

Acoustic Correlates
of Speech
Naturalness in
Post-Treatment
Adults Who Stutter

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What is Stuttering?

Definition

- Interruption in forward flow of speech (Van Riper, 1982)
- Part or whole word repetitions
 - (bu-bu-but or and-and-and)
- Prolongations
 - (Mo—mmy)
- Blocks of airflow before or during a sound or word production (Yairi & Seery, 2015).

Prevalence

- 1% of general population (Yairi & Seery, 2015)

Treatment

- Fluency Shaping Treatment
- Effects of treatment (Yairi & Seery, 2015)
- Post-treatment concerns of speech naturalness

Speech Naturalness Rating Procedures

○ **1-9 Interval Rating Procedures**

- Martin et al, 1984
- Metz et al, 1990
- Onslow et al, 1992
- Tasko et al, 2007

○ **Direct Magnitude**

- Metz et al, 1990

○ **Agreement Ratings**

- Schaeffer and Eichorn, 2001
- Schaeffer, 2006

Acoustic Characteristics Influencing Naturalness

○ **Vowel prolongation**

- Vowels prolonged at more than 150% were seen by 83% unnatural (Schaeffer & Eichorn, 2001)

○ **Sentence Duration**

- Utterances prolonged at 210% (Shaeffer, 2006)
- Correlated with picture description task ($r = .637$) (Metz et al, 1990)

○ **Voice Onset Time**

- Correlated with oral reading ($r = .679$) (Metz et al, 1990)

Acoustic Characteristics Influencing Naturalness

- Healey (1982)
- Studied variation of SFF two utterance types.
 - Mean SFF, SFF standard deviation, and SFF range
 - SFF standard deviation of adults who did not stutter were greater than those who did.
 - Adults who stutter had more restricted pitch ranges, less variance, more monotone.
 - Differences made them distinguishable from fluent speakers



Role of Fundamental Frequency in Speech Naturalness

Speaking Fundamental Frequency (SFF)

o What is SFF?

- o Rate at which vocal folds approximate together
- o Affects prosody of speech

Research Question

- Is there an association between measures of speaking fundamental frequency variation and listener ratings of speech naturalness?



Method

Participants

- Participants drawn from the Walter Reed - Western Michigan University Stuttering Database (43 adults who stutter & 43 healthy controls)
- Began with 34 adults who participated in the Walter Reed Stuttering Treatment Program
- 29 Adults (27 male, 2 female)
 - 3 excluded due to missing records
 - 1 excluded due to strong accent
 - 1 excluded due to poor audio quality of sample

Treatment Program

- One month
- Group based
- Fluency shaping
 - Three part program

Stuttering Severity Measures

- O Severity ratings before and after treatment
- O Monologue video
- O SSI-3 judged by two speech-language pathologists
- O Consensus format

Speech Naturalness Rating Procedure

- 1-9 interval rating scale
- Three groups of raters
- One minute segment from monologue before and after treatment
- Mean rating across samples was recorded

Sample Selection

- Rating based on naturalness of monologue
- Analysis of reading samples was chosen

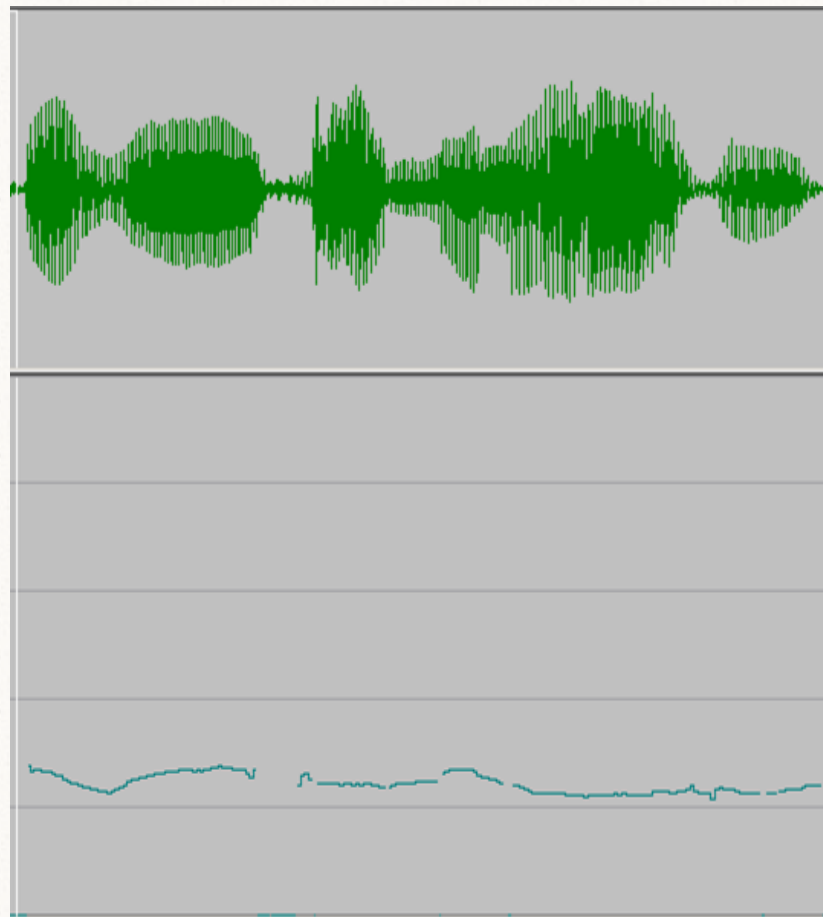
Speaker Fundamental Frequency Analysis

oAudio files were extracted from video recordings using Audacity

oExamined in TF-32 software.

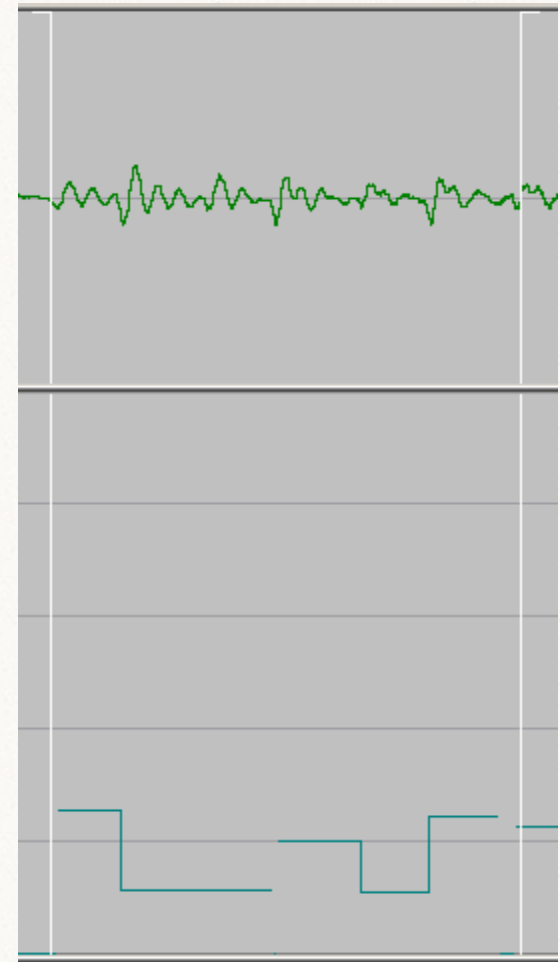
oSF contours computed

oThousands of f_0 moments and the frequencies at those moments



Speaker Fundamental Frequency Analysis

- Editing procedure completed to eliminate the discontinuities in the pitch trace
 - Halving or doubling of SFF due to misinterpretation of waveform



Speaker Fundamental Frequency Analysis

- Custom written Matlab program
 - Additional edits of outliers
- SFF measures based on the several thousand f_0 measurements were derived for each speech sample.
 - Mean SFF (Hz),
 - SFF standard deviation (in Hz and in semitones),
 - SFF interquartile range (in Hz and in semitones).
 - Method described in Baken (1987) was used to convert from Hz to semitones
- Descriptive statistics of behavioral and acoustic measures were generated
- Simple correlations were performed between acoustic measures and behavioral measures



Results

Speaker Fundamental Frequency Analysis

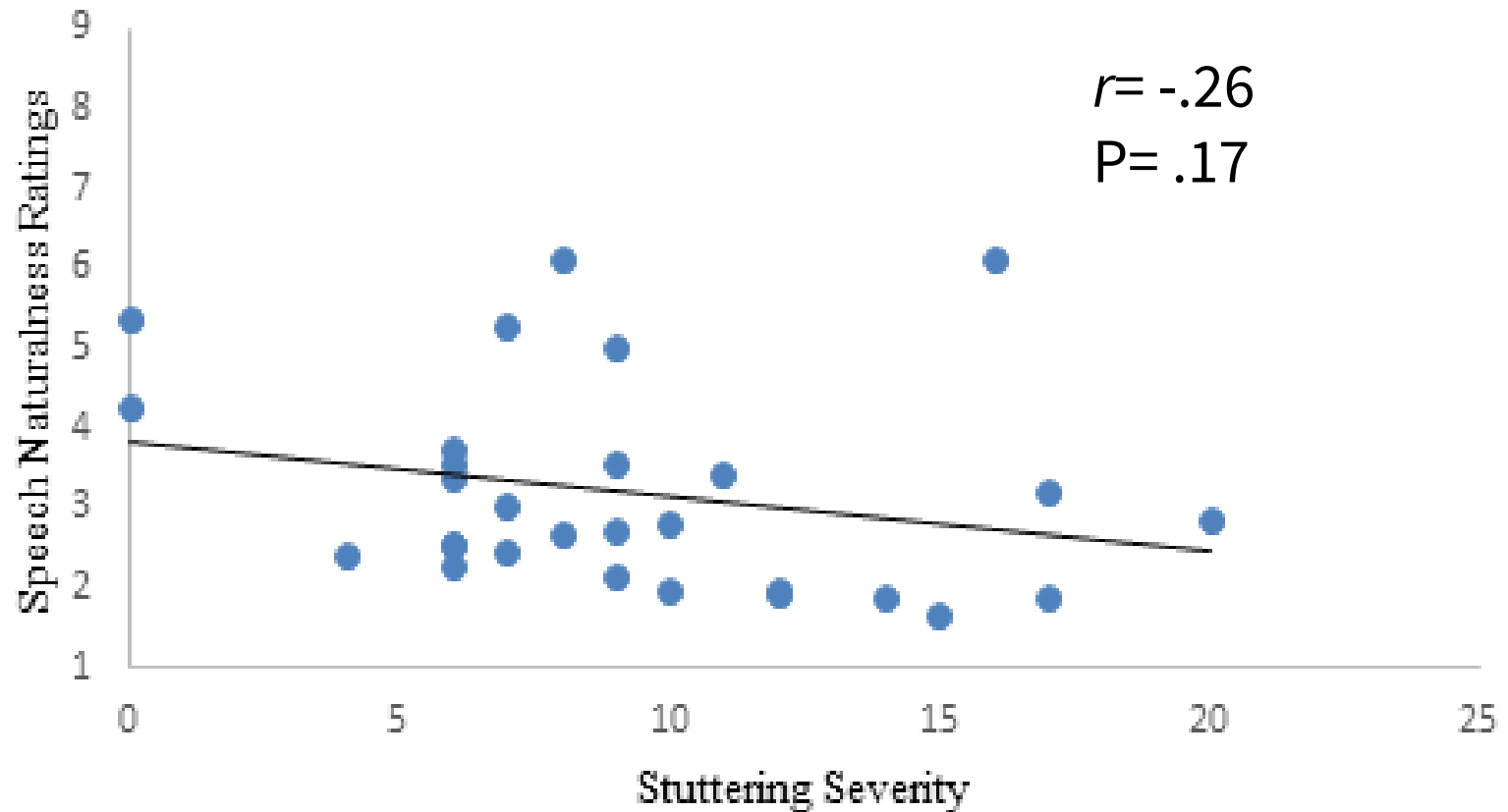
O Procedure reliability strong

Sample-Rater Initials	Mean	Std	Std_St	IQR	IQR_St
Sample 1 - CJ	106.90	13.73	2.09	15.96	2.60
Sample 1 - JS	107.00	13.87	2.11	15.98	2.60
Sample 2 - CJ	141.90	13.52	1.57	15.71	1.92
Sample 2 - JS	141.87	13.63	1.58	15.87	1.94
Sample 3 - CJ	111.94	15.98	2.31	17.86	2.76
Sample 3 - JS	112.19	15.05	2.179	17.63	2.72

Behavioral & Acoustic Measure Descriptive Statistics

	PRE SSI	Pre-tx Nat	PST SSI	Post_Tx Nat	Mean (Hz)	Std (Hz)	Std (St)	IQR (Hz)	IQR (St)
Average	24.82	4.215	4.215	3.573	128	17.5	2.21	21.78	2.9
Minimum	17	1.2	0	1.65	102	11.16	1.53	9.75	1.36
Maximum	35	7.4	20	6.14	208	31.97	3.58	47.64	4.86
Range	18	6.2	20	4.49	106	20.81	2.05	37.89	3.5

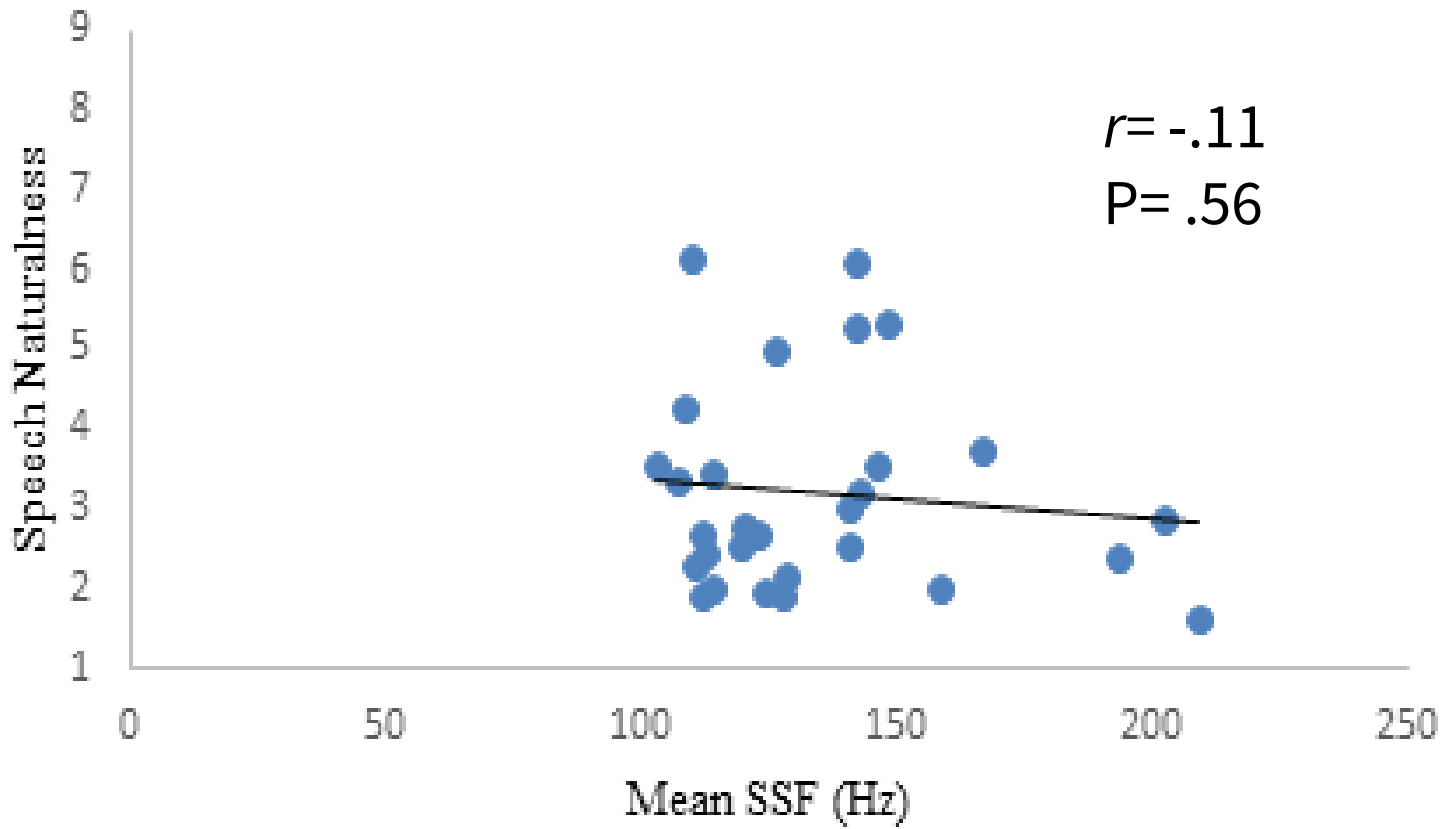
SSI-3 & Speech Naturalness Ratings



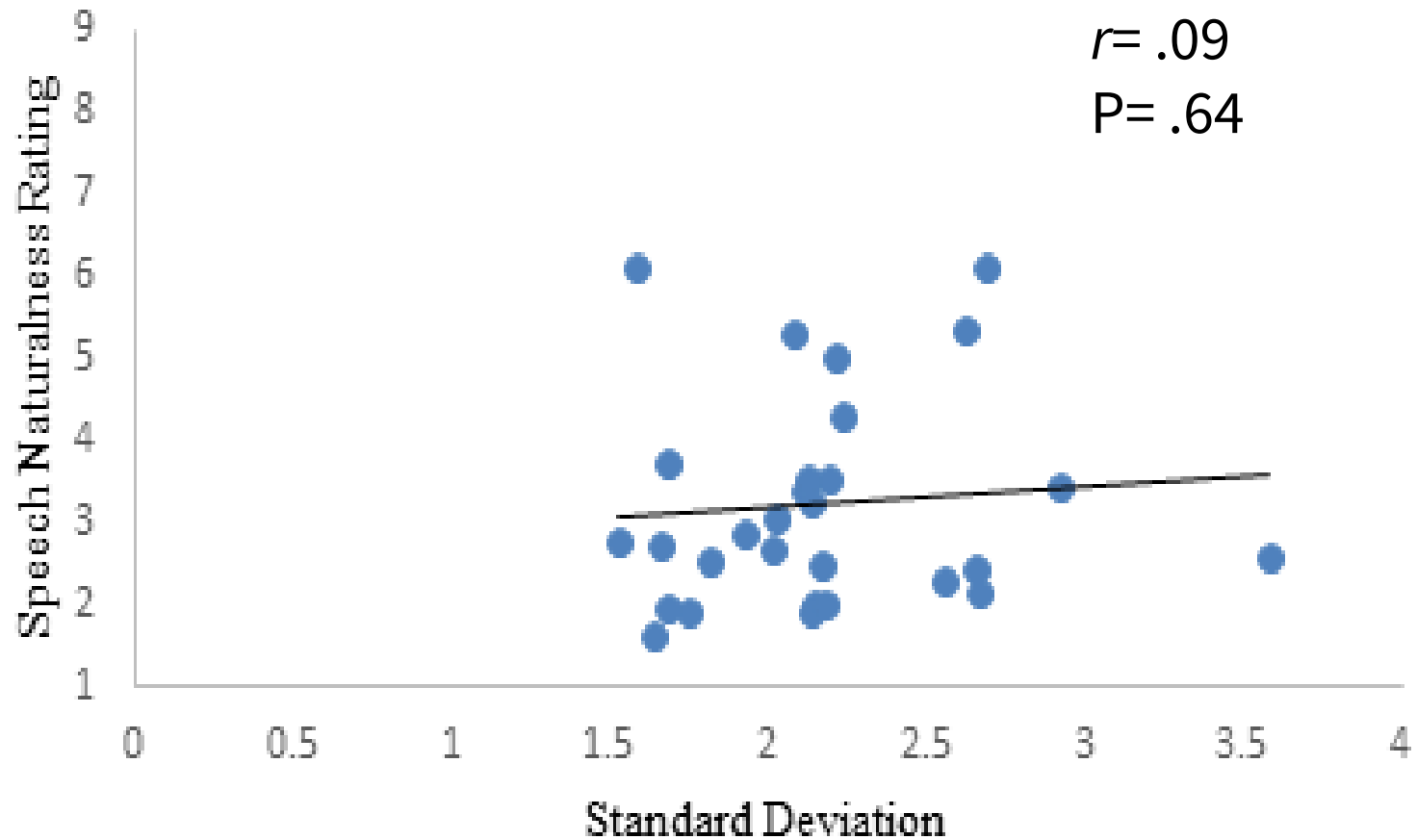
Correlation Coefficients of Acoustical Measurements, Speech Naturalness, & Stuttering Severity

	Pre tx SSI	Pre tx Nat	Post tx SSI	Post tx Nat	Mean (Hz)	Std (Hz)	Std_S t	IQR (Hz)	IQR_ St
Pre tx SSI	--	.674	-.1	.26	.153	.02	-.07	.06	-.11
Pretx Nat		--	.02	.41	.259	.01	-.23	.12	-.1
Post tx SSI			--	-.26	.272	-.14	-.37	-.12	-.32
Post tx Nat				--	-.11	-.01	.09	.01	.13

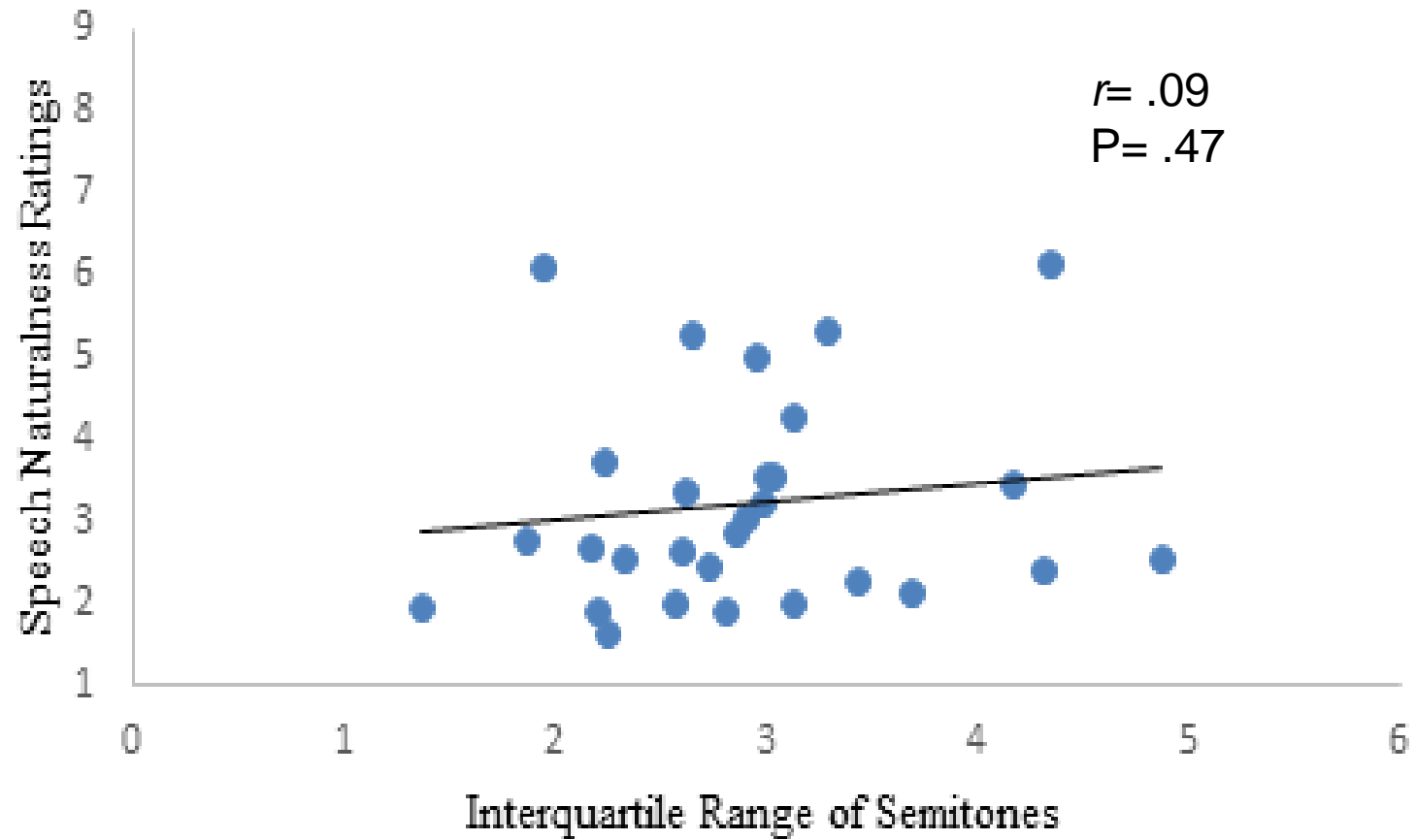
Mean SFF and Speech Naturalness



Standard Deviation of Semitones



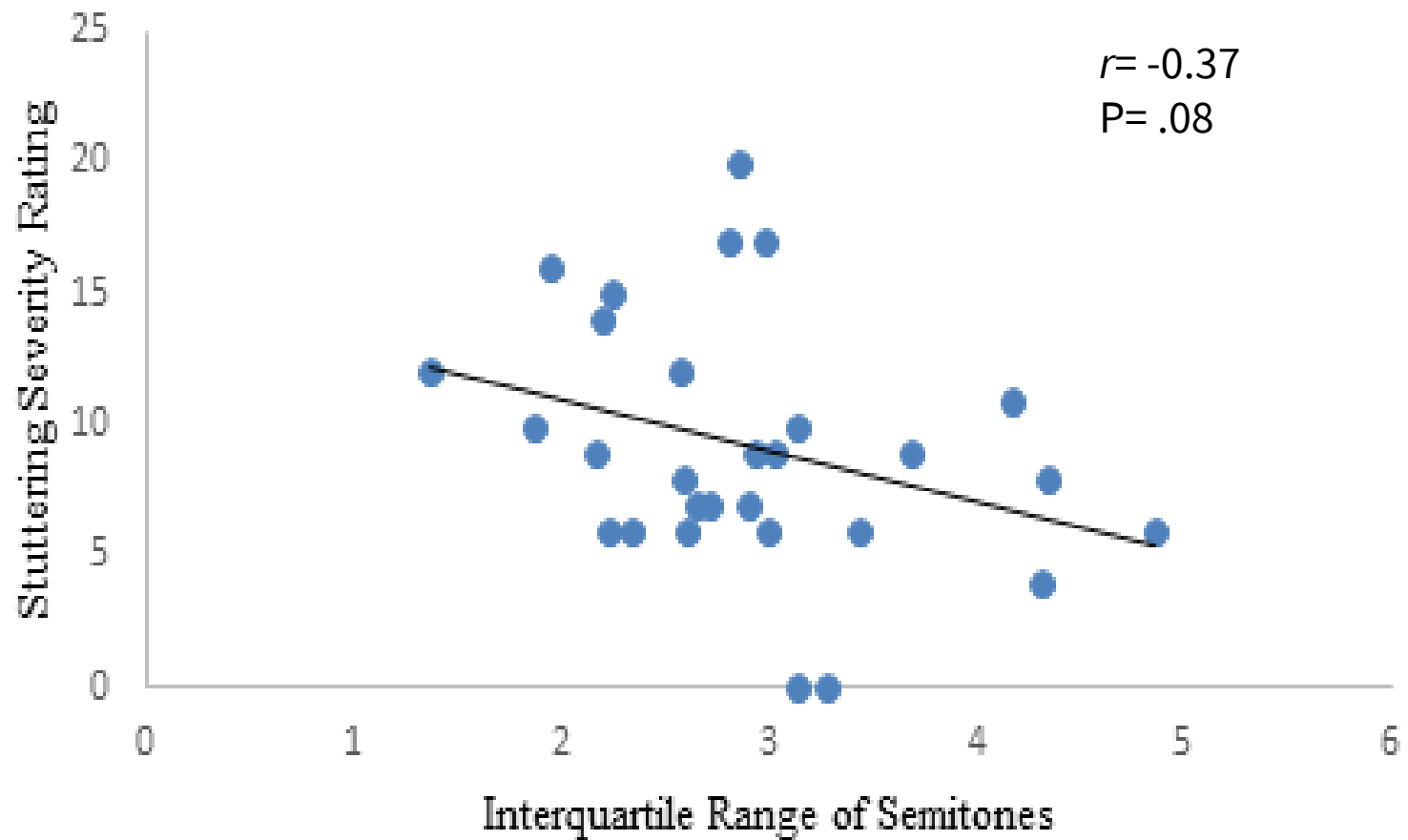
Interquartile Range of Semitones



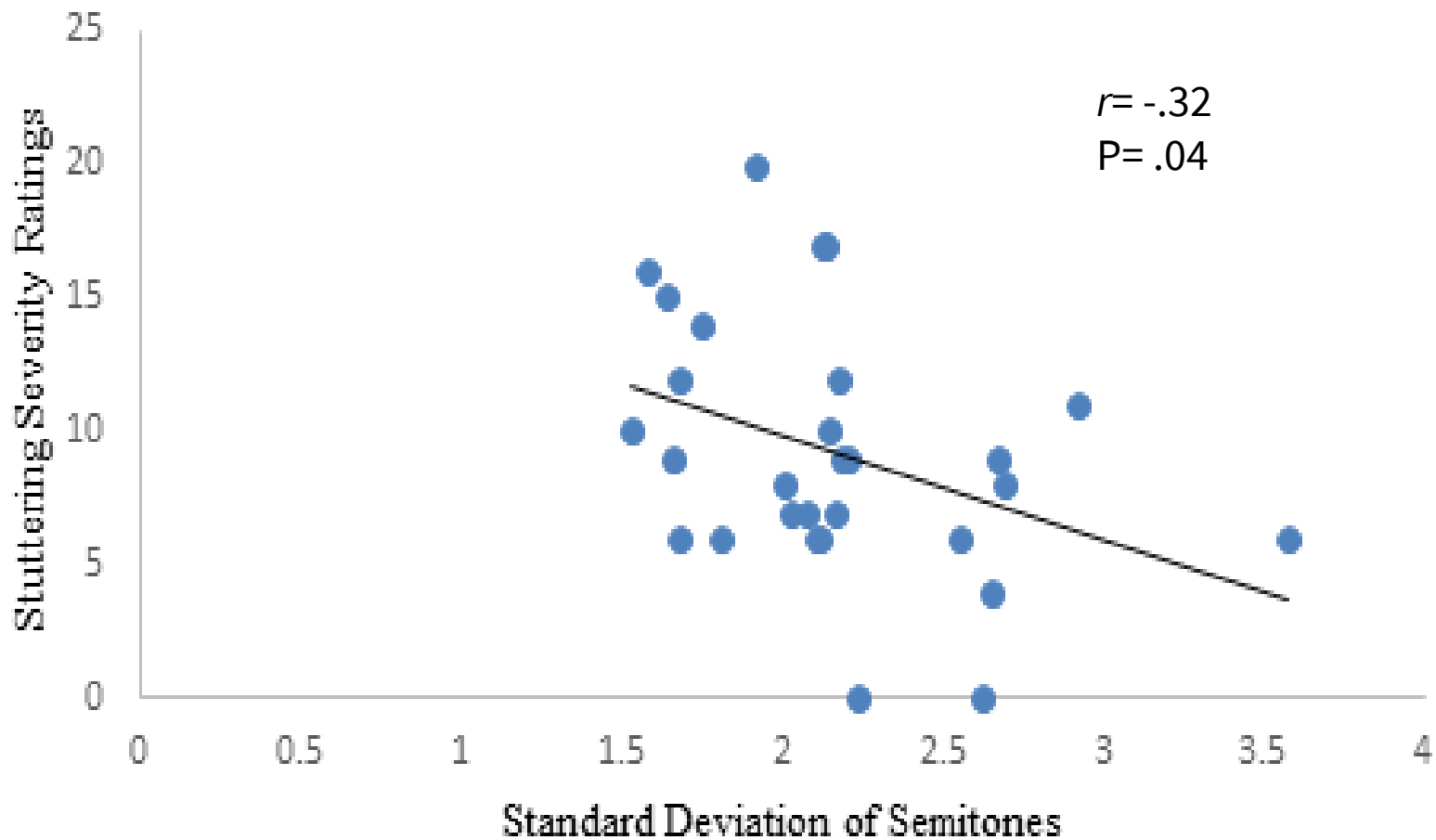
Correlation Coefficients of Acoustical Measurements, Speech Naturalness, & Stuttering Severity

	Pre tx SSI	Pre tx Nat	Post tx SSI	Post tx Nat	Mean (Hz)	Std (Hz)	Std_St	IQR (Hz)	IQR_ St
Pre tx SSI	--	.67	-.1	.26	.15	.02	-.07	.06	-.11
Pretx Nat		--	.02	.41	.25	.01	-.23	.12	-.1
Post tx SSI			--	-.26	.27	-.14	-.37	-.12	-.32
Post tx Nat				--	-.11	-.01	.09	.01	.13

Stuttering Severity & IQR Semitones



Stuttering Severity & Standard Deviation of Semitones





Discussion

Discussion

- Variability measurements vs naturalness ratings
- No relationships found
- Slight negative relationship between stuttering severity standard deviation and interquartile range of semitones
- The higher stuttering severity, the lower the range of SFF.

Limitations

- Reading sample vs naturalness ratings
- Variation measurements
- SSI – 3 variability
- Amount of participants
 - Gender Variation
 - Literacy skill
- No typically speaking control group

Future Directions

- Method of measurement
 - SFF contour onset of utterances
- New data set
 - Better audio quality
 - Larger participant pool
 - Control group



Questions