FISHING FOR THE PAST: REMANENTS OF EARLY LATERALIZATION OF [s]

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ABSTRACT

Five kindergarten children who lateralized /s/ were recorded as they imitated sentences with /s/ embedded in various phonetic contexts. They were rerecorded using identical stimuli in ninth or tenth grade of high school. Their /s/ productions were extracted from contexts in which / i, u, œ, _, k, l / followed /s/. Noise spectrum parameters: mean, standard deviation, skew, and kurtosis, were computed, as were four 3-point rating scale estimates of spectral fitness: 1) number, and 2) frequency of spectral peaks, 3) low frequency energy, and 4) compactness of spectral bandwidth. All subjects exhibited spectral evidence of lateralization; four improved with age by 4-47% more satisfactory measurements, and one declined in satisfactory measures by 13%. The speech pathologists who tested the high school students observed that all displayed oral gestures indicative of lateralization, and four blatantly lateralized. The most perceptually normal subject ended with 79% of spectral profile noise measures satisfactory as versus 85% for normals. Clinical implications are discussed.

1. INTRODUCTION

This experiment examined the acoustic evidence of the extent to which lateralization appeared to persist from kindergarten into high school in five children. The lateralized fricative /s/ is strongly resistant, McNutt (1977), to conventional speech therapy and to unassisted developmental recovery. However, Gibbon and Hardcastle (1987), Dent, Gibbon, Hardcastle and Wakumoto (1995) and Howard (1995) reported excellent results of treatment of lateralization utilizing biofeedback from electropalatographs.

This study considered the long term outcome of conventional speech therapy for a persistent misarticulation: lateral /s/. In addition, various acoustical criterion measures were compared for effective reflection of perceptually blatant lateralization.

2. METHODS

2.1 Subjects. A group of 51 /s/ misarticulating kindergarten children served as subjects. Among them were 11 /s/ lateralizers, eight of whom remained in the school district in their freshman or sophomore year of high school, of whom 5 consented to enter this study.. Criteria for inclusion were consistent /s, z/ misarticulation, no language problems on the SOLST test, at least one ear with hearing normal at 20 dB HL or better and only one other speech sound inconsistently in error. School policy was not to enroll single-sound misarticulators in speech therapy until the third grade. The children were examined twice a month during the school year to assess progress toward self correction. Although the majority of dentalizing and retracting /s/ misarticulating children recovered fully in two years, none of the lateralizing speakers did so, Stephens, Hoffman and Daniloff (1986). In each session, the children imitated a special set of sentences which contained /s, z/ in various contexts for two trials with intervening spontaneous speech.

They also commented upon the extent of therapy received and the impact of their misarticulation upon their lives. All five children received twice weekly speech therapy in grades 3, 4 and 5, and four similarly in grade 6. Two children were monitored throughout grades 7 and 8.

2.2 Methods of Spectral Analysis. Recorded samples of the lateralized /s/ stimuli were digitized at 22.4 KHz on a SoundScope 16 single channel spectrum analyzer. 21 coefficient LPC spectra with low smoothing were computed at the midpoint of the /s/ friction noise. The /s/ spectrum files were then subjected to statistical analysis, computing the MEAN (center of gravity), STANDARD DEVIATION, SKEWNESS (SK) AND KURTOSIS (KU) of the spectra.

Similar samples taken from the imitated sentences produced by two normally speaking children and two normally speaking young adults (six samples for each of six contexts) were analyzed. These data served as the basis of comparison of normals versus the lateralizing speakers.

In addition, four measures based upon experimenter rating of the extent to which the LPC spectra resembled ideal normal /s/ spectra for children and adults, Stevens (1998), were made. They consisted of: 1) Number of Peaks(NP) in the 4-8 kHz range, 2) Frequency of Peaks(FP) in the 4-5.5 and 6-8 KHz regions, 3) Spectral Fill (F) in the 0-3000 Hz region and, 4) Spectral Bandwidth- the degree to which the power spectrum was concentrated in the 3.5-8.5 KHz region. Three-point rating scores ranged from two (close match) to zero (poor match). Inter-rater reliability for measures of 60 spectra from the five subjects was a composite of 90% average agreement as to exact rating.

2.3. Statistical Analysis. The LPC spectral data were entered into series of two way analyses of variance with repetitions (3) as the source of the error variance term, and time of testing, and contexts as the within subjects terms. The rating measures were subject to similar analyses of variance, and post hoc testing was used to assess sources of significance.

3. RESULTS

3.1 Individual Results. Mean acoustic measures are shown for all subjects in Table 1. Spectral Fill (F) and Spectral Bandwidth (BW) scores declined significantly over time for S1 [$F(1,2)=27$, and 25, respectively, $p<.05$]. The Center of Gravity (CG) measure declined significantly over time for S2 [$F(1,2)=67.2$, $p<.05$]. Number of peaks (NP), Frequency of Peaks (FP), F, and BW scores all increased over time for S4 [$F(1,2)=51.57$, 400, 28, and 240.25, respectively]. NP, F, and BW scores increased significantly over time for S5 [$F(1,2)=75$, 400, and 21.05, respectively]. Data from S3 showed trends of improved scores over time in NP, FP, and F measures [$F(1,2)=9.31$, 12, and 9.31;

p=.09, .07, and .09, respectively]. Data from S3, S4, and S5 were collapsed in the analyses of group results.

	CG	SD	SK	KURT	NP	FP	F	BW
s1								
Pre	3505	3813	.47	-1.22	1.17	.44	.61	1.06
	(203)	(71)	(.10)	(.12)	(.14)	(.14)	(.16)	(.20)
Post	3186	3546	.64	-0.88	0.83	.72	.11	0.22
	(203)	(114)	(.10)	(.18)	(.17)	(.19)	(.08)	(.13)
s2								
Pre	4317	3514	.15	-1.22	0.78	.83	.11	0.11
	(168)	(83)	(.08)	(.05)	(.17)	(.20)	(.08)	(.08)
Post	3431	3743	.47	-1.21	1.11	.89	.00	0.17
	(191)	(132)	(.07)	(.06)	(.21)	(.18)	(.00)	(.09)
s3								
Pre	4235	3387	.15	-1.22	1.17	.00	.00	0.22
	(120)	(96)	(.06)	(.06)	(.09)	(.00)	(.00)	(.10)
Post	4618	3576	.17	-1.02	0.78	.33	.61	1.28
	(255)	(924)	(.12)	(.20)	(.17)	(.11)	(.16)	(.49)
s4								
Pre	4142	3526	.22	-1.22	0.28	.06	.06	0.11
	(207)	(75)	(.08)	(.06)	(.11)	(.06)	(.06)	(.08)
Post	3556	3346	.34	-1.25	1.33	1.17	.83	1.83
	(214)	(95)	(.08)	(.07)	(.16)	(.14)	(.14)	(.12)
s5								
Pre	3245	3348	.52	-1.04	0.78	.50	.56	0.78
	(261)	(120)	(.11)	(.15)	(.17)	(.14)	(.14)	(.19)
Post	3705	3359	.33	-1.19	1.61	1.22	1.67	1.89
	(192)	(90)	(.07)	(.06)	(.12)	(.13)	(.11)	(.08)
Mean								
Pre	3889	3518	.30	-1.18	0.63	.37	.27	0.46
	(98)	(43)	(.04)	(.04)	(.07)	(.07)	(.05)	(.07)
Post	3699	3513	.39	-1.11	1.13	.87	.64	1.08
	(106)	(49)	(.04)	(.06)	(.08)	(.08)	(.08)	(.13)

Table 1. Means and SEM's of acoustic measures.

Spectral rating results for all five subjects are presented in figure one together with the average score from two normal adults and two normal children as controls (CTRL).

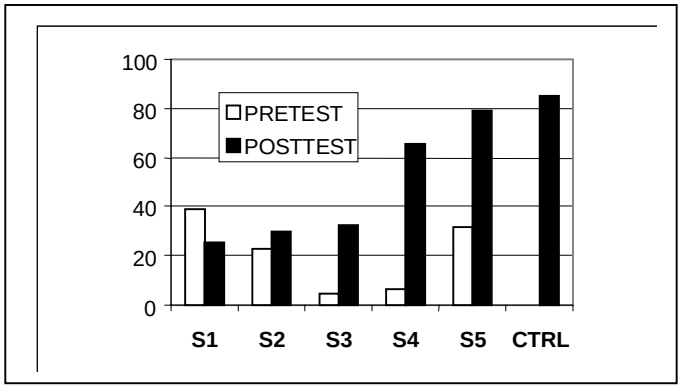

Figure 1. Overall rating scores (%) for test subjects and controls.

3.2 Group Results. NP, F, and BW scores improved significantly over time for S3-5 combined [F(1,2)=42.19, 32.14, and 36.84, respectively, p<.05]. The average scores for the three subjects are presented in figure two.

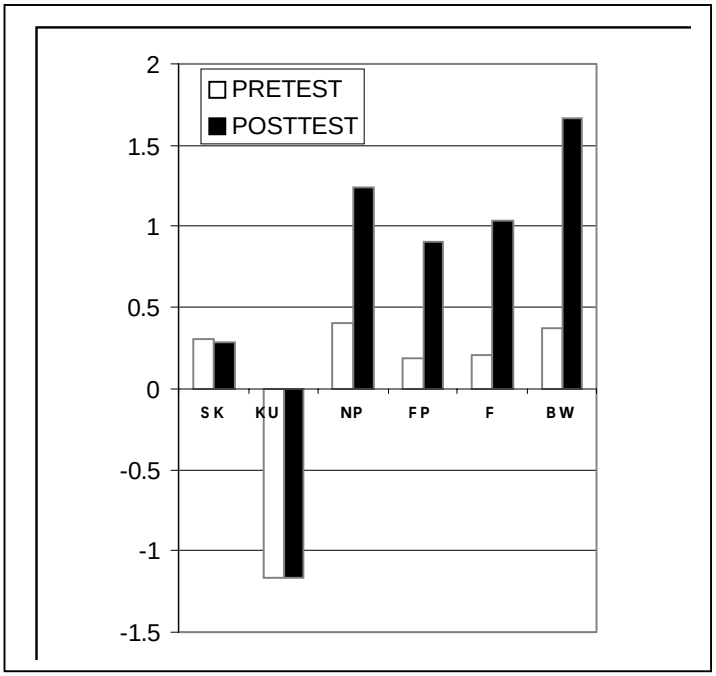

Figure 2. Average SK, KU, NP, FP, F, and BW scores for S3-S5.

Spectral rating results for all five subjects as a group also showed no significant change over time [t(4)=1.94, p>.05]. When data from S3, S4 and S5 were analyzed as a group, a significant increase was found over time [t(2)=4.91, p<.05]. Figure three shows average percent perfect "2" rating results for three and five subjects during pretest and posttest.

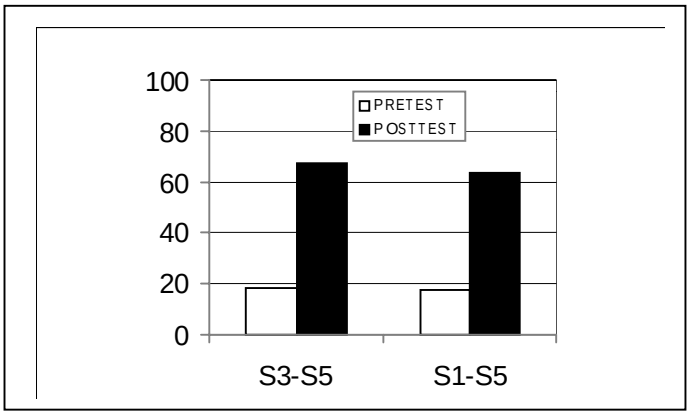

Figure 3. Average overall rating scores (%) for 3 and 5 subjects.

DISCUSSION

The results of this study demonstrate that the first four moments of the noise spectrum for disordered /s/ do not offer a useful way to differentiate between /s/ fricatives with various degrees of lateralization. The Mean, Standard Deviation, Skewness and Kurtosis do not present a pattern of change which resembles the change in the rating measurements of spectral fitness which do show a strong pattern of developmental change. Inspection of the mean values of the spectral measures for the lateralizers and averages of 40 measures of spectral parameters from the speech of a normal adult and child reveal minor differences. In other words, Moments 1-4 of the LPC power spectrum are insufficiently sensitive to variations in laterality evident to the speech pathologists who tested the older group of subjects.

On the other hand, spectral "fitness" estimates derived from studies of adult and child /s/ spectra, see Stevens (1998): 1) spectra which present two substantial peaks in the 2) 4 - 8 KHz region, with 3) little spectral fill or strong peaks below 4KHz, and 4) a -10 dB power spectrum bandwidth centered in the 3.5 - 9 KHz region, revealed a developmental increase of spectral fitness, and reduction of spectral cues which support the perception of lateralization. This trend was significant in three subjects, nonsignificant in one, and revealed significantly decreased fitness in a fifth subject. One subject 's fitness measures rose within 10% of the average fitness measures for normal adult /s/ spectra.

It is noteworthy that up to five years of speech therapy failed to resolve the misarticulation of four, while one subject worsened. The improvement in four of the subjects can be traced either to therapy, to maturation, or some combination of both factors.

Suffice to say, all of the high school students intimated that they were adversely affected by their persistent, highly audible misarticulation. It is the opinion of the present authors that school authorities should strive to identify children who lateralize /s/ as early as their third or fourth year of age, and provide intensive speech therapy which could be supplemented with more heroic measures such as palatography if the problem does not resolve by the 1st or 2nd grade.

As was mentioned previously, Dent. et al.(ibid). Gibbon and Hardcastle, (ibid), Howard (ibid) and Fletcher (1989) have commented upon the usefulness of visual/auditory biofeedback from a palatograph in remedying lateralization, even for the older children such as were reported on by McNutt (ibid). However, Schuckers (see Stevens, Lu, Kahvazadeh, Krueger, Kao, Daniloff and Schuckers (this volume)) has reported success with primary school children in resolving lateral /s/ misarticulation by using selected phonetic contexts properly monitored to enhance adoption of central rather than lateral grooving of the tongue. In the present authors' opinion, the lateral /s/ relies on a relaxed, almost flaccid posture of the tongue blade which readily coproduces with adjacent consonants made on or near the alveolar ridge. It therefore is imperative that treatment seek to establish less flaccid positioning of the tongue blade for /s/ and adjacent consonants as an antecedent step in establishing a centrally grooved tongue.

The acoustic results of this study more successfully illuminate the differences between normal and lateral /s/ spectra than results reported by Daniloff, Wilcox and Stephens (1980), probably because of the completeness of the sample, the use of template measurement of spectral "fitness" and the use of LPC analysis to generate spectra. Our data demonstrated that low frequency spectral fill and low frequency peaks abounded along with shifted, absent, and on occasion, extra peaks in the expected region of highest spectral power.Our impression of the variability of the lateralized spectra suggest that a variety of oral slit and resonating tube dimensions are responsible for the variable spectral patterns observed. That is, there are a number of differing tract configurations for lateralized /s/ attributable to variable oral and labial channel configurations.

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