Acoustic Analysis of Accurate Word Stress Patterning in Patients With Apraxia of Speech and Broca's Aphasia

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Stress-marking strategies employed by subjects with apraxia of speech were compared to those of matched normal controls, for real disyllabic words produced in isolation and in sentences, across acoustic variables of fundamental frequency, syllable duration, and vocal intensity. Heterogeneity of stress marking in terms of acoustic trading relationships was observed in both the apraxic and normal subjects. Strategies varied depending on whether words were produced in isolation or in sentences, and whether the first or second syllable was stressed. Allowing for marked durational increases in apraxia, there were negligible differences in stress marking between groups. However, some idiosyncratic strategies and a tendency toward reduced durational contrast between stressed and unstressed syllables were observed.

The nature of prosodic behavior in patients with apraxia of speech (AOS) remains controversial. Some investigators believe reported prosodic alterations to be compensatory, whereas others suggest that they constitute a primary component of the disorder (Kent & Rosenbek, 1982). Divergent prosodic findings in patients with Broca's aphasia and/or apraxia of speech have been reported across studies. For example, some researchers have reported abnormally exaggerated intonation in Broca's aphasia (Danley & Shapiro, 1982), whereas others report abnormally reduced variability of intonation (Cooper, Soares, Nicol, Michelou, & Goloskie, 1984; Ryalls, 1982), or no intonational impairment (Kent & Rosenbek, 1983). Because many therapy approaches for apraxia of speech rely on prosodic manipulations to facilitate articulatory accuracy (Rosenbek, 1985), a better understanding of the prosodic capabilities of AOS patients is needed.

A fundamental aspect of prosodic control is the ability to encode stress or "prominence" on a particular syllable within polysyllabic words. In the domain of word-level stress patterning, there are also discrepant findings across studies of apraxic patients. Kent and Rosenbek (1983) reported flattening of the intensity envelope and equalization of syllable durations across sequences of syllables; these have a neutralizing effect on the perception of stress. Odell, McNeil, Rosenbek, and Hunter (1991) reported a high incidence of perceived stress placement errors in imitative productions of real words by four apraxic patients. Many of the perceived stress placement errors were attributed to alterations of vowel duration or vowel quality of unstressed syllables. However, neutralization of fundamental frequency and voice intensity differences between stressed and unstressed syllables were also implicated.

The interactive roles of fundamental frequency, duration, and intensity were investigated in three apraxic and three normal subjects by Colson, Luschei and Jordan (1986). For imitative nonsense disyllables (e.g., /pEkØ/) that were perceived as accurately produced, there were no significant differences in fundamental frequency, syllable duration, or vocal intensity between groups. Apraxic subjects who tended to neutralize duration differences between stressed and unstressed syllables compensated by exaggerating fundamental frequency differences. An apraxic subject who exaggerated the durational contrast tended to minimize the fundamental frequency distinction. Intensity was not used consistently by either group to mark stress. It is not clear from this study, however, whether reported findings may be generalized to real words (as opposed to nonsense syllables), to initial as opposed to final stressed syllables, or to longer units of connected speech.

Given the growing recognition that prosodic ability may be important to an understanding of the nature of AOS, and the relevance of prosody to apraxia treatment, continued investigation of the stress-marking capabilites of individuals with AOS is warranted. Therefore, the present study examined strategies employed by individual apraxic and normal subjects to mark stress in real disyllabic words produced in isolation and in sentences. Specific strategies for marking syllable stress in word-initial as opposed to word-final position were evaluated. To accomplish these purposes, acoustic analyses of the suprasegmental variables of fundamental frequency (F_0), syllable duration, and vocal intensity were employed.

Method

Subjects

Three English-speaking adults with left anterior brain damage and acquired AOS were included as subjects. The type, site, and extent of brain damage was determined by a neurologist based on medical history, neurological examination, and the results of computerized axial tomography. Assessment data available for each subject included results from the Western Aphasia Battery (Kertesz, 1982), the Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1983), an oral peripheral examination of the speech mechanism, diadochokinesis and word repetition tasks, and analysis of a videotaped speech sample. Two of the subjects exhibited mild-to-moderate Broca's aphasia, and one exhibited a residual apraxia subsequent to an initial diagnosis of mild Broca's aphasia. Apraxia of speech was the most prominent feature of the communication pattern of the subjects. Each subject had clinical characteristics of effortful, groping articulation, speech dysprosody, variable articulation errors, and other symptomatology congruent with the diagnosis (Darley, 1984; Rosenbek, 1985). Their clinical characteristics are summarized in Table 1. Three control subjects were matched to the AOS subjects on the basis of age and gender.

Stimuli and Data Analysis

Stimulus materials consisted of five pairs of two-syllable words differing only in syllabic stress (i.e., comBINE/COMbine, desSERT/DESert, reCORD/RECord, reBEL/REBel, inCITE/INsight). These were presented in isolation and embedded in the middle of short, simple sentences (e.g., "We will comBINE their ideas"/"Take the COMbine to the field"). Subjects were required to imitate the clinician's productions until two productions of the target word had been achieved that were perceived by the examining clinician to be accurately stressed. High quality audiotape recordings were obtained using a Sharp Model RD-667AVI cassette recorder and Model MC 78DV microphone (positioned below the breath stream approximately 3 cm from the subject's mouth) in a sound-treated booth.

Prior to acoustical analysis, two phases of perceptual analysis were completed. First, a certified speech-language pathologist (TPM) with extensive experience evaluating AOS analyzed all productions of the target words in order to determine the frequency of occurrence of word level stress placement errors in relation to other error types. Stress placement errors, articulatory errors (e.g., substitutions, deletions, distortions, and additions) affecting specific phonetic segments, syllable deletions, and lexical word production errors (e.g., perseveration and paraphasia) were identified and tabulated. Second, to verify accuracy of perceived stress placement in all words selected for acoustical analysis, two naive listeners independently reviewed the recorded speech samples and, using a stimulus word list prepared for this purpose, matched each subject's productions with the words from the list. These listeners exhibited 100% agreement with each other and with the examining clinician.

Perceptually accurate productions of the target words were submitted for acoustic analysis, which was accomplished using the Kay Elemetrics Model 4300 Computerized Speech Laboratory (CSL) system implemented on an IBM-compatible personal computer. The samples were digitized using a sampling rate of 20 kHz with low-pass filtering at approximately 10 kHz. A combination of simultaneous waveform, spectrographic, pitch contour, and intensity contour displays, which were temporally linked,

TABLE 1. Demographic and clinical data for apractic (A1–A3) subjects. Aphasia quotient (AQ) and cortical quotient (CQ) scores are from the Western Aphasia Battery (Kertesz, 1982). Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1983) values are mean percentiles from subtests in fluency, auditory comprehension, naming, and repetition.

Gender	Age	Education	Occupation	Etiology	Lesion Site	Western Aphasia Battery	Boston Diagnostic Aphasia Examination	Speech Description
F	58	High school	Bookkeeper	Stroke	Subcortical lesion extending from left frontal to left temporal lobe.	AQ = 87.8 CQ = 89.7	Fluency = 31.3% Aud. Comp. = 83.8% Naming = 94.7% Repetition = 63.0%	Slow, effortful speech with omission of function words and dysprosody. Difficulty in the maintenance of voicing distinctions, particularly in word initial stops and fricatives. Connected speech characterized by reductions in phrase length with extended pauses during attempts to execute articulatory sequences or retrieve words. Diadochokinetic tasks marked by slow, irregular rate and inability to produce complex sequences.
F	53	College	Piano teacher	Stroke	Lesion confined to left frontal lobe.	AQ = 88.2 CQ = 91.2	Fluency = 61.3% Aud. Comp. = 97.5% Naming = 95.0% Repetition = 95.0%	Speech produced at a slow rate with infrequent word retrieval difficulty. Diadochokinesis characterized by reduction in rate. Multisyllabic words and connected speech marked by restricted prosodic variation and vowel distortions.
M	35	High school	Auto mechanic	Trauma (gunshot)	Lesion involving anterior left temporal lobe ascending with considerable involvement of the left frontal lobe.	AQ = 70.4 CQ = 73.1	Fluency = 37.5% Aud. Comp. = 81.3% Naming = 74.7% Repetition = 46.7%	Telegraphic speech output with instances of repetitive, fluent, stereotypic productions used to maintain a conversational turn. Particular difficulty with multisyllabic words with articulatory breakdowns and repeated attempts at production. Cluster reduction, inconsistent substitution and distortion errors, and dysprosody in connected speech and in repetition tasks.

were used to segment the signals and obtain fundamental frequency, syllable duration, and intensity measurements of the target syllables. Syllable durations were identified using floating cursors and CSL algorithms for pitch and intensity extraction.

To determine interjudge reliability of the acoustic variables, a second examiner independently analyzed the F_0, intensity, and duration of two stressed syllables and two unstressed syllables, from randomly selected target words produced by each of the six subjects in isolation (total of 12 observations) and in sentences (total of 12 observations). Pearson Product Moment Correlation Coefficients were computed to assess the similarity of measurements obtained by the two examiners. Resultant r values for unstressed syllables were .809 for duration, .846 for F_0, and .825 for intensity. For stressed syllables, r values were .736 for duration,.912 for F_0, and .958 for intensity. All correlations were statistically significant at the .01 level of probability. In addition, t-tests demonstrated that the distributions obtained from each examiner did not differ significantly ($p > .10$) for any of the acoustic variables.

Results

Perceptual analysis of errors completed for the word and sentence data from each subject revealed the following patterns. Stress placement errors produced by normal subjects occurred on 1.6% of the total number of attempts at target words that were produced. Two normal subjects each produced one word with ambiguous stress, so these were repeated for acoustical analysis. All other productions in words and sentences by normal subjects were accurate. For the apraxic subjects there were typically repeated efforts to produce the correct word. For example, one AOS subject had six phonetic error productions during the production of the word "conDUCT" in isolation. In general, there were extremely few perceived errors in stress marking. Almost all errors were phonetic (segmental), perseverative, verbal paraphasic, or related to articulatory breakdown in the production of the words and sentences. Stress placement errors produced by apraxic subjects occurred on 2.3% of the total number of attempts at target words that were produced.

Acoustic measurements obtained from each syllable of the two perceptually accurate tokens of each of the 10 words produced in isolation and in sentences yielded a total of 240 discrete observations per subject. Means and standard deviations for acoustic measures of stressed and unstressed syllables in isolated words are provided for each subject in Table 2. All subjects exhibited longer durations for stressed than unstressed syllables. F_0 was

TABLE 2. Normal (C1–C3) and apractic subject (A1–A3) means, standard deviations, and mean differences in duration (ms), fundamental frequency (Hz), and intensity (dB) for stressed (S) and unstressed (U) syllables in isolated words.

Subject	Mean Duration (S)	Mean Duration (U)	Difference in Mean Duration	Mean F_0 (S)	Mean F_0 (U)	Difference in Mean F_0	Mean Intensity (S)	Mean Intensity (U)	Difference in Mean Intensity
C_1	.389 *SD* = .179	.272 *SD* = .142	.117	157.745 *SD* = 19.994	143.866 *SD* = 25.09	13.879	27.541 *SD* = 2.318	26.078 *SD* = 3.169	1.463
C_2	.35 *SD* = .133	.26 *SD* = .101	.09	202.569 *SD* = 7.934	190.193 *SD* = 34.862	12.376	25.029 *SD* = 1.117	23.737 *SD* = 1.885	1.292
C_3	.307 *SD* = .149	.227 *SD* = .134	.08	116.793 *SD* = 18.268	112.292 *SD* = 21.204	4.501	26.903 *SD* = 1.768	24.753 *SD* = 1.855	2.15
A_1	.57 *SD* = .21	.512 *SD* = .199	.058	130.926 *SD* = 11.586	125.461 *SD* = 21.366	5.465	26.538 *SD* = 1.722	26.102 *SD* = 2.157	.436
A_2	.608 *SD* = .24	.527 *SD* = .187	.081	198.096 *SD* = 15.247	184.25 *SD* = 25.103	13.846	28.798 *SD* = 1.823	28.102 *SD* = 2.17	.696
A_3	.435 *SD* = .213	.32 *SD* = .131	.115	122.893 *SD* = 18.279	125.817 *SD* = 28.045	-2.924	30.186 *SD* = 1.093	28.742 *SD* = 1.752	1.444

TABLE 3. Normal (C1–C3) and apractic subject (A1–A3) means, standard deviations, and mean differences in duration (ms), fundamental frequency (Hz), and intensity (dB) for stressed (S) and unstressed (U) syllables in sentences.

Subject	Mean Duration (S)	Mean Duration (U)	Difference in Mean Duration	Mean F_0 (S)	Mean F_0 (U)	Difference in Mean F_0	Mean Intensity (S)	Mean Intensity (U)	Difference in Mean Intensity
C_1	.312 *SD* = .1.02	.24 *SD* = .118	.072	162.808 *SD* = 14.982	164.412 *SD* = 18.782	-1.604	28.469 *SD* = 1.348	27.609 *SD* = 1.804	.86
C_2	.295 *SD* = .1	.225 *SD* = .087	.07	208.571 *SD* = 6.959	202.845 *SD* = 9.232	5.726	25.341 *SD* = 1.199	23.944 *SD* = .611	1.397
C_3	.244 *SD* = .083	.181 *SD* = .07	.063	128.63 *SD* = 24.608	129.374 *SD* = 22.375	-.744	26.275 *SD* = 1.243	25.711 *SD* = 1.236	.564
A_1	.473 *SD* = .207	.389 *SD* = .152	.084	153.33 *SD* = 17.089	148.917 *SD* = 27.073	4.413	25.938 *SD* = .1.938	25.261 *SD* = 1.831	.677
A_2	.486 *SD* = .185	.411 *SD* = .155	.075	221.07 *SD* = 9.311	215.543 *SD* = 12.299	5.527	28.19 *SD* = .985	27.41 *SD* = 1.495	.78
A_3	.441 *SD* = 1.351	.337 *SD* = .126	.104	116.884 *SD* = 26.07	116.769 *SD* = 25.656	.115	29.182 *SD* = 1.091	28.061 *SD* = 1.351	1.121

greater for stressed than unstressed syllables for all but one apraxic subject. Vocal intensity was slightly greater in stressed syllables for all subjects; however, the smallest differences (<1 dB) were seen in two of the apraxic subjects.

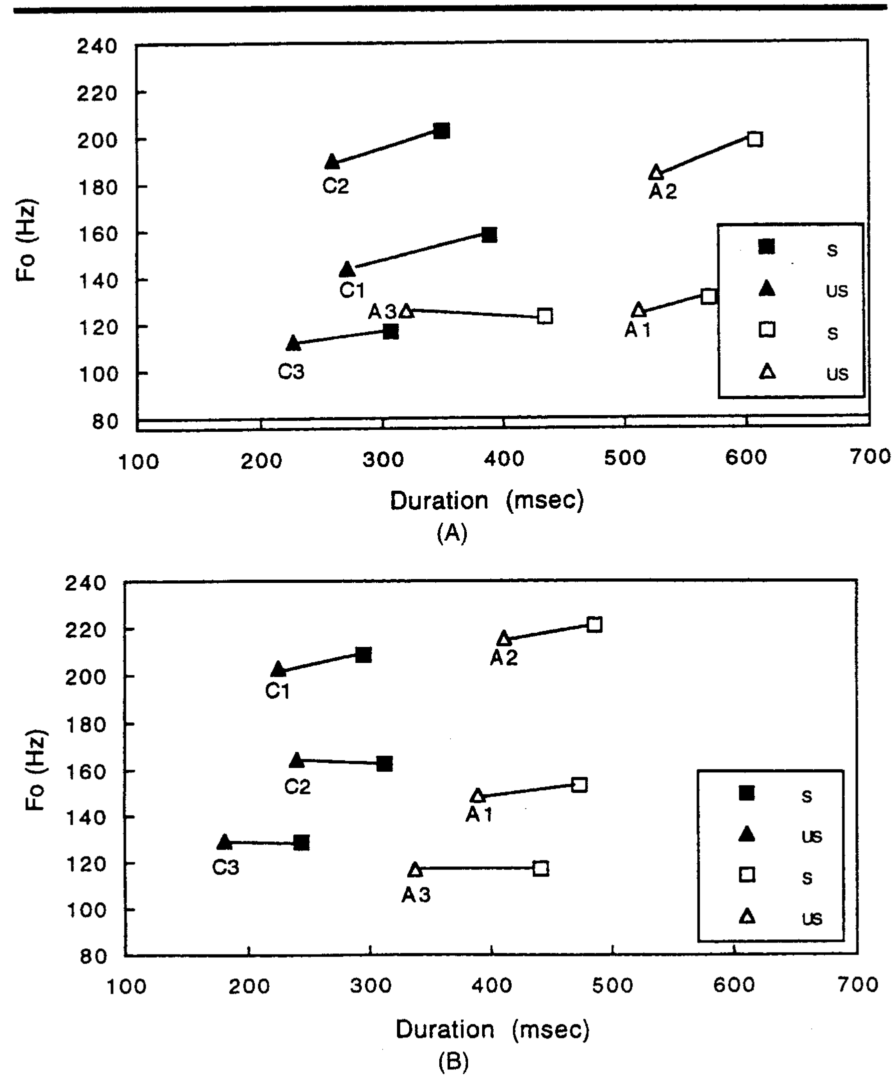
Sentence data are provided in Table 3. Durational findings were similar to those for isolated words, expected F_0 relationships were reversed for two control subjects, and intensity differences were minimized for two control and two apraxic subjects. Average ratios of unstressed-to-stressed syllables were similar (U/S > .930) across subject groups for F_0 and intensity. Average ratios for duration were less comparable. The mean control values were .733 for isolated words and .758 for sentences, whereas the apraxic values were .834 for words and .811 for sentences. This distinction between the groups occurred reliably across subjects within each group.

Figure 1 plots the data for F_0 by duration for stressed and unstressed syllables in isolated words for the controls (C) and apractic (A) subjects. Except for a shifting of the duration data to the right for the AOS subjects (i.e., longer durations overall), the two plots are similar. Although subject A3 violated the expected F_0 relationship (stressed > unstressed), the durational stress marking (stressed > unstressed) was maintained. Figure 1 also provides F_0/duration relationships for control and AOS subjects in sentences. In this context, again allowing for overall durational increases in AOS, stress marking appears to be similar between groups and is dominated by increases in duration.

Figure 2 shows the data for intensity by duration for stressed and unstressed syllables in isolated words and in sentences. Allowing for overall durational increases for the apraxic subjects, it is apparent that increased intensity was consistently employed to mark stressed syllables for both the apractic and control subjects.

When the data were examined further on the basis of which syllable was stressed (see Tables 4 and 5), it is clear that differential strategies for stress marking were employed by all of the subjects. In isolated words, when the first syllable was stressed, a combination of increased F_0 and intensity was employed, whereas duration was *shorter* for stressed than for unstressed syllables. When the second syllable was stressed, the duration of the second syllable was greater than that of the first syllable, but F_0 and intensity differences between stressed and unstressed syllables were reversed in comparison to the first-syllable stressed condition. Similar findings were observed in sentences.

FIGURE 1. Relationship of mean duration (msec) and F_0 (Hz) for the control (C1–C3) and apractic (A1–A3) subjects in stressed (S) and unstressed (US) syllables in isolated words (A) and sentences (B).

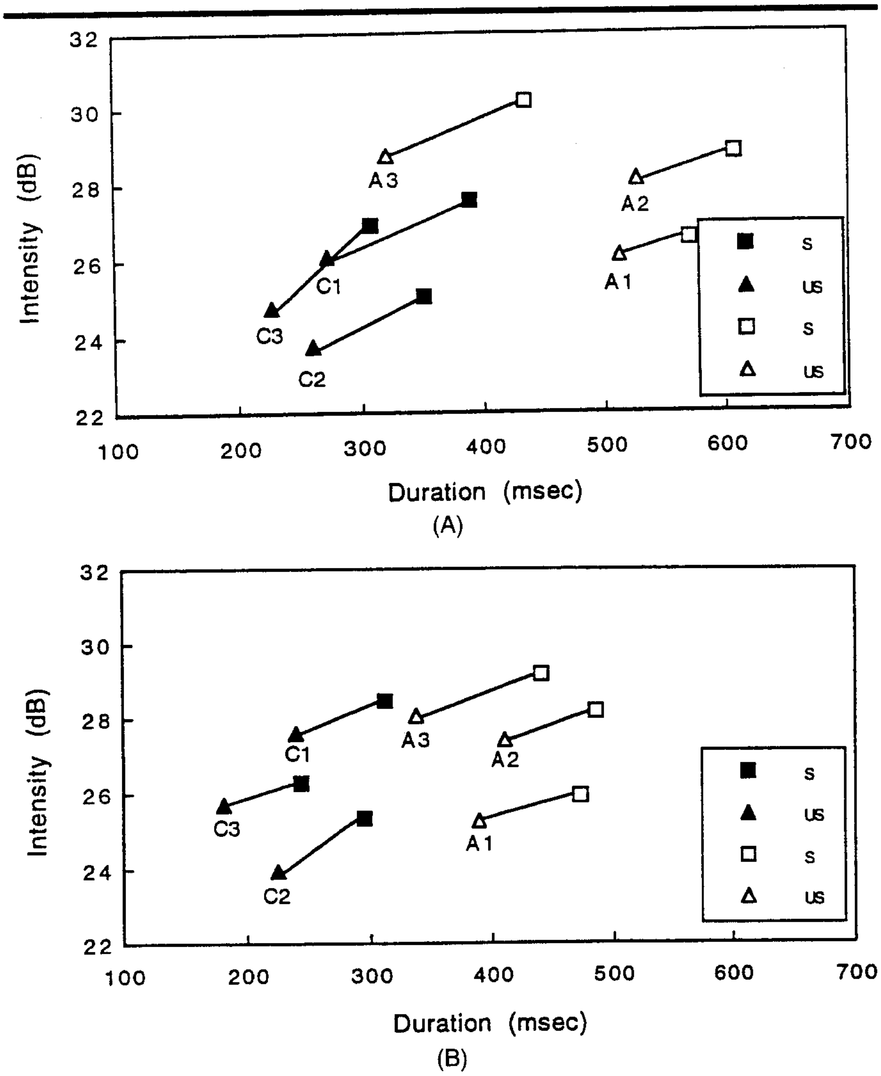


Discussion

The findings of this study concur with data from normal subjects suggesting that word stress marking in English is accomplished primarily through a combination of duration and F_0 cues, which may vie with each other in differing linguistic contexts (Beckman, 1986). The data indicate that individuals with AOS are capable of producing acoustic distinctions between stressed and unstressed syllables in real disyllabic words regardless of whether the first or second syllable is stressed. They also are able to do so in words produced within sentences as well as in isolation. Furthermore, the AOS subjects were able to mark stress using strategies that were similar to those used by the control subjects.

When the first syllable was stressed in isolated words, the AOS subjects behaved similarly to the controls by producing second syllables of longer duration. This demonstrates that both groups appropriately applied a phonological rule for word final lengthening (Cruttenden, 1986) which took precedence over the use of duration for stress marking. In this constrained environment, both groups of subjects relied on fundamental frequency and intensity to distinguish stress. Note that these findings are not based on a small percentage of prosodically correct productions. Although articulation errors and other errors occurred frequently, perceived errors of word stress placement were not

FIGURE 2. Relationship of mean duration (msec) and intensity (dB) for the control (C1–C3) and apractic (A1–A3) subjects in stressed (S) and unstressed (US) syllables of isolated words (A) and sentences (B).



common in isolated words or sentences produced by the AOS subjects.

Stress-related acoustic differences did occur inconsistently in the AOS data, however. These took the form of either reduced or exaggerated durational contrasts, and the reversal of expected F_0 relationships in individual cases. These findings are compatible with those reported by Colson et al. (1986) for nonsense disyllables. The finding of greater than normal average ratios of unstressed-to-stressed syllables in AOS also suggests that, although duration was used appropriately to mark stress, there was some tendency toward stress neutralization. The apraxic subjects lengthened unstressed syllables to a slightly greater extent than stressed syllables. This may help to explain the impression of impaired stress marking reported in other studies.

The present results, however, do not support a strong interpretation of a primary prosodic impairment at the word stress level in acquired AOS. Overall durational increases combined with articulatory errors such as vowel distortions may contribute to the clinical impression of abnormal word stress patterning in AOS. Perhaps these patterns of syllabic stress are preserved in AOS because they are originally acquired as part of the phonological representation of a word (Waterson, 1971). In addition, accurate stress marking was needed in these particular words to signal meaning. This may be quite different from other prosodic behaviors, such as sentence accent or contrastive emphasis, which must be computed on line with respect to syntactic and pragmatic contexts (Pierrehumbert, 1980). Given the small number of subjects in this investigation, as well as the focus on accurately imitated

TABLE 4. Normal (C1–C3) and apractic subject (A1–A3) means, standard deviations, and mean differences in duration (ms), fundamental frequency (Hz), and intensity (dB) for stressed (S) and unstressed (U) syllables in isolated words with first-syllable stress.

Subject	Mean Duration (S)	Mean Duration (U)	Difference in Mean Duration	Mean F_0 (S)	Mean F_0 (U)	Difference in Mean F_0	Mean Intensity (S)	Mean Intensity (U)	Difference in Mean Intensity
C_1	.222 *SD* = .069	.389 *SD* = .102	-.167	155.964 *SD* = 33.679	129.422 *SD* = 28.665	26.542	29.111 *SD* = 1.924	24.325 *SD* = 2.176	4.786
C_2	.228 *SD* = .05	.343 *SD* = .069	-.115	203.162 *SD* = 10.608	173.174 *SD* = 43.641	29.988	25.57 *SD* = 1.035	22.052 *SD* = .963	3.518
C_3	.181 *SD* = .064	.32 *SD* = .13	-.139	111.506 *SD* = 12.791	101.954 *SD* = 9.74	9.552	27.272 *SD* = 1.735	24.183 *SD* = 1.668	3.089
A_1	.447 *SD* = .216	.606 *SD* = .145	-.159	139.318 *SD* = 8.66	114.469 *SD* = 19.329	24.849	27.242 *SD* = 1.614	24.919 *SD* = 1.467	2.323
A_2	.391 *SD* = .098	.661 *SD* = .162	-.27	206.045 *SD* = 9.606	175.67 *SD* = 31.215	30.375	30.149 *SD* = .867	26.429 *SD* = 1.489	3.72
A_3	.262 *SD* = .117	.386 *SD* = .141	-.124	117.622 *SD* = 12.027	113.017 *SD* = 25.467	4.605	30.692 *SD* = 1.043	27.702 *SD* = 1.302	2.99

TABLE 5. Normal (C1–C3) and apractic subject (A1–A3) means, standard deviations, and mean differences in duration (ms), fundamental frequency (Hz), and intensity (dB) for stressed (S) and unstressed (U) syllables in isolated words with second-syllable stress.

Subject	Mean Duration (S)	Mean Duration (U)	Difference in Mean Duration	Mean F_0 (S)	Mean F_0 (U)	Difference in Mean F_0	Mean Intensity (S)	Mean Intensity (U)	Difference in Mean Intensity
C_1	.539 *SD* = .082	.155 *SD* = .039	.384	154.823 *SD* = 17.625	158.311 *SD* = 6.608	-3.488	25.971 *SD* = 1.473	27.831 *SD* = 3.105	-1.86
C_2	.473 *SD* = .032	.178 *SD* = .042	.295	201.976 *SD* = 4.426	207.212 *SD* = 4.202	-5.236	24.488 *SD* = .955	25.423 *SD* = .867	-.935
C_3	.432 *SD* = .086	.135 *SD* = .045	.297	122.08 *SD* = 21.881	122.63 *SD* = 24.836	-.55	26.535 *SD* = 1.812	25.322 *SD* = 1.928	1.213
A_1	.694 *SD* = .111	.418 *SD* = .271	.276	122.533 *SD* = 7.202	136.453 *SD* = 17.935	-13.92	25.834 *SD* = 1.548	27.286 *SD* = 2.135	-1.452
A_2	.824 *SD* = .086	.393 *SD* = .088	.431	190.147 *SD* = 16.064	192.829 *SD* = 13.869	-2.682	27.477 *SD* = 1.487	29.775 *SD* = 1.229	-2.328
A_3	.609 *SD* = .121	.255 *SD* = .083	.354	128.164 *SD* = 22.338	138.617 *SD* = 25.452	-10.453	29.679 *SD* = .929	29.782 *SD* = 1.543	-.103

responses, additional study will be needed to clarify the nature of word stress errors in AOS and their relationship to other prosodic impairments.

References

Beckman, M. E. (1986). *Stress and nonstress accent*. Dordrecht, Holland: Foris Publications.

Colson, K. A., Luschei, E. S., & Jordan, L. S. (1986). Perceptual and acoustic analyses of stress patterning in apraxic and normal speech. In R. Brookshire (Ed). *Clinical Aphasiology Conference Proceedings, Vol. 16* (pp. 281–290). Minneapolis, MN: BRK Publishers.

Cooper, W. E., Soares, C., Nicol, J., Michelou, D., & Goloskie, S. (1984). Clausal intonation after unilateral brain damage. *Language and Speech, 27*, 17–24.

Cruttenden, A. (1986). *Intonation*. Cambridge: Cambridge University Press.

Danly, M., & Shapiro, B. (1982). Speech prosody in Broca's aphasia. *Brain and Language, 16*, 171–190.

Darley, F. L. (1984). Apraxia of speech: A neurogenic articulation disorder. In H. Winitz (Ed). *Treating articulation disorders: For clinicians by clinicians* (pp. 289–305). Austin, TX: Pro-Ed.

Goodglass, H., & Kaplan, E. (1983). *The assessment of aphasia and related disorders*. Philadelphia: Lea & Febiger.

Kent, R., & Rosenbek, J. (1982). Prosodic disturbances and neurologic lesion. *Brain and Language, 15*, 259–291.

Kent, R., & Rosenbek, J. (1983). Acoustic patterns of apraxia of speech. *Journal of Speech and Hearing Research, 26*, 231–249.

Kertesz, A. (1982). *The Western Aphasia Battery*. New York: Grune & Statton.

Odell, K., McNeil, M. R., Rosenbek, J. C., & Hunter, L. (1991). Perceptual characteristics of vowel and prosody production in apraxic, aphasic and dysarthric speakers. *Journal of Speech and Hearing Research, 34*, 67–80.

Pierrehumbert, J. B. (1980). *The phonology and phonetics of English intonation.* Unpublished Doctoral Dissertation, Massachusetts Institute of Technology.

Rosenbek, J. C. (1985). Treating apraxia of speech. In D. F. Johns (Ed.), *Clinical management of neurogenic communication disorders* (pp. 267–312). Boston: Little, Brown.

Ryalls, J. H. (1982). Intonation in Broca's aphasia. *Neuropsychologia, 20*, 355–360.

Waterson, N. (1971). Child phonology: A prosodic view. *Journal of Linguistics, 7*, 179–211.

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