LONGITUDINAL DATA ON ARTICULATION RATE AND PRODUCTION UNIT LENGTH IN CHILDREN WITH SPEECH DELAY

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Introduction

Data presented in the attached tables are based on a long-term follow-up study of two groups of children originally diagnosed with Speech Delay (SD) of unknown origin at preschool age. Both groups were recruited in Madison, Wisconsin using the following criteria: (1) three to six years of age, (2) presenting with SD of unknown origin, including (a) no significant defects in the structure or function of the speech and hearing mechanisms, (b) no significant cognitive deficits, (c) no significant psychosocial dysfunction, (3) producing speech errors of sufficient severity to interfere with intelligibility and to warrant speech services, and (4) native speakers of General American English. Most of the children had no received speech services at the time of the initial assessment session. Further details on the recruitment of the participants and the assessment procedures used can be found in Flipsen (1999, 2001a). Speaker demographic and classification data are shown in Table 1.

Included in Table 1 are both initial and follow-up status of each child as derived from the Speech Disorders Classification System (SDCS; Shriberg, Austin, Lewis, McSweeny, & Wilson, 1997). The column labeled "Outcome Group" indicates classification stems of Normalized Speech Acquisition (NSA) or Residual Errors (RE) as defined by the SDCS which were used for comparisons in Flipsen (1999, 2001b).

Note that the children in Group 2 were the same children studied by Gruber (1999) but tested at a later date. Gruber proposed that children within this group followed one of two paths to normalization (defined as achieving at least 85% on the Percentage of Consonants Correct metric[1]). In Gruber's study, one group (following what he termed path A) improved all error types concurrently as they approached normalization, while the second (Gruber's path B) increased their distortion errors while omission and substitution errors decreased. Children from Group 2 are identified in Table 1 as to which of Gruber's paths they followed.

Rate Measurements.

Analysis of articulation rate on all 106 conversational speech samples (53 initial and 53 follow-up) was conducted by the current author using digitized versions of the samples created using the Record utility of the program CSpeech (Milenkovic, 1996). Digitizing conditions included a sampling rate of 22 KHz, 15 bits of quantization, 72 dB of dynamic resolution, and low-pass filtering at 9.8 KHz.

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[1] This criterion differs qualitatively from the age-specific, error-table lookup procedure used by the SDCS.

Phonetic phrases were defined as stretches of continuous speech bounded by pauses; such units have occasionally been referred to as "runs" (e.g., Walker, Archibald, Cherniak, & Fish, 1992). Pauses were identified using wideband (500 Hz) spectrograms and defined as silent intervals of 250 ms or longer, a criterion chosen to avoid confusion with articulatory events such as stop closures. For cases in which potential pauses were bounded by two stop consonants, a modified criterion of 400 ms was used. It should be noted that it was quite possible for a phonetic phrase to extend across an utterance boundary if a pause was not observed. Potential pauses were measured using specific acoustic criteria (see Appendix).

Articulation rate measurements on the overall conversational samples were derived from durations of the phonetic phrases (see below), which were combined with syllable counts and phone counts, obtained manually from the phonetic transcriptions, to yield articulation rate values in both syllables per second and phones per second for each phonetic phrase.Per speaker average rates were then calculated. Individual speaker data for articulation rate from the overall conversational samples in syllables per second are presented in Table 2 and in phones per second in Table 3.

For purposes of the analyses dealing with conversational speech ((Tables 2, 3, 4, & 5), a syllable was defined as any vowel, diphthong or syllabic consonant in the child's production; vowelized consonants (e.g., for), vowel onglides or vowel offglides were not counted as syllables. Unintelligible syllables (where they did not interfere with identifying the beginning or end of a phonetic phrase) were also counted because listeners can reliably identify syllables in unintelligible strings (Shriberg, 1986). A phone was defined as an independent speech sound represented by a phoneme symbol in the transcript; diphthongs were considered single phones. Phone counts could only be obtained from phrases that were fully intelligible resulting in a slight reduction in the number of phonetic phrases used for the calculations involving phones. Reductions occurred for 22/36 children in Group 1 and 16/17 children in Group 2 at initial testing and 12/26 in Group 1 and 7/17 in Group 2 at follow-up testing.

Articulation rate was also examined while controlling for phonetic phrase length. First length was controlled in syllables by using the approach of Haselager, Slis, and Rietveld (1991) in which phrases were grouped into short (2-4 syllables), medium (5-7 syllables) and long (8 or more syllables) categories. For the initial conversational samples there were sufficient phonetic phrases of both short and medium length available. Within each length category, a subset of the first five phonetic phrases was selected (except as noted below) including at least three different lengths (if available) and optimally no more than two phonetic phrases of any one length (never more than three). For the initial samples, all 53 of the short length samples included five phonetic phrases. All of the medium length samples included five phonetic phrases except for one speaker, which included only 3 phonetic phrases. For the follow-up samples, only long phonetic phrases (8-

12 syllables) yielded enough data for analysis. Preference was given to phonetic phrases of 8-10 syllables. For 48/53 speakers, five phonetic phrases were available; for four speakers, only four phonetic phrases met the criteria and for one speaker, only 3 phonetic phrases met the criteria. One speaker was excluded from the follow-up analysis because only two phonetic phrases were between 8 and 12 syllables long. Individual speaker data from these "syllable-length-controlled" samples are presented in Table 4.

No precedent studies could be located to provide an example to follow for controlling length in phones. Examination of the distribution of phone lengths in the samples suggested groupings into short phrases (6-10 phones), medium phrases (11-15 phones) and long phrases (16-22 phones). For the long phrases, preference was given to phonetic phrases of 16-20 phones. For the initial samples, 51/53 of the short-length samples included at least 5 short phrases; one included four phrases and one included three phrases. For the medium-length samples, 47/53 samples included five phrases, one included four phrases and four included three phrases. One child was excluded from the analysis of medium phrases because only two phrases between 11 and 15 phones in length were available. For the follow-up samples, 45/53 included five phrases, two included four phrases and six included three phrases. Individual speaker data from the "phone length-controlled" samples are shown in Table 5.

Rate measurements at follow-up were also derived from productions of words produced in structured-phrases. The task involved the production of 10 words containing (assign, cosine, kicks, kiss, kits, sin, skin, soon, spin, spoon) and 12 words containing (bird, burg, burr, cried, crude, pried, prude, rebel (noun), rebel (verb), ride, rude, tried). It also included the words kin and pin as controls for the cluster contexts. Following presentation of the word by the examiner, the speaker's task was to produce the target word in the phrase "Say _____ again." For purposes of the structured-phrase task syllable counts and phone counts were based on the adult target (i.e., what an adult speaker of General American English would produce).

Articulation rate measurements for the structured-phrase task (conducted by two trained research assistants) were based on digitized versions of the productions prepared using the same procedures as for the conversational samples. Incorrectly produced tokens and those with obvious dysfluencies or intra-phrase pauses (>250 ms) were excluded from the analysis. For words containing , tokens were also excluded if either of F2 or F3 for could not be reliably identified and tracked throughout the entire transition from the preceding vowel or consonant to the following vowel or consonant. Because the original intent of the structured-phrase task was to examine the acoustics of either or in the target words, only the target word was stored for analysis. The result was that rate measurements for the current study were derived from durations of the target words only (i.e., not the entire phrase; see Flipsen, Tjaden, Weismer & Karlsson, 1996). Word durations were converted to articulation rate (in syllables per second) by dividing the

obtained duration values (in milliseconds) into 1000 and 2000 for the one- and two-syllable words respectively. Rates in phones per second were also calculated using phrase durations and phones counts. Rates in both syllables per second and phones per second were then averaged across each speaker for all available tokens of each word type (i.e., words, words, kin/pin).. Because speakers were to be represented by means, words were not included in the analysis unless at least 3 tokens were available. Speakers were not included in the analysis for a particular type of target unless at least 65% of the words of that type were available. For one speaker (SD14), technical problems with the tape precluded analysis of the task. The net result of these exclusions was that 52/53 of the speakers were used for the analysis, 46/53 for the analysis, and 51/53 for the kin/pin analysis. Data from the structured-phrase task are presented in Table 6.

Length Measurements.

Phonetic phrases were defined as strings of speech bounded by pauses (see definition above). Phrases beginning or ending with unintelligible syllables were excluded because of concerns about measurement precision. In addition, phrases were also excluded if they (a) consisted of single words or frank imitations of the examiner, (b) were produced during obviously excited states or using a play register, (c) contained extraneous noise or simultaneous talk by both participants, or (d) was not produced with sufficient energy to allow reliable identification of the initial or final speech segment from the spectrogram. Phrases containing obvious dysfluencies (e.g., sound repetitions, prolongations) were also excluded but those containing normal nonfluencies (e.g., whole-word repetitions or interjections) were retained. The net result was samples of 22-61 useable phrases across speakers in the initial samples and 18-65 useable phrases in the follow-up samples. To limit the variation in sample size across the speakers, average rates for each child were calculated based on samples of 18-30 phrases. In cases where more than 30 phrases were available, a sample of 30 was selected to represent the distribution of phrase lengths available. To avoid possible fatigue effects, phrases occurring earlier in the sample were chosen before phrases occurring later in the sample. Mean phonetic phrase length (in syllables and phones) for each child was calculated using syllable and phone counts obtained manually from the transcripts. Individual speaker data for phonetic phrase length from the overall conversational samples are presented in Table 2 (for syllables) and Table 3 (for phones).

Mean utterance length (in words) was also calculated for each child by an updated version of the software program PEPPER (Shriberg, 1986) using the entire transcript (i.e., all utterances up to the one containing the 90th non-questionable word type for the initial samples and the 100th non-questionable word type for the follow-up samples). A word was defined as a string of segments in the transcript bounded by spaces. Morpheme counts were inaccessible in many of the initial samples because of the presence of unintelligible syllables. The high proportion of unintelligibles in many of the initial samples suggested that using only the complete and intelligible utterances would result in potentially biased

samples (a review of the seven most unintelligible samples revealed that over 65% of utterances would have been discarded). Transcribers were able to identify the number of syllable pulses present and unintelligible syllables were then grouped into words using estimations of the known distributional characteristics of word lengths in child speech (Shriberg, 1986). Using a ratio of 3:1 of monosyllabic to polysyllabic words (Shriberg & Kwiatkowski, 1980, 1983), a string of five unintelligible syllables, for example, would be grouped into three monosyllabic words and one disyllabic word. Individual speaker data for utterance length from the overall conversational samples are presented in Table 2.

TABLE 1

Speaker Demographic and Classification Data

ID	Sex	Study Group [a]	Initial Age	Initial SDCS	Follow-up Age	Follow-up SDCS
SD1	M	2	5;0	SD	9;4	NS7-
SD2	M	2	5;3	SD	9;1	<RE_A1>
SD4	M	1	4;5	SD	14;2	NS14
SD5	F	1	4;4	SD	14;2	<RE_A1>
SD6	F	1	4;0	SD+	14;2	NS14
SD7 [b]	M	1	4;1	SD[+]	12;8	NS12-
SD8	M	1	4;2	SD	14;0	NS14
SD9	M	1	3;7	NSA-/SD[+]	13;5	NS13
SD11	M	1	4;7	SD[+]	14;6	{NS14}
SD12	F	1	4;7	NSA-/SD[+]	14;6	NS14
SD13	F	1	4;6	QSD[+]	14;4	<RE_A1>
SD14	M	1	5;5	SD[+]	15;3	NS15
SD15	F	1	4;9	NSA-/SD	14;8	NS14

ID	Sex	Study Group [a]	Initial Age	Initial SDCS	Follow-up Age	Follow-up SDCS
SD16	M	1	4;8	SD	14;7	NS14-
SD17	M	1	4;11	NSA-/SD	14;10	NS5-
SD18	M	1	3;10	SD!	13;10	NS13-
SD19 [c]	M	1	3;11	NSA-/SD[+]	14;0	RE_A1
SD20	M	1	4;4	SD[+]	14;10	NS14
SD22	F	1	4;0	NSA-/SD	14;5	RE_A1
SD23	M	1	4;2	QSD	14;8	NS5
SD24	M	1	3;4	QSD[+]	13;10	{NS13}
SD25	M	1	4;3	SD[+]	14;9	NS5
SD26	M	1	5;1	SD	15;8	NS15-
SD27	M	1	5;6	{NSA-}[+]	16;2	NS16
SD28 [c]	M	1	4;8	SD	14;10	NS14-
SD29	M	1	4;0	QSD[+]	14;6	NS14-
SD30 [c]	F	1	4;1	QSD[+]	14;8	NS5-
SD31	F	1	3;3	QSD	13;5	NS13-
SD32	F	1	5;2	{NSA-}	15;9	NS15-

ID	Sex	Study Group [a]	Initial Age	Initial SDCS	Follow-up Age	Follow-up SDCS
SD33	F	1	4;6	QSD	15;1	NS15
SD35	M	1	3;5	QSD	13;4	{NS13}
SD36	M	2	4;4	NSA-/SD	9;9	NS5-
SD37 [c]	M	1	4;1	SD[+]	13;2	[RE_A2][+]
SD38	M	1	4;7	{NSA-}[+]	15;3	NSA-
SD39	F	1	4;11	SD[+]	15;7	<RE_A1>
SD40	M	1	4;4	NSA-/SD	14;6	NS14-
SD41	F	2	4;6	NSA-/SD	9;10	<RE_A1>
SD42	M	2	4;4	NSA-/SD	9;8	<RE_A1>
SD43	M	2	4;2	QSD	9;8	RE_A1
SD44	M	2	3;9	NSA-/SD	9;2	[RE_A2]
SD45	M	2	3;8	SD![+]	9;1	<RE_A1>
SD46	M	1	4;4	NSA-/SD[+]	15;2	{NS15-}
SD47	M	2	4;1	QSD	9;2	<RE_A1>
SD48 [c]	M	2	3;10	NSA-/SD	9;2	RE_A1
SD49	F	2	4;1	QSD	9;8	NS4-

ID	Sex	Study Group [a]	Initial Age	Initial SDCS	Follow-up Age	Follow-up SDCS
SD50	F	2	3;11	NSA-/SD	9;3	NS4-
SD51	F	1	5;7	SD	15;10	NS15-
SD52	M	2	4;0	SD	9;4	<RE_A1>
SD53 [c]	F	2	3;5	SD!*[+]	9;0	<RE_A1>
SD54	M	2	3;5	SD!*+	9;1	RE_A2
SD55	M	1	5;4	NSA-/SD	16;9	NS16
SD56	F	2	3;2	QSD	9;2	NS5-
SD58	M	2	2;11	SD![+]	9;2	RE_A1

[a] Within the context of the Phonology Project, Group 1 is also known as "DCS" and Group 2 is also kno

[b] Initial testing was conducted at age 2;11, but no conversational speech sample could be evoked at that 1-year follow-up was used for initial analysis of both segmental speech skills and articulation rate.

[c] Initial conversational speech samples were unsuitable for articulation rate measurements (see Flipsen, 6-12 months later were used for rate measurements.

[d] Followed Gruber's Path A to normalization (see Gruber, 1999).

[e] Followed Gruber's Path B to normalization (see Gruber, 1999).

TABLE 2

Articulation Rate and Production Unit Length Data (using syllables and words) from the Overall Conversational Samples

ID	Initial Samples				Follow-up Sample		
	n	Mean Articulation Rate [a]	Mean Phonetic Phrase Length [b]	Mean Utterance Length [c]	n	Mean Articulation Rate [a]	Mean Phonetic Phra Length [b]
SD1	30	2.71	5.10	4.33	30	3.20	5.17
SD2	25	3.16	4.60	4.02	30	3.82	6.43
SD4	30	3.72	4.97	2.76	30	5.21	6.73
SD5	30	4.03	4.83	4.06	30	6.03	6.33
SD6	30	3.15	4.43	3.27	22	4.80	8.36
SD7	30	4.29	4.37	3.79	30	4.21	6.13
SD8	30	3.34	5.20	3.73	30	4.21	5.77
SD9	30	3.83	4.57	2.99	28	4.56	8.00
SD11	30	3.02	4.20	2.25	30	5.74	7.07
SD12	30	3.01	6.00	5.80	29	4.07	6.14
SD13	30	3.48	4.33	4.46	30	4.35	5.33
SD14	22	3.36	7.41	5.19	27	5.69	7.11

ID	Initial Samples				Follow-up Sample		
	n	Mean Articulation Rate [a]	Mean Phonetic Phrase Length [b]	Mean Utterance Length [c]	n	Mean Articulation Rate [a]	Mean Phonetic Phra Length [b]
SD15	30	2.81	6.73	4.26	26	5.22	7.92
SD16	30	3.86	4.73	4.80	30	4.09	7.30
SD17	30	3.16	4.57	3.56	30	4.10	5.30
SD18	30	3.49	4.00	2.99	30	4.97	5.70
SD19	30	3.36	4.93	3.75	26	4.96	9.62
SD20	30	3.37	4.57	2.60	30	4.49	5.93
SD22	30	3.13	4.13	3.94	30	5.03	7.50
SD23	30	3.17	3.63	2.41	30	5.47	6.17
SD24	30	4.10	4.17	2.68	24	5.78	11.46
SD25	30	2.85	4.80	4.04	30	4.92	6.53
SD26	30	3.69	5.03	3.38	30	5.27	7.13
SD27	30	3.57	4.93	4.63	30	4.92	7.53
SD28	30	4.26	4.57	4.00	27	5.13	8.44
SD29	30	2.91	3.53	3.03	30	4.74	6.23

ID	Initial Samples				Follow-up Sample		
	n	Mean Articulation Rate [a]	Mean Phonetic Phrase Length [b]	Mean Utterance Length [c]	n	Mean Articulation Rate [a]	Mean Phonetic Phra Length [b]
SD30	25	3.45	3.44	3.20	30	4.01	4.63
SD31	30	2.85	4.20	3.90	16	5.41	14.25
SD32	30	3.62	5.63	5.51	30	4.99	5.77
SD33	24	3.67	6.63	7.54	26	6.01	9.31
SD35	30	3.35	4.90	3.72	27	5.41	6.59
SD36	30	4.15	6.20	4.51	24	4.81	8.96
SD37	30	2.63	4.30	3.30	30	3.77	6.17
SD38	22	3.23	5.59	3.60	30	4.54	6.67
SD39	30	4.08	5.17	4.59	28	4.92	8.36
SD40	30	3.62	4.30	3.80	28	5.06	6.96
SD41	28	3.54	6.96	10.13	30	3.81	7.27
SD42	30	4.47	4.73	4.26	30	5.31	7.93
SD43	30	3.55	6.10	6.70	30	4.31	6.83
SD44	30	3.37	4.43	3.58	30	4.00	6.77

ID	Initial Samples				Follow-up Sample		
	n	Mean Articulation Rate [a]	Mean Phonetic Phrase Length [b]	Mean Utterance Length [c]	n	Mean Articulation Rate [a]	Mean Phonetic Phra Length [b]
SD45	30	3.08	4.17	3.71	29	4.13	8.17
SD46	30	3.29	4.33	3.13	30	5.83	7.33
SD47	30	3.11	5.00	4.67	27	3.71	8.52
SD48	30	3.60	6.20	6.00	30	4.59	7.23
SD49	30	3.33	6.50	7.96	28	4.29	8.79
SD50	30	3.19	4.30	4.41	30	3.83	7.27
SD51	22	3.09	5.14	3.24	30	4.60	7.87
SD52	30	3.19	4.60	3.42	30	3.31	5.97
SD53	30	2.88	4.47	3.34	30	5.19	4.57
SD54	28	3.06	2.89	2.56	30	3.12	6.33
SD55	25	3.67	6.32	6.24	22	5.22	10.36
SD56	30	3.36	5.57	3.64	30	4.83	6.27
SD58	30	3.20	3.27	2.51	30	4.27	6.07

[a] expressed in syllables per second. [b] expressed in syllables. [c] expressed in words.

TABLE 3

Articulation Rate and Production Unit Length Data (using phones) from the Overall Conversational Samples

ID	Initial Samples			Follow-up Samples		
	n	Mean Articulation Rate [a]	Mean Phonetic Phrase Length [b]	n	Mean Articulation Rate [a]	Mean Phonetic Phrase Length [b]
SD1	29	6.37	11.52	30	7.71	12.63
SD2	24	7.46	10.58	30	9.48	16.27
SD4	30	8.89	12.13	30	12.79	16.67
SD5	30	9.53	11.17	30	15.36	16.30
SD6	29	6.78	9.14	22	11.76	19.91
SD7	26	9.93	9.19	30	10.23	14.6
SD8	28	6.88	10.14	30	11.01	15.00
SD9	30	8.38	10.03	28	10.88	19.21
SD11	30	7.27	10.20	29	13.65	16.62
SD12	30	7.14	14.33	29	10.37	15.55
SD13	30	7.34	8.97	30	9.68	12.27
SD14	22	7.80	17.32	27	14.43	18.33
SD15	29	6.61	15.55	26	12.66	19.31
SD16	29	8.32	10.41	30	9.92	17.83
SD17	27	8.24	11.37	29	9.85	13.48
SD18	29	8.03	8.86	29	11.98	14.41
SD19	28	7.90	11.82	25	11.66	22.76
SD20	30	7.40	10.00	30	10.81	14.33
SD22	26	7.14	8.85	30	12.74	18.83

ID	Initial Samples			Follow-up Samples		
	n	Mean Articulation Rate [a]	Mean Phonetic Phrase Length [b]	n	Mean Articulation Rate [a]	Mean Phonetic Phrase Length [b]
SD23	29	7.94	8.38	29	12.89	14.79
SD24	25	8.37	8.16	23	13.75	25.39
SD25	28	6.43	10.79	30	11.87	15.53
SD26	28	7.89	10.57	30	12.78	17.37
SD27	30	8.37	11.60	30	11.83	17.77
SD28	29	9.63	10.21	27	12.72	20.81
SD29	30	6.77	8.30	29	11.34	15.86
SD30	25	8.40	8.64	30	10.29	11.77
SD31	29	5.85	8.86	15	12.66	33.13
SD32	30	8.69	13.93	29	12.11	14.34
SD33	22	8.41	14.73	26	14.28	22.58
SD35	27	7.40	9.67	27	12.69	16.04
SD36	26	9.09	13.46	22	11.63	22.27
SD37	28	5.51	8.75	29	9.02	14.31
SD38	22	7.94	13.86	30	10.79	14.77
SD39	27	8.82	10.74	28	12.12	20.43
SD40	27	8.39	10.11	27	13.46	18.30
SD41	24	8.72	15.08	30	8.84	17.03
SD42	27	10.46	10.48	30	12.46	19.13
SD43	29	8.61	14.34	30	10.79	17.37
SD44	29	8.03	10.14	29	8.80	15.38
SD45	28	6.94	8.61	29	9.72	19.48

ID	Initial Samples			Follow-up Samples		
	n	Mean Articulation Rate [a]	Mean Phonetic Phrase Length [b]	n	Mean Articulation Rate [a]	Mean Phonetic Phrase Length [b]
SD46	29	7.81	10.07	30	14.00	17.47
SD47	26	7.55	11.35	26	10.93	20.88
SD48	29	8.43	14.07	30	10.99	17.20
SD49	29	7.53	14.48	28	10.78	22.39
SD50	29	7.77	10.07	30	9.23	17.6
SD51	19	6.81	10.95	30	11.25	19.03
SD52	28	7.06	10.18	29	8.29	13.97
SD53	29	6.36	9.83	28	10.41	9.89
SD54	26	5.81	5.54	28	7.06	13.96
SD55	25	8.56	15.32	21	12.78	25.71
SD56	27	7.35	11.78	30	11.23	14.87
SD58	30	6.58	6.70	29	9.97	14.76

[a] expressed in phones per second. [b] expressed in phones.

TABLE 4

Articulation Rate Data from the Syllable-Length-Controlled Samples

ID	Initial Samples						Follow-	
	Short Phrases (2-4 syllables)			Medium Phrases (5-7 syllables)			Long Phrases	
	n	syl / sec	phon / sec	n	syl / sec	phon / sec	n	syl / sec
SD1	5	3.11	5.68	5	2.83	6.50	4	3.32
SD2	5	2.99	6.86	5	3.59	8.38	5	4.06
SD4	5	4.12	8.45	5	4.08	9.18	5	5.68
SD5	5	4.66	10.04	5	4.60	10.84	4	4.25
SD6	5	3.28	6.53	5	3.37	6.76	3	5.25
SD7	5	4.65	9.98	5	4.52	10.18	5	4.89
SD8	5	4.69	8.93	5	3.03	6.34	5	4.31
SD9	5	3.86	8.51	5	3.45	7.35	5	4.82
SD11	5	3.22	8.21	5	2.71	6.75	5	6.26
SD12	5	2.53	5.83	5	2.81	6.97	5	4.56
SD13	5	3.78	8.02	5	3.57	7.24	5	4.72
SD14	5	3.32	7.56	5	3.26	7.67	5	6.04

ID	Initial Samples						Follow-	
	Short Phrases (2-4 syllables)			Medium Phrases (5-7 syllables)			Long Phrases	
	n	syl / sec	phon / sec	n	syl / sec	phon / sec	n	syl / sec
SD15	5	3.23	7.00	5	2.40	6.15	5	5.92
SD16	5	4.12	8.95	5	3.87	8.95	5	4.15
SD17	5	2.75	8.50	5	3.85	8.70	5	4.72
SD18	5	3.09	6.77	5	3.46	7.49	5	5.78
SD19	5	2.92	7.28	5	3.05	7.97	4	5.36
SD20	5	3.01	7.64	5	3.53	7.38	5	4.26
SD22	5	2.60	6.44	5	3.26	7.72	5	4.39
SD23	5	2.87	8.09	5	3.01	6.63	5	5.93
SD24	5	4.33	8.75	5	4.93	9.46	5	5.75
SD25	5	3.07	7.82	5	3.22	6.67	5	5.20
SD26	5	3.09	6.27	5	3.88	8.42	5	5.82
SD27	5	3.74	8.53	5	3.16	7.43	5	5.14
SD28	5	3.80	9.23	5	4.88	10.13	5	4.42
SD29	5	3.81	9.21	5	2.81	6.27	4	5.42
SD30	5	2.87	7.15	5	3.92	9.78	5	4.18

ID	Initial Samples						Follow-	
	Short Phrases (2-4 syllables)			Medium Phrases (5-7 syllables)			Long Phrases	
	n	syl / sec	phon / sec	n	syl / sec	phon / sec	n	syl / sec
SD31	5	3.08	5.72	5	2.98	5.41	0	0
SD32	5	2.91	8.05	5	3.92	9.95	5	5.14
SD33	5	2.94	7.06	5	3.53	8.60	5	5.42
SD35	5	2.63	6.38	5	3.36	6.57	5	5.48
SD36	5	4.68	7.84	5	4.02	8.60	5	5.43
SD37	5	2.31	4.35	5	2.55	5.56	5	4.01
SD38	5	2.65	5.93	5	3.26	7.39	5	5.58
SD39	5	3.70	8.77	5	4.10	8.61	5	5.01
SD40	5	3.31	7.73	5	4.33	10.14	5	5.83
SD41	5	3.66	8.71	5	4.03	9.67	5	4.29
SD42	5	3.31	8.22	5	4.88	10.20	5	4.83
SD43	5	3.08	7.79	5	3.89	10.47	5	4.12
SD44	5	3.23	8.65	5	3.69	9.00	5	4.09
SD45	5	2.76	6.64	5	3.36	6.59	5	5.14
SD46	5	2.36	6.59	5	4.49	10.33	5	7.08

ID	Initial Samples						Follow-	
	Short Phrases (2-4 syllables)			Medium Phrases (5-7 syllables)			Long Phrases	
	n	syl / sec	phon / sec	n	syl / sec	phon / sec	n	syl / sec
SD47	5	2.65	6.94	5	3.28	8.02	5	4.03
SD48	5	3.09	6.91	5	3.65	8.44	5	4.93
SD49	5	2.73	6.31	5	3.12	6.71	5	4.28
SD50	5	2.89	7.71	5	3.39	7.58	5	3.54
SD51	5	2.83	6.65	5	3.56	7.35	5	4.57
SD52	5	3.09	6.07	5	3.55	7.08	5	4.09
SD53	5	2.67	5.77	5	3.10	6.21	5	5.24
SD54	5	3.01	5.45	3	3.29	6.07	5	3.61
SD55	5	3.82	8.16	5	3.98	9.48	5	5.67
SD56	5	3.96	8.82	5	3.54	7.50	5	5.00
SD58	5	2.73	5.06	5	3.16	6.37	5	5.33

"0" entries = insufficient data available.

TABLE 5

Articulation Rate Data from the Phone-Length-Controlled Samples

ID	Initial Samples						Follow-	
	Short Phrases (6-10 phones)			Medium Phrases (11-15 phones)			Long Phrase	
	n	syl / sec	phon / sec	n	syl / sec	phon / sec	n	syl / sec
SD1	5	2.23	5.78	5	2.73	6.11	5	3.35
SD2	5	2.56	5.67	3	3.26	7.64	5	4.32
SD4	5	4.02	8.33	5	3.85	9.88	5	4.88
SD5	5	3.47	7.47	5	4.81	11.03	3	6.91
SD6	5	2.52	6.49	5	3.06	6.26	4	4.71
SD7	5	4.47	9.76	5	4.02	10.03	5	3.87
SD8	5	3.12	6.91	5	3.24	6.68	5	4.53
SD9	5	2.86	7.02	5	3.67	7.79	3	4.39
SD11	5	3.72	8.62	5	2.67	6.30	5	5.25
SD12	5	2.69	6.29	5	2.79	6.95	5	4.38
SD13	5	4.32	10.09	5	3.06	6.92	5	4.76
SD14	5	3.12	7.04	3	3.13	7.72	5	4.81

ID	Initial Samples						Follow-	
	Short Phrases (6-10 phones)			Medium Phrases (11-15 phones)			Long Phrase	
	n	syl / sec	phon / sec	n	syl / sec	phon / sec	n	syl / sec
SD15	5	2.73	6.25	5	2.48	6.83	5	6.01
SD16	5	3.18	7.55	5	3.48	8.56	5	4.03
SD17	5	3.08	7.41	5	3.18	7.56	5	4.58
SD18	5	3.30	7.40	5	2.86	6.91	5	5.61
SD19	5	3.10	7.42	5	3.47	8.54	3	5.57
SD20	5	3.77	8.30	5	3.90	8.16	5	4.18
SD22	5	2.54	6.45	5	3.17	7.42	5	4.62
SD23	5	2.92	8.60	5	3.28	7.60	5	5.51
SD24	5	4.25	9.27	5	4.17	10.04	5	5.97
SD25	5	2.59	6.36	5	2.66	6.52	5	5.12
SD26	5	3.03	6.58	5	4.02	8.67	5	5.23
SD27	5	3.43	8.35	5	3.35	8.05	5	5.17
SD28	5	4.11	10.39	5	5.01	11.49	5	4.39
SD29	5	3.58	8.03	5	2.93	6.69	5	4.99
SD30	5	2.58	6.93	3	3.47	9.28	5	4.31

ID	Initial Samples						Follow-	
	Short Phrases (6-10 phones)			Medium Phrases (11-15 phones)			Long Phrase	
	n	syl / sec	phon / sec	n	syl / sec	phon / sec	n	syl / sec
SD31	5	3.00	5.97	5	2.59	6.13	3	5.63
SD32	5	3.07	8.14	5	3.72	9.50	5	4.83
SD33	4	3.32	7.94	5	3.50	7.34	5	5.55
SD35	5	2.98	6.70	5	3.32	7.92	5	6.32
SD36	3	3.97	8.71	5	3.37	8.39	3	5.47
SD37	5	2.96	6.67	5	2.89	6.05	5	3.88
SD38	4	2.45	5.69	5	2.97	7.16	5	4.14
SD39	5	3.75	8.32	5	3.74	8.47	5	5.46
SD40	5	3.20	7.93	5	3.52	8.60	5	5.33
SD41	5	3.78	9.10	5	3.45	8.96	5	3.23
SD42	5	4.41	9.69	5	3.98	9.47	5	4.76
SD43	5	3.36	8.36	5	3.35	7.36	5	4.41
SD44	5	3.35	8.41	5	3.33	7.56	5	3.76
SD45	5	3.28	7.89	5	3.32	7.66	5	4.43
SD46	5	2.59	6.94	5	4.07	8.33	5	6.37

ID	Initial Samples						Follow-	
	Short Phrases (6-10 phones)			Medium Phrases (11-15 phones)			Long Phrase	
	n	syl / sec	phon / sec	n	syl / sec	phon / sec	n	syl / sec
SD47	5	2.94	6.88	5	3.36	8.77	5	3.71
SD48	5	3.63	8.09	5	3.71	8.61	5	5.16
SD49	5	3.72	8.37	5	3.23	7.39	3	4.17
SD50	5	2.67	6.83	5	3.37	8.55	5	3.91
SD51	5	2.87	6.66	5	3.30	7.29	5	4.32
SD52	5	3.10	6.38	5	3.36	8.15	5	3.29
SD53	5	3.13	6.74	5	3.02	6.61	5	5.23
SD54	5	3.50	7.01	0	0	0	5	3.27
SD55	5	3.54	7.60	4	3.95	9.10	4	6.83
SD56	5	3.73	7.76	5	3.08	6.48	5	5.80
SD58	5	3.50	7.41	3	3.30	6.69	5	4.74

"0" entries = insufficient data available.

TABLE 6

Articulation Rate Data from the Structured-Phrase Task at Follow-up Testing

ID	Words		Words		kin / pin	
	syl / sec	phon / sec	syl / sec	phon / sec	syl / sec	phon / sec
SD1	2.17	6.9	2.69	9.28	2.75	8.24
SD2	2.76	8.87	0	0	4.21	12.62
SD4	3.13	9.90	4.24	13.20	3.66	10.98
SD5	2.33	7.52	3.10	10.29	3.00	9.01
SD6	3.19	10.56	4.39	13.97	4.24	12.71
SD7	3.22	10.55	4.30	13.91	4.54	13.63
SD8	2.40	7.70	3.10	9.82	2.96	8.87
SD9	2.51	7.98	3.43	10.60	2.75	8.24
SD11	3.55	11.38	4.69	14.81	4.40	13.20
SD12	2.67	8.49	3.15	10.51	3.19	9.57
SD13	2.19	6.93	3.21	10.55	2.79	8.36
SD14	0	0	0	0	0	0
SD15	3.26	10.36	4.90	15.90	5.00	15.01
SD16	2.61	8.52	3.29	10.43	3.61	10.82
SD17	2.52	8.50	0	0	4.25	12.75
SD18	3.45	11.93	5.36	17.20	6.06	18.18
SD19	3.32	10.71	4.40	14.54	4.51	13.53
SD20	2.80	9.04	3.82	12.21	3.56	10.68
SD22	2.18	6.92	0	0	2.77	8.32
SD23	3.10	9.92	4.07	13.14	4.79	14.37

ID	Words		Words		kin / pin	
	syl / sec	phon / sec	syl / sec	phon / sec	syl / sec	phon / sec
SD24	3.45	11.06	4.58	14.33	4.32	12.97
SD25	2.97	9.38	4.10	13.05	3.55	10.66
SD26	3.36	10.77	4.45	14.04	4.91	14.73
SD27	3.06	9.78	4.25	13.92	4.04	12.13
SD28	3.36	10.26	4.55	13.70	0	0
SD29	3.00	9.44	4.41	14.23	4.93	14.80
SD30	3.00	9.65	3.89	13.21	4.34	13.01
SD31	3.36	10.79	4.75	15.74	5.85	17.54
SD32	3.55	11.58	4.61	14.86	4.77	14.32
SD33	3.14	10.08	4.47	14.61	4.29	12.85
SD35	4.26	13.64	5.51	17.88	6.45	19.34
SD36	3.17	10.17	3.56	11.55	3.30	9.90
SD37	2.61	8.65	3.41	10.80	3.95	11.85
SD38	3.14	10.19	4.27	13.61	4.22	12.65
SD39	2.72	9.27	3.66	12.17	3.74	11.20
SD40	2.42	7.40	0	0	2.70	8.09
SD41	1.77	5.73	2.13	7.30	2.35	7.06
SD42	2.23	7.03	2.63	8.71	2.59	7.77
SD43	3.36	10.93	4.79	16.09	4.95	14.85
SD44	2.46	8.10	2.83	9.43	3.18	9.53
SD45	3.62	11.56	4.54	14.30	4.61	13.82
SD46	3.87	12.40	5.21	16.26	3.08	18.23
SD47	3.14	9.84	4.16	14.08	4.50	13.51

ID	Words		Words		kin / pin	
	syl / sec	phon / sec	syl / sec	phon / sec	syl / sec	phon / sec
SD48	2.79	8.76	3.33	11.23	3.57	10.69
SD49	3.12	9.91	4.28	13.34	3.78	11.35
SD50	2.89	9.18	3.46	11.08	4.46	13.38
SD51	3.32	10.76	4.65	15.29	5.30	15.89
SD52	2.92	9.32	3.70	11.97	4.82	14.45
SD53	2.91	9.58	0	0	4.06	12.17
SD54	2.58	8.83	0	0	0	0
SD55	3.26	10.42	4.27	13.40	4.25	12.75
SD56	3.59	11.56	4.64	14.61	5.66	16.98
SD58	3.19	10.19	3.85	12.05	4.71	14.14

"0" entries = insufficient data available.

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Appendix:

Acoustic Measurement Criteria

Phonetic phrases were defined as stretches of speech surrounded by pauses.

Potential pauses were judged to precisely **begin** at the offset of acoustic energy defined relative to the preceding speech segment in the transcript, specifically:

a. for vowels and resonant consonants, the offset of formant energy in the area of F1
b. for fricative and affricate consonants, the offset of broadband noise
c. for stop consonants, the onset of stop closure.

Potential pauses were judged to precisely **end** at the onset of acoustic energy defined relative to the following speech segment in the transcript, specifically:

a. for vowels and resonant consonants, the onset of formant energy in the area of F1
b. for fricative consonants, the onset of broadband noise
c. for stop and affricate consonants, the onset of the burst release.