

Analysis of the Duration of English Rhythm Units

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Abstract

The properties of the duration in the rhythm unit, which comprised a set of stressed and unstressed syllables, were analyzed. In this study, based on the acoustical analyses, a phase showing the most concentrated duration in a period of a rhythm unit among native speakers was analyzed by shifting the start point of a period, and this phase was used to define the rhythm unit. As a result of analyses, it is suggested that the rhythm has underlying target period of 600 milliseconds, depending on the speech rate of the text. The distributions of the duration of the primary and secondary stressed periods could not be put closer to a single distribution by exchanging the secondary stressed syllable for the primary one or the unstressed syllable. So the rhythm is described by a series of the target periods into which a half period was interpolated.

Keywords

English rhythm, Duration, Syllable, Stress

Introduction

English rhythm is related to contrast between the stressed and the unstressed in duration structure (Ladefoged, 1993). The construction of rhythm units, which comprised a set of stressed and unstressed syllables, has been variously defined by the perceptual ways (Kawasaki, 1983). In this study, based on the acoustical analyses, a phase showing the most concentrated duration in a period of a rhythm unit among native speakers was analyzed by shifting the start point of a period, and this phase was used to define the rhythm unit. In the following chapters, the experimental setup and results of the properties of the duration in the rhythm unit based on the above definition were reported.

1 Speech Materials

Stress characterizes rhythm in English speech (Jones, 1960). The reason that a stressed syllable is recognized as a syllable with a stress is the following: it is heard to stand out more prominently than its immediate unstressed syllables by longer

duration, greater intensity, and higher pitch (Roach, 2009). Repetition of these stressed syllables alternating with unstressed syllables makes hearers perceive rhythm (Lehiste, 1970).

In this study, focusing on the property of salient stressed syllables in the repetition, the number of stressed syllables included in a text defined in the previous study (Nakamura, 2011) was treated as an element of a requirement of texts.

The speech sounds of short sentences, each including three to five stressed syllables, spoken by 20 native speakers were used. They were selected from the “English speech database read by Japanese students” (Minematsu, 2003) which includes texts satisfying the requirements for this study.

Five kinds of the texts were used in this study. Text i is an example.

Text i

I' m a.mused by the man and his ver.y fun.ny jokes.

- - @ - - @ - - + - + - @

@ : Primary stressed

+ : Secondary stressed

- : Unstressed

2 Measurements and Rhythm Units

The physical quantities of acoustical features that relate to rhythm are duration, fundamental frequency, and intensity (Lehiste, 1970). They correspond to the psychological quantities of phone length, pitch, and loudness, respectively. Among these acoustical features, durations, which are the basis of the duration structure, are focused on in this paper for the following reasons: 1) Duration can be thought to include most of the information of fundamental frequency and intensity, and 2) The information of duration, which is based at the start and the end points of each phoneme unit, can be measured with relatively high reliability. Duration of the syllables in the speech materials was measured from their waveform and spectrograms, in the accuracy of 10 milliseconds.

As mentioned in Introduction, a phase showing the most concentrated duration in a period of a rhythm unit among native speakers was analyzed by

shifting the start point of a period. A stressed syllable and also an unstressed syllable sequence were treated as a unit, and the interval of shifting was set to 1/n of them. As a result of the analysis, the following phase was the best: 1/4 Unstressed syllable sequence + Stressed syllable + 3/4 Unstressed syllable sequence. Therefore, the phase was used to define a rhythm unit in this study.

3 Experimental Results

Using the rhythm unit, probability of occurrence of the duration of the period in the rhythm unit was calculated to investigate the properties of the duration in the rhythm unit. The example result using Text i is shown in Figure 1. Duration of the period is shown in the horizontal axis, and probability of occurrence of the duration is shown in the vertical axis. Solid and dotted lines indicate the duration of the primary and secondary stressed periods, respectively.

Each text included three primary stressed syllables and two or three secondary stressed syllables. As shown in Figure 1, the duration of the primary stressed periods distributes around 600 milliseconds, while that of the secondary stressed periods around a half of the duration of primary stressed periods. This tendency was common to the other texts.

This suggests that the rhythm has underlying target period of 600 milliseconds, depending on the speech rate of the text. The distributions of the duration of the primary and secondary stressed periods could not be put closer to a single distribution by exchanging the secondary stressed syllable for the primary one or the unstressed syllable. So the rhythm is described by a series of the target periods into which a half period was interpolated.

4 Conclusions

The properties of the duration in the rhythm unit, which comprised a set of stressed and unstressed syllables, were analyzed. In this study, based on the acoustical analyses, a phase showing the most concentrated duration in a period of a rhythm unit among native speakers was analyzed by shifting the start point of a period, and this phase was used to define the rhythm unit. As a result of the analysis, the following phase was the best in this study: 1/4 Unstressed syllable sequence + Stressed syllable + 3/4 Unstressed syllable sequence. Using the rhythm unit, probability of occurrence of the duration of the period in the rhythm unit was calculated to investigate the properties of the duration in the rhythm unit. As a result of analyses, it is suggested that the rhythm has underlying target period of 600

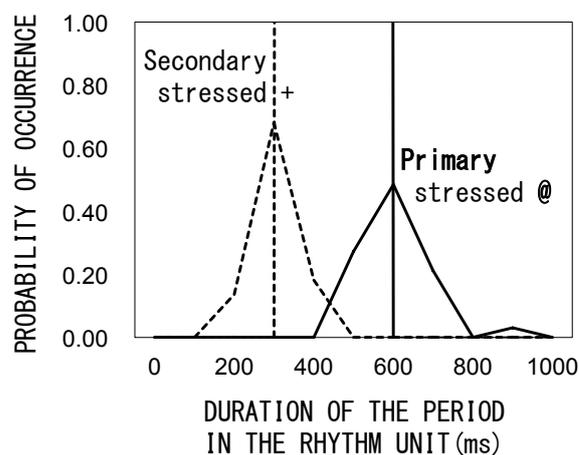


Figure 1: The example probability of occurrence of the duration of the period in the rhythm unit for Text i

milliseconds, depending on the speech rate of the text. The distributions of the duration of the primary and secondary stressed periods could not be put closer to a single distribution by exchanging the secondary stressed syllable for the primary one or the unstressed syllable. So the rhythm is described by a series of the target periods into which a half period was interpolated.

References

- Jones, D. (1960). *An outline of English phonetics*. Cambridge: W. Heffer & Sons LTD.
- Kawasaki, H. (1983). Models and data on the temporal regulation of speech: Isochrony in Japanese and English. *Journal of the Acoustical Society of Japan*, 39(6), 389-397.
- Ladefoged, P. (1993). *A Course in phonetics*. Texas: Harcourt Brace Jovanovich.
- Lehiste, I. (1970). *Supraunitals*. Cambridge: MIT Press.
- Minematsu, N., Nishina, K., & Nakagawa, S. (2003). Read speech database for foreign language learning. *Journal of Acoustical Society of Japan*, 59, 345-350.
- Nakamura, S. (2011). Characteristics of contrast between the stressed and the unstressed in rhythm units observed in duration structure in English speech by Japanese learners. *Journal of the Pan-Pacific Association of Applied Linguistics*, 15(1), 177-189.
- Roach, P. (2009). *English phonetics and phonology*. Cambridge: Cambridge University Press.