Reference Data for the Madison Speech Assessment Protocol (MSAP):

A Database of 28 Participants, 3-to-6 Years of Age, with Speech Delay

Technical Report No. 19

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June, 2012

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CONTENTS

Reference Data: Segmental

       A. Competence
          1. Percentage of Non-Rhotic Vowels/Diphthongs Correct
          2. Percentage of Rhotic Vowels/Diphthongs Correct
          3. Percentage of Phonemic Diphthongs Correct
          4. Percentage of Vowels/Diphthongs Correct
          5. Percentage of Non-Rhotic Vowels/Diphthongs Correct-Revised
          6. Percentage of Rhotic Vowels/Diphthongs Correct-Revised
          7. Percentage of Phonemic Diphthongs Correct-Revised
          8. Percentage of Vowels/Diphthongs Correct-Revised
          9. Percentage of Relative Non-Rhotic Vowel/Diphthongs Distortions

       B. Precision
          1. Reduced Vowel Space: Quadrilateral VSQI
          2. Reduced Vowel Space: Quadrilateral VSQIL
          3. Reduced Vowel Space: Distance from Center VSD
          4. Reduced Vowel Space: Distance from Center VSDL
          5. Reduced Vowel Space: /i, æ, ɑ/ Distance from Center VSD3
          6. Reduced Vowel Space: /i, æ, ɑ/ Distance from Center VSD3L
          7. Lengthened Vowels: Corners
          8. Lengthened Vowels: Non-Rhotic Mids
          9. Lengthened Vowels: Phonemic Diphthongs
          10. Reduced Vowel Substitution Coefficients
          11. Increased Distorted Vowel Substitutions
          12. Less Precise Diphthongs (5 points)
          13. Less Precise Diphthongs (3 points)
          14. Distorted Rhotics: F3-F2
          15. Distorted Rhotics: F3/F2
          16. Reduced Pairwise Vowel Duration Variability

       C. Stability
          1. Less Stable Vowel Space: Quadrilateral VSQI
          2. Less Stable Vowel Space: Quadrilateral VSQIL
          3. Less Stable Vowel Space: Distance from Center VSD

3. Less Stable Sibilant Centroids: M1 at Midpoint
4. Less Stable Sibilant Centroids: Maximum M1

    A. Competence
        1. Intelligibility Index: Tabular
        2. Percentage of Structurally Correct Words: Tabular

    B. Precision
        1. Increased Percentage of Phoneme Distortions: Place
        2. Increased Percentage of Phoneme Distortions: Additions
        3. Increased Percentage of Phoneme Distortions: Duration
        4. Increased Percentage of Phoneme Distortions: Force
        5. Increased Percent of EMMA errors by type

    C. Stability
        1. Less Stable Whole Word Errors: Targets
        2. Less Stable Whole Word Errors: Error Types
        3. Less Stable Percentage of Phonemes Correct in Complex Words
        4. Increased Percent of EMMA errors by token

Reference Data: Suprasegmental

    A. Competence
        1. Percentage of Appropriate Phrasing

    B. Precision
        1. Increased Repetitions and Revisions: 2-4 Word Utterances
        2. Increased Repetitions and Revisions: 5-7 Word Utterances
        3. Increased Repetitions and Revisions: 8+ Word Utterances
        4. Increased Repetitions and Revisions: All Utterances
        5. Increased Syll/Word Segregation: Percentage of Btwn/Within-Wd Pauses
        6. Increased Syll/Word Segregation: Duration of Btwn/Within-Wd Pauses
        7. Increased Percentage of Inappropriate Pauses
        8. Increased Percentage of Pauses
        9. Reduced Speech-Pause Duration Variability Ratio: 2-4 Word Utterances
        10. Reduced Speech-Pause Duration Variability Ratio: 5-7 Word Utterances
        11. Reduced Speech-Pause Duration Variability Ratio: 8+ Word Utterances
        12. Reduced Speech-Pause Duration Variability Ratio: All Utterances

    A. Competence
        1. Percentage of Appropriate Rate

B. Precision
    1. Slower Speaking Rate: 2-4 Word Utterances
    2. Slower Speaking Rate: 5-7 Word Utterances
    3. Slower Speaking Rate: 8+ Word Utterances
    4. Slower Speaking Rate: All Utterances
    5. Slower Articulation Rate: 2-4 Word Utterances
    6. Slower Articulation Rate: 5-7 Word Utterances
    7. Slower Articluation Rate: 8+ Word Utterances
    8. Slower Articulation Rate: All Utterances

C. Stability
    1. Less Stable Speaking Rate: 2-4 Word Utterances
    2. Less Stable Speaking Rate: 5-7 Word Utterances
    3. Less Stable Speaking Rate: 8+ Word Utterances
    4. Less Stable Speaking Rate: All Utterances
    5. Less Stable Articulation Rate: 2-4 Word Utterances
    6. Less Stable Articulation Rate: 5-7 Word Utterances
    7. Less Stable Articluation Rate: 8+ Word Utterances
    8. Less Stable Articulation Rate: All Utterances

A. Competence
    1a. Percentage of Appropriate Stress

B. Precision
    1. Lexical Stress: Trochees
    2. Lexical Stress: All
    3. Emphatic Stress
    4. Sentential Stress

C. Stability
    1. Less Stable Lexical Stress: Trochees
    2. Less Stable Lexical Stress: All
    3. Less Stable Emphatic Stress
    4. Less Stable Sentential Stress

A. Competence
    1. Percentage of Appropriate Loudness

B. Precision
    1. Vowels-Consonants Intensity Ratios: Vowels-Stops
    2. Vowels-Consonants Intensity Ratios: Vowels-Affric/Fricatives
    3. Vowels-Consonants Intensity Ratios: All

C. Stability
    1. Less Stable Vowels-Consonants Intensity Ratios: Vowels-Stops
    2. Less Stable Vowels-Consonants Intensity Ratios: Vowels-Affric/Fric
    3. Less Stable Vowels-Consonants Intensity Ratios: All

A. Competence
    1. Percentage of Appropriate Pitch

B. Precision
    1. Midpoint Fundamental Frequency Mean
    2. Midpoint Fundamental Frequency Range

C. Stability
    1. Less Stable Mean Midpoint Fundamental Frequency

A. Competence
    1a. Percentage of Appropriate Laryngeal Quality

B. Precision
    1. Percentage of Breathy Utterances
    2. Percentage of Rough Utterances
    3. Percentage of Strained Utterances
    4. Percentage of Break/Shift/Tremulous Utterances

A. Competence
    1. Percentage of Appropriate Resonance Quality

B. Precision
    1. Percentage of Nasal Utterances
    2. Lowered /ɑ/ F1 (Nasal)
    3. Percentage of Nasopharyngeal Utterances
    4. Lowered /i/ F2 (Nasopharyngeal)
    5. Lowered /u/ F2 (Nasopharyngeal)

C. Stability
    1. Less Stable /ɑ/ F1 (Nasal)
    2. Less Stable /i/ F2 (Nasopharyngeal)
    3. Less Stable /u/ F2 (Nasopharyngeal)

Background

Phonology Project Technical Reports provide technical and substantive information on methods developed for a program of research in speech sound disorders of known and unknown origins. Primary goals of the Phonology Project are to identify etiologic origins, risk and protective factors, and diagnostic markers for eight subtypes of speech sound disorders of currently unknown origin (Shriberg, 2010).

The diagnostic framework used in all Phonology Project studies is termed the Speech Disorders Classification System (SDCS: Shriberg et al., 2010a). The SDCS includes a typologic nosology for research and practice in speech sound disorders, and an etiologic nosology for the eight putative subtypes of speech sound disorders of currently unknown origin. The assessment protocol used in all studies since approximately 2010 is termed the Madison Speech Assessment Protocol (MSAP). Data reduction for the MSAP includes both perceptual and acoustic methods. Perceptual methods for narrow phonetic transcription of speech are based on extensions to the system described in *Clinical Phonetics* (Shriberg & Kent, 2012). Perceptual methods to code speakers' prosody and voice are based on extensions to the system described in *The Prosody-Voice Screening Profile* (PVSP: Shriberg, Kwiatkowski, & Rasmussen, 1990) and Phonology Project Technical Report No. 1 (Shriberg, Kwiatkowski, Rasmussen, Lof, & Miller, 1992). Acoustic methods and reliability findings for speech, prosody, and voice variables are described in Shriberg et al. (2010a, 2010b) and in the Phonology Project Laboratory Manual (PPLM; unpublished). Shriberg et al. (2010a) provides extensive information on the structure and content of the MSAP relevant for the present report and is not summarized in this report.

The goal of this technical report is to provide reference data from children with Speech Delay (Shriberg, 1993) for the 145 speech, prosody, and voice signs organized by the Ten Linguistic Domains Analytics (TLDA) and the Competence, Precision, Stability Analytics (CPSA) shown in Table 1. Shriberg et al. (2010a) describes rationale for and content of the TLDA-CPSA framework.

Table 1. Organization and current number of speech, prosody, and voice signs in the Speech Disorders Classification System (SDCS). Shriberg et al. (2010a) provides a description of the rationale for and content of the Ten Linguistic Domains Analytics (TLDA) and the Competence, Precision, Stability Analytics (CPSA), which together form the TLDA-CPSA framework.[a]

Ten Linguistic Domains Analytics (TLDA)	Competence, Precision, Stability Analytics (CPSA)						Total
	Competence		Precision		Stability		
	Perceptual	Acoustic	Perceptual	Acoustic	Perceptual	Acoustic	
Segmental							
I. Vowels	9	0	0	16	4	16	45
II. Consonants	8	0	4	9	2	2	25
III. Vowels & Consonants	2	0	5	0	4	0	11
Total	19	0	9	25	10	18	81
Suprasegmental							
Prosody							
IV. Phrasing	1	0	6	6	0	0	13
V. Rate	1	0	0	8	0	8	17
VI. Stress	1	0	0	4	0	4	9
Voice							
VII. Loudness	1	0	0	3	0	3	7
VIII. Pitch	1	0	0	2	0	1	4
IX. Laryngeal Quality	1	0	4	0	0	0	5
X. Resonance	1	0	2	3	0	3	9
Total	7	0	12	26	0	19	64
Overall Total	26	0	21	51	10	37	145

[a] Data for 6 of the acoustic Laryngeal Quality variables are not included in this report due to as yet unresolved technical needs.

Method

Procedures

All parents signed an informed consent form, approved by a University of Wisconsin-Madison institutional review board, granting permission for their children to participate in the study. Parents completed a short case history.

The MSAP was administered individually to all participants in a quiet room in a speech clinic. MSAP tasks were presented using puzzles, bubbles, games, and small reinforcers to maintain the children's attention and performance. Children received prizes at the end of each session as a reward for their "hard work." For those children who were scheduled to complete the MSAP in one session, a break was taken approximately halfway through the protocol, and the children were offered juice and a snack.

The MSAP includes a hearing screening at 25 dB HL for 1000, 2000, and 4000 Hz; the Goldman-Fristoe Test of Articulation-2 (GFTA-2; Goldman & Fristoe, 2000); an oral structure-function examination; and, the remaining tests and tasks assessing speech and language. Responses to all speech tasks were recorded on a Marantz CDR420 HD/CD digital audio recorder with matching external Shure MX412DC cardioid condenser microphone. All participants completed the MSAP in one or two sessions. Fifteen of the children completed the protocol in one session, and the remaining thirteen of the 28 children were seen for two sessions scheduled within a one-week time frame. The administration time for the full MSAP averaged approximately 3 hours. The audio samples were processed using the procedures described in the prior citations.

Participants

Potential participants for the reference database were recruited over several years while they were receiving or scheduled to receive services at the Phonology Clinic, Waisman Center, University of Wisconsin-Madison. The goal was to assemble information on young children typical of those referred to the clinic for mild-moderate to severe Speech Delay, unconstrained by cognitive, language, or affective issues that would preclude their completing the MSAP in one or two sessions.

Parents/caregivers were first approached by the co-director of the Phonology Clinic and asked if they would be interested in having their children participate in the study. Those willing to participate were contacted by phone by the research examiner, who described the study in greater detail, addressed any questions or

concerns, and scheduled the assessments. Of the 31 parents contacted, all expressed interest in participating; however, due to scheduling challenges, three children (all males) who were eligible for the study were not able to participate.

Inclusionary criteria for the final data set of 28 children were English (General American dialect) as the primary spoken language and mild-moderate to severe Speech Delay as determined by a computer-based algorithm that identifies age-inappropriate speech sound deletions and substitutions (Shriberg, 1993). Exclusionary criteria were a significant deficit in language comprehension or language expression that would reduce a participant's ability to complete the MSAP, and/or the presence of any known complex neurodevelopmental disorder including cognitive disability, craniofacial anomaly, sensory-motor deficits, and/or affective disorder.

As shown in Table 2, the 28 participants include 13 males ages 41 to 65 months ($M = 52.2$, $SD = 7.3$) and 15 females ages 40 to 67 months ($M = 52.5$, $SD = 9.1$). For standardization purposes, the MSAP data are divided into two reference groups. The "Younger SD" age group ($n = 19$) includes participants from 40 to 53 months of age ($M = 47.7$; $SD = 4.6$). The "Older SD" group ($n = 9$) includes participants from 54 to 67 months of age ($M = 62.0\%$; $SD = 4.6$). There are too few children to provide age x gender data.

Table 2. Number of participants per group with data from each Madison Speech Assessment Protocol (MSAP) task.

Task		Male (n = 13)				Female (n = 15)				Both (n = 28)		
		Younger (n = 9)	Older (n = 4)	Both (n = 13)		Younger (n = 10)	Older (n = 5)	Both (n = 15)		Younger (n = 19)	Older (n = 9)	Both (n = 28)
CSS		9	3	12		10	5	15		19	8	27
CWT		9	4	13		10	5	15		19	9	28
EST		9	4	13		10	5	15		19	9	28
GF		9	4	13		10	5	15		19	9	28
LST		9	4	13		10	5	15		19	9	28
MWT1		8	4	12		8	5	13		16	9	25
SVT		9	4	13		8	5	13		17	9	26
VT1		9	4	13		10	5	15		19	9	28
VT2		9	4	13		10	5	15		19	9	28
SPT		0	0	0		1	2	3		1	2	3
SRT		9	4	13		10	5	15		19	9	28

Table 3 includes descriptive statistics for the cognitive, language, and speech characteristics of the 28 participants with Speech Delay. The cognitive and language statistics are consistent with the goals of recruiting participants who could complete the MSAP, with all participants within the normal range on the cognitive measures and most participants having typical language development. The PCC and GFTA-2 scores are consistent with mild-moderate to severe Speech Delay, with proportionally more children with moderate-severe to severe SD. Prior reports of cohorts of participants with SD have average PCC scores of 70% (SD = 10), whereas the PCC scores in Table 2 for children are lower for both genders and for the younger age group. Thus, the data from this reference database are considered representative of children with significant idiopathic SD without cognitive, language, or psychosocial constraints.

Table 3. Descriptive statistics by gender and age group for the cognitive, language, and speech characteristics of the 28 participants with Speech Delay.

Variable	Male M (SD)	Female M (SD)	Both M (SD)	Younger M (SD) 3;6-4;5	Older M (SD) 4;6-5;7
Cognition[a]					
Verbal	106 (13)	117 (7)	112 (11)	112 (13)	112 (6)
Non-verbal	106 (14)	107 (11)	106 (12)	106 (14)	107 (8)
IQ Composite	107 (12)	114 (9)	111 (11)	111 (13)	111 (7)
Language[b]					
Listening Comprehension	102 (11)	104 (10)	103 (11)	104 (11)	101 (10)
Oral Expression	91 (8)	101 (11)	96 (11)	94 (9)	100 (13)
Oral Composite	95 (7)	102 (10)	99 (9)	98 (9)	100 (11)
Speech					
Percentage of Consonants Correct	62.0 (14.0)	68.4 (13.1)	65.6 (13.6)	63.4 (13.8)	70.9 (12.3)
GFTA-2[c]	14 (11)	11 (7)	13 (9)	14 (9)	10 (8)

[a] Kaufman Brief Intelligence Test-2 (2000) standard scores; [b] Oral and Written Language Scales (1995) standard scores; [c] Goldman-Fristoe Test of Articulation-2 (2000) percentile scores.

Summary

The reference data in the following pages are presented without comment. Obvious constraints include the possibility of sampling errors due to small cell sizes and the lack of geographic and sociolinguistic diversity. Thorough analysis of trends between and among the variables in the following tables is beyond the scope of the present goal of disseminating these descriptive data on young children with significant Speech Delay. Studies in preparation with children who have motor speech disorders use these findings to standardize scores on selected signs. We invite correspondence on any aspect of the data that may be helpful for clinical or research projects on all topics.

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Key to Sources (Tasks) and Measurement Units, Abbreviations, and Symbols

ALL = All available sources

AT = Articulation Test

CSS = Conversational Speech Sample

CWT = Challenging Words Task

EST = Emphatic Stress Task

LST = Lexical Stress Task

MWT = Multisyllabic Words Task

RSTR = Rhotics and Sibilants Task [R]

RSTS = Rhotics and Sibilants Task [S]

SPT = Speech Phrases Task

SRT = Syllable Repetition Task

SVT = Sustained Vowel Task

VT1 = Vowel Task 1

VT2 = Vowel Task 2

VT12 = Vowel Tasks 1 & 2

VT3 = Vowel Task 3

count = count

Hertz = Hz

kiloHertz = kHz

milliseconds = ms

millisyllables = %$_o$

percentage = %

syllables/sec = syll/sec

unitless = u

* = No Data

Vowels/Diphthongs

Sign	Gender						Age (yrs)			
	Male		Female		Both		3;6-4;5		4;6-5;7	
	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence										
Percentage of Non-rhotic Vowels/Diphthongs Correct: CSS (%)	90.1	7.1	92.6	8.8	91.5	8.1	90.0	9.0	94.9	3.8
Percentage of Rhotic Vowels/Diphthongs Correct: CSS (%)	36.6	42.3	12.9	25.9	23.4	35.5	22.6	35.0	25.5	39.3
Percentage of Phonemic Diphthongs Correct: CSS (%)	89.6	6.9	92.5	15.3	91.2	12.2	89.1	13.9	96.3	2.9
Percentage of Vowels/Diphthongs Correct: CSS (%)	87.6	6.9	88.5	8.8	88.1	7.9	86.8	8.7	91.2	4.4
Percentage of Vowels/Diphthongs Correct: AT (%)	78.1	14.0	82.4	14.4	80.4	14.1	76.5	14.5	88.6	9.2
Percentage of Non-rhotic Vowels/Diphthongs Correct-Revised: CSS (%)	91.2	6.7	93.4	8.1	92.4	7.4	91.2	8.4	95.4	3.5
Percentage of Rhotic Vowels/Diphthongs Correct-Revised: CSS (%)	57.9	33.6	59.0	31.0	58.5	31.6	56.8	34.2	62.6	25.7
Percentage of Phonemic Diphthongs Correct-Revised: CSS (%)	90.5	6.6	92.8	15.4	91.8	12.2	89.7	14.0	96.7	3.2
Percentage of Vowels/Diphthongs Correct-Revised: CSS (%)	89.6	6.5	91.6	8.7	90.7	7.8	89.5	8.8	93.5	3.5
Percentage of Vowels/Diphthongs Correct-Revised : AT (%)	81.6	13.0	86.1	14.9	84.0	14.0	80.7	14.8	91.0	9.2
Percentage of Relative Non-rhotic Vowel/Diphthong Distortions: CSS (%)	13.0	10.0	14.5	13.2	13.9	11.8	90.0	9.0	94.9	3.8
B. Precision										
Reduced Vowel Space: Quadrilateral VSQI[a]: VT1 (u)	79202	16384	78080	24343	78598	20654	772068	195062	812273	236689
Reduced Vowel Space: Quadrilateral VSQI[a]: CSS (u)	38171	13986	39064	15293	38667	14453	424800	140217	296133	117153
Reduced Vowel Space: Quadralateral VSQIL: VT1 (u)	0.48	0.13	0.46	0.17	0.47	0.15	0.47	0.15	0.48	0.17
Reduced Vowel Space: Quadralateral VSQIL: CSS (u)	0.24	0.09	0.24	0.09	0.24	0.09	0.26	0.08	0.19	0.10
Reduced Vowel Space: Distance from Center VSD: VT1 (u)	709.7	59.0	729.2	104.1	720.2	85.2	719.6	79.4	721.5	100.5
Reduced Vowel Space: Distance from Center VSD: CSS (u)	602.3	66.4	599.3	102.0	600.6	86.4	610.8	77.0	576.6	107.6
Reduced Vowel Space: Distance from Center VSDL: VT1 (u)	0.60	0.08	0.57	0.08	0.59	0.08	0.58	0.08	0.60	0.07
Reduced Vowel Space: Distance from Center VSDL: CSS (u)	0.48	0.06	0.45	0.06	0.46	0.06	0.48	0.06	0.43	0.06
Reduced Vowel Space: /ɪ, æ, ɑ/ Distance from Center VSD3: VT1 (u)	644.8	59.7	646.8	100.5	645.9	82.3	634.3	81.6	667.7	84.7
Reduced Vowel Space: /ɪ, æ, ɑ/ Distance from Center VSD3: CSS (u)	596.4	63.3	563.8	103.9	578.3	88.2	570.3	84.3	597.3	100.1
Reduced Vowel Space: /ɪ, æ, ɑ/ Distance from Center VSD3L: VT1 (u)	0.53	0.08	0.53	0.06	0.53	0.07	0.52	0.07	0.55	0.07
Reduced Vowel Space: /ɪ, æ, ɑ/ Distance from Center VSD3L: CSS (u)	0.47	0.06	0.42	0.05	0.44	0.06	0.44	0.06	0.43	0.06

Lengthened Vowels: Corners: VT1 (ms)	212.0	52.7	208.2	41.3	210.0	46.1	208.1	51.2	214.0	35.3
Lengthened Vowels: Corners: CSS (ms)	187.0	59.2	162.5	54.0	173.4	56.6	188.2	59.7	138.2	26.8
Lengthened Vowels: Non-Rhotic Mids: VT2 (ms)	182.3	47.3	172.0	30.8	176.7	38.9	176.0	41.8	178.4	34.2
Lengthened Vowels: Non-Rhotic Mids: CSS (ms)	176.0	48.7	164.5	70.6	169.6	61.0	187.1	64.6	128.0	17.0
Lengthened Vowels: Phonemic Diphthongs: VT2 (ms)	292.2	76.9	271.7	35.3	281.5	58.9	275.4	63.5	293.8	49.4
Lengthened Vowels: Phonemic Diphthongs: CSS (ms)	199.1	33.9	202.0	70.9	200.7	56.5	218.1	57.8	159.4	22.7
Reduced Vowel Substitution Coefficients: ALL (u)	0.03	0.04	0.08	0.10	0.06	0.08	0.07	0.08	0.02	0.01
Increased Distorted Vowel Substitutions: VT12 (count)	2.5	1.5	2.3	2.1	2.4	1.8	2.7	1.8	1.8	1.8
Less Precise Diphthongs (5 points)[a]: VT2 (u)	16173	11517	13841	54164	14964	87919	148201	93183	152528	81586
Less Precise Diphthongs (3 points)[a]: VT2 (u)	73348	55784	66299	24197	69693	41736	67158	42863	74766	41397
Distorted Rhotics: F3-F2: VT2 (Hz)	1258.8	634.4	1845.7	485.4	1587.5	619.5	1565.0	569.0	1635.2	756.3
Distorted Rhotics: F3-F2: RSTR (Hz)	*	*	*	*	*	*	*	*	*	*
Distorted Rhotics: F3-F2: CSS (Hz)	1184.4	579.7	1643.0	586.8	1459.5	613.4	1434.5	479.4	1518.0	909.1
Distorted Rhotics: F3/F2: VT2 (u)	1.8	0.5	2.3	0.5	2.1	0.6	2.0	0.4	2.2	0.8
Distorted Rhotics: F3/F2: RSTR (u)	*	*	*	*	*	*	*	*	*	*
Distorted Rhotics: F3/F2: CSS (u)	1.7	0.4	2.1	0.5	1.9	0.5	1.9	0.4	2.0	0.8
Reduced Pairwise Vowel Duration Variability: CSS (u)	45.3	12.4	44.6	14.0	44.9	13.0	41.9	12.7	51.8	11.6
C. Stability										
Less Stable Vowel Space: Quadrilateral VSQI: VT1 (u)	74.7	8.1	75.1	14.2	74.9	11.6	76.5	11.5	72.0	11.9
Less Stable Vowel Space: Quadrilateral VSQI: CSS (u)	35.5	19.1	45.3	26.9	41.0	23.8	46.2	23.2	28.5	21.6
Less Stable Vowel Space: Quadrilateral VSQIL: VT1 (u)	73.9	8.1	74.6	13.6	74.3	11.2	75.2	11.0	72.5	12.0
Less Stable Vowel Space: Quadrilateral VSQIL: CSS (u)	36.5	14.2	47.3	29.2	42.5	23.9	47.8	21.9	29.8	25.3
Less Stable Vowel Space: Distance from Center VSD: VT1 (u)	55.6	11.0	62.4	9.1	59.3	10.4	59.2	10.3	59.3	11.2
Less Stable Vowel Space: Distance from Center VSD: CSS (u)	49.9	9.9	51.2	15.6	50.6	13.2	53.8	9.7	43.1	17.6
Less Stable Vowel Space: Distance from Center VSDL: VT1 (u)	77.4	8.6	71.6	10.2	74.3	9.8	73.6	9.3	75.5	11.0
Less Stable Vowel Space: Distance from Center VSDL: CSS (u)	61.5	12.8	61.8	12.7	61.6	12.5	64.7	10.4	54.4	14.7
Less Stable Vowel Space: /ɪ, æ, ɑ/ Distance from Center VSD3: VT1 (u)	52.5	7.9	51.9	11.0	52.2	9.5	52.2	10.5	52.1	7.9
Less Stable Vowel Space: /ɪ, æ, ɑ/ Distance from Center VSD3: CSS (u)	51.7	10.3	49.5	11.6	50.5	10.9	51.5	9.9	48.2	13.5
Less Stable Vowel Space: /ɪ, æ, ɑ/ Distance from Center VSD3L: VT1 (u)	57.8	7.0	54.0	6.8	55.8	7.0	54.4	7.5	58.4	5.4
Less Stable Vowel Space: /ɪ, æ, ɑ/ Distance from Center VSD3L: CSS (u)	56.1	11.5	53.0	6.2	54.4	8.9	54.7	7.6	53.6	11.9

Less Stable F1: /i/: VT1 (u)	84.8	10.4	84.6	7.2	84.7	8.7	84.2	9.2	85.6	8.1
Less Stable F1: /i/: CSS (u)	83.6	10.0	86.0	4.9	84.9	7.5	84.1	8.1	86.8	6.0
Less Stable F1: /æ/: VT1 (u)	92.2	5.6	91.1	3.2	91.6	4.4	91.4	4.7	92.0	4.0
Less Stable F1: /æ/: CSS (u)	73.4	17.4	78.3	14.0	76.0	15.6	77.2	16.8	73.3	13.1
Less Stable F1: /u/: VT1 (u)	89.1	5.3	91.8	3.3	90.4	4.5	90.1	4.3	91.1	5.1
Less Stable F1: /u/: CSS (u)	87.5	11.6	85.8	8.6	86.5	9.8	85.8	11.1	88.3	6.2
Less Stable F1: /ɑ/: VT1 (u)	92.9	5.8	92.0	8.6	92.4	7.3	91.8	8.1	93.7	5.6
Less Stable F1: /ɑ/: CSS (u)	85.0	11.8	86.3	8.9	85.8	10.0	85.8	9.9	85.6	11.1
Less Stable F2: /i/: VT1 (u)	89.3	5.7	90.5	6.1	89.9	5.8	91.1	5.0	87.5	6.8
Less Stable F2: /i/: CSS (u)	91.1	6.3	87.6	8.9	89.2	7.9	89.7	8.3	88.0	7.3
Less Stable F2: /æ/: VT1 (u)	94.7	2.8	93.0	5.9	93.8	4.8	93.3	5.6	94.8	2.5
Less Stable F2: /æ/: CSS (u)	82.5	5.1	88.1	10.7	90.1	8.7	90.8	6.1	88.5	13.2
Less Stable F2: /u/: VT1 (u)	82.2	9.7	88.0	8.0	85.1	9.2	84.8	8.9	85.7	10.2
Less Stable F2: /u/: CSS (u)	79.7	15.2	85.4	9.8	82.8	12.6	82.5	14.0	83.7	9.3
Less Stable F2: /ɑ/: VT1 (u)	94.1	3.3	92.5	5.6	93.2	4.7	93.1	4.6	93.5	5.0
Less Stable F2: /ɑ/: CSS (u)	85.6	10.2	91.9	5.3	89.2	8.2	89.8	6.3	87.5	12.4
Less Stable Vowel Duration: Corners: VT1 (u)	77.2	5.3	73.9	6.2	75.4	5.9	74.8	6.2	76.7	5.3
Less Stable Vowel Duration: Corners: CSS (u)	50.6	17.4	51.3	13.5	51.0	15.1	52.5	15.6	47.3	14.0
Less Stable Vowel Duration:Non-Rhotic Mids: VT2 (u)	69.7	5.4	60.4	9.1	64.7	8.9	63.9	9.0	66.4	8.8
Less Stable Vowel Duration:Non-Rhotic Mids: CSS (u)	40.0	21.7	44.9	13.9	42.7	17.6	44.1	19.1	39.3	14.0
Less Stable Vowel Duration: Phonemic Diphthongs: VT2 (u)	72.4	12.5	61.6	12.1	66.8	13.2	66.3	13.7	67.7	12.9
Less Stable Vowel Duration: Phonemic Diphthongs: CSS (u)	60.0	11.5	53.0	20.0	56.1	17.0	56.4	14.2	55.5	23.5
Less Stable Rhotic Distortions: F3-F2: VT2 (u)	70.2	15.0	81.4	11.4	76.6	13.9	75.1	15.0	79.5	11.8
Less Stable Rhotic Distortions: F3-F2: RSTR (u)	*	*	*	*	*	*	*	*	*	*
Less Stable Rhotic Distortions: F3-F2: CSS (u)	59.7	*	77.4	16.2	76.0	16.3	71.4	17.6	86.5	4.7
Less Stable Rhotic Distortions: F3/2: VT2 (u)	86.8	10.8	85.4	7.4	86.0	8.8	86.0	10.0	85.9	6.3
Less Stable Rhotic Distortions: F3/2: RSTR (u)	*	*	*	*	*	*	*	*	*	*
Less Stable Rhotic Distortions: F3/2: CSS (u)	93.7	*	87.6	9.3	88.0	9.0	85.3	9.0	94.2	6.1
Less Stable Vowel Errors: Targets: VT12 (%)	54.4	21.1	50.9	24.6	52.5	22.6	58.0	22.7	40.7	18.7
Less Stable Vowel Errors: Targets: CWT (%)	45.1	13.5	41.9	13.3	43.5	13.2	42.8	14.6	44.9	10.2
Less Stable Vowel Errors: Targets: MWT (%)	41.3	14.0	50.4	17.0	45.8	15.9	37.4	11.2	59.9	12.4
Less Stable Vowel Errors: Targets: VT3 (%)	*	*	*	*	*	*	*	*	*	*
Less Stable Vowel Errors: Targets: CSS (%)	40.4	26.3	59.0	25.5	50.5	27.0	51.6	25.9	47.7	32.1

Less Stable Vowel Errors: Error Types: VT12 (%)	84.2	17.3	75.5	31.7	79.5	25.9	84.4	17.1	69.0	38.5
Less Stable Vowel Errors: Error Types: CWT (%)	47.6	20.5	46.8	22.3	47.1	21.0	49.2	22.2	42.3	18.4
Less Stable Vowel Errors: Error Types: MWT (%)	34.1	17.4	31.5	24.7	32.8	20.9	31.3	14.7	35.4	29.5
Less Stable Vowel Errors: Error Types: VT3 (%)	*	*	*	*	*	*	*	*	*	*
Less Stable Vowel Errors: Error Types: CSS (%)	45.7	33.8	63.4	30.1	55.4	32.3	50.9	31.3	67.3	34.9

[a]All original cell values in this table referenced to this footnote were divided by 10.

Consonants

Sign	Gender						Age (yrs)			
	Male		Female		Both		3;6-4;5		4;6-5;7	
	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence										
Percentage of Consonants in Inventory: CSS (%)	80.0	13.3	83.0	15.9	81.7	14.6	77.2	14.9	92.3	6.0
Percentage of Consonants Correct: CSS (%)	62.0	14.0	68.4	13.1	65.6	13.6	63.4	13.8	70.9	12.3
Percentage of Consonants Correct: AT (%)	53.2	19.2	59.9	18.1	56.8	18.6	50.9	17.8	69.5	13.6
Percentage of Consonants Correct- Revised : CSS (%)	68.5	12.9	74.8	15.5	72.0	14.5	68.2	14.3	81.1	11.0
Percentage of Consonants Correct- Revised: AT (%)	59.7	20.6	69.1	21.6	64.7	21.3	57.5	20.2	80.0	15.2
SRT % total PCC-R: SRT (%)	61.3	12.6	71.6	18.2	67.2	16.6	64.1	17.0	74.3	14.2
Percentage of Consonants Correct in Complex Words: MWT (%)	35.5	19.2	46.8	15.4	41.4	17.9	34.5	14.5	53.7	17.4
Relative Omission Index (ROI) : CSS (%)	35.0	9.6	28.1	17.6	31.2	14.8	35.8	14.2	20.2	9.6
Relative Substitution Index (RSI) : CSS (%)	46.7	6.1	47.2	13.2	47.0	10.4	49.0	10.6	42.3	8.9
Relative Distortion Index (RDI) : CSS (%)	18.3	8.1	24.7	17.1	21.8	14.0	15.2	7.2	37.6	13.9
B. Precision										
Nasal Emissions: MWT (%)	0.0	0.0	0.6	1.5	0.3	1.1	0.5	1.4	0.1	0.2
Nasal Emissions: AT (%)	0.0	0.1	0.1	0.4	0.1	0.3	0.1	0.3	0.1	0.2
Nasal Emissions: CSS (%)	0.0	0.1	0.2	0.6	0.1	0.4	0.2	0.5	0.1	0.2
Reduced Percentage of Glides Correct: MWT (%)	33.3	32.6	34.6	37.6	34.0	34.5	28.1	31.5	44.4	39.1
Reduced Percentage of Glides Correct: SPT (%)	*	*	57.1	14.3	57.1	14.3	57.1	*	57.1	20.2
Reduced Percentage of Glides Correct: AT (%)	59.6	23.5	77.5	14.3	69.2	20.8	64.5	20.1	79.2	19.8
Reduced Percentage of Glides Correct: CSS (%)	87.7	10.3	86.3	12.5	86.9	11.4	84.7	11.9	92.0	8.6
Increased Percentage of /j/ deletions in Clusters: ALL (%)	27.8	44.1	34.6	47.4	31.8	45.1	39.3	48.7	18.8	37.2
Lowered Sibilant Centroids: M1 at Mid Point: RSTS (kHz)	*	*	*	*	*	*	*	*	*	*
Lowered Sibilant Centroids: M1 at Mid Point: MWT (kHz)	6.3	1.0	7.0	0.9	6.7	1.0	6.8	0.6	6.6	1.2
Lowered Sibilant Centroids: M1 at Mid Point: AT (kHz)	7.2	0.9	7.1	0.5	7.2	0.7	7.2	0.8	7.0	0.5
Lowered Sibilant Centroids: M1 at Mid Point: CSS (kHz)	6.3	0.8	6.5	1.0	6.4	0.9	6.3	1.0	6.6	0.7
Lowered Sibilant Centroids: Maximum M1: RSTS (kHz)	*	*	*	*	*	*	*	*	*	*
Lowered Sibilant Centroids: Maximum M1: MWT (kHz)	6.9	1.1	7.5	1.0	7.2	1.1	7.4	0.7	7.1	1.3

Lowered Sibilant Centroids: Maximum M1: AT (kHz)	7.8	0.9	7.7	0.5	7.7	0.7	7.8	0.8	7.6	0.6
Lowered Sibilant Centroids: Maximum M1: CSS (kHz)	6.9	0.7	7.1	1.0	7.0	0.9	6.9	1.0	7.2	0.6
Lengthened Cluster Durations: Relative Duration of Cluster: MWT (ms)	828.3	186.1	929.7	377.4	885.4	304.2	960.4	403.9	810.4	149.2
Lengthened Cluster Durations: Relative Duration of Cluster: AT (ms)	639.4	196.2	876.2	209.0	779.3	232.0	720.1	253.3	882.9	151.9
Lengthened Cluster Durations: Relative Duration of Cluster: CSS (ms)	808.6	256.8	861.1	351.6	839.0	308.2	882.5	359.1	779.1	230.2
Lengthened Cluster Durations: Relative Duration of First Consonant: MWT (% o)	461.5	138.2	432.2	127.8	445.0	128.7	416.0	151.3	473.9	103.6
Lengthened Cluster Durations: Relative Duration of First Consonant: AT (% o)	281.1	184.9	475.2	150.0	395.8	188.2	377.2	214.0	428.3	139.1
Lengthened Cluster Durations: Relative Duration of First Consonant: CSS (% o)	372.8	155.6	393.3	229.1	384.6	196.7	408.1	243.4	352.4	113.0
Lengthened Cluster Durations: Relative Duration of Second Consonant: MWT (% o)	352.4	131.9	414.4	126.2	387.3	128.3	451.0	145.3	323.6	69.8
Lengthened Cluster Durations: Relative Duration of Second Consonant: AT (% o)	347.9	135.6	386.7	121.5	370.8	125.8	333.6	122.6	436.0	109.2
Lengthened Cluster Durations: Relative Duration of Second Consonant: CSS (% o)	416.3	187.8	460.3	212.0	441.8	198.0	468.4	232.8	405.2	144.0
Lengthened Cluster Durations: Percentage of S-F/F-S Cluster Disruptions: MWT (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lengthened Cluster Durations: Percentage of S-F/F-S Cluster Disruptions: AT (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lengthened Cluster Durations: Percentage of S-F/F-S Cluster Disruptions: CSS (%)	3.1	8.8	0.0	0.0	1.3	5.7	0.0	0.0	3.1	8.8
Lengthened Cluster Durations: Rel. Duration of S-F/F-S Cluster Disruptions: MWT (% o)	12.4	4.5	11.7	6.5	12.0	5.6	12.5	7.8	11.5	3.4
Lengthened Cluster Durations: Rel. Duration of S-F/F-S Cluster Disruptions: AT (% o)	12.6	3.9	10.7	4.6	11.4	4.4	10.2	4.5	14.3	2.3
Lengthened Cluster Durations: Rel. Duration of S-F/F-S Cluster Disruptions: CSS (% o)	19.5	35.6	7.5	5.8	12.6	23.4	6.0	5.6	21.5	34.7
Lengthened Cluster Durations: Relative Duration of Pause Disruptions: MWT (% o)	0.0	0.0	47.0	140.9	26.4	105.7	52.9	149.5	0.0	0.0
Lengthened Cluster Durations: Relative Duration of Pause Disruptions: AT (% o)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lengthened Cluster Durations: Relative Duration of Pause Disruptions: CSS (% o)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lengthened Cluster Durations: Relative Duration of Addition Disruptions: MWT (% o)	0.0	0.0	22.1	66.4	12.4	49.8	24.9	70.4	0.0	0.0
Lengthened Cluster Durations: Relative Duration of Addition Disruptions: AT (% o)	0.0	0.0	3.8	13.8	2.3	10.6	0.0	0.0	6.2	17.5
Lengthened Cluster Durations: Relative Duration of Addition Disruptions: CSS (% o)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SRT Transcoding: SRT (%)	62.6	21.4	80.4	13.9	72.9	19.3	71.9	19.3	75.0	20.4
C. Stability										
Less Stable Consonant Errors: Targets: RSTR (%)	*	*	*	*	*	*	*	*	*	*
Less Stable Consonant Errors: Targets: CWT (%)	43.3	6.8	55.8	11.9	49.8	11.5	47.7	9.8	54.7	14.4
Less Stable Consonant Errors: Targets: MWT (%)	30.4	10.3	37.3	10.6	34.0	10.8	29.8	6.3	41.4	13.5
Less Stable Consonant Errors: Targets: CSS (%)	60.8	11.0	63.0	18.3	62.0	15.3	67.6	11.7	48.8	15.0
Less Stable Consonant Errors: Error Types: RSTR (%)	*	*	*	*	*	*	*	*	*	*
Less Stable Consonant Errors: Error Types: CWT (%)	51.3	11.7	55.1	15.7	53.3	13.8	52.8	13.0	54.5	16.5
Less Stable Consonant Errors: Error Types: MWT (%)	26.8	6.4	28.9	9.7	27.9	8.2	28.5	6.6	26.8	10.9
Less Stable Consonant Errors: Error Types: CSS (%)	78.4	10.7	80.6	13.9	79.6	12.4	82.2	9.6	73.5	16.5
Less Stable Sibilant Centroids: M1 at Mid Point: RSTS (u)	*	*	*	*	*	*	*	*	*	*
Less Stable Sibilant Centroids: M1 at Mid Point: MWT (u)	87.3	5.8	89.6	8.0	88.6	7.0	89.8	8.1	87.7	6.4

Less Stable Sibilant Centriods: M1 at Mid Point: AT (u)	84.1	10.9	87.3	7.0	86.0	8.8	85.9	10.0	86.0	7.5
Less Stable Sibilant Centriods: M1 at Mid Point: CSS (u)	74.3	17.7	75.1	17.4	74.7	17.2	72.1	20.3	80.1	6.2
Less Stable Sibilant Centriods: Maximum M1: RSTS (u)	*	*	*	*	*	*	*	*	*	*
Less Stable Sibilant Centriods: Maximum M1: MWT (u)	88.2	7.2	91.9	4.8	90.3	6.1	93.1	4.6	88.1	6.4
Less Stable Sibilant Centriods: Maximum M1: AT (u)	87.2	7.4	90.2	3.1	88.9	5.4	88.7	6.1	89.1	4.7
Less Stable Sibilant Centriods: Maximum M1: CSS (u)	78.8	19.5	78.1	13.8	78.4	16.3	75.5	19.2	84.2	5.3

Vowels/Diphthongs & Consonants

Sign	Gender						Age (yrs)			
	Male		Female		Both		3;6-4;5		4;6-5;7	
	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence										
Intelligibility Index: CSS (%)	18.3	8.1	24.7	17.1	21.8	14.0	84.6	13.2	92.9	10.1
Percentage of Structurally Correct Words: CSS (%)	83.2	13.3	90.2	11.9	87.1	12.8	80.7	9.6	87.5	7.5
B. Precision										
Increased Percentage of Phoneme Distortions: Place: RSTR (%)	*	*	*	*	*	*	*	*	*	*
Increased Percentage of Phoneme Distortions: Place: LST (%)	8.4	3.0	7.2	2.3	7.8	2.7	6.8	2.4	9.7	2.2
Increased Percentage of Phoneme Distortions: Place: CWT (%)	11.4	5.1	10.6	4.7	10.9	4.8	9.7	4.7	13.6	4.2
Increased Percentage of Phoneme Distortions: Place: MWT (%)	8.3	4.3	7.7	4.6	8.0	4.3	6.8	3.8	10.0	4.7
Increased Percentage of Phoneme Distortions: Place: EST (%)	3.5	3.1	4.4	4.5	4.0	3.9	3.2	2.9	5.8	5.2
Increased Percentage of Phoneme Distortions: Place: VT3 (%)	*	*	*	*	*	*	*	*	*	*
Increased Percentage of Phoneme Distortions: Place: AT (%)	9.4	3.9	9.3	4.0	9.3	3.8	8.1	2.9	11.9	4.5
Increased Percentage of Phoneme Distortions: Place: CSS (%)	7.6	3.0	7.1	2.3	7.3	2.6	6.3	2.1	9.7	2.0
Increased Percentage of Phoneme Distortions: Additions: RSTR (%)	*	*	*	*	*	*	*	*	*	*
Increased Percentage of Phoneme Distortions: Additions: LST (%)	4.6	4.4	2.5	2.0	3.4	3.4	4.1	3.8	2.0	1.8
Increased Percentage of Phoneme Distortions: Additions: CWT (%)	3.5	3.8	2.5	3.2	3.0	3.4	3.3	3.9	2.3	2.3
Increased Percentage of Phoneme Distortions: Additions: MWT (%)	5.3	2.2	4.1	2.0	4.7	2.2	4.8	2.3	4.5	2.1
Increased Percentage of Phoneme Distortions: Additions: EST (%)	5.1	5.5	3.2	4.1	4.1	4.8	5.1	5.3	1.9	2.3
Increased Percentage of Phoneme Distortions: Additions: VT3 (%)	*	*	*	*	*	*	*	*	*	*
Increased Percentage of Phoneme Distortions: Additions: AT (%)	4.0	4.5	3.8	2.4	3.8	3.5	4.2	4.0	3.1	2.0
Increased Percentage of Phoneme Distortions: Additions: CSS (%)	2.5	1.0	2.4	1.2	2.4	1.1	2.5	1.1	2.2	1.0
Increased Percentage of Phoneme Distortions: Duration: RSTR (%)	*	*	*	*	*	*	*	*	*	*
Increased Percentage of Phoneme Distortions: Duration: LST (%)	1.3	2.3	1.3	2.7	1.3	2.5	1.8	2.9	0.3	0.4
Increased Percentage of Phoneme Distortions: Duration: CWT (%)	0.6	0.5	1.0	2.0	0.8	1.5	1.1	1.7	0.3	0.3
Increased Percentage of Phoneme Distortions: Duration: MWT (%)	0.9	0.9	0.6	0.6	0.7	0.8	0.7	0.8	0.7	0.7
Increased Percentage of Phoneme Distortions: Duration: EST (%)	0.7	1.3	1.3	2.8	1.0	2.2	1.5	2.6	0.0	0.0
Increased Percentage of Phoneme Distortions: Duration: VT3 (%)	*	*	*	*	*	*	*	*	*	*
Increased Percentage of Phoneme Distortions: Duration: AT (%)	2.0	2.1	2.0	3.0	2.0	2.6	2.6	2.9	0.7	0.7
Increased Percentage of Phoneme Distortions: Duration: CSS (%)	2.1	1.7	1.8	1.1	2.0	1.4	2.1	1.5	1.6	0.9
Increased Percentage of Phoneme Distortions: Force: RSTR (%)	*	*	*	*	*	*	*	*	*	*
Increased Percentage of Phoneme Distortions: Force: LST (%)	0.5	0.9	0.5	0.7	0.5	0.8	0.5	0.7	0.7	1.0
Increased Percentage of Phoneme Distortions: Force: CWT (%)	0.9	0.9	0.3	0.5	0.6	0.8	0.6	0.8	0.5	0.6
Increased Percentage of Phoneme Distortions: Force: MWT (%)	0.1	0.4	0.5	0.8	0.3	0.7	0.3	0.6	0.4	0.7
Increased Percentage of Phoneme Distortions: Force: EST (%)	2.0	2.9	0.7	1.6	1.3	2.3	1.0	1.9	1.9	3.2
Increased Percentage of Phoneme Distortions: Force: VT3 (%)	*	*	*	*	*	*	*	*	*	*

Increased Percentage of Phoneme Distortions: Force: AT (%)	1.2	1.3	1.0	1.1	1.1	1.2	1.4	1.2	0.5	0.9
Increased Percentage of Phoneme Distortions: Force: CSS (%)	0.7	0.5	0.7	0.4	0.7	0.4	0.7	0.4	0.6	0.4
Increased Percent of EMMA errors by type: CWT (%)	46.2	19.8	46.5	22.7	46.3	21.0	53.4	16.3	31.5	23.1
Increased Percent of EMMA errors by type: MWT (%)	48.5	12.5	43.5	12.5	45.9	12.5	49.5	11.7	39.5	11.9
Increased Percent of EMMA errors by type: AT (%)	16.7	10.2	16.3	7.1	16.5	8.5	18.5	8.5	12.3	7.3
Increased Percent of EMMA errors by type: CSS (%)	16.4	4.7	14.5	6.9	15.3	6.0	16.3	6.1	13.0	5.4
C. Stability										
Less Stable Whole Word Errors: Targets: VT12 (%)	43.4	14.6	38.3	17.0	40.6	15.8	41.9	15.7	37.6	16.8
Less Stable Whole Word Errors: Targets: RSTR (%)	*	*	*	*	*	*	*	*	*	*
Less Stable Whole Word Errors: Targets: VT3 (%)	*	*	*	*	*	*	*	*	*	*
Less Stable Whole Word Errors: Targets: CSS (%)	39.8	9.3	46.1	13.6	43.3	12.1	46.9	9.9	34.9	13.1
Less Stable Whole Word Errors: Error Types: VT12 (%)	64.5	24.1	60.3	31.5	62.2	27.8	64.1	25.1	57.8	35.4
Less Stable Whole Word Errors: Error Types: RSTR (%)	*	*	*	*	*	*	*	*	*	*
Less Stable Whole Word Errors: Error Types: VT3 (%)	*	*	*	*	*	*	*	*	*	*
Less Stable Whole Word Errors: Error Types: CSS (%)	44.9	12.0	56.3	13.9	51.2	14.1	52.9	12.7	47.4	17.3
Less Stable Percentage of Phonemes Correct in Complex Words: CWT (%)	46.8	8.9	50.8	10.9	48.9	10.1	48.1	10.5	50.6	9.3
Less Stable Percentage of Phonemes Correct in Complex Words: MWT (%)	33.1	6.5	36.8	11.1	35.0	9.2	31.7	5.6	40.9	11.5
Less Stable Percentage of Phonemes Correct in Complex Words: VT3 (%)	*	*	*	*	*	*	*	*	*	*
Less Stable Percentage of Phonemes Correct in Complex Words: CSS (%)	58.2	12.7	67.0	14.1	63.1	14.0	64.7	15.2	59.4	10.4
Increased Percent of EMMA errors by token: CWT (%)	33.4	16.6	34.4	18.0	33.9	17.0	39.5	14.4	22.2	16.7
Increased Percent of EMMA errors by token: MWT (%)	48.5	12.5	43.5	12.5	45.9	12.5	49.5	11.7	39.5	11.9
Increased Percent of EMMA errors by token: AT (%)	16.7	10.2	16.3	7.1	16.5	8.5	18.5	8.5	12.3	7.3
Increased Percent of EMMA errors by token: CSS (%)	9.8	2.7	8.3	3.7	9.0	3.3	9.3	3.2	8.1	3.6

Phrasing

Sign	Gender						Age (yrs)			
	Male		Female		Both		3;6-4;5		4;6-5;7	
	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence										
Percentage of Appropriate Phrasing: CSS (%)	87.0	10.6	86.9	11.1	86.9	10.7	87.9	10.7	84.9	11.1
B. Precision										
Increased Repetitions and Revisions: 2-4 Word Utterancess : CSS (%)	5.4	7.2	2.6	4.9	3.9	6.1	4.1	6.1	3.5	6.6
Increased Repetitions and Revisions: 5-7 Word Utterances: CSS (%)	19.6	10.3	14.5	13.3	17.0	11.9	18.4	11.6	13.6	12.8
Increased Repetitions and Revisions: 8+ Word Utterances: CSS (%)	22.6	35.2	28.4	33.3	25.9	33.3	27.7	40.5	23.0	18.6
Increased Repetitions and Revisions: All Utterances: CSS (%)	14.1	12.1	13.3	11.1	13.7	11.3	12.1	10.6	17.0	12.7
Increased Syllable/Word Segregation: % of Btw/Wthn-Word Pauses: MWT (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Increased Syllable/Word Segregation: % of Btw/Wthn-Word Pauses: AT (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Increased Syllable/Word Segregation: % of Btw/Wthn-Word Pauses: CSS (%)	0.5	0.4	0.6	0.4	0.5	0.4	0.5	0.4	0.6	0.4
Increased Syllable/Word Segregation: Duration of Btw/Wthn-Word Pauses: MWT (ms)	*	*	380.0	*	380.0	*	380.0	*	*	*
Increased Syllable/Word Segregation: Duration of Btw/Wthn-Word Pauses: AT (ms)	*	*	*	*	*	*	*	*	*	*
Increased Syllable/Word Segregation: Duration of Btw/Wthn-Word Pauses: CSS (ms)	494.6	126.2	438.5	126.8	465.4	127.1	458.5	123.8	480.1	141.5
Increased Percentage of Inappropriate Pauses: CSS (%)	14.6	17.1	15.5	18.5	15.1	17.5	13.3	18.8	18.8	14.8
Increased Percentage of Pauses: CSS (%)	13.6	5.8	12.7	5.6	13.2	5.6	13.6	6.0	12.3	5.0
Reduced Speech-Pause Duration Variability Ratio: 2-4 Word Utterances: CSS (u)	1.2	0.6	0.9	0.6	1.0	0.6	1.0	0.6	1.2	0.6
Reduced Speech-Pause Duration Variability Ratio: 5-7 Word Utterances: CSS (u)	0.9	0.5	1.0	0.5	0.9	0.5	0.9	0.4	1.1	0.6
Reduced Speech-Pause Duration Variability Ratio: 8+ Word Utterances: CSS (u)	1.2	0.4	0.7	0.3	0.9	0.4	0.9	0.3	0.9	0.6
Reduced Speech-Pause Duration Variability Ratio: All Word Utterances: CSS (u)	1.2	0.4	0.9	0.2	1.0	0.4	1.1	0.4	0.9	0.3

Rate

Sign	Gender						Age (yrs)			
	Male		Female		Both		3;6-4;5		4;6-5;7	
	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence										
Percentage of Appropriate Rate: CSS (%)	90.4	17.2	92.6	9.6	91.6	13.5	90.3	15.8	94.3	6.7
B. Precision										
Slower Speaking Rate: 2-4 Word Utterances: CSS (syll/sec)	2.9	0.4	3.1	0.5	3.0	0.5	2.9	0.4	3.3	0.5
Slower Speaking Rate: 5-7 Word Utterances: CSS (syll/sec)	3.1	0.5	3.2	0.7	3.1	0.6	3.1	0.5	3.2	0.7
Slower Speaking Rate: 8+ Word Utterances: CSS (syll/sec)	2.5	0.6	3.4	0.7	3.0	0.7	2.8	0.9	3.4	0.4
Slower Speaking Rate: All Utterances: CSS (syll/sec)	2.9	0.4	3.2	0.5	3.1	0.5	2.9	0.5	3.3	0.4
Slower Articulation Rate: 2-4 Word Utterances: CSS (syll/sec)	3.1	0.4	3.3	0.5	3.2	0.5	3.1	0.5	3.4	0.4
Slower Articulation Rate: 5-7 Word Utterances: CSS (syll/sec)	3.5	0.5	3.6	0.7	3.5	0.6	3.5	0.5	3.6	0.7
Slower Articulation Rate: 8+ Word: CSS (syll/sec)	3.2	0.9	3.8	0.6	3.6	0.8	3.3	0.9	4.0	0.5
Slower Articulation Rate: All Utterances: CSS (syll/sec)	3.2	0.4	3.5	0.5	3.4	0.5	3.2	0.5	3.7	0.3
C. Stability										
Less Stable Speaking Rate: 1-4 Word Utterances: CSS (u)	69.1	10.3	69.0	8.2	69.1	9.0	70.1	9.2	66.5	8.8
Less Stable Speaking Rate: 5-7 Word Utterances: CSS (u)	74.3	10.9	74.2	8.0	74.3	9.2	75.9	8.7	70.7	9.9
Less Stable Speaking Rate: 8+ Word Utterances: CSS (u)	75.2	9.1	75.8	12.8	75.5	11.1	73.8	14.2	77.1	8.3
Less Stable Speaking Rate: All Utterances: CSS (u)	69.8	7.6	71.9	5.3	70.9	6.5	70.8	6.5	71.0	6.7
Less Stable Articulation Rate: 1-4 Word Utterances: CSS (u)	74.0	11.7	71.0	7.3	72.3	9.5	71.9	9.1	73.3	11.0
Less Stable Articulation Rate: 5-7 Word Utterances: CSS (u)	83.4	7.0	79.0	7.8	81.0	7.6	80.8	8.2	81.6	6.9
Less Stable Articulation Rate: 8+ Word Utterances: CSS (u)	81.1	17.0	78.5	8.9	79.5	12.3	82.9	12.8	76.6	11.8
Less Stable Articulation Rate: All Utterances: CSS (u)	75.0	8.9	74.7	4.7	74.8	6.9	74.4	7.0	75.6	7.1

Stress

Sign	Gender						Age (yrs)			
	Male		Female		Both		3;6-4;5		4;6-5;7	
	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence										
Percentage of Appropriate Stress: CSS (%)	88.2	6.6	91.0	6.6	89.7	6.6	88.7	6.7	91.7	6.3
B. Precision										
Lexical Stress: Trochees: LST (u)	1.1	0.3	1.3	0.5	1.2	0.5	1.2	0.5	1.2	0.2
Lexical Stress: All: LST (u)	1.1	0.3	1.3	0.5	1.2	0.5	1.2	0.5	1.2	0.2
Emphatic Stress: EST (u)	1.4	0.2	1.3	0.2	1.3	0.2	1.3	0.2	1.5	0.1
Sentential Stress: CSS (u)	1.0	0.4	0.9	0.3	1.0	0.4	0.9	0.3	1.1	0.4
C. Stability										
Less Stable Lexical Stress: Trochees: LST (u)	48.5	19.5	39.1	23.3	43.6	21.7	45.2	26.0	40.9	11.5
Less Stable Lexical Stress: All (u)	48.5	19.5	39.1	23.3	43.6	21.7	45.2	26.0	40.9	11.5
Less Stable Emphatic Stress: EST (u)	64.6	12.8	68.6	13.3	66.6	12.9	66.5	14.7	66.8	10.1
Less Stable Sentential Stress: CSS (u)	40.7	22.9	40.7	20.8	40.7	21.4	37.8	22.1	46.8	19.9

Loudness

Sign	Gender						Age (yrs)			
	Male		Female		Both		3;6-4;5		4;6-5;7	
	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence										
Percentage of Appropriate Loudness: CSS (%)	95.8	6.2	97.8	3.2	96.8	4.9	95.8	5.5	99.0	1.9
B. Precision										
Vowels-Consonants Intensity Ratios: Vowels-Stops: VT12 (u)	9.4	3.6	7.5	2.5	8.4	3.2	8.0	3.2	9.2	3.1
Vowels-Consonants Intensity Ratios: Vowels-Stops: LST (u)	11.8	4.9	11.7	4.4	11.8	4.6	11.5	5.1	12.2	3.5
Vowels-Consonants Intensity Ratios: Vowels-Stops: AT (u)	11.3	7.7	8.4	3.8	9.8	6.0	10.3	6.9	8.8	4.3
Vowels-Consonants Intensity Ratios: Vowels-Stops: CSS (u)	10.7	5.3	9.5	4.2	10.0	4.7	9.7	5.3	10.8	3.0
Vowels-Consonants Intensity Ratios: Vowels-Affricates/Fricatives: LST (u)	14.1	8.4	7.5	5.7	10.6	7.6	12.6	7.8	7.6	6.8
Vowels-Consonants Intensity Ratios: Vowels-Affricates/Fricatives: AT (u)	14.1	5.6	11.9	4.9	12.8	5.1	12.8	5.7	12.8	4.6
Vowels-Consonants Intensity Ratios: Vowels-Affricates/Fricatives: CSS (u)	14.2	4.8	14.0	5.9	14.1	5.4	14.6	5.8	13.1	4.7
Vowels-Consonants Intensity Ratios: All: VT12 (u)	9.1	3.5	7.3	2.5	8.1	3.1	7.8	3.1	8.9	3.1
Vowels-Consonants Intensity Ratios: All: LST (u)	11.4	4.8	10.2	4.2	10.8	4.5	10.7	4.7	11.1	4.2
Vowels-Consonants Intensity Ratios: All: AT (u)	13.6	6.2	9.8	4.2	11.5	5.4	12.0	6.3	10.7	3.2
Vowels-Consonants Intensity Ratios: All: CSS (u)	11.5	4.5	10.5	4.5	11.0	4.4	10.5	5.0	11.9	2.5
C. Stability										
Less Stable Vowels-Consonants Intensity Ratios: Vowels-Stops: VT12 (u)	24.2	71.7	20.4	27.9	22.1	51.9	14.3	61.2	38.7	14.0
Less Stable Vowels-Consonants Intensity Ratios: Vowels-Stops: LST (u)	59.2	20.7	58.4	17.7	58.7	18.2	52.7	16.2	68.1	18.1
Less Stable Vowels-Consonants Intensity Ratios: Vowels-Stops: AT (u)	21.6	106.6	26.0	74.2	23.8	88.3	54.5	42.6	0.8	108.5
Less Stable Vowels-Consonants Intensity Ratios: Vowels-Stops: CSS (u)	13.8	61.9	30.4	39.8	22.7	50.8	23.2	45.4	21.6	64.9
Less Stable Vowels-Consonants Intensity Ratios: Vowels-Affricates/Fricatives: LST (u)	*	*	67.2	27.1	67.2	27.1	97.0	*	52.3	11.9
Less Stable Vowels-Consonants Intensity Ratios: Vowels-Affricates/Fricatives: AT (u)	78.3	15.2	66.8	25.0	71.2	21.8	71.9	26.8	70.5	16.7
Less Stable Vowels-Consonants Intensity Ratios: Vowels-Affricates/Fricatives: CSS (u)	48.4	48.7	47.0	32.5	47.7	39.9	60.4	28.1	27.0	49.2
Less Stable Vowels-Consonants Intensity Ratios: All: VT12 (u)	21.2	72.3	16.5	32.4	18.7	53.6	11.6	63.0	33.6	19.7
Less Stable Vowels-Consonants Intensity Ratios: All: LST (u)	11.4	4.8	10.2	4.2	10.8	4.5	10.7	4.7	11.1	4.2
Less Stable Vowels-Consonants Intensity Ratios: All: AT (u)	48.9	34.9	58.3	26.7	53.8	30.5	58.2	27.4	46.7	35.7
Less Stable Vowels-Consonants Intensity Ratios: All: CSS (u)	30.9	33.2	32.7	22.8	31.9	27.5	31.8	30.7	32.1	20.2

Pitch

Sign	Gender						Age (yrs)			
	Male		Female		Both		3;6-4;5		4;6-5;7	
	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence										
Percentage of Appropriate Pitch: CSS (%)	97.9	3.8	95.8	9.5	96.8	7.2	99.0	1.8	92.2	11.7
B. Precision										
Midpoint Fundamental Frequency Mean: VT12 (Hz)	247.2	35.4	242.3	29.2	244.5	31.7	249.8	32.4	233.4	28.6
Midpoint Fundamental Frequency Mean: CSS (Hz)	270.8	37.8	260.4	33.7	265.1	35.3	274.7	36.1	242.0	20.3
Midpoint Fundamental Frequency Range: VT12 (Hz)	166.5	94.0	208.1	196.4	188.8	156.1	169.9	89.5	228.6	248.2
Midpoint Fundamental Frequency Range: CSS (Hz)	360.8	121.4	298.0	82.9	325.9	104.6	333.4	118.8	308.1	62.4
C. Stability										
Less Stable Mean Midpoint Fundamental Frequency: VT12 (u)	87.3	6.4	85.3	10.3	86.2	8.6	86.6	6.8	85.5	12.0
Less Stable Mean Midpoint Fundamental Frequency: CSS (u)	77.0	7.4	80.0	5.9	78.7	6.6	78.8	7.0	78.4	6.1

Laryngeal Quality

Sign	Gender						Age (yrs)			
	Male		Female		Both		3;6-4;5		4;6-5;7	
	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence										
Percentage of Appropriate Laryngeal Quality: CSS (%)	76.3	25.3	74.3	23.8	75.3	24.0	72.7	24.3	80.7	24.0
B. Precision										
Percentage of Breathy Utterances: CSS (%)	1.5	3.8	0.0	0.0	0.7	2.7	1.1	3.2	0.0	0.0
Percentage of Rough Utterances: CSS (%)	16.1	21.8	16.9	14.8	16.5	18.1	16.8	15.8	16.0	23.6
Percentage of Strained Utterances: CSS (%)	3.1	10.8	3.5	9.0	3.3	9.7	4.9	11.5	0.0	0.0
Percentage of Break/Shift/Tremulous Utterances: CSS (%)	2.6	5.1	3.6	5.1	3.1	5.0	3.6	5.7	2.3	3.3

Resonance

Sign	Gender						Age (yrs)			
	Male		Female		Both		3;6-4;5		4;6-5;7	
	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence										
Percentage of Appropriate Resonance Quality: CSS (%)	94.5	12.0	90.7	15.4	92.5	13.7	91.9	14.4	93.8	13.0
B. Precision										
Percentage of Nasal Utterances: CSS (%)	2.1	3.8	1.3	4.6	1.7	4.2	2.0	4.7	1.0	2.9
Lowered /ɑ/ F1 (Nasal): VT12 (Hz)	1253.9	91.7	1337.1	66.3	1298.5	88.3	1310.6	96.5	1272.9	65.4
Lowered /ɑ/ F1 (Nasal): SVT (Hz)	1196.3	157.9	1242.3	156.1	1223.5	154.8	1257.5	140.2	1150.6	169.9
Lowered /ɑ/ F1 (Nasal): CSS (Hz)	1100.6	200.0	1033.1	259.1	1063.1	232.9	1117.9	196.0	933.1	274.2
Percentage of Nasopharyngeal Utterances: CSS (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lowered /i/ F2 (Nasopharyngeal): VT12 (Hz)	3145.0	165.9	3186.7	304.0	3166.6	243.6	3148.3	218.5	3203.2	298.7
Lowered /i/ F2 (Nasopharyngeal): CSS (Hz)	3050.9	152.3	2988.7	289.7	3016.3	236.6	3011.0	258.8	3029.0	188.3
Lowered /u/ F2 (Nasopharyngeal): VT12 (Hz)	1595.7	278.4	1704.2	397.9	1652.0	343.5	1611.1	336.9	1733.8	361.9
Lowered /u/ F2 (Nasopharyngeal): CSS (Hz)	1889.6	379.7	1680.1	275.9	1773.2	336.5	1740.8	330.1	1850.2	361.5
C. Stability										
Less Stable /ɑ / F1 (Nasal): VT12 (u)	92.9	5.8	92.0	8.6	92.4	7.3	91.8	8.1	93.7	5.6
Less Stable /ɑ / F1 (Nasal): CSS (u)	85.0	11.8	86.3	8.9	85.8	10.0	85.8	9.9	85.6	11.1
Less Stable /i / F2 (Nasopharyngeal): VT12 (u)	89.3	5.7	90.5	6.1	89.9	5.8	91.1	5.0	87.5	6.8
Less Stable /i / F2 (Nasopharyngeal): CSS (u)	91.1	6.3	87.6	8.9	89.2	7.9	89.7	8.3	88.0	7.3
Less Stable /u / F2 (Nasopharyngeal): VT12 (u)	82.2	9.7	88.0	8.0	85.1	9.2	84.8	8.9	85.7	10.2
Less Stable /u / F2 (Nasopharyngeal): CSS (u)	79.7	15.2	85.4	9.8	82.8	12.6	82.5	14.0	83.7	9.3