Speech Rate and its Differential Influence on the Perception of Normally Hearing and Hearing-impaired Subjects

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1. Introduction

Prosody has been firmly integrated into phonetic research. Speech rate is an important prosodic cue, which has not been extensively investigated especially as far as the influence on intelligibility is concerned. As regards normally hearing listeners, it is generally accepted that as the rate of speech is increased beyond 'normal' limits, articulation deteriorates and thus affects intelligibility. Besides if speech is produced at a very high rate, it cannot be processed as fast as it is received, which results in a loss of speech information. As to hearing-impaired listeners, it is often assumed that slowing down the speech rate will improve intelligibility and it is common usage in clinical practice to speak at a significantly slower than normal rate when communicating with the hearing-impaired. The aim of the experiment to be reported on here was to investigate whether speech rate is of comparable influence on the speech decoding process of normally hearing and hearing-impaired listeners.

2. Method

The stimulus material used in this experiment consisted of 25 sentences, selected from the corpus as described by Plomp and Mimpen (1979). With regard to the arguments in favour of using sentences instead of words, the reader is referred to Gil-Günzburger and Vingerling (1981). The sentences were read out by two native speakers of Dutch: one male and one female, who had been instructed to speak at a rate they considered to be normal. The rate at which the sentences had been spoken was taken as a starting-point for further processing. By means of LPC the sentences were artificially expanded to 156% of the original duration (slow rate), and compressed to 64% of the original duration (fast rate). The resulting 50 sentences were offered to the original speakers with the instruction to repeat them trying to keep as closely as possible to the rate of speech of the sentence presented. In order to prevent ceiling effects in the case of the normally hearing listeners, the stimulus material was masked with noise. The type of noise used was speech noise i.e. noise with a spectrum that corresponded with the average of the speech spectra of both speakers. Based on a pilot study the S/N ratio was set at -1 dB

for normally hearing listeners and +7 dB for hearing-impaired listeners aiming at a target level of approximately 50% correct responses for the normal rate.

In all 168 subjects participated in the test. The hearing-impaired subjects (40) were pupils from various secondary schools for hearing-impaired children, their age ranged from 10 to 17 years and they all suffered from a congenital hearing loss of maximally 60 dB for the best ear. The normally hearing subjects (128) were pupils from the fifth and the sixth forms of various primary schools, their age ranged from 10 to 12 years and they had no self-reported hearing deficiencies. All subjects took the test individually. They received oral and written instructions and were asked to write down what they heard after every test sentence, even if this amounted only to fragments.

3. Analysis and Results

3.1. Hearing-impaired listeners

The results were analysed as to influence of speech rate and sex of the speaker. Table I gives the results per condition i.e. normal, slow and fast rate and per speaker for hearing-impaired listeners only.

This table shows that the differences in mean scores between the conditions normal and slow are very small in all cases i.e. per speaker and pooled for both speakers. Analyses of variance showed that the mean scores for the fast condition differed significantly from the mean scores for the normal and slow conditions ($p < .01$) with one exception: the difference in mean scores between the slow and the fast condition in the case of the female speaker proved to be insignificant. A post-hoc analysis (Scheffé) showed that the conditions normal and slow can be grouped together i.e. they do not differ significantly from each other in terms of mean scores (in all cases). The fast condition differed significantly from the normal and slow condition in the case of the male speaker and pooled for both speakers. In the case of the female speaker all conditions could be grouped together i.e. there was no significant difference in scores between the three conditions.

Table I. Mean correctly perceived words and standard deviations (in %) per condition, per speaker and pooled for male and female speaker (= total)

	Correct in % ♂		Correct in % ♀		Correct in % total	
Condition	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Normal	59	38	64	30	62	33
Slow	63	35	59	30	61	29
fast	7	13	50	29	28	21

3.2. Normally hearing listeners

The results were analysed with regard to the influence of speech rate only. As to the influence of the sex of the speaker, the results of the normally hearing listeners will be compared with those obtained from the hearing-impaired listeners. Table II gives the results per condition i.e. normal, slow and fast rate, pooled for both speakers, for normally hearing listeners only.

Table II shows that the difference in mean scores between the conditions normal and slow is negligible whereas the mean scores for the fast condition appear to be considerably lower than those obtained in both the normal and the slow condition. Further analysis will be carried out and reported on later.

4. Conclusion

Test results show that the difference in scores (in mean % correctly perceived words) between the speech rates normal and slow are extremely small; this holds for both normally hearing and hearing-impaired listeners. Speaking at a fast rate appears to have dramatic consequences for both subject groups.

As regards normally hearing listeners the effect of speech rate on intelligibility has not been extensively investigated. Therefore, a more detailed analysis of the stimulus material used in this experiment seems warranted. This analysis might concentrate on the following two questions

1. What kind of factors play a role in the realisation of speech rate?
2. Are the factors responsible for the realisation of speech rate the same as those that are involved in the perception of speech rate and its influence on intelligibility?

As to hearing-impaired listeners, studies of the effect of time-compression and expansion of speech have been conducted in order to document the degenerative effects associated with various kinds of hearing loss and the process of aging (cf. Spitzer and Osborne, 1980). With regard to the influence of speech rate on intelligibility, it is commonly accepted to rely on mere assumptions. Seeing that the results of this experiment fail to support what is generally believed, viz. that slowing down the speech rate will improve

Table II. Mean correctly perceived words and standard deviations (in %) per condition, pooled for male and female speaker (= total)

	Correct in % total	
Condition	$\bar{x}$	SD
Normal	74	16
Slow	76	18
Fast	26	14

intelligibility, further investigation into this matter seems feasible.

As regards the aim of this experiment, viz. to investigate whether speech rate is of comparable influence on the speech decoding process of normally hearing and hearing-impaired listeners, the results seem to indicate that there are no important differences.

References

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