Acoustic Features of English Phonemes Obtained with Multivariate Analyses

張, 一新

氏　　名　：張一新

論 文 名　：Acoustic Features of English Phonemes Obtained with Multivariate Analyses
（多変量解析を用いた英語音素の音響的特徴の分析）

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論　文　内　容　の　要　旨

The general purpose of the dissertation is to elucidate how acoustic features of English speech can be expressed using multivariate analyses. There were three research purposes. The first purpose was to investigate the suitability of factor analyses of changing spectra for studying acoustic natures of English phonemes. Here, the results of a newly developed factor analysis, “origin-shifted factor analysis”, were compared with the results of a normal factor analysis to analyze the spectral power fluctuations in English speech. The methods mainly differed in whether to use cepstral liftering and/or the origin shift. The results showed that three spectral factors were obtained in four main frequency bands, and neither the cepstral liftering nor the origin shift distorted the essential characteristics of the factors. This confirms that origin-shifted factor analysis is more recommendable for future speech analyses since it would reduce the generation of continuous noise in the data reduction procedure of factor analysis.

The second purpose was to determine the acoustic features of English phonemes in general, by analyzing the results of the aforementioned factor analyses. In the previous research on factor analysis of English phonemes by Nakajima et al. (2017), they indicated the English database that was used had poor recording quality and some phoneme labeling issues. To better explore the acoustic features of English speech, a newly recorded and labeled database with higher quality was created. The results showed that by using origin-shifted factor analysis, regardless of whether three or four spectral factors were extracted, the factors always appeared in a similar set of four frequency bands. When three spectral factors were extracted, the distributions of the factor scores on a factor with the frequency loadings around

1200 Hz were very close to the sonority hierarchy in phonology. Sonority is a concept related to phoneme classification, and it is considered necessary to understand syllable formation. The analysis results with the new speech database corresponded to the notion in phonology that vowels have the highest sonority, followed by sonorant consonants, while obstruents are the lowest in terms of sonority. The present results revealed that, when four factors were extracted, the distributions of factor scores on two factors were highly related to the sequence of the sonority hierarchy. One factor had frequency loadings around 1200 Hz, and the other was double-peaked around 700 Hz and 2200 Hz. Furthermore, the factor with the frequency loadings around 300 Hz clearly divided English phonemes into obstruents and non-obstruents (vowels and sonorant consonants).

The third purpose was to obtain clear insight into whether and how obstruents would appear in the factor spaces. In an English syllable, an isolated obstruent always has a position as a syllable onset or a syllable end. Analyzing obstruents acoustically as in the present study helps to understand this phonological phenomenon. The current three-factor analysis provided evidence that obstruents were not only associated with the factor related to a frequency loadings around 4100 Hz, as suggested in previous research, but also with the double-peaked factor with frequencies around 300 Hz and 2300 Hz. Moreover, in the four-factor analysis, the distribution of obstruents in English speech was related to two spectral factors. One factor had frequency loadings around 4100 Hz, while the other around 300 Hz. Generally, the results of the present dissertation clearly show that multivariate analyses can be utilized to connect English phonology and speech acoustics, even for low-sonorous phonemes such as obstruents.