SPEECH TIMING IN ATAXIC DYSARTHRIA

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ABSTRACT

The production of articulate speech involves the complex spatiotemporal organization of articulatory gestures, resulting in characteristic timing patterns across speakers. Acoustic studies of ataxic dysarthria report lengthening of segments and increased mean syllable and utterance durations, but utterance-level durational effects have been described infrequently. In this study, French-speaking ataxic dysarthric speakers failed to show final lengthening effects.

1. INTRODUCTION

This study comparing dysarthric and normal speech was undertaken in an initial attempt to explore the roles of different parts of the CNS in two utterance-level timing patterns: compensatory shortening and final lengthening. The term dysarthria refers generally to a group of speech disorders resulting from neurological damage or disease, and may be characterized by slow, weak, imprecise and/or uncoordinated movements of the speech musculature [9]. We chose to study dysarthric speech because traditional descriptions of the speech characteristics of most dysarthrias include disturbances of speaking rate [3]. We hope that by describing the speech timing patterns of individuals with known neurological pathologies we may improve our understanding of the contributions of specific neural mechanisms to speech timing patterns. This should allow us, eventually, to locate the origins of specific timing differences at motor-execution or higher levels [e.g., 2, 5]. Furthermore, since the existing clinical descriptions of these disorders are sufficiently vague that the same descriptions are often used for patterns that are clearly distinguishable, an added benefit of these studies may be descriptions of timing patterns of the various dysarthrias that have diagnostic value. Since the cerebellum has been implicated in movement timing, and because there are few studies that attempt to relate empirical measures of dysarthric speech timing with perceptual judgments, we have begun with a study of ataxic dysarthric speakers--that is, speakers whose speech pathology arises from cerebellar pathology.

2. METHODS

The data were recorded at L'hôpital de la Salpetrière, in Paris. The subjects were eight native speakers of French, four ataxic dysarthric speakers, and four age-matched control speakers.

Two nonsense "target words," [pɑt] and [splɑt], were embedded in eight sentence frames. The target words occurred medially in four sentences and finally in four sentences. The sentences were of four lengths: 4-, 5-, 6-, and 7-syllables. A native French speaker produced exemplars of each sentence. These were presented in two random orders, with two tokens of each sentence produced on each of two presentations, resulting in eight repetitions of each sentence by each subject. The sentences were produced without pauses, and all were intelligible. All stop closures were achieved, but some ataxic speakers distorted the /s/ frication. All target words were produced with an aspirated /t/ release by all subjects on all repetitions in both target positions. We measured the durations of the /ɛ/ of "C'est une (1-4 syllables)______" and "C'est une______ (1-4 syllables)," the /s/ (of 'splat'), the /p/ closure, the vocalic nucleus (/lɑ/ in 'splat" and /ɑ/ in 'pat'), /t/ closure, and /t/ aspiration from the acoustic waveforms.

3. RESULTS

3.1 Overall Speaking Rate

For both subject groups, as the number of syllables per sentence increased, sentence duration increased; this is shown for "pat" target-word utterances in Figure 1, and was also found for "splat" target-word utterances. In this figure, it is also obvious that ataxics' sentences were longer than those of the control subjects. In one sense, at least, then, the ataxic subjects' speech was "slower" than that of the control subjects, as reported in the literature [3]. To see if this "slowness" was distributed uniformly across a sentence, we examined durations of medially and finally positioned target words and their constituent segments.

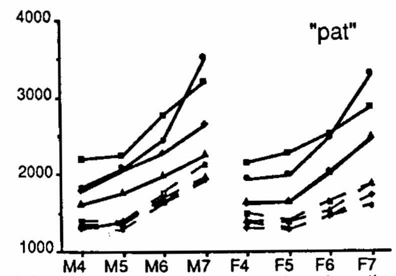

Figure 1. Mean utterance duration (in ms) for each subject and sentence. 'M' indicates medial position target words, 'F' final target words in sentences of 4-, 5-, 6-, and 7-syllables. Ataxic subjects' data are connected with solid lines; control subjects' data are connected with dashed lines.

3.2 Final Lengthening

In accord with previously published data on Swedish and English [e.g., 4, 8], our control subjects produced significantly longer target words when they occurred in final than in medial position (see Fig. 2) for "pat" target-word data; ("splat" data are equivalent for both speaker groups). The final lengthening effect, however, was not evenly distributed across the segments of the target words: the target-word vowels were about 25 ms longer for final-position targets (see Fig. 3 for "pat" data; "splat" data are equivalent for both speaker groups), while the corresponding /t/ closures were 75-100 ms longer (see Fig. 4 for "pat" data; "splat" data are equivalent for both speaker groups).

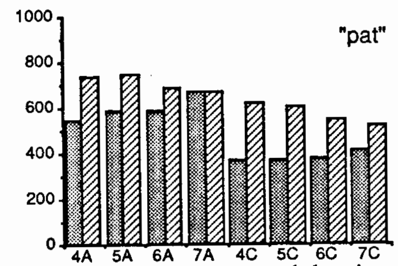

Figure 2. Mean target-word durations for ataxic ('A') and control ('C') subject groups, in 4-7 syllable-sentences. Filled bars represent durations of target words in medial position; striped bars, in final position.

The ataxic subjects, on the other hand, failed to differentiate the target-word durations as a function of sentence position. Indeed, in some comparisons the medial-position vowel was longer than the final-position vowel (Fig. 3), and the final lengthening so evident in the final /t/ closures of the control subjects was absent in the speech of these dysarthric speakers (Fig. 4).

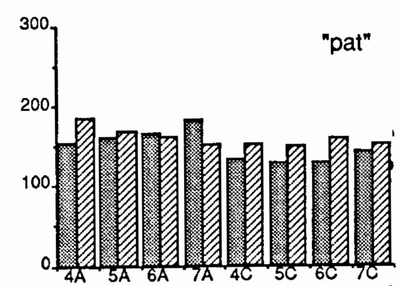

Figure 3. Mean target-word vowel nuclei durations for ataxic ("A") and control ("C") groups for 4-7 syllable-sentences. Filled bars represent durations in medial target words; striped bars, in final target words.

In order to present a more general picture of position effects on segment duration, we have collapsed the data for each group across the sentences of different lengths (Fig. 5). Not surprisingly, neither group showed a difference in initial /ɛ/ duration as a function of target-word position. The control subjects, however, did show differences in all target-word segment durations as a function of target-word position, while the ataxic speakers showed differences only for the initial consonant (/p/) and final aspiration. In the parallel data for "splat," the controls subjects again showed positional effects for all target-word segments ($p<.001$), while the ataxic subjects produced only the initial /s/ and final aspiration with greater length in final-position target words ($p<.05$ and $p<.001$, respectively). The /p/, no longer an initial segment, did not show durational differences as a function of target-word position.

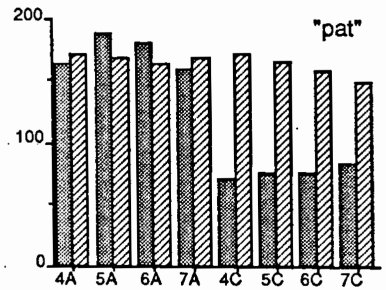

Figure 4. Mean /t/-closure durations for ataxic ("A") and control ("C") groups in 4-7 syllable-sentences..

3.3 Compensatory Shortening

There was no correlation between the duration of /ɛ/ and total utterance duration for the control or for the ataxic speakers. This is in contrast to an earlier study with a different group of French-speaking subjects [1], in which such a correlation was found. It is possible that the syllable-timed structure of French is only minimally compatible with compensatory shortening.

4. DISCUSSION

Our results show that the ataxic speakers differed from the controls in at least two ways: the total durations of their utterances were longer, and they failed to show final-lengthening effects. These differences can be attributed, whether directly or indirectly, to the cerebellar dysfunction. While the role of the cerebellum is incompletely understood, it is thought to be involved in coordinating the motor system. One hypothesis is that the cerebellum is involved in setting the initial parameters of the movement [7], perhaps by biasing muscle spindles; these parameters would be responsible for the effect of syllable position on segment duration observed in normal speakers. Thus, it has been suggested that the hypotonia of cerebellar ataxia results from reduced spindle biasing and leads to the associated slowing of movement [7]. In addition, one of the hallmarks of cerebellar disorders is difficulty terminating movements, a difficulty that may contribute to the longer segment durations of our ataxic speakers. It is unclear whether the increased segment durations and absence of final lengthening are independent aspects of the timing disorder or reflections of disruption of a single underlying mechanism. Finally, the question remains as to whether the timing patterns observed in normal speakers result from speakers' intentions to produce durational differences that may be perceptually important to listeners [6], or whether the durational differences are due to a physiological unwinding as the motor act unfolds.

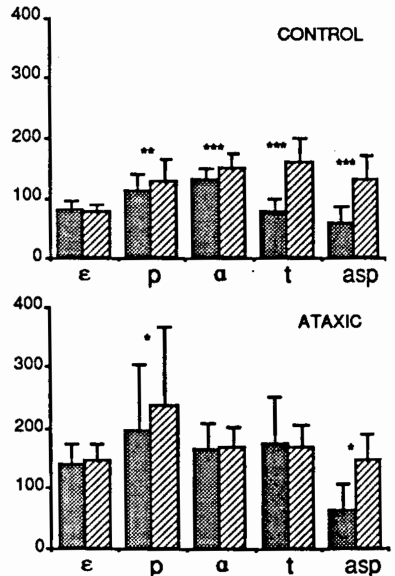

Figure 5. /ɛ/, /p/ closure, /a/, /t/ closure, and final aspiration durations. Segments occurring in medial position are shown with filled bars; final, with striped bars (*$p<.05$, **$p<.01$, ***$p<.001$.)

Our failure to find compensatory shortening effects may result from the syllable-timed structure of French, which may be only minimally compatible with compensatory shortening. That is, the effect may be so small that a much larger sample may be necessary to reveal any effect, and this may explain the difference between these results and those of Bell-Berti and Chevrie-Muller [1].

5. SUMMARY

The utterances of our ataxic subjects were of substantially greater duration than those of our control subjects. In addition, final-lengthening effects were present in the speech of the control subjects (although they were not uniform across the segments of the target words), but were not seen in the speech of our ataxic subjects. Finally, we found no evidence of utterance-length effects in either the control or the ataxic subjects.

6. ACKNOWLEDGMENTS

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