Word Frequency Effects on Duration and F0 in English Homophone Utterances

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Abstract

We investigate whether the word frequency effects occur in native speakers' homophone speech in such a way that less frequent words are produced with greater magnitudes in duration and F0 than more frequent words. Acoustic analyses of homophone data produced by four speakers reveal that there is a tendency that vowels in less frequent words get longer than those in more frequent words, and statistical tests verify the significance of their differences. On the other hand, no considerable correlation has been discovered between F0 and word frequency.

I. Introduction

Over the last decades, a number of studies have reported that the segments in high frequency words are more prone to such phonological processes as reduction, lenition, or even deletion than the segments in rare words ([1, 2, 3, 4, 5], among others). As a consequence, duration of low frequency words is, in general, turned out to be relatively greater than that of high frequency words.

We find a few studies which try to find the same frequency effect in homophones (e.g., Guion 1995, Cohn 2005), but distinct differences in duration as well as F0 have not been reported yet.

In the current study, consequently, the behaviour of segmental duration and F0 will be closely investigated especially when they are produced in homophones.

II. Methods

2.1. Subjects

Four speakers take part in the recording: three Americans (BR, 41, male; MC, 58, male; PL, 59, female) and one Canadian (LI, 36, female). All of them are practical English instructors at a university in Korea but none has any expertise in linguistics or phonetics. No information is given to them regarding the purpose of experimentation.

2.2. Prompt

The recording prompt includes 78 homophone pairs picked from the MICASE corpus[1]. Each pair consists of a monosyllabic high frequency word and its counterpart low frequency word. We follow criteria in [8] in distinguishing high and low frequency words: (a) a high frequency word has at least 100 occurrences per million, (b) the difference in frequency between the high frequency word the corresponding low frequency word should be at least 100. Examples in the homophone list are: *jean/gene, tern/turn*. Each word is carried by the frame sentence "Say the word _____ for me". To avoid the bias in order of appearance and to hide the

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1) Publically available at
   "http://micase.umdl.umich.edu/m/micase".

purpose of the experiment, all the sentences are randomly mixed.

2.3. Recording

The recording was performed in a sound-treated room using a DAT recorder and the microphone (ATM75, Audio Technica). After a practice session, each token has been asked to read only once unlike in other production tests in general. This is because repeated tokens will increase the frequency counting and undermine our original goal of the experiments, the frequency effect. [9] also indicates this difficulty. Recorded data was digitized to 16-bit mono sound at 44,100Hz. All acoustic analyses were performed by Praat (version 4.5.20).

2.4. Analysis

Phonetic segmentation of recorded signals are performed by the criteria based on formant characteristics and zero-crossing point convention [10]. Then, durations of the vowel part and whole word of the target homophone are measured, respectively. Although vowels have been found to be more variable in duration than consonants [11], we assume that the consonantal duration, and consequently the whole word duration, might also be affected by word frequency. In measuring F0, only the peak point of each vowel is considered. Praat scripts and MS Excel are used for these procedures and measurements.

In order to see whether the frequency effect works, we calculated the duration ratio (DR) between the two words in each homophone pair as follows:

$$DR = \frac{Duration\ of\ high\ frequency\ word}{Duration\ of\ low\ frequency\ word}$$

For example, $DR_{quay-key}$ is the duration of the word *key* divided by the duration of the word *quay*. If the DR value is below 1, word frequency can be regarded as effective between the two relevant words.

Statistical significant tests are performed wherever relevant. As the normal distribution of the value differences are not guaranteed, the two-tailed *Wilcoxon Matched-Pairs Signed-Ranks Test* [12], known for its usefulness in dealing with non-parametic data sets, is used.

III. Results and discussion

3.1. Duration

The distribution of DR values for each speaker is shown in <Table 1>.

Table 1. Word frequency effect for each speaker

speaker	no. of tokens	DR<1	percentage of affected pairs
BR	78	52	67%
LI	77	46	60%
MC	78	46	59%
PL	77	50	65%

Overall, as expected, vowels in less frequent words are longer than those in more frequent words in utterances of all four speakers. Results of significance tests are summarised in Table 2.

Table2. Results of the two-paired Wilcoxon Matched-Pairs Signed-Ranks Test

speaker	w	N	p
BR	773	78	p<0.001**
LI	1242	77	p>0.1
MC	974	78	p<0.01*
PL	785	77	p<0.001**

In utterances by three speakers (BR, MC, PL), the word frequency effect has turned out to be highly significant. It is not clear, in the current analysis, why the effect is not shown in the LI's case. Her data needs to be more closely examined in future studies.

The result is especially meaningful in that previous studies have not been successful to find the frequency effects in homophone utterances (e.g., [6, 7]).

3.2. F0

While few previous studies have even tried to discover the F0 differences depending upon word frequency, it is meaningful in the current study to examine if the word frequency effect stretches to other prosodic features.

Unfortunately, however, no such effect has been found in our data as well. But it is premature to deny its effect on F0 as a whole, as our comparison of F0 values have not been quite refined to effectively absorb a lot more variable F0 behaviour than segmental duration. For more accurate investigation, normalisation of pitch range and control of other factors influencing F0 fluctuation appear to be necessary. We leave this for future studies.

IV. Conclusion

The major finding in the current study can be summarised as: First, the word frequency appears to affect segmental duration in homophone utterances, though unknown factors may disguise the effect in particular speakers' utterances. As for F0, more refined experimental settings seem necessary to clarify the frequency effects on it.

To confirm the duration behaviour and to elucidate F0 variation depending upon word frequency, investigation of a larger amount of data and further control of extra factors will be essential in the future.

References

[1] P. Liberman, "Some effects of semantic and grammatical context on the production and perception of speech," *Language and Speech*, 6, 172-187, 1963.

[2] J. B. Hooper, "Word frequency in lexical diffusion and the source of morphophonological change," in W. Christie (ed.) *Current progress in historical linguistics.* Amsterdam: NorthHolland 96-105. 1976.

[3] C. E. Wright, "Duration differences between rare and common words and their implications for the interpretation of word frequency effects," *Memory and Cognition*, 7, 411-419, 1979.

[4] J. Bybee, *Phonology and Language Use,* Cambridge: Cambridge University Press, 2001.

[5] D. Jurafsky, A. B. Gregory, & W. D. Raymond, "Probabilistic relations between words: Evidence from reduction in Lexical Production," In J. Bybee and P. Hopper (Eds) *Frequency and the emergence of linguistic structure.* Amsterdam: John Benjamins, 229-254, 2001.

[6] S. Guion, "Word frequency effects among homonyms," *Texas Linguistic Forum*, 35, 103-116. 1995.

[7] A. Cohn, J. Brugman, C. Crawford, & A. Joseph, "Phonetic duration of English homophones: an investigation of lexical frequency effects," in *Proceedings of LSA*. Oakland, CA, 2005.

[8] H. Kucera, & W. N. Francis, *Computational Analysis of Present-day English,* Providence, RI: Brown University Press, 1976.

[9] L. Henderson, "*Orthograpy and word recognition in reading,*" London: Academic Press, 1982.

[10] J. van Santen, "Contextual effects on vowel duration," *Speech Communication*, 11(6):513-546, 1992.

[11] T. H. Crystal & A. S. House, "Segmental durations in connected speech signals: Preliminary results," *Journals of the Acoustical Society of America*, 72, 705-716, 1982.

[12] J. S. Milton & J. C Arnold, *Introduction to Probability and Statistics*, 4th Ed. New York: McGraw Hill, 2003.