be inconsistent over time. Prosodic exercises were initially used in the realm of speech therapy for persons with PD (Scott & Caird, 1983). Scott and Caird (1983) examined the effects of pro-

sodic exercises as well as their visual reinforcement via a Vocalite machine. Subjects significantly improved speech intelligibility and prosody for up to three months after treatment. The visual reinforcement device, however, appeared to only greatly benefit those with the most severe speech disorder. The long-term effects of intensive speech therapy focusing on prosody were also examined (Robertson & Thomson, 1984). Therapy targeted respiration, pitch variation, vocal loudness, articulation, strength and speed of the articulators, rate of speech, intonation and stress patterns, and communication intelligibility. Results revealed improvement in almost every aspect of speech (respiration, phonation, intelligibility, prosodic aspects of stress, intonation, and rate), as well as the ability to maintain these improvements for up to three months following the intensive treatment.

The effects of less intensive speech therapy on persons with PD were also examined (Johnson & Pring, 1990). In lieu of giving therapy to each patient for 35–40 hours over 2 weeks (Robertson & Thomson, 1984), 10 hours of treatment was given over 4 weeks. Therapy focused on improving two prosodic aspects of speech: vocal loudness and pitch, during spontaneous speech and reading tasks. Patients demonstrated objective improvement in these areas, indicating that therapy was beneficial. No follow-up measures were noted. Three prosodic aspects of speech in a woman with Parkinsonian dysarthria were also examined (Le Dorze, Dionne, Ryalls, Julien, & Ouellet, 1992). These aspects included linguistic modulation of fundamental frequency, mean fundamental frequency, and rate of speech. The results of the study revealed that the patient benefited from speech therapy in that she had more normal prosody and greater speech intelligibility. It was also noted that the patient's improvement was maintained 10 weeks post-treatment.

As stated previously, the current primary focus in speech therapy for individuals with hypokinetic dysarthria is vocal loudness. The most recent and efficacious therapy of this type is known as the Lee Silverman Voice Treatment (LSVT), which was developed by Ramig et al. (Ramig, Bonitati, Lemke, & Horii, 1994). The LSVT focuses on increasing both respiratory effort and vocal fold adduction. The combination of these entities is necessary in order to increase vocal loudness in individuals with PD (Ramig & Dromey, 1996). The five essential concepts of the LSVT include focusing on loudness, using increased effort, having an intensive treatment regimen, calibration, or knowing and accepting the amount of effort needed to increase vocal loudness consistently, and quantification, or measuring the patient's performance to increase motivation (Ramig, Pawlas, & Countryman, 1995b). Patients are given vocal loudness exercises such as maximum duration of sustained vowel phonation, maximum fundamental frequency range, and maximum functional speech loudness drill (Ramig et al., 1995b). The LSVT has been proven to be a successful long-term (12 months post-treatment) form of treatment in large numbers of participants (45) for increasing vocal loudness when compared to ther-

apy targeting respiratory effort only (Ramig, Countryman, O'Brien, Hoehn, & Thompson, 1996; Ramig, Countryman, Thompson, Horii, 1995a). Not only does LSVT improve vocal loudness, but it also decreases the negative impact of PD on communication (Ramig et al., 1995a). The LSVT also has a positive impact on intelligibility, pitch variability, phonatory stability, rate, and vocal fold adduction (Dromey, Ramig, & Johnson, 1995; Ramig et al., 1995a; Smith et al., 1995).

Although speech therapy may not have been effective in the past, current speech therapy techniques have proven efficacious in contributing to greater speech intelligibility in persons with PD. The successful speech therapy treatments, it should be noted, were performed on persons with PD who were also receiving pharmacologic treatment(s). For example, the participants in the LSVT studies were reported to be optimally medicated with dopamine replacement medications (L-dopa).

PHARMACOLOGICAL TREATMENT METHODS

Many different drugs have been developed to treat PD. Some of these medications enhance (DA agonists) or replace (L-dopa) the DA that is no longer present in the brain of persons with PD. Adjunctive treatments to these medications include: anticholinergic agents, monoamine oxidase-B (MAO-B) inhibitors, and catechol-*O*-methyl transferase (COMT) inhibitors (Calne, 1994; Tolosa & Valldeoriola, 1994).

Anticholinergic agents are the oldest form of pharmacotherapy for PD. They act to reduce tremor by blocking the action of acetylcholine (ACh), which is predominant due to the deficiency of DA (Stern & Lees, 1990). The goal in turn is to create a balance between both neurotransmitters. Two common anticholinergics are trihexyphenidyl (Artane) and benztropine (Cogentin). Little improvement has been noted in the speech of persons with PD following the use of anticholinergics. When comparing Artane to a placebo, objectively, little significant effect on overall speech was found, but subjectively, maximum intensity speech range and speaking rate ". . . showed a tendency toward significant improvement" [(Brumlik, Canter, De La Torre, Mier, Petrovick, & Boshes, 1964), p. 431]. Little improvement in articulation followed the administration of anticholinergic agents (Critchley, 1981).

MAO-B inhibitors such as selegiline (Deprenyl) inhibit the degradation of DA and may prolong the antiParkinsonian action of L-dopa. COMT inhibitors such as tolcapone (Tasmar) also increase the length of time that L-dopa is effective (Jankovic & Marsden, 1993). Selegiline has been shown to improve speech in both subjective and objective measures of articulation and respiration (Shea, Drummond, Metzer, & Krueger, 1993). Articulatory improvements were noted in rate and range of oral motor diadochokinesis; respiratory improvements were noted in measures of vital capacity and words per exhala-

tion during speech reading (Shea et al., 1993). On the other hand, deprenyl was shown to have no consistent affect on acoustic measures of speech in persons with early PD who were not taking L-dopa (Stewart, Winfield, Hunt, Bressman, Fahn, Blitzer, & Brin, 1995).

L-dopa, first introduced in 1968, acts to replenish DA levels in the brain. Combining L-dopa with carbidopa produces Sinemet the principle medication for treating PD. Carbidopa prevents L-dopa from converting into DA before crossing the blood-brain barrier. Short-term side effects include dyskinetic and involuntary movements, orthostatic hypotension, and nausea (Marsden & Parkes, 1977). An effect termed the "on-off" phenomenon occurs after several years of DA replacement treatment. After years of L-dopa therapy, the motoric improvements of the "on" period begin to wane and become shorter in duration, and the person with PD becomes "disabled" due to the prolonged reappearance of Parkinsonian symptoms during the "off" period (Marsden & Parkes, 1977). Many patients become akinetic and experience postural instability during the "off" period. These "on-off" swings gradually become more rapid and violent, increasing the patient's need for L-dopa. This may be due to the inability of L-dopa to convert to DA or the limited space available for DA storage and release by diminishing dopaminergic neurons (Rabey, 1995).

Findings appear to show a general trend in improvement of speech production through the use of L-dopa. Though speech improvement was not found to be as dramatic as limb symptoms, subjectively, " . . . there appeared to be a trend in the direction of improved speech during L-dopa therapy" [(Rigrodsky & Morrison, 1970), p. 142]. This trend was observed subjectively in spontaneous speech as well as in oral reading by evaluating overall speech adequacy, clarity of articulation, normalcy of nasal resonance, and temporal aspects of speech (rate, pauses, and rhythm). During the oral reading task, rate, pauses, and rhythm were observed as the most improved (Rigrodsky & Morrison, 1970). In another study, the speech of most persons with PD became more intelligible after L-dopa treatment, primarily as a result of improved vocal loudness (Mawdsley & Gamsu, 1971). Although the rate of speech did not show change in this study, the tendency for a more regular distribution of both speech time and pauses was noted after L-dopa treatment, thus increasing intelligibility (Mawdsley & Gamsu, 1971).

Physiological studies have concentrated on measuring labial kinematics and muscle recordings as a function of L-dopa medication. In a study of labial kinematics related to speech intelligibility, after the administration of L-dopa, labial movement tracings showed a shorter period of time between the initiation of labial movement and speech, and increased speed and symmetry of labial activity (Nakano, Zubick, & Tyler, 1973). Nakano et al. (1973) also reported that 16 out of 18 persons with PD subjectively felt that their speech had improved as compared with procyclidine or placebo. Labial pressures in speech and non-speech tasks also tended to improve following L-dopa admin-

istration (Cahill, Murdoch, Theodoros, Triggs, Charles, & Yao, 1998). In another study, electromyographic recordings of labial muscles revealed tonic hyperactivity before taking L-dopa, which decreased after taking this medication (Leanderson, Meyerson, & Persson, 1971). This suggests that L-dopa normalized the neuromotor control of labial muscular activity, which may have contributed to the subjective improvements observed in six out of seven patients' hypokinetic dysarthria (Leanderson et al., 1971). Although labial rigidity may continue to decrease throughout the drug cycle, Caligiuri and Abbs (1986) found that movements of lips did not change in a parallel fashion. This may mean that while rigidity improved, reduced motor drive to labial muscles may still have been a factor preventing improvement in labial movement.

Short-term and long-term effects of L-dopa on speech production have also been examined. Short-term L-dopa therapy "has a favorable influence upon" Parkinsonian dysarthria in the form of improved voice quality, pitch variation, and articulation as measured subjectively [(Wolfe, Garvin, Bacon, & Waldrop, 1975), p. 277]. After four years of L-dopa treatment, subjective observations revealed that 75% of persons with PD either maintained or improved over their initial improvement in speech when comparing results to those variables examined in the short-term study (Wolfe et al., 1975).

Other and more recent studies have not shown a positive impact of L-dopa on speech production. For example, subjective improvement was not noted in speech following L-dopa therapy (Quaglieri & Celesia, 1977) and there have been reports from neurologists of "peak-dose dysphonia" noted (Critchley, 1976). More recent studies have shown no difference in acoustic measures in persons with PD in the "on" or "off" state. Persons with PD had lower intensity, lower variability of fundamental frequency and intensity, and greater degrees of whisperiness and harshness in both the "on" and "off" states as compared to healthy control subjects and these measures did not change between the "on" and "off" state (Daniels, Oates, Phyland, Feiglin, & Hughes, 1996). Additionally, Poluha, Teulings, and Brookshire (1998) demonstrated no significant change in acoustic measures of vowels in ten persons with PD across their L-dopa drug cycle. Likewise, Solomon and Hixon (1993) failed to find significant differences in speech breathing measures as a function of the L-dopa drug cycle. Finally, no differences in vocal stability measures (amplitude and frequency pertubation) nor in indirect vocal fold movement measures (electroglottograph) were demonstrated across changes in drug cycles in two persons with PD (Larson, Ramig, & Scherer, 1994).

Such discrepancies in voice and speech function reported following L-dopa treatment might be attributable to participant related differences across studies. For example, studies may differ in other medications that participants may have been taking and/or there may be differences in dysarthria severity of participants in various studies. Measures of vocal intensity (Schulz et al., in press) and speech duration (Schulz et al., 1998) have been found to differ as a

function of dysarthria severity. The studies reviewed did not account for possible differences in dysarthria severity.

Dopamine agonists enhance DA levels in the brain. These include apomorphine, bromocriptine (Parlodel), lisuride, pergolide (Permax), cabergoline, quinpirole, ropinirole (Requip), and pramipexole (Mirapex). DA agonists are often taken during the "off" periods to enhance the supply of L-dopa or to prolong the effect of DA (Tolosa & Valldeoriola, 1994). For example, as assessed by the Unified Parkinson Disease Rating Scale (UPDRS), Mirapex improved the motor function of persons with PD during "on" and "off" periods as well as decreased the time spent in and reduced the severity of "off" periods (Lieberman, Ranhosky, & Korts, 1997). DA agonists may also be used to delay the beginning of L-dopa therapy (Piccoli & Riuggeri, 1995). Although they all have different pharmacological properties, all DA agonists stimulate D2 receptors (Calne, 1994). D2 receptors are highly specialized DA receptors in the brain. DA agonists have been shown to improve motor symptoms in persons with PD; however, their effects on speech have not been reported.

SURGICAL TREATMENT METHODS

Surgical intervention is another form of treatment for individuals with PD. The following types of surgery have been performed in order to reduce Parkinsonian symptoms: thalamotomy, pallidotomy, transplantation (i.e., fetal cell), and deep brain stimulation.

Thalamotomy

The surgical procedure known as thalamotomy consists of lesioning the ventralis intermedius (VIM) of the ventrolateral thalamus (Grossman & Hamilton, 1993). This is accomplished with a technique known as stereotactic surgery, in which " . . . a thin probe is delicately inserted into the brain through a hole in the skull" [(Stern & Lees, 1990), p. 36]. This method has produced a significant reduction of contralateral tremor and rigidity for persons with PD (Tasker, Lang, & Lozano, 1997) and is used to treat severe drug-resistant Parkinsonian tremor (Tasker, Siqueira, & Hawrylyshyn, 1983).

Speech has not been shown to improve postoperatively after VIM thalamotomy, it has shown some evidence of deterioration after the procedure and as PD progresses (Tasker et al., 1983). Those persons with PD who had thalamotomy were more dysarthric than those who had not had surgery (Quaglieri & Celesia, 1977). Unilateral operations of the thalamus in the individual's dominant hemisphere were more likely to produce speech disturbances such as dysarthria, monotonous voice, slow speech (Jenkins, 1968), and decreased vocal loudness and articulation difficulties (Allan, Turner, & Gadea-Ciria, 1966) than operations in the non-dominant hemisphere. Initiation of speech, mainte-

nance and control of speech, fluency, and vocal loudness were disturbed in VIM thalamotomy in either hemisphere (Petrovici, 1980), and diminished loudness, dysarthria, and dysphasia were present after lesioning the ventral lateral thalamus (Bell, 1968).

Bilateral thalamotomy is performed to relieve bilateral tremor and rigidity (Grossman & Hamilton, 1993). Speech problems resulting from bilateral thalamotomy include persistent worsening of dysarthria (Tasker et al., 1983), word blocking, slow speech, and hypophonia (Matsumoto, Asano, Baba, Miyamoto, & Ohmoto, 1976). Jenkins (1968) reported that persons with PD were less likely to have speech disturbances in bilateral operations whose less impaired side was performed first; Allan et al. (1966) reported that bilateral operations in which the left hemisphere lesion was performed before the right hemisphere lesion more commonly produced dysarthria than vice versa. L-dopa and carbidopa therapy failed to significantly improve speech of persons with PD who had recently undergone unilateral or bilateral thalamotomy (Quaglieri & Celesia, 1977).

Posteroventral Pallidotomy

The surgical procedure known as posteroventral pallidotomy (PVP) involves lesioning the globus pallidus internus (GPi) of the basal ganglia. Under normal conditions, DA is found in high concentrations in the corpus striatum. For persons with PD, DA input into the corpus striatum is depleted, resulting in overactivity of the GPi, which is inhibitory to the thalamus and brainstem (Eller & Dan, 1997). Lesioning the GPi thus causes the release of inhibition to the thalamic and brainstem motor centers. This lesion may improve all major Parkinsonian symptoms, including bradykinesia (Grossman & Hamilton, 1993; Laitinen, Bergenheim, & Hariz, 1992). Another benefit of PVP is that antiParkinsonian medications can be reduced. During the late stages PD, PVP significantly decreases L-dopa-induced movement disorders and "off"-periods (Lang, Lozano, Montgomery, Duff, Tasker, & Hutchinson, 1997).

Few investigators have examined the effects of PVP on Parkinsonian dysarthia. After undergoing neurosurgical intervention in the form of anterior choroidal occlusion or chemopallidectomy, the speech of persons with PD did not subjectively improve (Buck & Cooper, 1956). They suggested that ". . . improvement in speech should not be a prime goal in selecting patients for surgical treatment of Parkinsonism" [(Buck & Cooper, 1956), p. 1290]. One study showed that bilateral PVP resulted in similar speech ratings on the UPDRS as did unilateral pallidotomy (Iacono, Lonser, & Kuniyoshi, 1995).

More recently, Barlow et al. (Barlow, Iacono, Paseman, Biswas, & D'Antonio, 1998) reported on labial force production and stability and aerodynamics following bilateral PVP. They found that 45–55% of their 11 subjects had significantly reduced labial force instability and peak and average rate of la-

bial force recruitment during non-speech tasks. Additionally, some of their subjects exhibited translaryngeal airflow and intraoral pressures that were more like control subjects during consonant vowel consonant (CVC) syllable repetitions. Interestingly, the distribution of voice onset time (VOT) remained unchanged in one of these patients. They concluded that bilateral PVP might reflect a ". . . global rescaling of neural inputs or concomitant adjustments in muscle stiffness among muscle subsystems of the vocal tract" [(Barlow et al., 1998), p. 150].

Research is presently being conducted on the effects of voice and speech following PVP. Preliminary findings indicated that four out of six patients demonstrated positive changes in either phonatory or both phonatory and articulatory measures post unilateral PVP surgery (Schulz et al., 1999). Some subjects demonstrated greater intensity, more syllables per second, longer extended vowel duration, and longer syllable vowel duration post-surgery (Schulz et al., 1999). Analysis of the vocal intensity changes following unilateral PVP in a greater number of participants (25) with a greater range of hypokinetic severity has recently been completed (Schulz et al., in press). Results revealed that the greatest improvements in vocal intensity were observed in those participants who were rated as having mild hypokinetic dysarthria prior to surgery. Mildly dysarthric Parkinson's patients may benefit most from unilateral PVP perhaps due to less overall destruction of the basal ganglia sensorimotor control circuits involved in oral facial functions, thus increasing the chances to observe improvements post-surgery. This would suggest that PVP be performed while speech symptoms are still relatively mild to derive the greatest benefit in vocal SPL. Although further research is necessary on this surgical procedure in order to determine the full effects on speech production, these studies demonstrate the potential beneficial effects of this treatment for persons with PD. In addition, if future studies follow the trends demonstrated by Schulz and her colleagues, beneficial PVP surgical effects may be dependent upon the severity of hypokinetic dysarthria.

Fetal Cell Transplantation (FCT)

Transplantation refers to the placement of fetal dopaminergic cells within the caudate or putamen of the basal ganglia of persons with PD. This surgical technique is still considered experimental. It is based on the theory that grafts of dopaminergic cells can survive and secrete DA into the striatum of individuals with PD. Fetal cell nigral graft survival was demonstrated by autopsy findings of graft survival and striatal innervation in humans (Olanow, Kordower, & Freeman, 1996). For this reason fetal nigral transplants are considered the "gold" standard donor tissue [(Kordower, Goetz, Freeman, & Olanow, 1997), p. 45]. Embryonic mesencephalic tissue transplants lead to the survival of dopaminergic neurons and improvements for the majority of the

recipients (Wenning, Odin, Morrish, Rehncrona, Widner, Brundin, Rothwell, Brown, Gustavii, Hagell, Jahanshahi, Sawle, Bjorklund, Brooks, Marsden, Quinn, & Lindvall, 1997). These improvements were observed in rigidity, hypokinesia, reduction of L-dopa dosage, and reduction of "off" time (Wenning et al., 1997). It also appears that variations of fetal graft volume have an impact on performance of persons with PD during motor tasks (Kopyov, Jacques, Lieberman, Duma, & Rogers, 1997). For instance, those who received higher volumes of fetal grafts had significantly improved UPDRS scores in all areas than those who received lower volumes (Kopyov et al., 1997). Improvements five years after implantation of fetal ventral mesencephalic tissue in the caudate nucleus included improved motor function and the persons with PD had less severe and more "on" time with less intense and shorter periods of dyskinesia (Hauser, Freeman, Snow, Nauert, Gauger, Kordower & Olanow, 1999; Lopez-Lozano, Bravo, Brera, Millan, Dargallo, Salmean, Uria, & Insausti, 1997).

Since this technique is still new and experimental, its effects on speech production have just begun to be investigated. The effects of FCT on speech and voice production suggested that FCT had a greater positive effect on limb motor than speech motor symptoms of persons with PD (Baker, Ramig, Johnson, & Freed, 1997). Pre- and post-FCT surgery results revealed variable, inconsistent, and unremarkable changes in phonatory and articulatory measures for each person with PD. Measures included phonatory variables of jitter an shimmer, semitone standard deviation of voice fundamental frequency, speech acoustic variables of vowel duration, extent of glide, voice onset time, spirantization, as well as the listener's perception of speech intelligibility, articulatory precision, and voice quality.

Deep Brain Stimulation (DBS)

Deep brain stimulation (DBS) refers to the electrical stimulation of the thalamus, the subthalamic nucleus (STN), or the GPi for treatment of Parkinsonian symptoms. DBS is performed in lieu of ablation techniques such as pallidotomy in order to duplicate the results of pallidotomy with a decreased risk of permanent neurologic deficit in persons with PD (Pahwa, Wilkinson, Smith, Lyons, Miyawaki, & Koller, 1997).

Chronic high-frequency unilateral thalamic stimulation is effective in reducing both essential and Parkinsonian (resting) tremor (Koller, Pahwa, Busenbark, Hubble, Wilkinson, Lang, Tuite, Sime, Lazano, Hauser, Malapira, Smith, Tarsy, Miyawaki, Norregaard, Kormos, & Olanow, 1997). The role of thalamic participation in speech production has been questioned. Basic motor speech functions such a speaking rate and articulation accuracy are suggested to be organized asymmetrically at the level of the thalamus, as found by thalamic stimulation (Mateer, 1978). Stimulation of the ventral-oral nucleus of

the thalamus produced silencing and slowing of speech (Schaltenbrand, 1975). Electrical stimulation of the left ventrolateral thalamus also caused alterations in object naming in the form of anomia, perseveration, and anarthria (Ojemann & Ward, 1971). No studies investigating speech production in persons with PD who have had thalamic stimulation have been reported.

Stimulation of the STN excites the globus pallidus, so if there is excess inhibition from the globus pallidus, then the STN works against this inhibition. Bilateral electrical stimulation of the STN improves akinesia and rigidity in persons with PD (Limousin, Pollak, Benazzouz, Hoffmann, Le Bas, Broussolle, Perret, & Benabid, 1995). Its effect on speech production has yet to be determined.

Pallidal stimulation improved L-dopa-induced dyskinesias and to a lesser extent bradykinesia and rigidity (Tronnier, Fogel, Kronenbuerger, & Steinvorth, 1997; Gross, Rougier, Guehl, Boraud, Julien, & Bioulac, 1997). A subjective assessment of speech disturbances has shown general improvement during high-frequency stimulation of the GPi (Gross et al., 1997). No objective studies have reported the effects of pallidal stimulation on voice and speech production in PD.

OTHER TREATMENTS/COMBINED TREATMENTS

Clearly all of the current successful voice/speech therapy studies have been in effect, combined treatment studies. That is, all of the persons with PD that participated were optimally medicated. In another study, the combined effect of intensive speech therapy following bilateral thalamotomy was reported (Countryman & Ramig, 1993). A person with PD who had previously undergone bilateral thalamotomy was given the LSVT program. They had significant improvements in vocal functioning (e.g., increased intensity, increased vocal steadiness, increased harmonics to noise ratios, etc.) were measured immediately post treatment. However, they were unable to maintain these improvements at six and 12 months following treatment. The authors speculated that this lack of maintenance was due to lack of continued practice and/or a progression of their PD.

One treatment method that has not received much attention in the literature is augmentation of the vocal folds by injection of collagen, gelfoam, or Teflon. This method increases the bulk of one or both vocal folds, thus reducing the gap between the vocal folds often observed in persons with PD. In theory, this results in better vocal fold closure and thus improvements in vocal intensity and vocal quality. One recent study investigated the effects of vocal fold augmentation with percutaneous collagen injection (Berke, Gerratt, Kreiman, & Jackson, 1999). The self reported response (to a telephone survey) of 35 idiopathic persons with PD and glottal insufficiency was reported to be favorable in 75% compared to 16% unsatisfactory responses. Favorable responses

were found to correlate moderately with the duration of the dysphonia improvement. Clearly this treatment method offers promise for reducing the dysphonia common to persons with PD and this method could also be combined with voice therapy for perhaps longer duration of improved voice.

Another treatment method recently reported involves transcranial electromagnetic stimulation (Sandyk, 1997). In this case study of a young onset PD patient who reportedly had a severe speech impairment with severe stuttering, pulsed electromagnetic stimulation trascranially, subjectively improved above the improvement observed following drug treatment. This person's speech was said to improve 20–30% following the addition of sertraline (a serotonin reuptake inhibitor) to his dopaminergic medications. Following four years of regular weekly administration of transcranial electromagnetic stimulation, greater and more consistent improvement in his speech was observed (Sandyk, 1997). The author attributes the improvement in speech to be the result of a facilitation of serotonergic transmission in conjunction with the sertraline. To date, the speech impairments of persons with PD have not been localized to a reduction of serotonin transmission, additionally, the weekly administration of this treatment method is not feasible for the majority of persons with PD.

CONCLUSION

Parkinsonian dysarthria, or hypokinetic dysarthria, affects five speech subsystems: respiration, phonation, articulation, resonance, and prosody. According to Darley et al. (1969a, 1969b), characteristics of hypokinetic dysarthria include monotonous pitch and loudness, reduced stress, variable rate, short rushes of speech, imprecise consonants, and breathy and harsh voice. All of these characteristics reduce overall speech intelligibility.

The purpose of this paper was to examine the different treatment approaches for persons with PD and to report the effects of these treatments on speech. Treatment methods included speech therapy, pharmacologic, and surgical.

Several types of drugs are used in treating persons with PD. L-dopa may be more effective than anticholinergics, MAO-B and COMT inhibitors, and DA agonists for improving speech. Sinemet treatment contributes to greater speech intelligibility through increased vocal loudness and more regular distribution of phonation and pauses (Mawdsley & Gamsu, 1971). Improved voice quality, pitch variation, and articulation with both short- and long-term use have also been observed (Wolfe et al., 1975). On the other hand, Daniels et al. (1996) demonstrated that there are no significant differences between vocal performance measures during the "on" or the "off" state.

Literature on the surgical treatments for PD suggest that these methods primarily improve limb motor symptoms of PD. Unilateral thalamotomy pro-

duced the deterioration of speech in the form of monotonous voice, slow speech (Jenkins, 1968), and diminished vocal loudness (Allan et al., 1966; Petrovici, 1980). Bilateral thalamotomy produced the same results, including word blocking as well (Matsumoto et al., 1976). There are not many reports supporting consistent improvement in specific subsystems of the speech mechanism following pallidotomy. A preliminary study indicated positive changes in some persons with PD in either phonatory or phonatory and articulatory measures post-surgery (Schulz et al., 1999). In addition, positive changes in vocal intensity have been reported in persons with mild hypokinetic dysarthria following unilateral PVP (Schulz et al., in press). Also, Barlow et al. (1998) found that following bilateral PVP, persons with PD exhibited greater force stability in their perioral system, and laryngeal resistance became more like control values. Though it was not reported, this evidence could correlate with increasing speech intelligibility. The study of the effects of speech after FCT revealed a greater effect on the limb motor system than the speech motor system (Baker, Ramig, Johnson, & Freed, 1997). No literature has been published regarding the effects DBS of the GPi, STN, nor the thalamus bilaterally on speech, but unilateral thalamic stimulation produced silencing and slowing of speech in persons with PD (Schaltenbrand, 1975) and anomia, perseveration, and anarthria (Ojemann & Ward, 1971). It therefore appears that these surgical procedures have little positive effect on speech production. The suggestion by Buck and Cooper (1956) still appears to hold true: ". . . improvement in speech should not be a prime goal in selecting patients for surgical treatment of parkinsonism" (p. 1290).

Speech therapy (in persons who are optimally medicated) appears to be the most effective method of treatment for improving voice and speech production in persons with PD. The therapeutic devices used in speech therapy include the voice amplifier, DAF, the wearable intensity biofeedback device, and a masking device. Overall, these devices increased speech intelligibility, but were primarily used in a clinical setting (with the exception of the wearable biofeedback device), so generalizing persons with PD speech outside of the clinic has not been fully demonstrated. Though the biofeedback device indicated improvement in quality of life (Rubow & Swift, 1985), the person with PD had to wear the cumbersome device in all situations in order to be understood, which may not be desired by others.

Although today treatment focusing only on prosody has largely been abandoned, improvements have been noted in the following aspects of speech: intelligibility (Scott & Caird, 1983; Robertson & Thomson, 1984), phonation or vocal loudness (Robertson & Thomson, 1984; Johnson & Pring, 1990), respiration, prosodic aspects of stress, and intonation (Robertson & Thomson, 1984), and rate of speech (Robertson & Thomson, 1984; Le Dorze et al., 1992), and pitch (Johnson & Pring, 1990; Le Dorze et al., 1992). A noted drawback in using this speech therapy method is that there is no literature sup-

porting maintenance of improvement past three months. It would be beneficial to obtain data on more long-term effects of these methods of therapy.

The LSVT appears to be more beneficial to persons with PD speech than any other treatment method. It has proven to be efficacious both in the short- and long-term. Literature revealed that those who had undergone the LSVT (who were optimally medicated) had either maintained or improved their vocal loudness for 12 months after treatment (Ramig et al., 1996). Increasing vocal loudness has contributed to greater intelligibility in the speech of persons with PD and has decreased the negative impact of PD on communication (Ramig et al., 1995a).

This review has attempted to detail the effects of various treatment approaches on the speech of persons with PD. Neither pharmacological nor surgical methods of treatment alone appear to significantly improve voice and speech function in PD. Currently, speech therapy in combination with optimal pharmacologic intervention has proven to be the most efficacious therapeutic method for improving voice and speech function. Future studies should investigate the effects of other combined treatment approaches. Perhaps the combination of pharmacological, surgical, and speech treatment will prove to be the superior approach for improving the communication abilities of persons with PD.

REFERENCES

Ackermann, H., & Ziegler, W. (1991). Articulatory deficits in Parkinsonian dysarthria: An acoustic analysis. *Journal of Neurology, Neurosurgery, and Psychiatry, 54*, 1093–1098.

Adams, S.G., & Lang, A.E. (1992). Can the Lombard effect be used to improve low voice intensity in Parkinson's disease? *European Journal of Disorders of Communication, 27*, 121–127.

Allan, C.M. (1970). Treatment of non fluent speech resulting from neurological disease: Treatment of dysarthria. *British Journal of Disorders of Communication, 5*, 3–5.

Allan, C.M., Turner, J.W., & Gadea-Ciria, M. (1966). Investigations into speech disturbances following stereotaxic surgery for Parkinsonism. *British Journal of Disorders of Communication, 1*, 55–59.

Alexander, G., Crutcher, M., & DeLong, M. (1990). Basal ganglia-thalamocortical circuits: Parallel substrates for motor, oculomotor, prefrontal and limbic functions. *Progress in Brain Research, 85*, 119–146.

Alexander, G.E., DeLong, M.R., & Strick, P.L. (1986). Parallel organization of functionally segregated circuits linking basal ganglia and cortex. *Annual Review of Neuroscience, 9*, 357–381.

Baker, K.K., Ramig, L.O., Johnson, A.B., & Freed, C.R. (1997). Preliminary voice and speech analysis following fetal dopamine transplants in 5 individuals with Parkinson disease. *Journal of Speech, Language, and Hearing Research, 40*, 615–626.

Baker, K.K., Ramig, L.O., Luschei, E.S., & Smith, M.E. (1998). Thyroarytenoid muscle activity associated with hypophonia in Parkinson disease and aging. *Neurology, 51*, 1592–1598.

Barlow, S.M., Iacono, R.P., Paseman, L.A., Biswas, A., & D'Antonio, L. (1998). The effects of posteroventral pallidotomy on force and speech aerodynamics in Parkinson's disease. In M. Cannito, K. Yorkston, & D. Beukelman (Eds.), *Neuromotor Speech Disorders: Nature, Assessment, & Management* (pp. 117–155). Baltimore, MD: Brookes.

Bassich, C.J., Ludlow, C.L., & Polinsky, R.J. (1984). Speech symptoms associated with early signs of Shy Drager syndrome. *Journal of Neurology, Neurosurgery, and Psychiatry, 47*, 995–1001.

Bell, D.S. (1968). Speech functions of the thalamus inferred from the effects of thalamotomy. *Brain, 91(4)*, 619–638.

Berke, G.S., Gerratt, B., Kreiman, J., & Jackson, K. (1999). Treatment of Parkinson hypophonia with percutaneous collagen augmentation. *Laryngoscope, 109*, 1295–1299.

Boshes, B. (1966). Voice changes in Parkinsonism. *Journal of Neurosurgery, 24*, 286–290.

Brown, R.G., & Marsden, C.D. (1984). How common is dementia in Parkinson's disease? *Lancet, 2*, 1262–1265.

Brumlik, J., Canter, G., De La Torre, R., Mier, M., Petrovick, M., & Boshes, B. (1964). A critical analysis of the effects of trihexyphenidyl (artane) on the components of the Parkinsonian syndrome. *Journal of Nervous and Mental Disease, 138*, 424–431.

Buck, J.F., & Cooper, I.S. (1956). Speech problems in Parkinsonian patients undergoing anterior choroidal artery occlusion or chemopallidectomy. *Journal of the American Geratric Society, 4*, 1285–1290.

Cahill, L.M., Murdoch, B.E., Theodoros, D.G., Triggs, E.J., Charles, B.G., & Yao, A.A. (1998). Effect of oral levodopa treatment on articulatory function in Parkinson's disease: Preliminary results. *Motor Control, 2*, 161–172.

Caligiuri, M.P. (1989). The influence of speaking rate on articulatory hypokinesia in Parkinsonian dysarthria. *Brain and Language, 36*, 493–502.

Caligiuri, M.P., & Abbs, J.H. (1986). *The influence of drug cycle on measures*

of labial kinematics in dysarthria associate with Parkinson's disease. Paper presented at the Clinical Dysarthria Conference, Tucson, Arizona.

Calne, D.B. (1994). Early idiopathic Parkinsonism: Initiation and optimization of treatment. *Clinical Neuropharmacology, 17(Suppl. 2)*, S14–S18.

Canter, G.J. (1963). Speech characteristics of patients with Parkinson's disease: I. Intensity, pitch, and duration. *Journal of Speech and Hearing Disorders, 28(3)*, 221–229.

Canter, G.J. (1965a). Speech characteristics of patients with Parkinson's disease: II. Physiological support for speech. *Journal of Speech and Hearing Disorders, 30(1)*, 44–49.

Canter, G.J. (1965b). Speech characteristics of patients with Parkinson's disease: III. Articulation, diadochokinesis, and over-all speech adequacy. *Journal of Speech and Hearing Disorders, 30(3)*, 217–224.

Connor, N.P., & Abbs, J.H. (1991). Task-dependent variations in parkinsonian motor impairments. *Brain, 114*, 321–332.

Connor, N.P., Ludlow, C.L., & Schulz, G.M. (1989). Stop consonant production in isloated and repeated syllables in Parkinson's disease. *Neuropsychologia, 27*, 829–838.

Countryman, S., & Ramig, L.O. (1993). Effects of intensive voice therapy on voice deficits associated with bilateral thalamotomy in Parkinson disease: A case study. *Jounal of Medical Speech-Language Pathology, 1*, 233–250.

Critchley, E. (1976). Letter: Peak-dose dysphonia in parkinsonism. *The Lancet, 1*, 544.

Critchley, E. (1981). Speech disorders of Parkinsonism: A review. *Journal of Neurology, Neurosurgery, and Psychiatry, 44*, 751–758.

Daniels, N., Oates, J., Phyland, D., Feiglin, A., & Hughes, A. (1996). Vocal characteristics and response to levodopa in Parkinson's disease. *Movement Disorders, 11(Suppl. 1)*, 117.

Darley, F.L., Aronson, A.E., & Brown, J.R. (1969a). Clusters of deviant speech dimensions in the dysarthris. *Journal of Speech and Hearing Research, 12*, 462–496.

Darley, F.L., Aronson, A.E., & Brown, J.R. (1969b). Differential diagnostic patterns of dysarthria. *Journal of Speech and Hearing Research, 12*, 246–269.

Downie, A.W., Low, J.M., & Lindsay, D.D. (1981). Speech disorder in Parkinsonism: Usefulness of delayed auditory feedback in selected cases. *British Journal of Disorders of Communication, 16(2)*, 135–139.

Dromey, C., Ramig, L.O., & Johnson, A.B. (1995). Phonatory and articulatory changes associated with increased vocal intensity in Parkinson disease: A case study. *Journal of Speech and Hearing Research, 38*, 751–764.

Eller, T.W., & Dan, D.A. (1997). Stereotactic pallidotomy for treatment of Parkinson's disease. *AORN Journal, 65(5)*, 903–918.

Erb, E. (1973). Improving speech in Parkinson's disease. *American Journal of Nursing, 73*, 1910–1911.

Fetoni, V., Genitrini, S., Monza, D., Soliveri, P., Testa, D., Caraceni, T., & Girotti, F. (1997). Variations in axial, proximal, and distal motor response to L-dopa in multisystem atrophy and Parkinson's disease. *Clinical Neuropharmacology, 20*, 239–244.

Forrest, K., Weismer, G., & Turner, G.S. (1989). Kinematic, acoustic, and perceptual analyses of connected speech produced by Parkinsonian and normal geriatric adults. *Journal of the Acoustic Society of America, 85*, 2608–2622.

Fox, C.M., & Ramig, L.O. (1997). Vocal sound pressure level and self-perception of speech and voice in men and women with idiopathic Parkinson disease. *American Journal of Speech-Language Pathology, 6*, 85–94.

Gamboa, J., Jimenez-Jimenez, F.J., Nieto, A., Montojo, J., Orti-Pareja, M., Molina, J.A., Garcia-Albea, E., & Cobeta, I. (1997). Acoustic voice analysis in patients with Parkinson's disease treated with dopaminergic drugs. *Journal of Voice, 11*, 314–320.

Greene, M.C.L., & Watson, B.W. (1968). The value of speech amplification in Parkinson's disease patients. *Folia Phoniatrica, 20*, 250–257.

Gross, C., Rougier, A., Guehl, D., Boraud, T., Julien, J., & Bioulac, B. (1997). High-frequency stimulation of the globus pallidus internalis in Parkinson's disease: A study of seven cases. *Journal of Neurosurgery, 87*, 491–498.

Grossman, R.G., & Hamilton, W.J. (1993). Surgery for movement disorders. In J. Jankovic & E. Tolosa (Eds.), *Parkinson's Disease and movement disorders* (pp. 531–548). Baltimore, MD: Williams & Wilkins.

Hammen, V.L., & Yorkston, K.M. (1996). Speech and pause characteristics following speech rate reduction in hypokinetic dysarthria. *Journal of Communication Disorders, 29*, 429–444.

Hanson, D., Gerratt, B., & Ward, P. (1984). Cinegraphic observations of laryngeal function in Parkinson's disease. *Laryngoscope, 94*, 348.

Hanson, D.G., Ludlow, C.L., & Bassich, C.J. (1983). Vocal fold paresis in Shy-Drager syndrome. *Annals of Otology, Rhinology, and Laryngology, 92*, 85–90.

Hanson, W.R., & Metter, E.J. (1983). DAF speech rate modification in Parkinson's disease: A report of two cases. In W. Berry (Ed.), *Clinical dysarthria* (pp. 231–251). San Diego, CA: College-Hill.

Hartelius, L., & Svensson, P. (1994). Speech and swallowing symptoms associated with Parkinson's disease and Multiple Sclerosis: A survey. *Folia Phoniatrica et Logopedia, 46*, 9–17.

Hauser, R.A., Freeman, T.B., Snow, B.J., Nauert, M., Gauger, L., Kordower, J.H., & Olanow, C.W. (1999). Long-term evaluation of bilateral fetal nigral transplantation in Parkinson disease. *Archives of Neurology, 56*, 179–187.

Hirose, H., Kiritani, S., Ushijima, T., Yoshioka, H., & Sawashima, M. (1981). Patterns of dysarthric movements in patients with Parkinsonism. *Folia Phoniatrica, 33*, 204–215.

Ho, A.K., Bradshaw, J.L., Cunnington, R., Phillips, J.G., & Iansek, R. (1998). Sequence heterogeneity in Parkinsonian speech. *Brain and Language, 64*, 122–145.

Ho, A.K., Iansek, R., & Bradshaw, J.L. (1999). Regulation of Parkinsonian speech volume: The effect of interlocuter distance. *Journal of Neurology, Neurosurgery, and Psychiatry, 67*, 199–202.

Hoodin, R.B., & Gilbert, H.R. (1989). Parkinsonian dysarthria: An aerodynamic and perceptual description of velopharyngeal closure for speech. *Folia Phoniatrica et Logopedia, 41*, 249–258.

Iacono, R.P., Lonser, R.R., & Kuniyoshi, S. (1995). Unilateral versus bilateral simultaneous posteroventral pallidotomy in subgroups of patients with Parkinson's disease. *Stereotactic and Functional Neurosurgery, 65*, 6–10.

Jankovic, J., & Marsden, C.D. (1993). Therapeutic strategies in Parkinson's disease. In J. Jankovic & E. Tolosa (Eds.), *Parkinson's Disease and movement disorders* (pp. 115–144). Baltimore, MD: Williams & Wilkins.

Jenkins, A.C. (1968). Speech defects following stereotaxic operations for the relief of tremor and rigidity in Parkinsonism. *The Medical Journal of Australia, 7*, 585–588.

Johnson, J.A., & Pring, T.R. (1990). Speech therapy and Parkinson's disease: A review and further data. *British Journal of Disorders of Communication, 25*, 183–194.

Koller, W., Pahwa, R., Busenbark, K., Hubble, J., Wilkinson, S., Lang, A., Tuite, P., Sime, E., Lazano, A., Hauser, R., Malapira, T., Smith, D., Tarsy, D., Miyawaki, E., Norregaard, T., Kormos, T., & Olanow, C.W. (1997). High-frequency unilateral thalamic stimulations in the treatment of essential and Parkinsonian tremor. *Annals of Neurology, 42(3)*, 292–299.

Kopyov, O.V., Jacques, D., Lieberman, A., Duma, C., & Rogers, R. (1997). Outcome following intrastriatal fetal mesencephalic grafts for Parkinson's patients is directly related to the volume of grafted tissue. *Experimental Neurology, 146*, 536–545.

Kordower, J.H., Goetz, C.G., Freeman, T.B., & Olanow, C.W. (1997). Dopaminergic transplants in patients with Parkinson's disease: Neuroanatomic correlates of clinical recovery. *Experimental Neurology, 144*, 41–46.

Krauss, J., & Jankovic, J. (1996). Surgical treatment of Parkinson's disease. *American Family Physician, 54*, 1621–1629.

Laitinen, L.V., Bergenheim, A.T., & Hariz, M.I. (1992). Ventroposterolateral pallidotomy can abolish all Parkinsonian symptoms. *Stereotactic and Functional Neurosurgery, 58*, 14–21.

Lang, A.E., Lozano, A.M., Montgomery, E., Duff, J., Tasker, R., & Hutchinson, W. (1997). Posteroventral medial pallidotomy in advanced Parkinson's disease. *The New England Journal of Medicine, 337(15)*, 1036–1042.

Larson, K.K., Ramig, L.O., & Scherer, R.C. (1994). Acoustic and glottograhic voice analysis during drug-related fluctuations in Parkinson's disease. *Journal of Medical Speech Pathology, 2*, 227–239.

Leanderson, R., Meyerson, B.A., & Persson, A. (1971). Effect of L-dopa on speech in Parkinsonism: An EMG study of labial articulatory function. *Journal of Neurology, Neurosurgery, and Psychiatry, 34*, 679–681.

Le Dorze, G., Dionne, L., Ryalls, J., Julien, M., & Ouellet, L. (1992). The effects of speech and language therapy for a case of dysarthria associated with Parkinson's disease. *European Journal of Disorders of Communication, 27*, 313–324.

Lieberman, A., Ranhosky, A., & Korts, D. (1997). Clinical evaluation of pramipexole in advanced Parkinson's disease: Results of a double-blind, placebo-controlled, parallel-group study. *Neurology, 49*, 162–166.

Limousin, P., Pollak, P., Benazzouz, A., Hoffmann, D., Le Bas, J.-F., Broussolle, E., Perret, J. E., & Benabid, A.-L. (1995). Effect on parkinsonian signs and symptoms of bilateral subthalamic nucleus stimulation. *The Lancet, 345*, 91–95.

Logemann, J.A., & Fisher, H.B. (1981). Vocal tract control in Parkinson's disease: Phonetic feature analysis of misarticulations. *Journal of Speech and Hearing Disorders, 46*, 348–352.

Logemann, J.A., Fisher, H.B., Boshes, B., & Blonsky, E.R. (1978). Frequency and co-occurrence of vocal tract dysfunctions in the speech of a large sample of Parkinson patients. *Journal of Speech and Hearing Disorders, 43*, 47–57.

Lopez-Lozano, J.J., Bravo, G., Brera, B., Millan, I., Dargallo, J., Salmean, J., Uria, J., & Insausti, J. (1997). Long-term improvement in patients with severe Parkinson's disease after implantation of fetal ventral meseencephalic tissue in a cavity of the caudate nucleus: 5-year follow up in 10 patients. *Journal of Neurosurgery, 86*, 931–942.

Ludlow, C.L., Connor, N.P., & Bassich, C.J. (1987). Speech timing in Parkinson's and Huntington's disease. *Brain and Language, 32*, 195–214.

Luschei, E.S., Ramig, L.O., Baker, K.L., & Smith, M.E. (1999). Discharge characteristics of laryngeal single motor units during phonation in young and older adults and in persons with parkinson disease. *Journal of Neurophysiology, 81*, 2131–2139.

Manyam, B.V. (1997). Practical guidelines for management of Parkinson disease. *Journal of the American Board of Family Practice, 10(6)*, 412–424.

Marsden, C.D. (1982). The mysterious motor function of the basal ganglia: The Robert Wartenberg lecture. *Neurology, 32*, 514–539.

Marsden, C.D. (1996). Parkinson's disease. *Trends in Neuroscience, 19(3)*, 102–109.

Marsden, C.D., & Parkes, J.D. (1977). Success and problems of long-term levodopa therapy in Parkinson's disease. *The Lancet, 1*, 345–349.

Mateer, C. (1978). Asymmetric effects of thalamic stimulation on rate of speech. *Neuropsychologia, 16*, 497–499.

Matsumoto, K., Asano, T., Baba, T., Miyamoto, T., & Ohmoto, T. (1976). Long-term follow-up results of bilateral thalamotomy for Parkinsonism. *Applied Neurophysiology, 39*, 257–260.

Mawdsley, C., & Gamsu, C.V. (1971). Periodicity of speech in Parkinsonism. *Nature, 231*, 315–316.

Metter, E.J., & Hanson, W.R. (1986). Clinical and acoustical variability in hypokinetic dysarthria. *Journal of Communication Disorders, 19*, 347–366.

Morley, D.E. (1955). The rehabilitation of adults with dysarthric speech. *Journal of Speech and Hearing Disorders, 20(1)*, 58–64.

Mueller, P.B. (1971). Parkinson's disease: Motor-speech behavior in a selected group of patients. *Folia Phoniatrica, 23*, 333–345.

Nakano, K.K., Zubick, H., & Tyler, H.R. (1973). Speech defects of Parkinsonian patients: Effects of levodopa therapy on speech intelligibility. *Neurology, 23*, 865–870.

Netsell, R., Daniel, B., & Celesia, G.G. (1975). Acceleration and weakness in Parkinsonian dysarthria. *Journal of Speech and Hearing Disorders, 40*, 170–177.

Ojemann, G.A., & Ward, A.A. (1971). Speech representation in ventrolateral thalamus. *Brain, 94*, 669–680.

Olanow, C.W., Kordower, J.H., & Freeman, T.B. (1996). Fetal nigral transplantation as a therapy for Parkinson's disease. *Trends in Neuroscience, 19(3)*, 102–109.

Pahwa, R., Wilkinson, S., Smith, D., Lyons, K., Miyawaki, E., & Koller, W.C. (1997). High-frequency stimulation of the globus pallidus for the treatment of Parkinson's disease. *Neurology, 49*, 249–253.

Perez, K.S., Ramig, L.O., Smith, M.E., & Dromey, C. (1996). The Parkinson larynx: Tremor and videostroboscopic findings. *Journal of Voice, 10*, 354–361.

Petrovici, J.-N. (1980). Speech disturbances following stereotaxic surgery in ventrolateral thalamus. *Neurosurgical Review, 3*, 189–195.

Piccoli, F., & Riuggeri, R.M. (1995). Dopaminergic agonists in the treatment of Parkinson's disease: A review. *Journal of Neural Transmission, 45(Suppl.)*, 187–195.

Pitcairn, T.K., Clemie, S., Gray, J.M., & Pentland, B. (1990). Impressions of Parkinsonian patients from their recorded voices. *British Journal of Disorders of Communication, 25*, 85–92.

Poewe, W., & Luginger, E. (1999). Depression in Parkinson's disease: Impediments to recognition and treatment options. *Neurology, 52*, S2–S6.

Poluha, P.C., Teulings, H.L., & Brookshire, R.H. (1998). Handwriting and speech changes across the levodopa cycle in Parkinson's disease. *Acta Psychologia (Amst), 100*, 71–84.

Quaglieri, C.E., & Celesia, G.G. (1977). Effect of thalamotomy and levodopa therapy on the speech of Parkinson patients. *European Neurology, 15*, 34–39.

Rabey, J.M. (1995). Second generation of dopamine agonists: Pros and cons. *Journal of Neural Transmission, 45*, 213–224.

Ramig, L.O., Bonitati, C., Lemke, J., & Horii, Y. (1994). Voice treatment for patients with Parkinson disease: Development of an approach and preliminary efficacy data. *Journal of Medical Speech-Language Pathology, 2*, 191–209.

Ramig, L.O., Countryman, S., O'Brien, C., Hoehn, M., & Thompson, L. (1996). Intensive speech treatment for patients with Parkinson's disease. *Neurology, 47*, 1496–1504.

Ramig, L.O., Countryman, S., Thompson, L.L. & Horii, Y. (1995a). Comparison of two forms of intensive speech treatment for Parkinson's disease. *Journal of Speech and Hearing Research, 38*, 1232–1251.

Ramig, L.O., & Dromey, C. (1996). Aerodynamic mechanisms underlying treatment-related changes in vocal intensity in patients with Parkinson disease. *Journal of Speech and Hearing Research, 39*, 798–807.

Ramig, L.O., Pawlas, A.A., & Countryman, S. (1995b). *The Lee Silverman Voice Treatment: A practical guide for treating voice and speech disorders in Parkinson disease*. Iowa City, IA: National Center for Voice and Speech.

Rigrodsky, S., & Morrison, E.B. (1970). Speech changes in Parkinsonism during L-dopa therapy: Preliminary findings. *Journal of the American Geriatrics Society, 18(2)*, 142–151.

Robertson, S.J., & Thomson, F. (1984). Speech therapy in Parkinson's disease: A study of the efficacy and long term effects of intensive treatment. *British Journal of Disorders of Communication, 19*, 213–224.

Rubow, R., & Swift, E. (1985). A microcomputer-based wearable biofeedback device to improve transfer of treatment in Parkinsonian dysarthria. *Journal of Speech and Hearing Disorders, 50*, 166–178.

Sandyk, R. (1997). Speech impairment in Parkinson's disease is improved by transcranial application of electromagnetic fields. *International Journal of Neuroscience, 92*, 63–72.

Sarno, M.T. (1968). Speech impairment in Parkinson's disease. *Archives of Physical Medicine and Rehabilitation, 49*, 269–275.

Schaltenbrand, G. (1975). The effects on speech and language of stereotactical stimulation in thalamus and corpus callosum. *Brian and Language, 2*, 70–77.

Schulz, G.M., Greer, M., & Friedman, W. (1998). Effects of pallidotomy surgery on Parkinson's patients sentence productions. Paper presented to the Speech Motor Control conference, Tucson, AZ.

Schulz, G.M., Greer, M., & Friedman, W. (in press). Changes in vocal intensity following pallidotomy surgery. *Journal of Voice.*

Schulz, G.M., Peterson, T., Sapienza, C.M., Greer, M., & Friedman, W. (1999). Voice and speech characteristics of persons with Parkinson's disease pre- and post-pallidotomy surgery: Preliminary findings. *Journal of Speech, Language and Hearing Research, 42*, 1176–1194.

Scott, S., & Caird, F. (1983). Speech therapy for Parkinson's disease. *Journal of Neurology, Neurosurgery, and Psychiatry, 46*, 140–144.

Scott, S., Caird, F.I., & Williams, B.O. (1984). Evidence for an apparent sensory speech disorder in Parkinson's disease. *Journal of Neurology, Neurosurgery, and Psychiatry, 47*, 840–843.

Scott, S., Caird, F.I., & Williams, B.O. (1985). *Communication in Parkinson's Disease*. Rockville, MD: Aspen.

Shea, B.R., Drummond, S.S., Metzer, W.S., & Krueger, K.M. (1993). Effect of selegiline on speech performance in Parkinson's disease. *Folia Phoniatrica Logopedia, 45*, 40–46.

Smith, M.E., Ramig, L.O., Dromey, C., Perez, K.S., & Samandari, R. (1995). Intensive voice treatment in Parkinson disease: Laryngostroboscopic findings. *Journal of Voice, 9*, 453–459.

Solomon, N.P., & Hixon, T.J. (1993). Speech breathing in Parkinson's disease. *Journal of Speech and Hearing Research, 36*, 294–310.

Stern, G., & Lees, A. (1990). *Parkinson's Disease: The Facts*. New York, NY: Oxford University Press.

Stewart, C., Winfield, L., Hunt, A., Bressman, S.B., Fahn, S., Blitzer, A., & Brin, M.F. (1995). Speech dysfunction in early Parkinson's disease. *Movement Disorders, 10*, 562–565.

Swigert, N.B. (1997). *The source for dysarthria*. East Moline, IL: LinguiSystems.

Tanner, C.M., & Goldman, S.M. (1996). Epidemiology of Parkinson's disease. *Neurologic Clinics, 14(2)*, 317–335.

Tapper, V.J. (1997). Pathophysiology, assessment, and treatment of Parkinson's disease. *The Nurse Practitioner, 22*, 76–95.

Tasker, R.R., Lang, A.E., & Lozano, A.M. (1997). Pallidal and thalamic surgery for Parkinson's disease. *Experimental Neurology, 144*, 35–40.

Tasker, R.R., Siqueira, J., & Hawrylyshyn, L.W.O. (1983). What happened to VIM thalamotomy for Parkinson's disease? *Applied Neurophysiology, 46*, 68–83.

Tolosa, E., & Valldeoriola, F. (1994). Mid-stage Parkinsonism with mild motor fluctuations. *Clinical Neuropharmacology, 17(Suppl 2)*, S19–S31.

Tronnier, V.M., Fogel, W., Kronenbuerger, M., & Steinvorth, S. (1997). Pallidal stimulation: An alternative to pallidotomy? *Journal of Neurosurgery, 87*, 700–705.

Volkmann, J., Hefter, H., Lange, H.W., & Freund, H.J. (1992). Impairment of temporal organization of speech in basal ganglia diseases. *Brain and Language, 43*, 386–399.

Wallin, A., Jennersjo, C., & Granerus, A.K. (1999). Prevalence of dementia and regional brain syndromes in long-standing Parkinson's disease. *Parkinsonism and Related Disorders, 5*, 103–110.

Wenning, G.K., Odin, P., Morrish, P., Rehncrona, S., Widner, H., Brundin, P., Rothwell, J.C., Brown, R., Gustavii, B., Hagell, P., Jahanshahi, M., Sawle, G., Bjorklund, A., Brooks, D.J., Marsden, C.D., Quinn, N.P., & Lindvall, O. (1997). Short- and long-term survival and function of unilateral intrastriatal dopaminergic grafts in Parkinson's disease. *Annals of Neurology, 42(1),* 95–107.

Wolfe, V.I., Garvin, J.S., Bacon, M., & Waldrop, W. (1975). Speech changes in Parkinson's disease during treatment with L-dopa. *Journal of Communication Disorders, 8,* 271–279.

CONTINUING EDUCATION

Effects of Speech Therapy and Pharmacologic and Surgical Treatments on Voice and Speech in Parkinson's Disease: A Review of the Literature

QUESTIONS

1. Which of the following has been proven to be the most efficacious speech therapy treatment for Parkinson's disease?
   a. Biofeedback training
   b. Respiratory training
   c. Phonatory and respiratory training
   d. Prosodic training
   e. None of the above have been proven efficacious

2. Which of the following procedures has been shown to make voice and speech worse in persons with PD?
   a. Bilateral thalamotomy
   b. Unilateral pallidotomy
   c. Fetal cell transplantation
   d. Deep brain stimulation
   e. Injection of collagen into the vocal folds

3. Pallidotomy alleviates limb symptoms of PD by:
   a. Increasing inhibitory outflow from the basal ganglia to the thalamus and cortex
   b. Increasing excitatory outflow from the basal ganglia to the thalamus and cortex
   c. Decreasing inhibitory outflow from the basal ganglia to the thalamus and cortex
   d. Decreasing excitatory outflow from the basal ganglia to the thalamus and cortex
   e. Eliminating the basal ganglia from participating in movement

4. Which of the following statements is true regarding speech and voice production following L-dopa treatment?
   a. Findings show a general trend for improvement in voice and speech function
   b. Subjective observations show improvement in voice quality, pitch variation, and articulation
   c. No difference in acoustic measures in the “on” and “off” medication state
   d. Reduced tonic activity of labial muscles following administration of L-dopa
   e. All of the above are true statements

5. Which of the following is *not* an explanation for discrepancies observed in voice and speech function following various medical treatments in persons with PD?
   a. Methodological differences between studies such as subject inclusion criteria, dysarthria severity, other co-occurring conditions.
   b. Differences between limb motor and speech motor substrates.
   c. Differences in tasks used to assess voice and speech functions.
   d. Differences in treatment durations.
   e. Differences in treatment responses due to neurophysiologic differences between limb motor and speech motor substrates.

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Speech therapy for children with dysarthria acquired before three years of age (Review)

Pennington L, Parker NK, Kelly H, Miller N

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[Intervention Review]

Speech therapy for children with dysarthria acquired before three years of age

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ABSTRACT

Background

Children with motor impairments often have the motor speech disorder dysarthria, a condition which effects the tone, strength and co-ordination of any or all of the muscles used for speech. Resulting speech difficulties can range from mild, with slightly slurred articulation and breathy voice, to profound, with an inability to produce any recognisable words. Children with dysarthria are often prescribed communication aids to supplement their natural forms of communication. However, there is variation in practice regarding the provision of therapy focusing on voice and speech production. Descriptive studies have suggested that therapy may improve speech, but its effectiveness has not been evaluated.

Objectives

To assess whether any speech and language therapy intervention aimed at improving the speech of children with dysarthria is more effective in increasing children's speech intelligibility or communicative participation than no intervention at all , and to compare the efficacy of individual types of speech language therapy in improving the speech intelligibility or communicative participation of children with dysarthria.

Search methods

We searched the Cochrane Central Register of Controlled Trials (CENTRAL; 2015 , Issue 7), MEDLINE, EMBASE, CINAHL , LLBA, ERIC, PsychInfo, Web of Science, Scopus, UK National Research Register and Dissertation Abstracts up to July 2015, handsearched relevant journals published between 1980 and July 2015, and searched proceedings of relevant conferences between 1996 to 2015. We placed no restrictions on the language or setting of the studies. A previous version of this review considered studies published up to April 2009. In this update we searched for studies published from April 2009 to July 2015.

Selection criteria

We considered randomised controlled trials and studies using quasi-experimental designs in which children were allocated to groups using non-random methods.

Data collection and analysis

One author (LP) conducted searches of all databases, journals and conference reports. All searches included a reliability check in which a second review author independently checked a random sample comprising 15% of all identified reports. We planned that two review authors would independently assess the quality and extract data from eligible studies.

Main results

No randomised controlled trials or group studies were identified.

Authors' conclusions

This review found no evidence from randomised trials of the effectiveness of speech and language therapy interventions to improve the speech of children with early acquired dysarthria. Rigorous, fully powered randomised controlled trials are needed to investigate if the positive changes in children's speech observed in phase I and phase II studies are generalisable to the population of children with early acquired dysarthria served by speech and language therapy services. Research should examine change in children's speech production and intelligibility. It must also investigate children's participation in social and educational activities, and their quality of life, as well as the cost and acceptability of interventions.

PLAIN LANGUAGE SUMMARY

Speech therapy for children with dysarthria ac quired before three years of age

The review question

This review aimed to investigate if therapy is generally effective for children with dysarthria acquired early in life, and if certain types of therapy may be better than others.

Background

Dysarthria is a speech disorder linked to difficulties controlling the muscles needed for speaking. Children with dysarthria often have shallow, irregular breathing which creates difficulties in generating sufficient breath to support speech. They have low pitched, breathy or harsh voices, nasalised speech and very poor pronunciation. Together, these difficulties make the children's speech difficult to understand. Dysarthria is caused by neurological impairment and can arise early in children's lives, from neurological damage sustained before, during or after birth, such as in cerebral palsy, or in early childhood through traumatic brain injury or neurological disease. Communication difficulties have a profound impact on children’s development. They reduce the quality of life of children with cerebral palsy and place children at risk of social exclusion, educational failure and later unemployment. Speech and language therapy aims to help children to control the movements for breathing and speech and so become more intelligible.

Study characteristics

We found no randomised controlled trials or controlled group studies which investigate the effects of speech and language therapy to improve the speech of children with dysarthria acquired below three years of age.

Key results

Small, observational studies have suggested that, for some children, therapy might have been associated with positive changes in intelligibility and clarity of voice. Rigorous research, using randomised controlled trials, is needed to evaluate if therapy can help children to increase the intelligibility of their speech and if enhanced intelligibility increases children's participation in social and educational activities and their quality of life.

BACKGROUND

Dysarthria is the term used to describe speech disorders that are caused by neuromuscular impairments. People with dysarthria have difficulties controlling and co-ordinating the speed, range, strength and duration of movements needed for speech and as a result their speech may be difficult to understand. For example, difficulties with lip and tongue movements may cause 'tip' to be heard as 'sip', 'hip' or 'sieve'; 'beach' to be heard as 'eats'; 'decide' as 'sigh' or 'say.' Difficulties affecting the larynx alter the quality of phonation (sound made when air passes through vibrating vocal folds) and the pitch and loudness of speech. Speech may lack variation in loudness, pitch and rhythm or there may be inappropriate swings in pitch and loudness. Difficulties with speech loudness, pitch and rhythm may also be associated with poor respiratory control. Speakers may have shallow breathing and have difficulty co-ordinating exhalation with phonation, giving them only a small amount of air on which to speak. Involvement of the soft palate typically leads to perceptions of excess nasality in a person's speech. Symptoms of dysarthria can range from mild slurring of speech sounds and slightly low pitch to complete inability to produce any intelligible words.

Dysarthria in childhood is associated with congenital disorders such as cerebral palsy (Lepage 1998; Kennes 2002; Bax 2006; Odding 2006) and with acquired aetiologies such as brain tumours (Van Mourik 1996; Cornwell 2003; Richter 2005) and traumatic brain injury (Chapman 2001; Netsell 2001; Cahill 2002). Approximately 20% of children with cerebral palsy have speech which is affected by dysarthria (Nordberg 2013). We do not know how many additional children have dysarthria arising from other causes , however, cerebral palsy and head injury remain two of the most common medical causes of referral to speech and language therapy (Petheram 2001). As the speech impairments of dysarthria are neurologically based they do not resolve. Intervention seeks to maximise children's speech performance, teaching them how to use different movements and lay down new motor programmes for those movements. The learning of new motor behaviours requires intensive practice (Schmidt 2005) involving considerable therapy input over long time periods. Dysarthria therapy, therefore, potentially carries considerable costs to health services even though the prevalence of the disorder in childhood may be small.

Speech and language therapy to reduce the motor speech impairments experienced by children, and the intelligibility limitations these impairments impose, has been advocated in textbooks on dysarthria (Love 1992; Hayden 1994; Strand 1995; Hodge 1999; Yorkston 1999). An approach that targets all subsystems of the vocal tract, breathing, nasal resonance, articulation and pitch control is commonly described, and is similar to interventions for adults with dysarthria acquired following neurological insults (e.g. a stroke). Treatment focusing on one or more subsystem in speech production may, for example, aim to help children control their breathing and maintain adequate pressure for speech across a phrase. This might involve teaching children how to start to speak at the beginning of exhalation and how to split utterances into smaller phases in which they can maintain adequate volume. Intervention also involves slowing children's speech rate, to allow more precise movement of muscles in the oral tract. Strand 1995 and Yorkston 1999 also advocate increasing respiratory effort and making jaw movements bigger in speech to increase oral cavity volume, plus the use of speech and non-speech exercises to help close the airway to the nose during speech. Treatment for articulation has only been advised when other aspects of speech production have been or are being addressed, as "imprecise production of speech sounds (which is the most common perceptual characteristic of dysarthria) is not simply an oral articulatory problem, and is usually the result of laryngeal, velopharyngeal, respiratory and oral articulatory problems" (Strand 1995, p134). Thus, more precise articulation and improved intelligibility is thought to be achieved through developing control of breathing for speech, increasing background effort and slowing speech rate (Love 1992; Strand 1995; Yorkston 1996 ; Yorkston 1999). Treatment for prosody (intonational contours of speech) and pitch control has been described (Strand 1995 ; Yorkston 1999). This comprises exercises to control the rate of words spoken and pauses used, increase volume and possibly the use of pitch change. As treatment of isolated oromotor movements has not been found to affect speech (Weismer 2006), all therapy is functional, being directed at speech production.

Although therapy for dysarthria in childhood has been described in speech and language therapy textbooks, its effects are currently unclear. An earlier version of this review (New Reference) showed that there were a small number of phase I and II studies of therapy for children with early acquired dysarthria but no controlled group studies. Speech and language therapists, therefore, have little evidence on which to base treatment decisions. Some may provide dysarthria intervention as there is no evidence to suggest that the treatment does not work or causes harm. Others may withhold treatment because there is no evidence showing its effectiveness (Watson 2015).

Speech allows us to share complex thoughts and ideas quickly, and is the most highly prized form of human communication. Communication difficulties are associated with lower quality of life and limited participation for children with cerebral palsy (Dickinson 2007; Fauconnier 2009) and children with speech and communication disorders are at risk of educational failure, social exclusion and later unemployment (ICAN 2007). Such problems not only have an obvious individual and family impact but also present considerable societal and economic consequences. To ensure that children have a clear means of communication, augmentative and alternative communication (AAC) systems, such as symbol books and speech synthesis ers, are often provided. However, many children still choose to communicate by speech. It is important to investigate if the intelligibility of the speech of children with dysarthria can be improved, as being more immediately understandable will maximise the chances of communication success and may facilitate interaction in all areas of life. We aimed to conduct a systematic review of the studies of speech therapy for children who have acquired dysarthria early in life and to investigate the relative effectiveness of different types of treatment. We focused on children who acquire dysarthria below three years of age as they may differ from children with later- acquired pathologies in terms of their neural development, plasticity and recovery patterns; memories of fluent speech; retrieval of previously developed motor programmes; self image (seeing themselves as a fluent speaker rather than a person with a speech disorder); and patterns of communication development. Children with early acquired dysarthria may never have developed motor programmes for fluent speech or have memories of non-dysarthric speech and may not see themselves as an intelligible speaker. Furthermore, children with severe speech

and motor impairments arising from congenital pathologies or those acquired in early infancy have highly unusual patterns of communication development. They take a mainly responsive role in communication and often fail to develop a full range of conversational skills (Pennington 1999). Interventions for children who acquire dysarthria at three years of age and above are the subjects of a separate review (Morgan 2008).

OBJECTIVES

To assess whether any speech and language therapy intervention aimed at improving the speech of children with dysarthria is more effective in increasing children's speech intelligibility or communicative participation than no intervention at all , and to compare the efficacy of individual types of speech language therapy in improving the speech intelligibility or communicative participation of children with dysarthria.

METHODS

Criteria for considering studies for this review

Types of studies

We looked for randomised controlled trials and studies using quasi-experimental designs in which children were allocated to groups using non-random methods.

Types of participants

Any young person under 19 years of age who acquired dysarthria below three years of age. No exclusions were made on the basis of additional impairments (intellectual or sensory impairments, the presence of epilepsy) or prior receipt of speech and language therapy. We excluded children who did not have a definite diagnosis of dysarthria with underlying neurological/ neuromuscular pathology, and those who took part in studies that did not explicitly list dysarthria in their inclusion criteria. Thus, children who had other types of speech disorders, such as articulation problems without dysarthria, were not eligible for inclusion in this review.

Types of interventions

Any speech and language therapy aimed at improving children's speech, whether provided individually or in groups, in the child's home, school or health service settings, except where it is provided as part of a holistic approach (e.g. as in conductive education where there are no specific speech interventions). Therapy can be provided directly by speech and language therapists (also known as speech-language pathologists, speech pathologists) or by other personnel under the direction of a speech and language therapist.

Types of outcome measures

Primary outcomes

Primary outcome measures relate to the extent to which children's speech is understood:

- objective measures of percentage of intelligible words (e.g. Assessment of Intelligibility of Dysarthric Speech (Yorkston 1981) TOCS+ (Wilcox 1999; Hodge 2009);
- subjective intelligibility scales;
- communicative participation scales (e.g. Focus on Communication Outcomes Under Six (FOCUS) (Thomas-Stonnell 2010);
- coding schemes developed for individual research studies that include validity and reliability data.

Secondary outcomes

Measures of speech subsystem function, which could underpin intelligibility, such as respiration, phonation, nasality, articulation, sound pressure level. Measures include:

- voice rating scales (Hirano 1981);
- oromotor skills tests (e.g. Robsertson Dysarthria Assessment (Robertson 1982);
- Verbal Motor Production Assessment for Children (Hayden 1994);
- articulation tests;
- phonology tests (Diagnositic Evaluation of Articulation and Phonology (DEAP) (Dodd 2006);
- acoustic measures of pitch and loudness;
- physiological tests e.g. of respiration and nasal emission.

Impact of intelligibility:

- quality of life (e.g. KIDSCREEN (Ravens-Sieberer 2005);
- generic measures of participation (e.g. CAPE (King 2004)).

Perceptions of treatment:

- satisfaction of participant and family with treatment;
- non-compliance with treatment.

Direct costs of treatment.

Adverse events, including time missed from education.

We planned to consider outcomes at the following time points:

- short term (less than one month following the end of the intervention);
- medium term (one to three months following the end of the intervention);
- and long term (more than four months following the end of the intervention).

Search methods for identification of studies

Electronic searches

We searched for papers written in any language and in any setting in the following databases from 1980 or from inception up until the end of July 2015:

- T he Cochrane Central Register of Controlled Trials (CENTRAL; 2015 Issue 7) ;
- MEDLINE (Ovid);
- EMBASE (Ovid) ;
- CINAHL (EBSCOhost);
- ERIC (EBSCOhost);
- Psych-INFO (Ovid);

- Linguistics and Language Behaviour Abstracts (LLBA) (ProQuest);
- Science Citation Index (Web of Science);
- Scopus;
- Dissertation Abstracts (P roQuest).

We used the search strategy developed from Robinson 2002 to search MEDLINE and modified it to search the other databases (see Appendix 1).

Searching other resources

We handsearched the following journals from their inception or from 1980 until the end of July 2015 (unless otherwise specified): American Journal of Speech-Language Pathology; Applied Psycholinguistics (1996 onwards); Augmentative and Alternative Communication; Child: Care, Health and Development and the Ambulatory Child; Child Language Teaching and Therapy; Developmental Medicine and Child Neurology; European Journal of Special Needs Education; Folia Phoniatrica; International Journal of Disability, Development and Education; International Journal of Language and Communication Disorders; International Journal of Rehabilitation Research; International Journal of Speech Pathology; Journal of Child Psychology and Psychiatry; Journal of Communication Disorders; Journal of Medical Speech-Language Pathology; Journal of Psycholinguistic Research; Journal of Special Education; Journal of Speech, Language and Hearing Research; Speech, Language and Hearing in Schools; Sprache Stimme Gehoer. (The current titles are given for journals whose names have changed since 1980.)

We checked published conference proceedings of the following organisations: European Academy of Child Development (1996 to 2015), International Society for Alternative and Augmentative Communication (1996 to 2015), American Speech and Hearing Association (1999 to 2015), Royal College of Speech and Language Therapists (1998 to 2015).

We checked the reference lists of all studies selected for possible inclusion for other possible eligible studies.

Data collection and analysis

Selection of studies

One of the review authors (LP) independently screened each title and abstract obtained from the database searches for inclusion. One of the four review authors handsearched the journals lis ted above. . Another review author independently selected 15% of the reports found as a result of the searches at random and checked them for inclusion eligibility by a second reviewer. Agreement between the reviewers on the reports included in the reliability check was 100%.

Data extraction and management

We planned that two of the thee review authors (LP, SR, NM) would independently extract data into Review Manager (RevMan) 5.3 (RevMan 2014). The data to be included is listed below.

- Participants:
  - age;
  - gender;
  - age of onset of disorder;
  - diagnosis of underlying disorder;
  - type of dysarthria;
  - severity of dysarthria relating to respiration, phonation, nasality, articulation, sound pressure level, intelligibility
- Co-morbidity
- Intervention:
  - type of intervention;
  - duration;
  - frequency;
  - provider: speec h and language therapy (SLT)/other.
- Focus of intervention:
  - respiration;
  - phonation;
  - nasality;
  - articulation;
  - sound pressure level;
  - intelligibility.
- Comparator intervention
  - type of intervention
  - duration
  - frequency
  - provider: SLT/other
  - focus of intervention: respiration, phonation, nasality, articulation, sound pressure level, intelligibility

We planned to develop and pilot data extraction sheets, which would include a methodological assessment table for application of the d omains of risk of bias assessment (see below) . We planned to enter extracted data into RevMan 5 .3 (RevMan 2014) , and to contact authors of studies to request missing data.

Assessment of risk of bias in included studies

We planned that the two review authors who extracted data on an individual study would also independently assess the study's risk of bias. We planned to resolve disagreements with the third review author and to use the Kappa statistic to calculat e agreement on methodology assessment (Higgins 2011a).

We planned to rate individual criteria for risk of bias as 'adequate', 'component not reported or unclear' or 'component reported but inadequate', according to the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011b):

- Method of allocation (assignment of participants to group)
  - Low risk: Well described randomised process.
  - High risk: Non-random method (e.g. days of the week, alternate).
  - Unclear risk : Allocation is not described or description leads to uncertainty in quality of allocation and possibility of bias.
- Allocation concealment
  - Low risk: Allocation was to be classed as adequately concealed if allocation was done using a centralised system independent of research team, use of pre-numbered opaque

sealed envelopes, generation of allocation by computer by person not in charge of allocation.
    - High risk: Providers of intervention undertake allocation or research team allocate participants and have access to participant characteristics.
    - Unclear risk: Methods of concealment not described or description does not allow bias to be ruled out.
- Blinding of outcome assessors. In the case of speech and language therapy interventions neither participant nor provider can be blind to the type of treatment given. Blinding in studies in this review was to refer to blinding of study research team and treatment provider to allocation process
    - Low risk: Reports state that assessors were blind to allocation.
    - High risk: Reports suggested that assessors were likely to know the group to which the participant had been allocated (e.g. provided treatment, worked with person delivering treatment).
    - Unclear risk: No information on blinding of assessors.
- Loss to follow up
    - Low risk: Attrition is similar in both conditions and no greater than 25% of participants entering the trial.
    - High risk: Loss of participants to follow up is greater than 25% or is distributed unevenly across groups.
    - Unclear risk: Loss of participants to follow up is not reported.
    - We planned to consider studies showing uneven loss to follow up separately in sensitivity analyses.
- Intention to treat analysis
    - Low risk: All trial participants entered into the analysis in the group to which they were originally allocated.
    - High risk: Trial participants who did not complete their originally allocated treatment removed from the analysis.
    - Unclear risk: Intention- to- treat analysis not reported.

Measures of treatment effect

Continuous data

We planned to summarise similar outcome measures with continuous data using standardised mean differences (SMD).

Binary data

Binary data (e.g. reaching normal loudness: yes or no) may be used in early reports. We planned to calculate a standard estimation of the odds ratio (OR) for binary data, with a 95% confidence interval (CI).

Dealing with missing data

Where information was unc l ear or missing we contacted study authors to request clarification and additional data.

Assessment of heterogeneity

We planned to undertake meta-analysis of studies that investigated similar interventions, used similar outcome measures and included groups of participants who were clinically homogeneous. We planned to assess possible inconsistency across studies using the I^2 statistic (Higgins 2003). For heterogeneous studies (Q-statistic = 0.1 and I^2 value of 50% or greater) we planned to conduct subgroup analysis only. We planned to undertake a narrative review of heterogeneous studies.

Assessment of reporting biases

We aimed to investigate associations between effect size and study precision in terms of sample size using funnel plots.

Data synthesis

We planned to assess the overall quality of the body of evidence using Grades of Recommendations, Assessment, Development and Evaluation approach (GRADE) and assign it a rating of ‘high’, ‘moderate’, low’ or ‘very low’ quality. We will use GRADE profiler (GRADEPro 2015) to construct a ‘Summary of findings’ table.

Subgroup analysis and investigation of heterogeneity

We planned to carry out subgroup analyses if studies fitting the criteria for meta-analysis could be grouped further according to participants' type of dysarthria, severity of dysarthria, age.

Sensitivity analysis

We planned to undertake sensitivity analyses to assess the robustness of review findings by investigating the impact of study quality:

- effects of randomisation;
- inadequate concealment;
- blinding of outcome assessors;
- unequal loss to follow up; and
- failure to employ intention- to- treat design.

RESULTS

Description of studies

Results of the search

We found a total of 1644 abstracts. Following removal of duplicates, we considered 48 full texts and 20 papers that initially appeared to meet the inclusion criteria for the review (Fischer-Brandies 1987; Ray 2001; Hartley 2003; Fox 2005; Puyuelo 2005; Pennington 2006; Fox 2008; Marchant 2008; Cleland 2009; Wood 2009; Pennington 2010; Nordberg 2011; Fox 2012; Levy 2012; Miller 2013; Pennington 2013; Ward 2013; Ward 2014; Boliek 2015; Fox 2015). Two papers involved children with Down's Syndrome (Cleland 2009; Wood 2009); one included children with a range of diagnoses (Romski 2010); all others included children with cerebral palsy. Cleland 2009 and Wood 2009 provided additional information to the published paper stating that participants in their studies did not have dysarthria. Romski 2010, was excluded because participants did not have confirmed dysarthria; additional information was requested but not provided. All other studies were excluded on the grounds that they used observational designs. Thus, no papers were identified as fitting the inclusion criteria for this review. Agreement between the reviewers on exclusion was 100%.

Included studies

No controlled studies were identified for this review.

Excluded studies

Excluded observational studies of speech and language therapy intervention aimed at improving the speech of children with dysarthria

Although not the focus of the review, we have summarised the findings of the excluded observational studies of speech and language therapy intervention aimed at improving the speech of children with dysarthria identified by our searches in order show developing evidence for dysarthria intervention for this clinical group. Studies are described in Table 1 and we present a summary of their findings here. Most observational studies investigated interventions designed to control respiratory effort and breath support for speech (Hartley 2003; Fox 2005; Puyuelo 2005; Pennington 2006; Fox 2008; Pennington 2010; Fox 2012; Levy 2012; Miller 2013; Pennington 2013; Boliek 2015; Fox 2015). Those that included motor learning principles of intensive practice, knowledge of results and fading feedback; multiple data collection points pre and post therapy; and blinded outcome assessment provide support for the potential effectiveness of this type of intervention, with increases in speech intelligibility and improvements in acoustic measures associated with voice quality being observed (Pennington 2006; Fox 2008; Fox 2012; Miller 2013 and Pennington 2010; Pennington 2013). Motor learning principles were also used with proprioceptive feedback in the hierarchical treatment PROMPT (Prompts for Restructuring Oral Muscular Phonetic Targets (Hayden 1994)), which was associated with increased oromotor movement and phonetic accuracy and possibly improved intelligibility (Ward 2013 ; Ward 2014). Three studies involved nonspeech exercises (Fischer-Brandies 1987; Ray 2001; Puyuelo 2005) and indicated no improvement or were unable to do so because of methodological flaws in the study design (e.g. lack of blinding of assessors, indefinite intervention and measurement). Electropalatography increased articulatory precision (Nordberg 2011). However, articulation therapy without biofeedback showed no effect on intelligibility or orofacial spasticity (Marchant 2008).

Risk of bias in included studies

No controlled studies were identified for this review.

Effects of interventions

No controlled studies were identified for this review.

DISCUSSION

Children with early acquired dysarthria often have reduced quality of life and are at risk of social exclusion, failure in education and later unemployment. In addition, there can be psychosocial, family and societal economic consequences. Children with severe dysarthria are often prescribed augmentative and alternative communication (AAC) systems (such as pictures, symbol or word charts or voice output communication aids) to supplement their natural modes of communication but children still prefer to communicate by speech wherever possible.

In this review we aimed to examine the effectiveness of interventions to improve the speech of children with dysarthria acquired below three years of age. We searched for randomised controlled trials and quasi-experimental designs but found no studies of these types. Searches did identify a number of observational studies, however, which have suggested that interventions which follow motor learning principles may be associated with increases in speech intelligibility, precision of articulatory movements and voice quality and clarity for children with moderate and severe dysarthria. Further interventions may have been reported in non-controlled studies, but may not have been identified in this review.

AUTHORS' CONCLUSIONS

Implications for practice

None

Implications for research

Observational studies identified during this review suggest that several interventions which follow motor learning principles may be associated with increases in speech intelligibility, voice quality and clarity. Rigorous research, in the form of randomised controlled trials, is needed to test the general effectiveness of speech and language therapy for children with early acquired dysarthria. Trials should include no therapy and attentional placebo control arms. They should evaluate changes in speech impairment and function, by measuring change in speech intelligibility, voice quality and clarity. And, as intelligible communication allows children to engage with the world around them, trials should also investigate the impact of intervention on children's social participation. This should include the extent and success of children's communication with friends, family, teachers and strangers and their engagement in social and educational activities. The consequent impact of communication change on well-being should also be evaluated using quality of life measures. Such primary and secondary effects may evolve over different periods of time. It is important, therefore, that development and potential decay of effects is evaluated in the short (e.g. one month), medium (e.g. three months) and long (e.g. six to twelve months) term. The costs of intervention and the acceptability of therapy to children and their parents must also be examined.

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REFERENCES

References to studies excluded from this review

Akin Senkal 2013 *{published data only}*

Akin Senkal O, Ciyiltepe M. Effects of voice therapy in school-age children. *Journal of Voice* 2013;**27**(6):e719-25.

Boliek 2015 *{published and unpublished data}*

Boliek C, Bakhtiari R, Reed AJ, Mager BJ, Cribben I, Gyane HHM, et al. Neural and physiological changes following intensive voice therapy in children with motor speech disorders secondary to cerebral palsy. 19th International Congress of Parkinson's Disease and Movement Disorders, San Diego, CA, June 14-18, 2015.

Cantarella 2010 *{published data only}*

Cantarella G, Viglione S, Forti S, Pignataro L. Voice therapy for laryngeal hemiplegia: the role of timing of initiation of therapy. *Journal of Rehabilitation Medicine* 2010;**42**(5):442-6.

Cleland 2009 *{published and unpublished data}*

Cleland J, Timmins C, Wood SE, Hardcastle WJ, Wishart JG. Electropalatographic therapy for children and young people with Down's syndrome EPG therapy in Down's syndrome. *Clinical Linguistics and Phonetics* 2009;**23**(12):926-39.

Fischer-Brandies 1987 *{published data only}*

Fischer-Brandies H, Avalle C, Limbrock G J. Therapy of orofacial dysfunctions in cerebral palsy according to Castillo-Morales: first results of a new treatment concept. *European Journal of Orthodontics* 1987;**9**(2):139-43.

Flipsen 2013 *{published data only}*

Flipsen P Jr, Sacks S, Neils-Strunjas J. Effectiveness of systematic articulation training program accessing computers (SATPAC) approach to remediate dentalized and interdental /s, z/: a preliminary study. *Perceptual & Motor Skills* 2013;**2**:559-77.

Forrest 2008 *{published data only}*

Forrest K, Iuzzini J. A comparison of oral motor and production training for children with speech sound disorders. *Seminars in Speech & Language* 2008;**29**(4):304-11.

Fox 2005 *{published and unpublished data}*

Fox CM, Boliek C, Ramig LO. The impact of intensive voice treatment (LSVT) on speech intelligibility in children with spastic cerebral palsy. *Movement Disorders* 2005;**20**(10):s149.

Fox 2008 *{published and unpublished data}*

Fox C, Boliek C, Namdaran N, Nickerson C, Gardner B, Piccott C, et al. Intensive voice treatment (LSVTR LOUD) for children with spastic cerebral palsy. *Movement Disorders* 2008;**23**(S1):S378.

Fox 2012 *{published and unpublished data}*

Fox CM, Boliek CA. Intensive voice treatment (LSVT LOUD) for children with spastic cerebral palsy and dysarthria. *Journal of Speech, Language, and Hearing Research* 2012;**55**(3):930-45.

Fox 2015 *{published and unpublished data}*

Fox CM, Boliek CA. Technology-enhanced maintenance practice following intensive voice therapy (LSVT LOUD®) in children with cerebral palsy and dysarthria. 19th International Congress of Parkinson's Disease and Movement Disorders, San Diego, CA, June 14-18, 2015.

Gallerano 2012 *{published data only}*

Gallerano G, Ruoppolo G, Silvestri A. Myofunctional and speech rehabilitation after orthodontic-surgical treatment of dento-maxillofacial dysgnathia. *Progress in Orthodontics* 2012;**13**(1):57-68.

Grigos 2010 *{published data only}*

Grigos MI, hayden D, Eigen J. Perceptual and articulatory changes in speech production following PROMPT treatment. *Journal of Medical Speech-Language Pathology* 2010;**18**(4):46-53.

Grill 2010 *{published data only}*

Grill MF, Ng YT. Dramatic first words spoken in 2 children after vagus nerve stimulation. *Seminars in Pediatric Neurology* 2010;**17**(1):54-7.

Hartley 2003 *{published data only}*

Hartley CL, Grove N, Lindsey J, Pring T. Treatment effects on speech production and speech intelligibility of dysarthric speech in children with cerebral palsy. Paper presented at Vth European CPLOL Congress, Edinburgh, UK, 5th - 7th September 2003.

King 2013 *{published data only}*

King AM, Hengst JA, DeThorne LS. Severe speech sound disorders: an integrated multimodal intervention. *Language, Speech & Hearing Services in the Schools* 2013;**44**(2):195-210..

Levy 2012 *{published and unpublished data}*

Levy ES, Ramig LO, Camarata SM. The effects of two speech interventions on speech function in pediatric dysarthria. *Journal of Medical Speech-Language Pathology* 2012;**20**(4):82-7.

Levy 2014 *{published data only}*

Levy ES. Implementing two treatment approaches to childhood dysarthria. *International Journal of Speech-Language Pathology* 2014;**International Journal of Speech-Language Pathology**(4):344-54.

Lousada 2013 *{published data only}*

Lousada M, Jesus LM, Capelas S, Margaça C, Simões D, Valente A, et al. Phonological and articulation treatment approaches in Portuguese children with speech and language impairments: A randomized controlled intervention study. *International Journal of Language and Communication Disorders* 2013;**48**(2):172-187.

Marchant 2008 *{published and unpublished data}*

Marchant J, McAuliffe MJ, Huckabee M. Treatment of articulatory impairment in a child with spastic

dysarthria associated with cerebral palsy. *Developmental Neurorehabilitation* 2008;**11**(1):81-90.

Miccio 2010 *{published data only}*

Miccio AW, Powell TW. Triangulating speech sound generalization. *Clinical Linguistics and Phonetics* 2010;**24**(4-5):311-22.

Miller 2013 *{published and unpublished data}*

Miller N, Pennington L, Robson S, Roelant E, Steen N, Eftychiou E. Changes in voice quality after speech-language therapy intervention in older children with cerebral palsy. *Folia Phoniatrica et Logopaedica* 2013;**65**(4):200-207.

Namasivayam 2013 *{published data only}*

Namasivayam AK, Pukonen M, Goshulak D, Yu D, Kadis D, Kroll R, et al. Relationship between speech motor control and speech intelligibility in children with speech sound disorders. *Journal of Communication Disorders* 2013;**46**(3):264-80.

Nordberg 2011 *{published and unpublished data}*

Nordberg A, Carlsson G, Lohmander A. Electropalatography in the description and treatment of speech disorders in five children with cerebral palsy. *Clinical Linguistics and Phonetics* 2011;**25**(10):831-52.

Nordberg 2014 *{published data only}*

Nordberg A, Miniscalco C, Lohmander A. Consonant production and overall speech characteristics in school-aged children with cerebral palsy and speech impairment. *International Journal of Speech-Language Pathology* 2014;**16**(4):386-95.

Pennington 2006 *{published and unpublished data}*

Pennington L, Smallman CE, Farrier F. Intensive dysarthria therapy for older children with cerebral palsy: findings from six cases. *Child Language Teaching & Therapy* 2006;**22**(3):255-73.

Pennington 2008 *{published and unpublished data}*

Pennington L, Robson S, Miller N, Steen N. Improving the intelligibility of children with dysarthria: results from a pilot study. *Developmental Medicine and Child Neurology* 2008;**Supplement 114**:23-4.

Pennington 2010 *{published and unpublished data}*

Pennington L, Miller N, Robson S, Steen N. Intensive speech and language therapy for older children with cerebral palsy: a systems approach. *Developmental Medicine and Child Neurology* 2010;**52**(4):337-44.

Pennington 2013 *{published and unpublished data}*

Pennington L, Roelant E, Thompson V, Robson S, Steen N, Miller N. Intensive dysarthria therapy for younger children with cerebral palsy. *Developmental Medicine and Child Neurology* 2013;**55**(5):464-71.

Preston 2013 *{published data only}*

Preston JL, Brick N, Landi N. Ultrasound biofeedback treatment for persisting childhood apraxia of speech. *American Journal of Speech-Language Pathology* 2013;**22**(4):627-43.

Puyuelo 2005 *{published data only}*

Puyuelo M, Rondal, JA. Speech rehabilitation in 10 Spanish-speaking children with severe cerebral palsy: a 4-year longitudinal study. *Pediatric Rehabilitation* 2005;**8**(2):113-6.

Ray 2001 *{published data only}*

Ray J. Functional outcomes of orofacial myofunctional therapy in children with cerebral palsy. *International Journal of Orofacial Myology* 2001;**27**:5-17.

Robson 2009 *{published and unpublished data}*

Robson S, Eftychiou E, Le Couteur J, Pennington L, Miller N, Steen N. Associations between speech intelligibility of children with cerebral palsy and the loudness and the clarity of their voice. Poster presented at the Royal College of Speech and Language Therapists Conference 'Partners in progress: spreading the word' London, 17-18 March 2009. London.

Rodriguez-Parra 2011 *{published data only}*

Rodriguez-Parra MJ, Adrian JA, Morente JC. Comparing voice-therapy and vocal-hygiene treatments in dysphonia using a limited multidimensional evaluation protocol. *Journal of Communication Disorders* 2011;**44**(6):615-30.

Romski 2010 *{published data only (unpublished sought but not used)}*

Romski RA, Sevcik RA, Adamson LB, Cheslock M, Smith A, Barker RM, et al. Randomized comparison of augmented and nonaugmented language interventions for toddlers with developmental delays and their parents. *Journal of Speech, Language, and Hearing Research* 2010;**53**:350-64.

Rong 2012 *{published data only}*

Rong P, Kuehn D. The effect of articulatory adjustment on reducing hypernasality. *Journal of Speech, Language, and Hearing Research* 2012;**55**(5):1438-48.

Schindler 2008 *{published data only}*

Schindler A, Bottero A, Capaccio P, Ginocchio D, Adorni, F, Ottaviani F. Vocal Improvement After Voice Therapy in Unilateral Vocal Fold Paralysis. *Journal of Voice* 2008;**22**(1):113-8.

Speake 2012 *{published and unpublished data}*

Speake J, Stackhouse J, Pascoe M. Vowel targeted intervention for children with persisting speech difficulties: Impact on intelligibility. *Child Language Teaching & Therapy* 2012;**28**(3):277-95.

Stepp 2011 *{published data only}*

Stepp CE, Merchant G, Heaton J, Hamilton R. Effects of voice therapy on relative fundamental frequency during voicing offset and onset in patients with vocal hyperfunction. *Journal of Speech Language & Hearing Research* 2011;**54**(5):1260-6.

Van Lierde 2010 *{published data only}*

Van Lierde KM, Mortier G, Huysman E, Vermeersch H. Long-term impact of tongue reduction on speech intelligibility, articulation and oromyofunctional behaviour in a child with Beckwith-Wiedemann syndrome. *International Journal of Pediatric Otorhinolaryngology* 2010;**74**(3):309-18.

Van Lierde 2012 *{published data only}*

Van Lierde K, Galiwango G, Hodges A, Bettens K, Luyten A. Impact of tongue reduction on overall speech intelligibility, articulation and oromyofunctional behavior in 4 children with Beckwith-Wiedemann syndrome. *Folia Phoniatrica et Logopaedica* 2012;**64**(2):55-63.

Van Nuffelen 2009 *{published data only}*

Van Nuffelen G, De Bodt M, Wuyts F, Van de Heyning P. The effect of rate control on speech rate and intelligibility of dysarthric speech. *Folia Phoniatrica et Logopaedica* 2009;**61**(2):69-7..

Van Nuffelen 2010 *{published data only}*

Van Nuffelen G, De Bodt M, Vanderwegen J, Van de Heyning P, Wuyts F. Effect of rate control on speech production and intelligibility in dysarthria. *Folia Phoniatrica et Logopaedica* 2010;**62**(3):110-19.

Van Rees 2012 *{published data only}*

van Rees LJ, Ballard KJ, McCabe P, Macdonald-D'Silva AG, Arciuli J. Training production of lexical stress in typically developing children using orthographically biased stimuli and principles of motor learning. *American Journal of Speech-Language Pathology* 2012;**21**(3):197-206.

Ward 2013 *{published and unpublished data}*

Ward R, Strauss G, Leitão S. Kinematic changes in jaw and lip control of children with cerebral palsy following participation in a motor-speech (PROMPT) intervention. *International Journal of Speech-Language Pathology* 2013;**15**(2):136-55.

Ward 2014 *{published and unpublished data}*

Ward R, Leitão S, Strauss G. An evaluation of the effectiveness of PROMPT therapy in improving speech production accuracy in six children with cerebral palsy. *International Journal of Speech-Language Pathology* 2014;**16**(4):355-71.

Wilk 2010 *{published data only}*

Wilk M, Pachalska M, Lipowska M, Herman-Sucharska I, Makarowski R, Mirski A, &Jastrzebowska G. Speech intelligibility in cerebral palsy children attending an art therapy program. *Medical Science Monitor* 2010;**16**(5):CR222-31.

Wood 2009 *{published and unpublished data}*

* Wood S, Wishart J, Hardcastle W, Cleland J, Timmins C. The use of electropalatography (EPG) in the assessment and treatment of motor speech disorders in children with Down's syndrome: e vidence from two case studies. *Developmental Neurorehabilitation* 2009;**12**(2):66-75.

Additional references

Bax 2006

Bax M, Tydeman C, Flodmark O. Clinical and MRI correlates of cerebral palsy: The European Cerebral Palsy Study. *JAMA* 2006;**296**:1602-8.

Cahill 2002

Cahill L, Murdoch B, Theodoros D. Perceptual analysis of speech following traumatic brain injury in childhood. *Brain Injury* 2002;**16**:415-46.

Chapman 2001

Chapman SB, McKinnon L, Levin HS, Song J, Meier MC, Chiu S. Longitudinal outcome of verbal discourse in children with traumatic brain injury: three-year follow-up. *Journal of Head Trauma Rehabilitation* 2001;**16**:441-55.

Cornwell 2003

Cornwell PL, Murdoch BE, Ward EC, Kellie S. Perceptual evaluation of motor speech following treatment for childhood cerebellar tumour. *Clinical Linguistics & Phonetics* 2003;**17**:5597-615.

Dickinson 2007

Dickinson HO, Parkinson KN, Ravens-Sieberer U, Schirripa G, Thyen U, Arnaud C, et al. Self-reported quality of life of 8-12-year-old children with cerebral palsy: a cross-sectional European study. *The Lancet* 2007;**369**(9580):2171-8.

Dodd 2006

Do d d B, Zhu H, Crosbie S, Holm A, Ozanne A. Diagnositic Evaluatio n of Articulation and Phonology . 2 . Oxford : Pearson , 2006 .

Fauconnier 2009

Fauconnier J, Dickinson HO, Beckung E, Marcelli M, McManus V, Michelsen SI, et al. Participation in life situations of 8-12 year old children with cerebral palsy: cross sectional European study. *BMJ* 2009;**338**(apr23_2):1458-71.

Hayden 1994

Hayden DA, Square PA. Motor speech treatment hierarchy: a systems approach. *Clinics in Communication Disorders* 1994;**4**:162-74.

Hayden 2006

Hayden, D. The PROMPT Model: u se and application for children with mixed phonological impairment. *Advances in Speech Language Pathology* 2006;**8**:265-81.

Higgins 2003

Higgins JPT, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ* 2003;**327**:557-60.

Higgins 2011a

Higgins JPT, Deeks JJ (editors). Chapter 7: Selecting studies and collecting data. In: Higgins JPT, Green S (editors),*Cochrane Handbook for Systematic Reviews of Interventions* Version 5.1.0 (updated March 2011). The Cochrane Collaboration, 2011 . Available from www.cochrane-handbook.org .

Higgins 2011b

Higgins JPT, Altman DG, Sterne JAC (editors). Chapter 8: Assessing risk of bias in included studies. In: Higgins JPT, Green S (editors). *Cochrane Handbook for Systematic Reviews of Interventions* Version 5.1.0 (updated March 2011). The

Cochrane Collaboration, 2011 . Available from www.cochrane-handbook.org .

Hirano 1981

Hirano M. Clinical examination of voice. Clinical examination of voice. Vienna: Springer-Verlag, 1981.

Hodge 1999

Hodge MM, Wellman L. Management of children with dysarthria. In: Caruso AJ, Strand E editor(s). Clinical management of motor speech disorders in children. New York: Thieme, 1999:209-80.

Hodge 2009 [Computer program]

Hodge M, Go e t zke. TOCS+ . Alberta : Univesrity of Alberta , 2009 .

ICAN 2007

ICAN 2007. Language and social exclusion. http://www.ican.org.uk/~/media/Ican2/Whats%20the%20Issue/Evidence/4%20Language%20and%20Social%20Exclusion%20pdf.ashx .

Kennes 2002

Kennes J, Rosenbaum P, Hanna SE, Walter S, Russell D, Raina P, et al. Health-status of school aged children with cerebral palsy: information from a population-based sample. *Developmental Medicine & Child Neurology* 2002;**44**:240-7.

King 2004

King G, Law L, King S, Hurley P, Rosenbaum P, H anna S, e t al. Children's Assessment of Participation and Enjoyment (CAPE) . San Antonio : Pearson , 2004 .

Lepage 1998

Lepage Cl, Noreau L, Bernard P-M, Fougeyrollas P. Profile of handicap situations in children with cerebral palsy. *Scandinavian Journal of Rehabilitation Medicine* 1998;**30**(4):263-72.

Love 1992

Love RJ. Childhood motor speech disability. 1st Edition. Boston: Allyn and Bacon, 1992.

Morgan 2008

Morgan AT, Vogel AP. Intervention for dysarthria associated with acquired brain injury in children and adolescents . *Cochrane Database of Systematic Reviews* 2008, Issue 3. [DOI: 10.1002/14651858.CD006279.pub2]

Netsell 2001

Netsell R. Speech aeromechanics and the dysarthrias: implications for children with traumatic brain injury. *Journal of Head Trauma Rehabilitation* 2001;**16**:415-25.

Nordberg 2013

Nordberg A, Miniscalco C, Lohmander A, Himmelmann K. Speech problems affect more than one in two children with cerebral palsy: Swedish population-based study. *Acta Paediatrica, International Journal of Paediatrics* 2013;**102**(2):161-6.

Odding 2006

Odding E, Roebroeck M, Stam H. The epidemiology of cerebral palsy: incidence, impairments and risk factors. *Disability and Rehabilitation* 2006;**28**:183-91.

Palisano 1997

Palisano R, Rosenbaum P, Walter S, Russell D, Wood E, Galuppi B. Development and reliability of a system to classify gross motor function in children with cerebral palsy. Developmental Medicine and Child Neurology 1997; Vol. 39, issue 4:214-23.

Pennington 1999

Pennington L, McConachie H. Mother-child interaction revisited: communication with non-speaking physically disabled children. *International Journal of Language and Communication Disorders* 1999;**34**:391-416.

Petheram 2001

Petheram B, Enderby P. Demographic and epidemiological analysis of patients referred to speech and language therapy at eleven centres 1987-95. *International Journal of Language & Communication Disorders* 2001;**36**:515-25.

Ravens-Sieberer 2005

Ravens-Sieberer U, Gosch A, Rajmil L, Erhart M, Brui l J, Duer W, e t al. KIDSCREEN-52 quality-of-life measure for children and adolescents . *Expert Review of Pharmacoeconomics & Outcomes Research* 2005 ; **5** (3):353-64.

RevMan 2014 [Computer program]

The Nordic Cochrane Centre, Cochrane . Review Manager (RevMan) . Version 5.3 . Copenhagen : The Nordic Cochrane Centre, Cochrane , 2014 .

Richter 2005

Richter S, Schoch B, Ozimek A, Gorissen B, Hein-Kropp C, Kaiser O, et al. Incidence of dysarthria in children with cerebellar tumors: a prospective study. *Brain & Language* 2005;**92**:153-67.

Robertson 1982

Robertson SJ. Dysarthria Profile. Bicester: Winslow Press, 1982.

Robinson 2002

Robinson KA, Dickersin K. Development of a highly sensitive search strategy for the retrieval of reports of controlled trials using PubMed. *International Journal of Epidemiology* 2002;**31**:150-3.

Schmidt 2005

Schmidt RA, Lee TD. Motor control and learning: A behavioural emphasis. 4th Edition. Champaign, Illinois: Human Kinetics, 2005.

Strand 1995

Strand EA. Treatment of motor speech disorders in children. *Seminars in Speech and Language* 1995;**16**:126-39.

Thomas-Stonnell 2010

Thomas-Stonell N, Oddson B, Robertson B, Walker J, Rosenbaum P. Development of the FOCUS (Focus on the Outcomes of Communication Under Six), a communication outcome measure for preschool children. *Developmental Medicine and Child Neurology* 2010;**52**(1):47-53.

Van Mourik 1996

V an Mourik M, Catsman-Berrevoets CE, Yousef-Bak E, Paquier PF, V an Dongen HR. Dysarthria in children with cerebellar or brainstem tumors. *Pediatric Neurology* 1998;**18**:411-4.

Watson 2015

Watson RM, Pennington L. A UK survey of SLT for children with communication disorder and cerebral palsy. *International Journal of Language and Communication Disorders* 2015;**50**(2):241–259.

Weismer 2006

Weismer, G. Philosophy of research in motor speech disorders. *Clinical Linguistics and Phonetics* 2006;**20**(5):315-49.

Wilcox 1999

Wilcox K, Morris S. Children's Speech Intelligibility Measure. Children's Speech Intelligibility Measure. San Antonio: Harcourt, 1999.

Yorkston 1981

Yorkston K, Beukleman D. Assessment of Intelligibility of Dysarthric Speech . Aus tin : Pro-Ed Inc , 1981 .

Yorkston 1996

Yorkston KM. Treatment efficacy: dysarthria. *Journal of Speech & Hearing Research* 1996;**39**(5):S46-57.

Yorkston 1999

Yorkston KM, Beukelman, DR, Strand, EA, Bell KR. In: Yorkston KM, Beukelman, DR, Strand, EA, Bell KR editor(s). Management of motor speech disorders in children and adults. Austin: Pro-Ed, 1999.

References to other published versions of this review

Pennington 2009

Pennington L, Miller N, Robson S. Speech therapy for children with dysarthria acquired before three years of age . *Cochrane Database of Systematic Reviews* 2009, Issue 4. [DOI: 10.1002/14651858.CD006937.pub2]

* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Akin Senkal 2013	Not nonprogressive dysarthria under three years of age
Boliek 2015	Observational study
Cantarella 2010	Not nonprogressive dysarthria under three years of age
Cleland 2009	Authors confirmed that participants did not have dysarthria
Fischer-Brandies 1987	Observational study
Flipsen 2013	Not nonprogressive dysarthria under three years of age
Forrest 2008	Not nonprogressive dysarthria under three years of age
Fox 2005	Observational study
Fox 2008	Observational study
Fox 2012	Single case experimental design
Fox 2015	Observational study
Gallerano 2012	Not nonprogressive dysarthria under three years of age

Study	Reason for exclusion
Grigos 2010	Not nonprogressive dysarthria under three years of age
Grill 2010	Not nonprogressive dysarthria under three years of age
Hartley 2003	Observational study
King 2013	Not nonprogressive dysarthria under three years of age
Levy 2012	Observational study
Levy 2014	Observational study
Lousada 2013	Not nonprogressive dysarthria under three years of age
Marchant 2008	Observational study
Miccio 2010	Not nonprogressive dysarthria under three years of age
Miller 2013	Observational study
Namasivayam 2013	Not nonprogressive dysarthria under three years of age
Nordberg 2011	Observational study
Nordberg 2014	Not intervention study
Pennington 2006	Observational study
Pennington 2008	Observational study. Preliminary report, more detailed information given on same study in Pennington 2009
Pennington 2010	Observational study
Pennington 2013	Observational study
Preston 2013	Not nonprogressive dysarthria under three years of age
Puyuelo 2005	Observational study
Ray 2001	Observational study
Robson 2009	Observational study
Rodriguez-Parra 2011	Not nonprogressive dysarthria under three years of age
Romski 2010	Speech intervention compared with augmented communication in randomised controlled trial. Not clear if participants had dysarthria; no motor speech measures included. Further information was requested from the authors but was not provided
Rong 2012	Not nonprogressive dysarthria under three years of age
Schindler 2008	Not nonprogressive dysarthria under three years of age
Speake 2012	Not nonprogressive dysarthria under three years of age

Study	Reason for exclusion
Stepp 2011	Not nonprogressive dysarthria under three years of age
Van Nuffelen 2009	Not nonprogressive dysarthria under three years of age
Van Lierde 2010	Not nonprogressive dysarthria under three years of age
Van Lierde 2012	Not nonprogressive dysarthria under three years of age
Van Nuffelen 2010	Not nonprogressive dysarthria under three years of age
Van Rees 2012	Not nonprogressive dysarthria under three years of age
Ward 2013	Single case experimental design
Ward 2014	Single case experimental design
Wilk 2010	Not speech and language therapy
Wood 2009	Authors confirmed that participants did not have dysarthria

ADDITIONAL TABLES

Table 1. Excluded, observational study findings

Study	Study design	Participants	Intervention type	Intervention duration	Outcome measures	Outcomes	Timing of outcome measures	Methodological problems
Fischer-Brandies 1987	Observational	71 (37 F, 34 M) children with cerebral palsy, age 4-14 years (mean = 10 years); 42 spastic type CP; 9 athetosis, 20 hypotonia; orofacial dysfunction	Oromotor intervention. Orofacial regulation therapy: wearing of removable plates for upper jaw, stimulators on palatal plate for tongue and upper lip plus motor speech therapy. 49 children also received physiotherapy (Vojta or Bobath or Castillo-Morales)	Appliances worn for several hours per day (exact duration not specified) over a mean period of 15 months (range 6 months to 3 years)	***Impairment:*** List of symptoms, rated as better or worse after treatment: abnormal tongue position; limited tongue mobility (single and multiple directions); type of tongue mobility problem (jerky, slow, vermicular); drooling; labial sound production; palatal sound production; dental sound production; feeding (sipping, sucking, chewing, choking)	***Impairment:*** Number of children showing improvement when symptoms rated as better or worse than at start of therapy by neuropaediatrician. Improvements observed (number showing improvement/number showing difficulties in area measured): abnormal tongue position 20/59; limited tongue mobility 33/56; jerky tongue movements 13/23, extremely slow tongue movements 10/21; sucking 15/31; sipping 23/30; chewing 21/37; severe drooling 28/40; labial sounds 24/38; palatal sounds 26/57; dental sounds 24/53. In 17 cases oral functions worsened after therapy	Beginning and end of treatment; timing not specified.	Rater not blind to prior scores; binary scale used in outcome measure (better/worse) with no information on validity or reliability of outcome measures; no control group; before and after treatment measures only.
Ray 2001	Observational	16 children (7 F, 9 M) with cerebral palsy; aged 7 – 10 years (mean = 8 years); mild to moderate spasticity. All children had scores within normal limits on Raven's Coloured Progressive Matrices (Ravens-Sieberer 2005), all had passe	Oromotor intervention. Orofacial myofunctional treatment, focusing on resting position of lips closed and tongue under hard palate, plus strength exercises for jaw, lips and tongue (exercises involving isolated	Treatment given 5 days per week for 4 months. Treatment sessions = 15 min individual therapy plus 10 min group treatment. Parents were provided with exercises for children to	***Impairment:*** 4-point rating scale of function of lips, jaw and tongue, by 1 orthodontist and 2 speech language pathologists. Percentage errors on production of phonemes in 20 single words, as transcribed independently by 2 speech language pathologists. Percentage errors then converted to 5-point scale	***Impairment:*** Group difference in pre and post therapy scores for lip and tongue position (mean pre-therapy score = 2.21, mean post- therapy score = 1.60; P value = 0.012) and for percentage phonemes correct (mean pre-therapy score = 1.00, mean post therapy score = 1.62; P value = 0.002)	Pre and post therapy. Timings not specified.	No blinding of assessors; no maturational or experimental control; no follow-up.

Table 1. Excluded, observational study findings *(Continued)*

		d pure tone screening at 25 dB HL bilaterally. Children had mild to moderate language delay but were able to understand simple instructions	movements not speech) and passive stretching of lips and tongue	complete at home				
Hartley 2003	Observational	4 boys with predominantly athetoid type cerebral palsy aged 10 – 13 years (mean 11 years). Speech described as "borderline intelligible". All children used augmentative and alternative communication systems.	Subsystems intervention. 2 blocks of therapy. 1st block concentrated on respiration and phonation. 2nd block focused on articulation deficiencies noted during assessment	Two 4-week blocks of therapy. Duration and frequency of session were not specified	***Impairment:*** Impairment scores on Dysarthria Profile (Robertson 1982) ***Activity:*** Percentage intelligibility of single word speech on Children's Speech Intelligibility Measure (Wilcox 1999) to one familiar and one unfamiliar listener per participant	***Impairment:*** Dysarthria profile showed positive change for one child ***Activity:*** Group comparison of intelligibility data across time. No difference in intelligibility across data collection points	6 weeks prior to therapy, 1 week prior to therapy, in the week between therapy blocks, 1 week after therapy completion, 6 weeks after therapy completion	Results of 4 cases presented as a group for intelligibility investigation; no blinding of outcome assessor; no maturational or experimental control; no follow-up
Marchant 2008	Single case experimental design	One 13 year old girl with spastic type cerebral, and severe spastic dysarthria. Hearing and vision within normal limits. Comprehension adequate for testing and therapy procedures	Subsystem and oromotor intervention. 2 blocks of therapy. 1st block: phonetic placement, articulation therapy involving teaching of correct movement patterns for target speech sounds. 2nd block: relaxation	2 blocks of therapy each comprising 10 sessions of 45 minutes over 2 weeks. Withdrawal of therapy for 2 weeks between therapy blocks	***Impairment:*** Surface EMG amplitude of left and right obicularis oris and submental muscles; vowel formant frequencies; duration of alternative motion rates of repeated syllables; perceptual rating of voice characteristics using Duffy scale by 2 therapists blind to time of recording but not to aims of study; self-perception of speech	***Impairment:*** Single word intelligibility improved after articulation therapy and improvement was maintained post EMG therapy (pre-therapy = 35%; post articulation therapy = 44.0%; post EMG = 44.45%). Slight change in motor control after EMG therapy: reduction in amplitude of nonspeech movements (approximately 30 microvolts) and gap between syllables (approx 0.1 sec). No change in participants' view of her speech disorder ***Activity:*** No change in intelligibility at sentence or paragraph level	On each of 3 consecutive days before 1st block of therapy, on the day following 1st block of therapy, on the day following the 2nd block of therapy	Therapists rating speech were not blind to aims of the study. No maturational or experimental control; no follow-up

Table 1. Excluded, observational study findings *(Continued)*

			of muscle groups using bio feedback from surface electromyography (EMG).		impairment by participant ***Activity:*** percentage intelligibility in single words, sentences and paragraphs. Significant difference assumed if post therapy results were +/- 1 SD from pre therapy scores			
Nordberg 2011	Observational	5 children with cerebral palsy (2 F, 3 M) aged 7-13 years (mean = 9 years) with mild to severe dysarthria. 3 children had dyskinetic cerebral palsy, 2 spastic cerebral palsy; 4 walked without aids, 1 used a walker	Subsystem intervention. Electropalatography (EPG). Target sounds = /t/, /d/, /n/, /s/	15 minutes per day, 5 days per week for 8 weeks	***Impairment:*** Analysis of place of articulation as shown on EPG pattern. Articulatory duration. Phonetic transcription of target sound	Tongue placement for targets in initial and medial word position changed post therapy (P value ≤ 0.01). Articulation approach and release time reduced after therapy for all participants, with wide variation between participants; all children increased contact between tongue and alveolar ridge; target perceived as /t/ for all children (no statistical testing)	1 week before and 1 week after therapy. No further information given	No blinding of assessors; no maturational or experimental control; no follow-up
Ward 2013 and Ward 2014	Single case experimental design	6 children (3 F, 3 M) with cerebral palsy; aged 3-11 years (mean = 5 years); moderate to severe speech impairment; < -1.5 SD on articulation test; 1 dyskinetic, 5 spastic type; IQ ≥ 70; receptive language within 2 SD; hearing within nor-	Subsystem intervention. PROMPT (Prompts for Restructuring Oral Musculature Phonetic Targets, Hayden 2006): focuses on timing and coordination of movements of speech subsystems; provides tac-	45- minute sessions, once weekly for 20 weeks. 1 lower level goal targeted in first 10 weeks. 1 higher level goal targeted during second 10 weeks. 3rd goal selected as con-	***Impairment:*** 3D motion analysis of movement accuracy in 11 untrained words repeated 5 times. Visual analysis of perceived movement accuracy and perceived phonetic accuracy (accurate/inaccurate) across 6 trained and untrained words selected from a corpus of 30	***Impairment:*** Motion analysis: all children changed their lip and/or jaw movements in untrained words following treatment (P value ≤ 0.05). Perceived movement and phonetic accuracy increased during the treatment phase for all children and was maintained above baseline at follow-up; 4 children increased movement and phonetic accuracy of higher level target; 2 children showed change in control target (no statistical testing)	Kinematic and intelligibility measures week before therapy, at end of each phase of therapy. Weekly speech probes for measures of perceived movement and pho-	Reliability of 3D motion analysis not tested. Confidence intervals for intelligibility test taken from the test standardisation, which did not include children with speech disorder

Table 1. Excluded, observational study findings *(Continued)*

		mal limits; correctable visual impairment	tile-kinaesthetic proprioceptive feedback during speech to train jaw, lip and tongue movements in a hierarchical sequence	trol, no intervention. Fidelity of treatment with protocol checked by independent therapist blind to study phase (77.7%-97%)	***Activity:*** Percentage intelligibility of single word speech (Children's Speech Intelligibility Measure) to one listener blind to speaker, time of recording and aim of research	***Activity:*** All children increased percentage intelligibility after block 2 (mean increase = 24%); increase maintained at follow-up	netic accuracy during 5 baseline therapy and during 20 weeks of therapy. Follow-up probe at 12 weeks post therapy
Fox 2005 and Fox 2012	Multiple baseline single case experimental design with replication across participants	5 children (2 F, 3 M), aged 5; 10–7; 10 years with spastic type cerebral palsy	Lee Silverman Voice Therapy LOUD® - targets respiratory effort and vocal loudness	4 weeks: 16 1-hour sessions (4 times per week for 4 weeks) plus minimum 36 practice sessions between treatment sessions. 4 children received therapy, 1 child received no treatment	***Impairment:*** Acoustic measures: dB Sound Pressure Level (SPL), maximum phonation duration in seconds, harmonics to noise ratios (HNR) in dB, maximum and minimum pitch in Hz, pitch range in Hz, elicited in maximum performance tests, sustained vowels, sentence repetition and cartoon description Perceptual measures: therapists' blinded preferences for recordings made at different times on overall loudness, loudness variability, overall pitch, pitch variability, articulatory precision, overall voice quality; parents' ratings of voice characteristics	***Impairment:*** Change (no overlapping data points) noted on all acoustic measures in maximum performance tests post therapy and at follow-up for 3 of the 4 children who received treatment. Trends noted in sustained phonation and sentence repetition for 3 children. No change or reducing scores for child who did not receive therapy. Therapists preferred overall loudness, loudness variability, pitch variability, articulatory precision, overall voice quality of post- treatment recordings. Parents noted change for 4 children, but changes not consistently maintained at follow-up ***Activity:*** 3 children judged to be more communicative after therapy, changes maintained for one child	2 weeks prior to treatment, 2 weeks post treatment and follow-up at 6 weeks post treatment

Table 1. Excluded, observational study findings *(Continued)*

					Activity: Parent ratings of spoken communicative activity			
Fox 2008	Observational	8 children (6 F, 2 M) aged 6 -12 years with spastic type cerebral palsy	Lee Silverman Voice Therapy LOUD®	4 weeks: 16 1- hour sessions (4 times per week for 4 weeks)	***Impairment:*** Acoustic measures: dB SPL, jitter, HNR and duration of phonation in maximum performance tests and in sentence repetition Perceptual ratings: children's parents rated voice quality using visual analogue scales	***Impairment:*** Increase in vocal SPL in sustained vowels (F (2-12) = 5.14, P value = 0.024) post therapy and follow-up; improvements in jitter (measure of voice quality) post therapy and at follow-up (F (2-12) = 5.27, P value = 0.02); increase in SPL of spoken sentences after therapy (F (2-12) = 5.29, P value = 0.02) Parents perceived their children's voices as "louder", less "nasal" and more "natural" after treatment	2 weeks prior to treatment, 2 weeks post treatment and 12 weeks post treatment	No blind rating of perceptual measures
Fox 2015 and Boliek 2015	Observational	8 children (3 F, 6 M) with cerebral palsy aged 8-16 (mean = 10 yrs) years Dysarthria characterised as mild to severe spastic or spastic-flaccid type GMFCS (Palisano 1997) II-V (median = III)	Lee Silverman Voice Therapy LOUD® with daily maintenance sessions (practice without therapist) for 12 weeks	4 weeks: 16 1-hour sessions (4 times per week for 4 weeks), followed by daily maintenance sessions (practice without therapist) for 12 weeks	***Impairment*** : Speech: speech rate in diadochokinetic (DDK) tasks/pataka/; dB SPL in sentence repetition. Neurophysiology: Diffusion Tensor Imaging DTI), functional Magnetic Resonance Imaging (fMRI), inter-muscular coherence comparison pre and post intervention and with typically developing controls matched for age and sex ***Activity*** : Percentage Intelligibility in repeated sentences. Subjective ratings of intelligibility and	***Impairment:*** No change in group mean SPL or DDK rate. Mean increase in maximum inter-muscular coherence in DDK at follow-up (t (7) = 2.34 P value < 0.02) Change in left corticospinal tract on DTI (fractional anisotropy change > 1 SD of typically developing controls). Change in fMRI activation maps post therapy (t > 3.11, P value < 0.001) ***Activity:*** Group increase in intelligibility post therapy (t (7) = 3.49, P value < 0.01) were maintained at follow-up. All parents rated their child's intelligibility as better after therapy	2 weeks prior to treatment, 2 weeks post treatment and follow-up at 12 weeks post treatment	No blind rating of perceptual measures. Fox 2015 states 9 children participated but results provided for 8

Table 1. Excluded, observational study findings *(Continued)*

					communication performance			
Levy 2012	Observational	3 girls with spastic type cerebral palsy. P1 age 8 years, mild dysarthria; P2 3 yrs, moderate dysarthria; P3 9 yrs, moderate dysarthria and apraxia, cognitive impairment and language delay	P1 and P2: Lee Silverman Voice Therapy LOUD®, P3: Therapy adapted from Pennington 2010: discussion of posture, speech clarity, monitoring of speech, breathing at start of exhalation, activities focusing on stress, intensity and breathing control	P1 and P2: 4 sessions of 50-60 min per week plus 10 min homework for 4 weeks. P3: 2 sessions of 50 minutes per week with homework for 4 weeks	***Impairment*** : dB SPL; articulation (Arizona Articulation Proficiency Scale). ***Activity*** : Listeners blind to the time of speech recording rated ease of understanding and made rated preference for paired recordings	***Impairment:*** All participants increased articulatory proficiency score by 9-19 points. P1 and P2 increased dB SPL in words or spontaneous speech by > 5 dB SPL; P3 words and spontaneous speech decreased by 6 dB SPL ***Activity:*** Post- therapy speech recordings preferred and judged as easier to understand for all participants	2 weeks prior to intervention; during 1s t week post intervention	No random allocation of participant to treatment. Participants differed in co-occuring difficulties likely to affect response to treatment. Treatment intensity differed between interventions
Pennington 2006	Observational	6 participants (4 F, 2 M), aged 10-18 years) all of whom had cerebral palsy: 4 spastic type, 1 mixed type, 1 ataxic type. Hearing within normal limits. 2 children with language delay, but comprehension adequate for simple verbal instructions; 4 children language comprehension within	Whole system approach, targeting control of breath supply for speech production and prosodic contrasts	Individual therapy for 20-30 min. 5 sessions per week for 5 weeks	***Activity:*** Percentage of single words (Children's Speech Intelligibility Measure) and connected speech (elicited in picture description) intelligible to three unfamiliar listeners. Listeners blind to time of recording ***Other:*** Semi-structured interview on acceptability of treatment	***Activity:*** Individual results presented for each participant and group. 4 students increased single word intelligibility immediately after therapy (2%-25%), but gains in intelligibility were not maintained at follow-up. 2 students did not increase intelligibility of single words. Increases in connected speech intelligibility were observed for 3 participants (75-13%), gains were not maintained at follow-up. No group change in intelligibility ***Other:*** 3 participants reported that the duration and intensity of the treatment were acceptable. 3 participants reported that the therapy was too inten-	1 week prior to therapy, 1 week after therapy completion, 6 weeks after therapy completion	No control group or maturational control

Table 1. Excluded, observational study findings *(Continued)*

		normal limits. All used speech to communicate. Dysarthria rated as mild to severe by local therapists				sive and that either 4 weeks of therapy 5 times per week or 3 sessions per week for 5 weeks would be preferred		
Pennington 2010; Miller 2013; Robson 2009	Observational	16 participants (9 F, 7 M); aged 12-18 years (mean = 14 years, SD = 2). 15 with cerebral palsy, 1 with Worster-Drought. 9 children had bilateral spastic type cerebral palsy, 2 had dyskinetic type, 4 had mixed (spastic and dyskinetic) and 1 child had Worster Drought. GMFCS ranged from I-V (median = IV). Dysarthria rated moderate to severe by referring speech and language therapists. All children were able to comprehend simple instructions	Whole systems approach which focused on stabilising the students' respiratory and phonatory effort and control, speech rate and phrase length/syllables per breath	3 individual sessions of 30-40 min each per week for 6 weeks	***Impairment:*** Perceived voice quality rating scale (GRBAS: Grade, Roughness, Breathiness, Aesthenia, Strain, Hirano 1981), therapists rated speech recordings blind to time of recording. Acoustic measures: HNR, amplitude, shimmer (regularity of amplitude o f vocal fold vibrations) , jitter (r egularity of f requency of vocal fold v ibratio n s) , F0 mean (average fundamental frequency), rate with pauses, rate without pauses, time with pauses and time without pauses ***Activity:*** Mean percentage intelligibility of single words (Children's Speech Intelligibility Measure) and connected speech to 3 familiar and 3 unfamiliar listeners. Listeners blind to time of recording for intelligibility measures	***Impairment:*** Slight reduction in fundamental frequency, intensity and jitter of children's voices (all P value < 0.05). Increase in speaking time between pauses by approx 1 second. Aesthenia reduced post therapy (-0.26 on 4-point GRBAS scale, effect size 0.4). No other differences in voice quality were perceived. Aesthenia was weakly associated with reduced intelligibility (R -0.11, 95% CI -0.58 to -0.15, with -10.7% reduction in intelligibility with an increase of 1 point on the aesthenia rating scale). No association between change in intelligibility and any other GRBAS ratings ***Activity:*** Statisictially significant gains in intelligibility post therapy: on average familiar listeners understood 14.7% more single words and 12.1% more words in connected speech after the therapy; unfamiliar listeners understood 15.0% more single words and 15.9% more words in connected speech after therapy (all P value < 0.05) ***Other:*** All children reported that the therapy was acceptable and would recommend it to a friend	6 weeks and 1 week before therapy, 1 week and 6 weeks after therapy completion	No treatment integrity checks; longer term effects of intervention were not evaluated. Participants acted as own controls, no control group

Table 1. Excluded, observational study findings *(Continued)*

					Other: Questionnaire on the acceptability of therapy, using Likert scales			
Pennington 2013	Observational	15 participants (6 F, 9 M) aged 5-11 years, mean = 8 years, SD = 2). 13 with cerebral palsy, 2 with Worster-Drought. 8 children had spastic type cerebral palsy, 4 had dyskinetic type and 1 ataxia. GMFCS ranged from II-IV (median = II). Dysarthria rated moderate to severe by referring speech and language therapists. All children were able to comprehend simple instructions	Whole systems approach which focused on stabilising the students' respiratory and phonatory effort and control, speech rate and phrase length/syllables per breath	3 individual sessions of 30-40 min each per week for 6 weeks.	***Activity:*** Mean percentage intelligibility of single words (Children's Speech Intelligibility Measure) and connected speech to 3 familiar and 3 unfamiliar listeners. Listeners blind to time of recording for intelligibility measures ***Participation:*** FOCUS (Focus on Communicaiton Outcomes Under Six, Thomas-Stonnell 2010) measure of perceived communication activity and participation completed by parents ***Other:*** Questionnaires on the effectiveness and acceptability of therapy, using Likert scales	***Activity:*** On average familiar listeners understood 10.8% more single words and 9.4% more words in connected speech after the therapy. Unfamiliar listeners understood 9.3% more single words and 10.5% more words in connected speech after therapy (all P value < 0.05) ***Participation:*** Mean improvement in FOCUS score = 30.3 (95% CI 10.2 to 50.4). No association between change in FOCUS score and percentage intelligibility observed ***Other:*** 12/15 parents rated therapy: 8 rated therapy as having good effects, 4 rated therapy as having moderate effects	6 weeks and 1 week before therapy, 1, 6 a nd 12 weeks after therapy completion	No treatment integrity checks. Participants acted as own controls, no control group
Puyuelo 2005	Observational	10 children (3 F; 7M) with cerebral palsy , aged 3 years at the start of the study. 5 children had athetoid type CP, 4 spastic type and 1 had ataxia. Children had "absence	First block of therapy focused on increasing control of oral movement used in articulation, chewing and expiration. Second block of therapy fo-	2 blocks of treatment. Each block comprised 11 months of twice-weekly therapy, each session lasting 30 min	***Impairment:*** Impairment scores on Spanish adaptation of Robertson Dysarthria Profile . Spectrographic analysis of a repeated sentence	***Impairment:*** Group results presented. Following the first treatment only voice control increased. Following the second treatment scores increased for respiration, voice, articulation, intelligibility and prosody (all P value < 0.05). Spectrographic analysis was also possible at the end of the second treatment, as children had developed some spoken output	Before intervention, between first and second interventions, after intervention 2. Exact timing of measures not specified	No control group; long duration of treatment; no control of maturational effects; no blinding of assessor

Table 1. Excluded, observational study findings *(Continued)*

	of articulated speech". Hearing and language comprehension within normal limits	cused on controlling exhalation for speech and co-ordination of exhalation and phonation; voice training; and prosody (intonation, pausing, rhythm and sound duration). In the second block of therapy advice was given to parents on stimulating communication, and children engaged in story telling and recall to practice their speech skills with their parents. Whilst receiving the above therapies children also received Bobath neurodevelopmental treatment

GMFCS = Gross Motor Function Classification System (Palisano 1997)

APPENDICES

Appendix 1. MEDLINE search strategy

1. dysarthria/rh, th [rehabilitation, therapy]
2. articulation disorders/rh,th [rehabilitation, therapy]
3. speech disorders/rh, th [rehabilitation, therapy]
4. voice disorders/rh, th [rehabilitation, therapy]
5. 1 or 2 or 3 or 4
6. child/ or adolescent/ or infant/ or child, preschool/
7. 5 and 6
8. randomized-controlled trial.pt.
9. controlled-clinical trial.pt.
10. randomized controlled trials/
11. random allocation/
12. double-blind method/
13. single-blind method/
14. or/8-13
15. animal/ not human/
16. 14 not 15
17. clinical trial.pt.
18. exp clinical trials/
19. (clinic$ adj25 trial$).tw.
20. ((singl$ or doubl$ or trebl$ or tripl$) adj (mask$ or blind$)).tw.
21. placebos/
22. placebo$.tw.
23. random$.tw.
24. research design/
25. (latin adj square).tw.
26. or/17-25
27. 26 not 15
28. 27 not 16
29. comparative study/
30. exp evaluation studies/
31. follow-up studies/
32. prospective studies/
33. (control$ or prospectiv$ or volunteer$).tw.
34. cross-over studies/
35. or/29-35
36. 35 not 15
37. 36 not (16 or 28)
38. 16 or 28 or 37

WHAT'S NEW

Date	Event	Description
24 June 2016	New citation required but conclusions have not changed	Review update - conclusions not changed
15 October 2015	New search has been performed	New authors added. New studies added. New funding declared. Conclusions not changed.
18 May 2009	Amended	Converted to new review format

HISTORY

Protocol first published: Issue 1, 2008
Review first published: Issue 4, 2009

Date	Event	Description
5 October 2007	New citation required and major changes	Substantive amendment

CONTRIBUTIONS OF AUTHORS

Lindsay Pennington and Nick Miller designed the study. Lindsay Pennington created the first draft of the review. Lindsay Pennington, Helen Kelly and Naomi Parker conducted searches, selected papers for inclusion and extracted data. All authors were involved in the writing of the final draft of the review.

DECLARATIONS OF INTEREST

Lindsay Pennington : none known
Nick Miller : none known
Sheila Robson : none known
Helen Kelly : extracted data from studies conducted by Lindsay Pennington and Nick Miller
Naomi Parker: extracted data from studies conducted by Lindsay Pennington and Nick Miller

SOURCES OF SUPPORT

Internal sources

- No sources of support supplied

External sources

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- National Insitute of Health Research, UK.

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DIFFERENCES BETWEEN PROTOCOL AND REVIEW

An earlier version of this review (New Reference) included measures of speech function (respiration, phonation, resonance, articulation and prosody) as primary outcome measures. These outcomes are secondary outcomes in this review. Primary outcomes in this review comprise speech intelligibility and communicative participation only. Quality of life was not considered in the original version of the review but has been added as secondary outcome in this version.

INDEX TERMS

Medical Subject Headings (MeSH)

*Speech Intelligibility; Age Factors; Dysarthria [etiology] [*therapy]; Speech Therapy [*methods]

MeSH check words

Child; Child, Preschool; Humans