

Conversational Speech Reference Data for Children with Speech Delay:

A Database of 180 Participants, 3-to-5 Years of Age

Technical Report No. 21

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CONTENTS

Background.....	8
Method.....	11
Participants	
Procedures	
References.....	14
Key to Sources (Tasks), Measurement Units, Abbreviations, and Symbols	16
Reference Data: Segmental	
I. Vowels/Diphthongs	17
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 , a/ Distance from Center VSD3	
6. Reduced Vowel Space: /i , æ , a/ 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. Distorted Rhotics: F3-F2	
12. Distorted Rhotics: F3/F2	
13. 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	
4. Less Stable Vowel Space: Distance from Center VSDL	
5. Less Stable Vowel Space: /i , æ , a/ Distance from Center VSD3	

6. Less Stable Vowel Space: /i, æ, a/ Distance from Center VSD3L
7. Less Stable F1: /i/
8. Less Stable F1: /æ/
9. Less Stable F1: /u/
10. Less Stable F1: /a/
11. Less Stable F2: /i/
12. Less Stable F2: /æ/
13. Less Stable F2: /u/
14. Less Stable F2: /a/
15. Less Stable Vowel Duration: Corners
16. Less Stable Vowel Duration: Non-Rhotic Mids
17. Less Stable Vowel Duration: Phonemic Diphthongs
18. Less Stable Rhotic Distortions: F3-F2
19. Less Stable Rhotic Distortions: F3/F2
20. Less Stable Vowel Errors: Targets
21. Less Stable Vowel Errors: Types

II. Consonants20

A. Competence

1. Percentage of Consonants in Inventory
2. Percentage of Consonants Correct
3. Percentage of Consonants Correct-Revised
4. Relative Omission Index
5. Relative Substitution Index
6. Relative Distortion Index

B. Precision

1. Nasal Emissions
2. Reduced Percentage of Glides Correct
3. Increased Percentage of /j/ Deletions in Clusters
4. Lowered Sibilant Centroids: M1 at Midpoint
5. Lowered Sibilant Centroids: Maximum M1
6. Lengthened Cluster Durations: Relative Duration of Cluster
7. Lengthened Cluster Durations: Relative Duration of First Consonant
8. Lengthened Cluster Durations: Relative Duration of Second Consonant
9. Lengthened Cluster Durations: Percentage of S-F/F-S Cl Disruptions
10. Lengthened Cluster Durations: Relative Duration of S-F/F-S Cl Disruptions
11. Lengthened Cluster Durations: Relative Duration of Pause Disruptions
12. Lengthened Cluster Durations: Relative Duration of Addition Disruptions

C. Stability

1. Less Stable Consonant Errors: Targets
2. Less Stable Consonant Errors: Error Types
3. Less Stable Sibilant Centroids: M1 at Midpoint
4. Less Stable Sibilant Centroids: Maximum M1

III. Vowels/Diphthongs & Consonants.....	22
A. Competence	
1. Intelligibility Index	
2. Percentage of Structurally Correct Words	
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	
IV. Phrasing	23
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	
V. Rate	25
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 Articulation 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 Articulation Rate: 8+ Word Utterances	
8. Less Stable Articulation Rate: All Utterances	
VI. Stress.....	27
A. Competence	
1. Percentage of Appropriate Stress	
B. Precision	
1. Sentential Stress	
C. Stability	
1. Less Stable Sentential Stress	
VII. Loudness.....	28
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

VIII. Pitch29

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

IX. Laryngeal Quality30

A. Competence

1. Percentage of Appropriate Laryngeal Quality

B. Precision

1. Percentage of Breathly Utterances
2. Percentage of Rough Utterances
3. Percentage of Strained Utterances
4. Percentage of Break/Shift/Tremulous Utterances
5. Percentage of Jitter
6. Percentage of Shimmer
7. Harmonics-to-Noise Ratio

C. Stability

1. Less Stable Jitter
2. Less Stable Shimmer
3. Less Stable Harmonics-to-Noise Ratio

X. Resonance31

A. Competence

1. Percentage of Appropriate Resonance Quality

B. Precision

1. Percentage of Nasal Utterances
2. Lowered /a/ 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; Shriberg et al., 2015a, 2015b, 2015c). 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 139 speech, prosody, and voice signs organized by the Ten Linguistic Domains Analytics (TLDA) and the Competence, Precision, Stability Analytics (CPSA) shown in Table 1. The 6 signs derived from sources other than a conversational speech sample are not provided in this report. Shriberg et al. (2010a) describes rationale for and content of the TLDA-CPSA framework.

Table 1. Organization 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.

	Competence, Precision, Stability Analytics (CPSA)							
	Competence		Precision		Stability			
Ten Linguistic Domains Analytics (TLDA)	<u>Perceptual</u>	<u>Acoustic</u>	<u>Perceptual</u>	<u>Acoustic</u>	<u>Perceptual</u>	<u>Acoustic</u>	<u>Total</u>	
Segmental								
I. Vowels	9	0	0	13	2	19	43	
II. Consonants	6	0	3	9	2	2	22	
III. Vowels & Consonants	2	0	4	0	4	0	10	
Total	17	0	7	22	8	21	75	
Suprasegmental								
Prosody								
IV. Phrasing	1	0	7	5	0	0	13	
V. Rate	1	0	0	8	0	8	17	
VI. Stress	1	0	0	1	0	1	3	
Voice								
VII. Loudness	1	0	0	3	0	3	7	
VIII. Pitch	1	0	0	2	0	1	4	
IX. Laryngeal Quality	1	0	6	1	2	1	11	
X. Resonance	1	0	2	3	0	3	9	
Total	7	0	15	23	2	17	64	
Overall Total	24	0	22	45	10	38	139	

METHOD

Participants

Tables 2 and 3 include, respectively, the number and ages of males and females in each of four cohorts of children with the class of Speech Sound Disorders (SSD) termed Speech Delay (SD). For the purposes of this technical report, children were arbitrarily divided into two age groups termed Younger and Older. On the dates they were assessed, Younger children were between the ages of 30 to 54 months and Older children were between the ages of 55 to 65 months. Sociodemographic information on the four cohorts is provided in Shriberg et al. (2015), which uses the same cohort labels (SD1-SD4).

Procedures

BACKGROUND includes citations for all procedures used to assess participants in the four cohorts and to reduce and analyze the data. Procedures to obtain conversational speech samples were standardized several decades ago and were used with some individual variation by the many examiners who obtained the speech samples. The computer-assisted procedure to classify children with SSD as SD has also been in continuous use for several decades. Essentially, the criterion for SD in each of the four samples is children who have speech sound deletions and/or substitutions that are inappropriate for their age and sex, as determined using previous database standardization procedures (Shriberg, 2010).

Table 2. Number of participants in each cohort.

Cohort	Male (n = 122)			Female (n = 58)			Both (n = 180)		
	Younger (n = 95)	Older (n = 27)	Both (n = 122)	Younger (n = 44)	Older (n = 14)	Both (n = 58)	Younger (n = 139)	Older (n = 41)	Both (n = 180)
SD1	32	8	40	17	1	18	49	9	58
SD2	0	8	8	0	4	4	0	12	12
SD3	53	7	60	19	5	24	72	12	84
SD4	10	4	14	8	4	12	18	8	26

Table 3. Average age (in months) of participants in each cohort.

Cohort	Male (n = 122)			Female (n = 58)			Both (n = 180)		
	Younger (n = 95)	Older (n = 27)	Both (n = 122)	Younger (n = 44)	Older (n = 14)	Both (n = 58)	Younger (n = 139)	Older (n = 41)	Both (n = 180)
SD1	44.6 (6.7)	61.0 (3.0)	47.9 (9.0)	44.6 (4.9)	58.0 (0.0)	45.3 (5.7)	44.6 (6.1)	60.7 (3.0)	47.1 (8.2)
SD2		61.1 (1.6)	61.1 (1.6)		61.5 (1.9)	61.5 (1.9)		61.3 (1.7)	61.3 (1.7)
SD3	44.7 (5.5)	57.1 (2.0)	46.2 (6.6)	44.7 (4.7)	56.6 (1.5)	47.2 (6.5)	44.7 (5.3)	56.9 (1.7)	46.5 (6.5)
SD4	48.3 (4.6)	61.5 (2.6)	52.1 (7.4)	46.4 (4.8)	62.0 (4.2)	51.6 (8.9)	47.4 (4.7)	61.8 (3.3)	51.8 (8.0)

SUMMARY

The reference data in the following pages are presented without comment. Constraints on these data include the possibility of sampling errors associated with 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 perceptual and acoustic 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

count = count

Hertz = Hz

kiloHertz = kHz

milliseconds = ms

millisyllables = ‰

percentage = %

syllables/sec = syll/sec

unitless = u

* = No Data

Vowels/Diphthongs

Sign	Males 3;0-4;6		Females 3;0-4;6		Males 4;7-5;5		Females 4;7-5;5		Males 3;0-5;5		Females 3;0-5;5		Males & Females 3;0-4;6		Males & Females 4;7-5;5	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence																
Percentage of Non-rhotic Vowels/Diphthongs Correct (%)	94.0	5.6	94.7	4.4	96.5	4.5	96.1	3.1	94.5	5.4	95.0	4.1	94.2	5.2	96.4	4.0
Percentage of Rhotic Vowels/Diphthongs Correct (%)	26.0	32.4	18.8	29.4	38.9	43.6	13.0	23.7	28.9	35.4	17.5	28.1	23.8	31.6	30.5	39.9
Percentage of Phonemic Diphthongs Correct (%)	94.5	7.3	94.8	7.6	95.6	9.2	95.7	6.1	94.7	7.7	95.0	7.2	94.6	7.4	95.6	8.2
Percentage of Vowels/Diphthongs Correct (%)	91.4	5.9	91.5	4.9	94.5	4.6	92.5	3.0	92.1	5.7	91.8	4.5	91.4	5.6	93.8	4.2
Percentage of Non-rhotic Vowels/Diphthongs Correct-Revised (%)	94.7	5.0	95.4	4.0	96.8	4.2	96.5	3.2	95.2	4.9	95.6	3.9	94.9	4.7	96.7	3.9
Percentage of Rhotic Vowels/Diphthongs Correct-Revised (%)	51.7	33.0	66.0	26.1	70.7	28.7	57.8	23.1	55.9	33.0	64.1	25.4	56.1	31.6	66.5	27.4
Percentage of Phonemic Diphthongs Correct-Revised (%)	95.8	5.3	95.3	6.6	96.0	9.2	96.6	6.4	95.8	6.3	95.6	6.5	95.6	5.7	96.2	8.3
Percentage of Vowels/Diphthongs Correct-Revised (%)	93.0	5.4	94.3	4.2	95.9	4.3	94.8	3.4	93.7	5.3	94.4	4.0	93.4	5.1	95.5	4.0
Percentage of Relative Non-rhotic Vowel/Diphthong Distortions (%)	11.5	19.5	12.4	12.9	9.5	16.3	16.3	20.0	11.1	18.8	13.3	14.7	11.8	17.6	11.9	17.7
B. Precision																
Reduced Vowel Space: Quadrilateral VSQI ^a (u)	33300	18986	42153	20488	28499	15969	26262	16084	32049	18290	38180	20530	36278	19858	27773	15817
Reduced Vowel Space: Quadrilateral VSQIL (u)	0.21	0.12	0.24	0.11	0.20	0.11	0.16	0.11	0.21	0.12	0.22	0.12	0.22	0.12	0.19	0.11
Reduced Vowel Space: Distance from Center VSD (u)	609.7	125.2	604.2	103.4	598.4	83.3	589.4	146.4	606.8	115.5	600.5	114.1	607.9	117.9	595.5	105.8
Reduced Vowel Space: Distance from Center VSDL (u)	0.42	0.09	0.44	0.06	0.42	0.06	0.40	0.08	0.42	0.08	0.43	0.07	0.42	0.08	0.42	0.07
Reduced Vowel Space: /i, æ, a/ Distance from Center VSD3 (u)	578.9	123.2	565.4	114.9	589.8	71.5	600.4	177.2	581.4	113.2	574.2	132.1	574.6	120.3	593.4	116.3
Reduced Vowel Space: /i, æ, a/ Distance from Center VSD3L (u)	0.39	0.08	0.40	0.06	0.42	0.06	0.40	0.09	0.40	0.08	0.40	0.07	0.39	0.07	0.42	0.07

Lengthened Vowels: Corners (ms)	175.1	42.6	176.1	47.5	158.9	30.3	140.7	27.6	171.5	40.7	167.5	45.9	175.4	44.1	152.7	30.4
Lengthened Vowels: Non-Rhotic Mids (ms)	162.3	39.2	151.0	32.2	139.3	26.7	136.0	25.3	157.2	37.9	147.4	31.1	158.7	37.3	138.1	26.0
Lengthened Vowels: Phonemic Diphthongs (ms)	206.4	53.8	206.7	65.1	183.8	35.6	166.1	34.9	201.4	51.1	196.8	61.4	206.5	57.3	177.8	36.0
Reduced Vowel Substitution Coefficients (u)	0.06	0.06	0.12	0.07	0.08	0.01	*	*	0.06	0.05	0.12	0.07	0.07	0.07	0.08	0.01
Distorted Rhotics: F3-F2 (Hz)	1224.2	498.1	1472.9	472.9	1330.0	563.9	1350.1	812.4	1250.7	512.4	1440.6	571.6	1319.6	500.3	1338.1	658.1
Distorted Rhotics: F3/F2 (u)	1.7	0.3	1.9	0.3	1.9	0.4	1.8	0.6	1.8	0.4	1.8	0.4	1.8	0.3	1.8	0.5
Reduced Pairwise Vowel Duration Variability (u)	48.5	13.2	49.1	12.4	55.4	9.9	52.9	11.2	50.1	12.8	50.0	12.2	48.7	12.9	54.5	10.3
C. Stability																
Less Stable Vowel Space: Quadrilateral VSQI (u)	21.0	75.7	57.5	24.0	27.9	54.1	-1.4	85.8	22.7	70.7	42.1	53.9	32.8	65.9	18.2	66.6
Less Stable Vowel Space: Quadrilateral VSQIL (u)	11.7	106.3	57.8	23.4	28.6	56.9	3.5	84.3	16.0	96.2	43.7	52.2	26.6	90.8	20.3	67.1
Less Stable Vowel Space: Distance from Center VSD (u)	49.4	12.6	55.8	11.1	46.3	15.3	45.8	16.0	48.6	13.3	53.3	13.1	51.6	12.4	46.1	15.3
Less Stable Vowel Space: Distance from Center VSDL (u)	57.7	11.6	64.1	13.0	54.7	15.0	56.9	8.8	56.9	12.5	62.3	12.4	59.9	12.4	55.4	13.2
Less Stable Vowel Space: /i, æ, a/ Distance from Center VSD3 (u)	53.2	12.0	51.1	12.6	46.7	15.2	51.8	11.8	51.7	13.0	51.2	12.3	52.5	12.2	48.4	14.2
Less Stable Vowel Space: /i, æ, a/ Distance from Center VSD3L (u)	58.3	11.6	56.9	11.2	53.5	11.0	58.3	8.5	57.2	11.6	57.3	10.5	57.9	11.4	55.2	10.4
Less Stable F1: /i/ (u)	85.1	9.0	84.7	9.1	82.6	11.3	84.3	9.8	84.5	9.6	84.6	9.2	85.0	9.0	83.2	10.7
Less Stable F1: /æ/ (u)	77.7	13.2	82.7	12.8	79.1	14.7	70.1	16.1	78.0	13.5	79.4	14.7	79.3	13.2	75.9	15.6
Less Stable F1: /u/ (u)	84.5	9.9	82.8	13.1	84.7	12.5	86.5	12.1	84.5	10.5	83.8	12.8	83.9	11.1	85.4	12.2
Less Stable F1: /a/ (u)	82.1	11.4	81.1	13.1	82.3	13.1	78.9	11.6	82.2	11.8	80.5	12.7	81.8	11.9	81.2	12.6
Less Stable F2: /i/ (u)	90.1	8.4	88.1	8.0	88.6	9.3	87.1	8.0	89.8	8.6	87.8	8.0	89.5	8.3	88.1	8.8
Less Stable F2: /æ/ (u)	88.0	9.0	87.4	11.9	89.4	9.1	88.6	10.4	88.3	9.0	87.8	11.4	87.8	9.9	89.2	9.4
Less Stable F2: /u/ (u)	78.6	16.0	80.8	9.6	78.5	14.2	83.3	8.6	78.6	15.5	81.5	9.3	79.4	14.0	80.4	12.3

Less Stable F2: /a/ (u)	87.8	8.5	88.5	7.3	83.9	14.9	87.5	7.6	86.9	10.4	88.2	7.4	88.0	8.1	85.1	12.9
Less Stable Vowel Duration: Corners (u)	52.2	14.0	50.9	13.3	49.4	13.7	47.2	16.2	51.6	14.0	50.0	14.0	51.8	13.8	48.7	14.4
Less Stable Vowel Duration: Non-Rhotic Mids (u)	45.9	14.0	43.3	14.6	45.2	11.1	39.9	15.6	45.7	13.3	42.5	14.8	45.1	14.2	43.4	12.8
Less Stable Vowel Duration: Phonemic Diphthongs (u)	53.2	19.1	52.7	18.1	57.6	13.3	49.4	18.2	54.2	18.0	51.9	18.0	53.0	18.8	54.8	15.5
Less Stable Rhotic Distortions: F3-F2 (u)	75.1	18.1	71.7	15.2	77.8	24.5	77.9	15.0	75.7	19.2	72.9	15.1	73.4	16.6	77.8	19.8
Less Stable Rhotic Distortions: F3/2 (u)	86.2	9.2	83.0	8.7	87.5	11.2	87.2	9.0	86.5	9.5	83.8	8.8	84.6	9.0	87.3	9.8
Less Stable Vowel Errors: Targets (%)	64.5	27.0	58.6	31.6	66.6	33.5	58.1	34.9	64.9	28.0	58.5	31.9	62.7	28.4	63.3	33.5
Less Stable Vowel Errors: Types (%)	76.9	26.3	67.4	37.0	86.5	29.9	70.2	32.4	78.6	27.0	68.1	35.6	74.1	30.0	80.1	31.2

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

Consonants

Sign	Males 3;0-4;6		Females 3;0-4;6		Males 4;7-5;5		Females 4;7-5;5		Males 3;0-5;5		Females 3;0-5;5		Males & Females 3;0-4;6		Males & Females 4;7-5;5	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence																
Percentage of Consonants in Inventory (%)	84.5	11.3	83.0	10.2	88.4	11.6	88.1	8.5	85.4	11.4	84.2	10.0	84.0	11.0	88.3	10.5
Percentage of Consonants Correct (%)	67.8	11.8	69.3	7.9	75.3	11.0	75.1	5.9	69.4	12.0	70.7	7.9	68.3	10.8	75.2	9.5
Percentage of Consonants Correct- Revised (%)	73.4	11.8	74.5	7.9	79.9	10.0	82.4	7.4	74.9	11.7	76.4	8.4	73.8	10.7	80.7	9.2
Relative Omission Index (ROI) (%)	30.7	15.4	30.5	11.8	23.2	10.5	21.6	13.9	29.1	14.8	28.4	12.8	30.7	14.3	22.7	11.6
Relative Substitution Index (RSI) (%)	50.7	13.6	51.7	11.5	56.8	12.4	48.1	12.2	52.0	13.6	50.9	11.6	51.0	13.0	53.8	12.8
Relative Distortion Index (RDI) (%)	18.6	12.5	17.8	9.9	20.0	10.8	30.3	19.3	18.9	12.1	20.8	13.7	18.3	11.7	23.5	14.9
B. Precision																
Nasal Emissions (%)	0.0	0.1	0.1	0.4	0.0	0.1	0.0	0.2	0.0	0.1	0.1	0.4	0.1	0.2	0.0	0.1
Reduced Percentage of Glides Correct (%)	90.8	14.9	89.3	11.0	96.6	5.1	95.8	6.5	92.1	13.5	90.8	10.4	90.3	13.8	96.4	5.5
Increased Percentage of /j/ deletions in Clusters (%)	19.2	38.4	12.5	35.4	0.0	0.0	0.0	0.0	15.6	35.2	9.1	30.2	16.7	36.5	0.0	0.0
Lowered Sibilant Centroids: M1 at Mid Point (kHz)	6.1	1.4	5.9	1.6	5.4	1.4	6.3	1.0	6.0	1.5	6.0	1.5	6.1	1.5	5.7	1.3
Lowered Sibilant Centroids: Maximum M1 (kHz)	6.6	1.4	6.5	1.6	6.0	1.3	6.8	1.1	6.5	1.4	6.6	1.5	6.6	1.5	6.2	1.3
Lengthened Cluster Durations: Relative Duration of Cluster (ms)	843.3	311.3	757.0	372.2	793.3	335.7	933.3	346.6	828.9	317.0	805.5	369.7	812.4	334.7	841.5	340.6

Lengthened Cluster Durations: Relative Duration of First Consonant (% o)	393.7	191.3	375.7	251.5	372.9	186.2	497.9	241.0	387.7	188.8	409.3	251.7	387.3	213.4	415.9	211.5
Lengthened Cluster Durations: Relative Duration of Second Consonant (% o)	436.1	213.1	364.1	267.0	400.6	185.3	424.6	148.6	425.9	204.8	380.7	240.0	410.3	234.7	408.9	171.5
Lengthened Cluster Durations: Percentage of S-F/F-S Cluster Disruptions (%)	0.0	0.0	2.0	7.6	1.2	5.5	0.0	0.0	0.3	2.9	1.5	6.5	0.7	4.6	0.8	4.4
Lengthened Cluster Durations: Rel. Duration of S-F/F-S Cluster Disruptions (% o)	13.4	9.7	17.3	28.8	19.8	21.4	10.8	5.4	15.3	14.2	15.5	24.8	14.8	18.8	16.7	18.0
Lengthened Cluster Durations: Relative Duration of Pause Disruptions (% o)	0.0	0.0	0.0	0.0	0.0	0.0	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 (% o)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C. Stability																
Less Stable Consonant Errors: Targets (%)	65.9	11.4	68.1	15.0	64.4	15.9	66.3	18.8	65.6	12.5	67.6	15.8	66.6	12.6	65.1	16.8
Less Stable Consonant Errors: Error Types: (%)	83.2	10.0	83.2	12.8	86.3	13.2	81.9	12.4	83.9	10.8	82.9	12.6	83.2	10.9	84.8	13.0
Less Stable Sibilant Centroids: M1 at Mid Point (u)	79.3	14.3	75.5	14.9	76.2	14.4	81.8	9.8	78.5	14.3	77.3	13.8	78.1	14.5	78.2	13.1
Less Stable Sibilant Centroids: Maximum M1 (u)	81.2	14.1	79.2	12.4	79.8	13.0	83.8	10.2	80.8	13.8	80.4	11.9	80.5	13.5	81.2	12.1

Vowels/Diphthongs & Consonants

Sign	Males 3;0-4;6		Females 3;0-4;6		Males 4;7-5;5		Females 4;7-5;5		Males 3;0-5;5		Females 3;0-5;5		Males & Females 3;0-4;6		Males & Females 4;7-5;5	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence																
Intelligibility Index (%)	86.4	11.2	89.7	8.2	88.2	12.5	94.5	4.8	86.8	11.4	90.9	7.7	87.5	10.4	90.4	10.8
Percentage of Structurally Correct Words (%)	83.7	11.4	85.6	5.3	89.9	6.3	88.8	7.2	85.1	10.8	86.4	5.9	84.3	9.9	89.5	6.5
B. Precision																
Increased Percentage of Phoneme Distortions: Place (%)	5.1	2.9	5.0	2.0	4.1	2.8	7.2	3.0	4.9	2.9	5.5	2.5	5.0	2.6	5.2	3.2
Increased Percentage of Phoneme Distortions: Additions (%)	1.4	1.0	1.5	1.1	0.9	0.7	1.5	1.2	1.3	1.0	1.5	1.2	1.4	1.1	1.1	1.0
Increased Percentage of Phoneme Distortions: Duration (%)	1.5	1.4	1.4	1.5	0.9	0.9	1.2	1.2	1.4	1.3	1.4	1.4	1.5	1.4	1.0	1.0
Increased Percentage of Phoneme Distortions: Force (%)	0.3	0.8	0.4	0.6	0.1	0.2	0.4	0.4	0.3	0.7	0.4	0.6	0.4	0.7	0.2	0.3
Increased Percent of EMMA errors by type (%)	11.0	5.5	11.5	5.3	8.3	4.0	10.2	5.2	10.4	5.3	11.2	5.3	11.1	5.4	8.9	4.5
C. Stability																
Less Stable Whole Word Errors: Targets (%)	49.9	13.1	47.8	14.4	54.0	19.8	55.2	19.8	50.8	14.8	49.6	16.0	49.2	13.5	54.4	19.6
Less Stable Whole Word Errors: Error Types (%)	59.5	15.5	55.7	16.0	67.9	20.3	63.9	19.8	61.3	17.0	57.7	17.2	58.3	15.7	66.6	20.0
Less Stable Percentage of Phonemes Correct in Complex Words (%)	73.0	12.7	72.0	18.5	76.7	14.1	72.1	18.4	73.8	13.1	72.0	18.3	72.7	14.7	75.1	15.6
Increased Percent of EMMA errors by token (%)	7.2	3.7	7.2	3.2	5.5	3.1	6.8	3.5	6.8	3.6	7.1	3.3	7.2	3.6	6.0	3.2

Phrasing

Sign	Males 3;0-4;6		Females 3;0-4;6		Males 4;7-5;5		Females 4;7-5;5		Males 3;0-5;5		Females 3;0-5;5		Males & Females 3;0-4;6		Males & Females 4;7-5;5	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence																
Percentage of Appropriate Phrasing (%)	90.2	9.8	90.1	9.6	86.4	9.4	89.5	8.7	89.3	9.8	89.9	9.3	90.1	9.7	87.4	9.1
B. Precision																
Increased Repetitions and Revisions: 2-4 Word Utterances (%)	3.6	5.4	2.9	5.6	2.2	4.6	1.5	3.9	3.3	5.2	2.6	5.2	3.4	5.4	2.0	4.3
Increased Repetitions and Revisions: 5-7 Word Utterances (%)	12.5	15.2	9.7	12.1	13.9	11.2	10.2	16.1	12.8	14.4	9.8	13.1	11.6	14.3	12.6	13.0
Increased Repetitions and Revisions: 8+ Word Utterances (%)	39.2	35.2	44.6	35.6	34.2	27.1	19.9	15.9	37.8	33.1	37.1	32.9	40.9	35.2	29.4	24.7
Increased Repetitions and Revisions: All Utterances (%)	9.8	9.8	9.9	9.5	14.2	10.2	10.6	8.9	10.8	10.0	10.0	9.3	9.8	9.7	12.9	9.8
Increased Syllable/Word Segregation: % of Btw/Wthn-Word Pauses (%)	0.5	0.3	0.5	0.3	0.6	0.4	0.7	0.4	0.5	0.3	0.6	0.4	0.5	0.3	0.7	0.4
Increased Syllable/Word Segregation: Duration of Btw/Wthn-Word Pauses (ms)	558.2	184.0	549.7	204.0	539.6	146.4	588.3	187.2	554.1	175.9	559.2	199.1	555.5	189.8	556.3	160.8
Increased Percentage of Inappropriate Pauses (%)	11.9	16.8	14.5	13.4	11.8	16.0	11.7	13.1	11.9	16.6	13.8	13.3	12.7	15.8	11.8	14.9
Increased Percentage of Pauses (%)	10.4	5.8	10.7	5.9	10.9	5.7	12.0	7.9	10.5	5.8	11.0	6.4	10.5	5.8	11.3	6.5

Reduced Speech-Pause Duration Variability Ratio: 2-4 Word Utterances (u)	0.9	0.5	1.1	1.1	0.9	0.4	1.5	0.2	0.9	0.5	1.1	1.0	0.9	0.7	1.1	0.5
Reduced Speech-Pause Duration Variability Ratio: 5-7 Word Utterances (u)	0.9	0.6	1.0	0.6	1.0	0.6	1.5	0.7	0.9	0.6	1.1	0.6	1.0	0.6	1.2	0.7
Reduced Speech-Pause Duration Variability Ratio: 8+ Word Utterances (u)	0.8	0.4	0.9	0.4	1.0	0.5	0.8	0.4	0.8	0.4	0.9	0.4	0.8	0.4	0.9	0.5
Reduced Speech-Pause Duration Variability Ratio: All Word Utterances (u)	0.9	0.4	0.9	0.4	0.9	0.4	1.0	0.4	0.9	0.4	1.0	0.4	0.9	0.4	0.9	0.4

Rate

Sign	Males 3;0-4;6		Females 3;0-4;6		Males 4;7-5;5		Females 4;7-5;5		Males 3;0-5;5		Females 3;0-5;5		Males & Females 3;0-4;6		Males & Females 4;7-5;5	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence																
Percentage of Appropriate Rate (%)	97.0	7.4	97.2	6.1	98.5	3.5	96.1	7.6	97.4	6.8	97.0	6.4	97.1	7.0	97.7	5.3
B. Precision																
Slower Speaking Rate: 2-4 Word Utterances (syll/sec)	3.0	0.6	3.2	0.5	3.5	0.9	3.4	1.0	3.2	0.7	3.2	0.6	3.1	0.6	3.5	0.9
Slower Speaking Rate: 5-7 Word Utterances (syll/sec)	3.1	0.7	3.4	0.8	3.4	0.6	3.6	1.0	3.2	0.7	3.4	0.8	3.2	0.7	3.4	0.8
Slower Speaking Rate: 8+ Word Utterances (syll/sec)	2.8	0.9	2.9	0.8	3.1	0.6	3.3	0.6	2.9	0.8	3.0	0.7	2.8	0.8	3.1	0.6
Slower Speaking Rate: All Utterances (syll/sec)	3.1	0.5	3.2	0.5	3.3	0.6	3.3	0.8	3.1	0.6	3.2	0.6	3.1	0.5	3.3	0.7
Slower Articulation Rate: 2-4 Word Utterances (syll/sec)	3.3	0.6	3.4	0.5	3.7	0.8	3.6	0.9	3.4	0.7	3.5	0.6	3.3	0.6	3.7	0.8
Slower Articulation Rate: 5-7 Word Utterances (syll/sec)	3.5	0.6	3.7	0.7	3.8	0.6	3.9	0.9	3.5	0.6	3.7	0.7	3.5	0.6	3.8	0.7
Slower Articulation Rate: 8+ Word Utterances (syll/sec)	3.5	0.8	3.4	0.6	3.7	0.7	3.9	0.6	3.6	0.8	3.6	0.6	3.5	0.8	3.8	0.6
Slower Articulation Rate: All Utterances (syll/sec)	3.4	0.5	3.5	0.5	3.6	0.6	3.8	0.7	3.4	0.6	3.5	0.6	3.4	0.5	3.7	0.6
C. Stability																
Less Stable Speaking Rate: 2-4 Word Utterances (u)	69.2	11.2	71.0	8.5	71.0	13.0	67.1	9.5	69.6	11.5	70.1	8.8	69.8	10.4	69.6	11.8
Less Stable Speaking Rate: 5-7 Word Utterances (u)	78.4	11.1	74.3	11.4	67.3	15.6	74.1	12.5	75.7	13.2	74.2	11.6	77.1	11.3	69.5	14.8
Less Stable Speaking Rate: 8+ Word Utterances (u)	76.4	14.9	81.3	14.8	76.5	10.3	76.4	12.2	76.4	13.4	79.4	13.9	78.1	14.9	76.4	10.9
Less Stable Speaking Rate: All Utterances (u)	70.6	8.2	71.2	6.9	69.7	6.6	69.4	6.8	70.4	7.9	70.8	6.8	70.8	7.8	69.6	6.6

Less Stable Articulation Rate: 2-4 Word Utterances (u)	72.5	10.9	72.9	9.7	75.3	10.6	71.0	6.7	73.1	10.9	72.5	9.0	72.7	10.5	73.7	9.5
Less Stable Articulation Rate: 5-7 Word Utterances (u)	84.4	9.1	79.4	9.7	75.7	9.4	80.0	11.5	82.3	9.9	79.5	10.1	82.8	9.6	77.2	10.2
Less Stable Articulation Rate: 8+ Word Utterances (u)	84.3	9.4	86.2	9.3	80.2	11.1	82.3	8.4	82.9	10.1	84.7	9.0	85.0	9.3	81.1	10.0
Less Stable Articulation Rate: All Utterances (u)	74.8	8.5	75.0	6.9	76.0	6.0	75.5	4.9	75.1	8.0	75.1	6.4	74.9	8.0	75.8	5.6

Stress

Sign	Males 3;0-4;6		Females 3;0-4;6		Males 4;7-5;5		Females 4;7-5;5		Males 3;0-5;5		Females 3;0-5;5		Males & Females 3;0-4;6		Males & Females 4;7-5;5	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence																
Percentage of Appropriate Stress (%)	88.2	10.1	89.7	8.6	89.2	10.5	89.7	7.0	88.4	10.2	89.7	8.2	88.7	9.7	89.4	9.4
B. Precision																
Sentential Stress (u)	1.3	0.8	1.0	0.5	1.2	0.4	1.2	0.5	1.3	0.7	1.0	0.5	1.2	0.7	1.2	0.5
C. Stability																
Less Stable Sentential Stress (u)	26.8	34.2	29.4	28.1	34.6	29.3	42.6	30.0	28.5	33.2	32.5	28.8	27.6	32.4	37.2	29.3

Loudness

Sign	Males 3;0-4;6		Females 3;0-4;6		Males 4;7-5;5		Females 4;7-5;5		Males 3;0-5;5		Females 3;0-5;5		Males & Females 3;0-4;6		Males & Females 4;7-5;5	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence																
Percentage of Appropriate Loudness (%)	88.5	16.6	87.7	14.4	92.9	11.8	97.0	5.8	89.5	15.7	90.0	13.4	88.3	15.8	94.3	10.2
B. Precision																
Vowels-Consonants Intensity Ratios: Vowels-Stops (u)	12.9	5.0	11.9	4.1	12.0	4.5	10.2	5.8	12.7	4.9	11.5	4.6	12.6	4.8	11.4	5.0
Vowels-Consonants Intensity Ratios: Vowels-Affricates/Fricatives (u)	15.6	6.5	17.2	5.4	16.6	5.2	14.0	9.3	15.9	6.2	16.3	6.7	16.2	6.2	15.7	6.9
Vowels-Consonants Intensity Ratios: All (u)	13.8	4.3	13.3	3.7	13.4	4.0	11.2	6.1	13.7	4.2	12.8	4.4	13.6	4.1	12.7	4.9
C. Stability																
Less Stable Vowels-Consonants Intensity Ratios: Vowels-Stops (u)	42.8	28.9	33.9	51.1	29.6	47.4	41.2	19.1	39.7	34.3	35.7	45.3	40.0	37.3	33.4	40.5
Less Stable Vowels-Consonants Intensity Ratios: Vowels-Affricates/Fricatives (u)	64.9	22.4	58.6	33.5	45.8	40.7	58.9	32.3	58.9	30.5	58.7	32.8	62.5	27.1	49.8	38.3
Less Stable Vowels-Consonants Intensity Ratios: All (u)	43.8	25.7	42.1	23.2	37.3	19.9	41.7	18.2	42.3	24.6	42.0	22.0	43.3	24.9	38.7	19.2

Pitch

Sign	Males 3;0-4;6		Females 3;0-4;6		Males 4;7-5;5		Females 4;7-5;5		Males 3;0-5;5		Females 3;0-5;5		Males & Females 3;0-4;6		Males & Females 4;7-5;5	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence																
Percentage of Appropriate Pitch (%)	95.6	9.7	96.3	7.7	96.9	5.9	98.0	4.2	95.9	9.0	96.7	7.0	95.8	9.1	97.2	5.4
B. Precision																
Midpoint Fundamental Frequency Mean (Hz)	294.5	50.1	279.5	33.3	274.7	34.0	263.4	34.8	290.1	47.6	275.6	34.0	289.8	45.9	270.9	34.3
Midpoint Fundamental Frequency Range (Hz)	374.8	154.8	345.6	148.3	315.8	114.1	301.1	122.2	361.7	148.4	334.9	142.7	365.6	45.9	310.8	115.6
C. Stability																
Less Stable Mean Midpoint Fundamental Frequency (u)	76.9	7.6	77.5	8.8	80.5	5.9	80.1	8.2	77.7	7.4	78.1	8.7	365.6	152.9	80.3	6.7

Laryngeal Quality

Sign	Males 3;0-4;6		Females 3;0-4;6		Males 4;7-5;5		Females 4;7-5;5		Males 3;0-5;5		Females 3;0-5;5		Males & Females 3;0-4;6		Males & Females 4;7-5;5	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence																
Percentage of Appropriate Laryngeal Quality (%)	83.9	19.9	74.8	29.8	85.5	23.5	78.6	25.4	84.2	20.7	75.7	28.7	81.0	23.8	83.1	24.1
B. Precision																
Percentage of Breathly Utterances (%)	1.9	4.5	2.2	6.6	0.5	1.3	3.2	8.1	1.6	4.1	2.4	6.9	2.0	5.2	1.4	4.9
Percentage of Rough Utterances (%)	10.5	18.0	14.7	19.7	12.2	23.3	14.3	24.7	10.8	19.2	14.6	20.8	11.8	18.6	12.9	23.5
Percentage of Strained Utterances (%)	0.7	4.0	3.1	9.5	0.3	1.1	0.0	0.0	0.6	3.5	2.4	8.3	1.5	6.3	0.2	0.9
Percentage of Break/Shift/Tremulous Utterances (%)	2.9	4.7	2.8	4.8	1.4	3.1	2.7	5.6	2.6	4.5	2.8	5.0	2.9	4.8	1.8	4.1
Percentage of Jitter (%)	1.3	0.7	1.6	1.1	1.2	1.0	1.1	0.5	1.3	0.8	1.5	1.0	1.4	0.9	1.2	0.9
Percentage of Shimmer (%)	8.3	3.4	9.1	3.9	7.9	5.7	7.5	2.3	8.2	4.0	8.7	3.7	8.5	3.6	7.8	4.7
Harmonics-to-Noise Ratio (dB)	19.3	3.2	18.8	3.1	18.8	3.5	19.2	2.4	19.2	3.3	18.9	2.9	19.1	3.2	18.9	3.2
C. Stability																
Less Stable Jitter (u)	5.3	41.0	-11.2	49.2	16.5	43.7	8.5	31.4	7.8	41.7	-6.4	46.1	0.1	44.3	13.8	39.7
Less Stable Shimmer (u)	34.4	27.2	27.3	31.7	41.3	23.6	22.7	20.6	35.9	26.5	26.2	29.3	32.1	28.8	35.0	24.1
Less Stable Harmonics-to-Noise Ratio (u)	73.1	8.9	71.6	8.0	72.8	9.9	73.4	8.8	73.0	9.1	72.0	8.2	72.6	8.6	73.0	9.4

Resonance

Sign	Males 3;0-4;6		Females 3;0-4;6		Males 4;7-5;5		Females 4;7-5;5		Males 3;0-5;5		Females 3;0-5;5		Males & Females 3;0-4;6		Males & Females 4;7-5;5	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
A. Competence																
Percentage of Appropriate Resonance Quality (%)	92.1	17.3	90.2	18.9	92.7	19.8	88.7	27.5	92.3	17.8	89.8	21.0	91.5	17.8	91.4	22.4
B. Precision																
Percentage of Nasal Utterances (%)	0.9	3.6	2.8	15.2	0.5	1.8	8.1	24.6	0.8	3.2	4.1	17.9	1.5	9.0	3.1	14.6
Lowered /ɑ/ F1 (Nasal) (Hz)	931.9	184.8	1047.4	172.6	891.4	198.4	962.8	230.7	922.7	187.9	1027.0	189.4	968.6	188.2	915.2	209.4
Percentage of Nasopharyngeal Utterances (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.9	0.0	0.0	0.1	0.9	0.0	0.0	0.2	1.1
Lowered /i/ F2 (Nasopharyngeal) (Hz)	2985.8	319.7	3004.2	418.9	2931.2	337.9	3036.7	356.0	2973.4	323.2	3012.5	400.8	2991.6	352.4	2968.1	343.6
Lowered /u/ F2 (Nasopharyngeal) (Hz)	1743.8	454.3	1751.2	324.2	1852.1	410.0	2107.0	602.8	1772.2	443.8	1838.4	431.9	1746.4	412.6	1934.9	488.4
C. Stability																
Less Stable /ɑ / F1 (Nasal) (u)	82.1	11.4	81.1	13.1	82.3	13.1	78.9	11.6	82.2	11.8	80.5	12.7	81.8	11.9	81.2	12.6
Less Stable /i / F2 (Nasopharyngeal) (u)	90.1	8.4	88.1	8.0	88.6	9.3	87.1	8.0	89.8	8.6	87.8	8.0	89.5	8.3	88.1	8.8
Less Stable /u / F2 (Nasopharyngeal) (u)	78.6	16.0	80.8	9.6	78.5	14.2	83.3	8.6	78.6	15.5	81.5	9.3	79.4	14.0	80.4	12.3