DURATIONAL PATTERNS IN THE SPEECH OF FINNISH APHASICS

Pirkko Kukkonen

Department of General Linguistics
University of Helsinki, Finland

ABSTRACT

In this study, consonant and vowel durations were compared in normal and aphasic speech. Some aphasic speakers produced longer sounds than normal. The durations in aphasic speech were more variable than in normal speech, but on the average, the aphasics were able to produce the length opposition. For vowels, the increase in variation seemed to depend on intrinsic factors, whereas for consonants also the effects of surrounding sounds had to be considered. The implications of these findings to speech production models were discussed.

1. THE RESEARCH QUESTIONS

The present study addresses questions of timing and the neurophysiological programming of speech. There should not be any differences in the durational patterns due to aerodynamic factors between normal and aphasic speech, whereas different types of deviations should appear in the patterns due to neuromuscular constraints in aphasic speech.

The questions addressed in the present study were whether or not the aphasics were able to produce the length opposition, whether or not they produced longer sounds than normal, and whether or not the durations in aphasic speech were more variable than in normal speech. Factors contributing to the variation for durations were discussed.

2. MATERIAL AND METHODS

The acoustically analyzed words were elicited in a repetition test presented to eleven aphasic speakers and four age-matched control subjects. The aphasic speakers were accepted on a first come, first served basis. All the subjects were male, right-handed native speakers of Finnish. The etiology of aphasia and the lesion localization varied, and the time post onset of aphasia was between 1,5 months and 12 years. Detailed backgound information is presented in Kukkonen [1]. The present study is based on case descriptions, and symptom dissociations are searched for.

The phonetic composition of the test items was systematically alternated. The duration of the eight Finnish vowel phonemes in the first syllable was determined, as well as the duration of word-initial and word-medial consonants /ptksln/. For word-initial stops, the voice-onset-time was measured. In Finnish there is a phonological length opposition for word-medial vowels and consonants. The items were isolated words, and the analysis was based only on correct repetitions.

3. RESULTS

3.1 First-Syllable Vowels

3.1.1 Length Opposition

The means for short and long vowels were clearly different, and a figure obtained by dividing the duration of a long vowel phoneme by the duration of the corresponding short vowel phoneme was approximately the same for both the control subjects and the aphasic speakers. The comparisons revealed two subjects whose vowels were on the average longer than normal (Subjects 4 and 14). This lengthening came into surface in a similar manner in all the vowels, and no differences were observed between, for example, closed and open vowels, or labial and illabial vowels.

The realization of the length opposition was further characterized by comparing the duration of the shortest long vowel with the longest short vowel for each speaker and each vowel phoneme. In the control data, there was always a "margin" between the short and long vowels. On the average, the duration of the margin was 61 - 85 ms for the control subjects. One of the aphasic speakers did not differ from the comparison group. For the other aphasic subjects, there was no margin between the short and the long vowels. The deviations were most notable for Subjects 6 and 11.

It was the easiest to produce the length opposition for vowel /æ/, and it was the most difficult to produce the opposition for vowels /y/ and /u/. These closed labial vowels are usually produced with lip protrusion in Finnish. Some differences were noted between the aphasic speakers, but there were not enough data to establish which of these differences were significant.

The deviations observed in the realization of length opposition were correlated with the increase in the amount of variation for vowel durations. All the subjects were obviously aiming at the correct phonological target phonemes.

3.1.2 Variation for Vowel Duration

In order to compare the amount of variation in the subjects' speech, the coefficient of variation was determined for each vowel. Furthermore, the means for these coefficients was calculated. As the variance for durations depends on the length of the segment--the longer the segment, the higher the variance--the present analysis was based on the logarithm of the vowel duration. For most of the aphasics, the c.v. was higher than for the control subjects. There were two aphasics (Subjects 9 and 11) with a remarkably high c.v.

3.1.3 Factors Behind the Increased Variation

It was expected that the vowels should be shorter between two stops than between two sibilants [3]. Different word structures were treated separately. First, the duration of the vowels occurring between two stops was compared with the duration of the vowels located between two sibilants (or between a stop and a sibilant). The effects of the surrounding consonants came mostly out as predicted, and the effects were similar for both the controls and the aphasic speakers. A comparison of word pairs (e.g. teettææ and seestyy) also supported the conclusion: there are no apparent differences between the controls and the aphasics in how the surrounding consonants affected the vowel duration.

The effects of word structure and word length were difficult to tell apart because the shorter words were of a different word structure than the longer words. This analysis did not reveal differences between the aphasics and the controls: the differences between the word structures were equally clear for all the speakers.

When discussing intrinsic duration, the different articulatory components should be compared. Ladefoged & al. [2] propose that vowel production is accounted for by three components: a posterior constriction, an anterior constriction, and a labial constriction. For all the subjects, and especially for the aphasics, the difference between short and long /æ/ (/æ/ requirs the least constriction of the Finnish vowels) was usually rather long. There were no clearcut differences such that some patients would fail with posterior tongue movements and others with anterior tongue movements. However, one aphasic subject seemed to find it more difficult to control vowel length for labial vowels than for illabial vowels. We could assume that both the execution of the constrictive movements and the coordination of these movements may lie behind the observed deviations. The vowel centralization observed for one of the aphasics supports the conclusion that it may be the reduction in muscular movements that lies behind the observed deviations [1, 5].

3.2 Word-Initial Consonants

The voice-onset-time of the word-initial stops and the segment duration of other consonants were measured.

The duration of VOT depended on the stop's place of articulation. The VOT was the shortest for /p/, and the longest for /k/. In this respect, there was some variation between the subjects, but no differences between the controls and the aphasics were observed. The effects of the following vowel and of the word structure were analyzed but no effects were found.

In aphasic speech, the VOT was never lengthened, whereas the word-initial consonants tended to be longer than normal in the speech of certain (nonfluent) aphasics. Especially for the nonfluent aphasics, the VOT was shorter than normal. Thus, there may be a reciprocal relationship between stop closure and VOT [4].

3.3 Word-Medial Consonants

3.3.1 Length Opposition

In the comparison data, there was a "margin" between the longest single consonants and the shortest geminate consonants. The exact duration of this margin varied depending on the speaker and the consonant in question. On the average, the margin was the shortest for /n/ (45 ms) and for other resonant consonants, and the longest for /s/ (118 ms). Three out of four control subjects produced long margins, whereas one control subject produced margins that were often remarkably shorter than the average margins in the control data.

Most of the aphasic speakers also produced a margin between the longest single consonants and the shortest geminate consonants, but this margin was on the average shorter than in the control data. For two of the aphasic speakers, there was overlap between the duration of single and geminate consonants. For these speakers the coefficient of variation for consonant duration was remarkably higher than normal.

3.3.2 Increase in Variation for Consonant Durations

The variation for durations of the word-medial consonants was characterized by the coefficient of variation. In order to be able to reliably compare consonants of different length, the analysis was based on the logarithm of the duration. As compared to the control subjects, most aphasic speakers showed some increase in the amount of variation for consonant duration, and for two speakers the c.v. was remarkably high. These were the same subjects for whom there was overlap between the duration of single and geminate consonants.

3.3.3 Factors Behind the Increase in Variation

According to Lehtonen [3], the consonants are longer after labial vowels than after illabial vowels. The effect of labiality was very weak in the present data, and a statistical analysis did not support Lehtonen's conclusion.

The word-medial consonant preceeded by a short vowel is longer than a consonant preceeded by a long vowel [3]. For the control subjects, the above rule was true in general. There was some tendency for stops /pk/ to obey the rule more often than for the other consonants. One of the aphasics (Subject 8) produced longer consonants after long vowels than after short vowels.

Voiceless plosives are the longest consonants, followed by fricatives and resonant consonants [3]. When different places of articulation are compared, labial consonants are on the average longer than dental and velar consonants [3].

In the present data, the manner of articulation had a stronger effect on consonant duration than place of articulation. For most of the speakers, resonants were on the average shorter than obstruents. For the control subjects, all the short consonants were shorter than the long consonants. For two of the nonfluent aphasic speakers, the geminate resonants were shorter than single obstruents.

The sibilant requires more sophisticated motor control than other consonants. In the present data, single stops were on the average longer than /s/, but the geminate /ss/ was often longer than geminate stops.

The comparison of different places of articulation (whether or not the labial sounds are longer than dental and velar sounds) did not give systematic results. One speaker had very long OFTs in the word medial position. His speech was not, however, distorted.

4. DISCUSSION

The length opposition was preserved in aphasic speech albeit some aphasics experienced difficulties with controlling the duration and therefore occasionally violated the length opposition.

Voice-onset-time is among the variables affected by aerodynamic factors. The duration of VOT seemed to be conditioned by the duration of the occlusion of the stop--the subjects with considerable consonant lengthening produced short voice-onset-times.

The present data gave only some hints to the processes between the selection of the phonological target and the aerodynamic processes. Lengthening was similar for both consonants and vowels, and the word structure did not have an effect on it. For vowels, the increase in variation for durations was not explained by the surrounding sounds or by word structure. Rather, there was some evidence for differing effects of the articulatory components of vowel production. For consonants, not only intrinsic factors but also for example the duration of the preceeding vowel should be considered.

Further evidence for different components of the articulation process was reported by Kukkonen [1] in connection with the different error types (some patients deleted word-initial consonants, some distorted them, and still others commited substitution errors that were not distortions).

The results point out that a comparison of acoustic properties of normal and deviant speech is a promising testing ground for theories of normal speech production. The findings will also have implications for the clinical classification of aphasics.

5. REFERENCES

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