PHONATORY INSTABILITIES IN ALS AND MS: GRAPHIC AND QUANTITATIVE ANALYSES.

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ABSTRACT

This paper reports on the use of a technique for examining long-term phonatory instabilities (flutter, tremor, and wow) in f_0 and dB of sustained phonations. The data are from subjects with amyotrophic lateral sclerosis (ALS) and multiple sclerosis (MS), and from gender- and age-matched controls. The poster displays the instabilities graphically. Initial results indicate excessive tremor in ALS and MS and excessive wow in ALS.

INTRODUCTION

A new technique [1] allows measurement of phonatory flutter, tremor and wow in f_0 and dB; Table 1 defines these domains for this study in terms of frequency range and minimum spectral magnitude. All of these phenomena are slower than cycle-to-cycle perturbations (jitter and shimmer), and are perceptible. The technique creates both graphic and statistical summaries.

Table 1. Domain Definitions

Domain	Frequency	Magnitude
Flutter	10 - 20 Hz	> 0.25
Tremor	2 - 10 Hz	> 1.00
Wow	0.2 - 2 Hz	> 1.50

This report applies the technique to 1) a group of four subjects with ALS (two men and two women) having mild to severe dysarthrias; 2) gender and age-matched subjects with MS having no discernible speech dysarthria; and 3) similarly matched control subjects. Table 2 provides the subjects' characteristics.

Previous work by our group has researched long-term phonatory instability of ALS ([2], [3], and [4]) and MS ([5], [6], and [7]) separately. The purpose of this study is to explore differences between small groups representing these populations, in order to guide hypothesis development for later work with larger datasets, and to demonstrate the technique.

Table 2. Subject Characteristics.

	Age	Yrs. Post-Diag	Dys-arthric
ALS, dysarthric			
Women	41	0.1	yes
	64	–	yes
Men	39	5.5	yes
	69	0.5	no
Age matched MS, non-dysarthric			
Women	40	1.0	no
	67	17.0	no
Men	40	6.0	no
	61	10.0	no
Age matched controls			
Women	39	–	no
	66	–	no
Men	40	–	no
	68	–	no

METHODS

Space does not permit a full description of the methods employed in this paper; details are reported elsewhere [1]. The technique includes the following steps: 1. a waveform of sustained phonation is digitized and analyzed for f_0

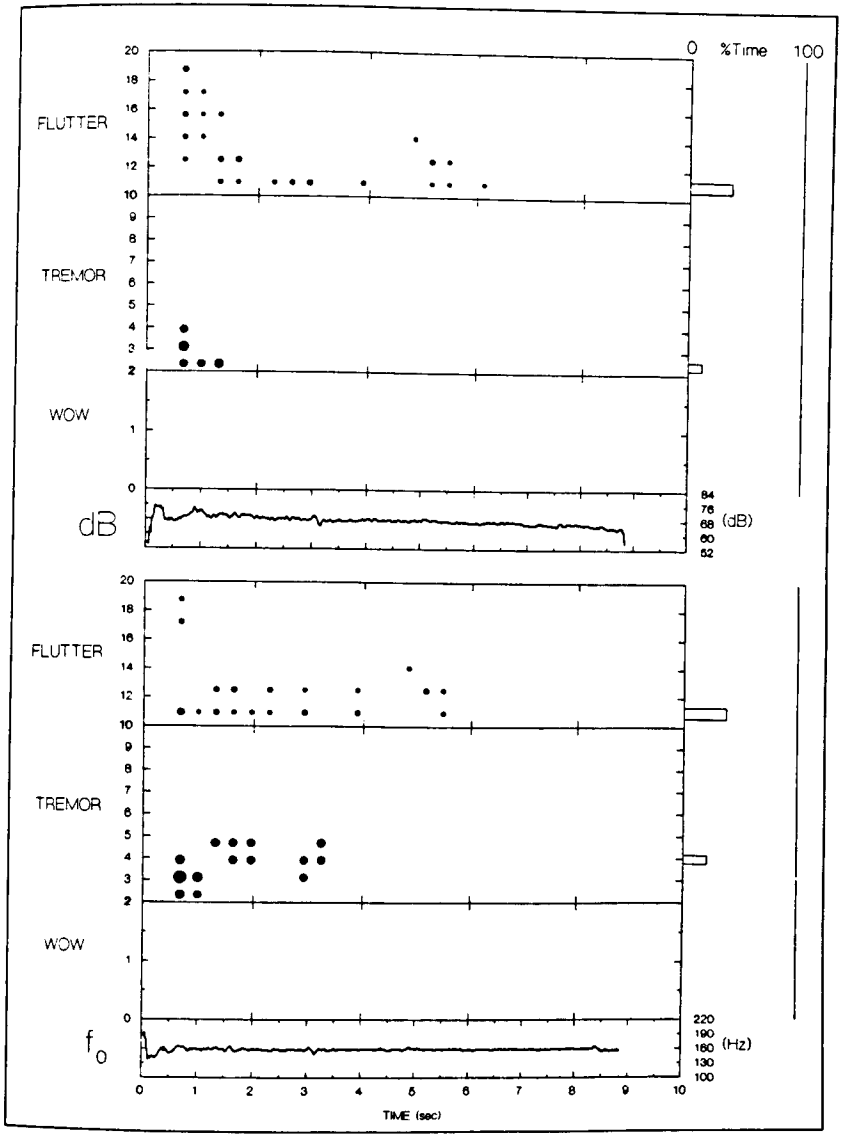

Figure 1. Graph of instabilities observed in a male subject with MS. Lower panels display f_0 and upper panels display dB. The display can be read like a spectrogram: time is on the abscissa, frequency on the ordinate, and magnitudes are displayed as dot size. Bars along the right edge indicate summary values of % time phonation as bar length and frequency of instability as vertical placement of the bar. See text for further details regarding analytical procedures.

and dB (performed in CSpeech [8] in our work), 2. the f_0 and dB data are smoothed and sampled at three different sampling rates — 200 Hz for flutter, 100 Hz for tremor, and 50 Hz for wow; 3. Fourier analyses are performed in successive frames using different transform sizes for the different domains — 0.64 s frames for flutter, 1.28 s frames for tremor, and 5.12 s frames for wow. The resulting magnitudes that pass the criteria listed in Table 1 are retained as observations for graphic or statistical analysis. We perform Step 3 and post-processing in Systat macros [9].

RESULTS

The observations can be graphed as in Figure 1, which provides a typical result from a (male) subject with MS: flutter in both f_0 and dB, some tremor in both parameters, but little or no wow. The instability observations as defined here can also be summarized by at least three different statistics: 1) the largest average magnitude at which a given instability was seen to occur, 2) the frequency at which this instability was observed, and 3) the percentage of total phonation time during which that instability was observed. The results for these variables are summarized within groups in Table 3. Gender is collapsed in this table, but the results are broken down by domain and parameter. For an initial exploration of effects associated with subject group, the data were also analyzed by a non-parametric Kruskal-Wallace analysis of variance. Figures 2 and 3 display some of the chief results obtained by this analysis, in which the data from f0 and dB parameters were pooled in order to maximize power. These are not the only significant results in the dataset, but isolate the effects that appear to be most strongly and uniquely associated with the different pathology groups. Figure 1 indicates that significant differences were found among all groups in percentage of time during which tremor was observed, and furthermore that the MS group is distinct from the controls in this measure. Figure 2 indicates that this pattern is slightly different in percent time of wow, showing that while there is again a significance of overall differences between groups, the MS group is in this case significantly lower than the ALS group. Together the results indicate that the distinction of domain of instability (e.g., tremor vs. wow) is helpful in isolating effects uniquely associated with the three conditions (ALS, MS, control).

Table 3. Phonatory instability measures (each group n =4).

		% Time	Freq.	Mag.
ALS, dysarthric				
flutter	f_0	77.6	10.9	0.59
	dB	27.2	11.3	0.39
tremor	f_0	53.6	2.5	1.59
	dB	16.6	2.3	1.39
wow	f_0	29.4	0.9	1.89
	dB	22.2	0.8	2.09
Age matched MS, non-dysarthric				
flutter	f_0	41.6	12.9	0.60
	dB	24.9	10.9	0.34
tremor	f_0	29.9	3.4	1.25
	dB	16.6	2.7	1.17
wow	f_0	3.6	0.4	1.79
	dB	3.6	0.6	1.51
Age matched controls				
flutter	f_0	24.1	11.7	0.35
	dB	3.9	11.5	0.32
tremor	f_0	12.0	3.1	1.23
	dB	5.0	3.9	1.51
wow	f_0	0.6	0.6	1.52
	dB	2.5	0.8	1.81

CONCLUSIONS

A technique has been presented for measuring, graphing, and summarizing phonatory instability in terms of two parameters (f_0 and dB) and three domains (flutter, tremor, and wow). The technique was applied to three groups (ALS, MS, and controls), and the feature allowing distinction of domain was found useful in discriminating samples from these populations. The phenomena identified by the technique are visually and perceptually clear, and may prove useful in clinical work. Research in the area is ongoing with larger populations ([1], [7]) allowing stronger statistical inference. Future research using the acoustic technique will focus on physiological and perceptual correlates.

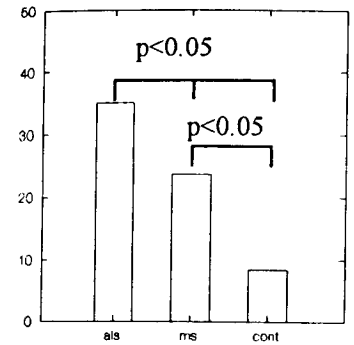

Figure 2. % Time Tremor in dB and f_0

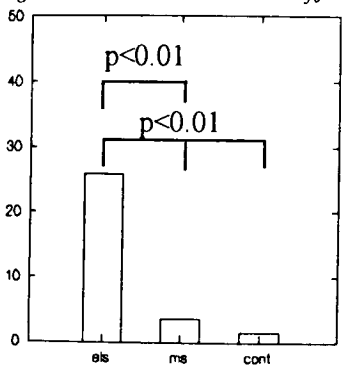

Figure 3. % Time Wow in dB and f_0

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