

A Quantitative θ_1 -Based Analysis of Vowel Tenseness: English Monophthongs /i:/, /ɪ/, /æ/, /ʌ/, /ɑ:/, /u:/, and /ʊ/

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Abstract

This paper examines the vowel tenseness indicator θ_1 in the English vowel /ɑ:/ and compares the results with previously reported findings in Ishizaki (2020, 2021, 2022, 2023, 2025a, 2025b) in order to provide a more comprehensive discussion. An investigation of the English vowels /ɑ:/, /æ/, and /ʌ/, which may cause confusion for Japanese speakers, shows that /ɑ:/ and /ʌ/ display similar θ_1 patterns, whereas /æ/ behaves differently. If vowel tenseness is assumed to be defined in the same way for both close and open vowels, comparison with the θ_1 behavior of the close vowels /i:/, /ɪ/, /u:/, and /ʊ/ may provide further insight into the tenseness of /ɑ:/, /æ/, and /ʌ/. Ishizaki (2025a) proposed the parameter “force of tenseness,” and further consideration of this parameter based on the present study may help clarify what vowel tenseness represents.

1. INTRODUCTION

Vowel tenseness does not have an established quantitative definition. Jakobson, Fant, and Halle (1951) and Chomsky and Halle (1968) examined the concept of vowel tenseness and argued that it is related to the configuration of the vocal tract. Later, Ishizaki (2019) attempted to define vowel tenseness quantitatively and proposed the indicator θ_1 as a measurable parameter.

Traditionally, in phonology and phonetics, vowel tenseness has been treated as a binary distinction between tense and lax vowels. Ishizaki (2019), however, argued that vowel tenseness can be understood as a continuous numerical value rather than a strictly binary feature.

At present, there is no widely accepted consensus in linguistics regarding what

vowel tenseness actually represents. Further research is therefore necessary to clarify the nature of vowel tenseness.

2. Objectives and Methodology

The aim of the present study is to examine the distribution of the vowel tenseness indicator θ_1 across the English vowels /i:/, /ɪ/, /æ/, /ʌ/, /ɑ:/, /u:/, and /ʊ/, and to estimate the tenseness behavior of each vowel through comparative analysis. In this paper, θ_1 is first measured for the vowel /ɑ:/, and the results are then compared with those of the other vowels reported by Ishizaki (2020, 2021, 2022, 2023, 2025a, 2025b). Based on these comparisons, the tenseness features of all the target English vowels are discussed. The audio data used in this study were obtained from the Cambridge Dictionary. All target words were recorded in American English and included the following fifteen items: bot, hot, dot, got, pot, dock, hock, jock, lock, sock, cop, hop, mop, pop, and top. Acoustic analysis was conducted using Praat (version 6.1.43). Measurement of θ_1 requires observation of formant movement. In order to minimize the influence of surrounding sounds, the formant transition was analyzed within the 33–66% portion of the vowel duration.

3. Results

Figure 1 presents the observed values of the tenseness indicator θ_1 and the first formant frequency $F1_{33}$ measured at 33% of the vowel duration for the English vowel /ɑ:/. The descriptive statistics for θ_1 are as follows: minimum = -0.99559 , first quartile = -0.71347 , median = -0.52435 , mean = -0.31153 , third quartile = 0.03673 , and maximum = 0.57866 .

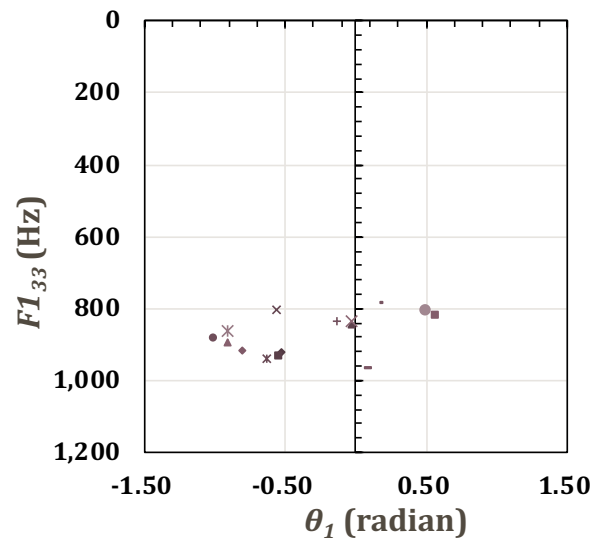


Fig. 1 Vowel Tenseness Indicator θ_1 vs. First Formant Frequency $F1_{33}$
English Vowel /ɑ:/

Figure 2 presents the observed θ_1 values for the English vowels /ɑ:/, /æ/, and /ʌ/. The values for /ɑ:/ were obtained in the present study, while those for /æ/ and /ʌ/ were reported in Ishizaki (2025b). The vertical axis represents θ_1 , and the horizontal axis represents the three vowels, arranged from left to right as /ɑ:/, /æ/, and /ʌ/. In the figure, /ɑ:/ is labeled as “o,” /æ/ as “ae,” and /ʌ/ as “v.”

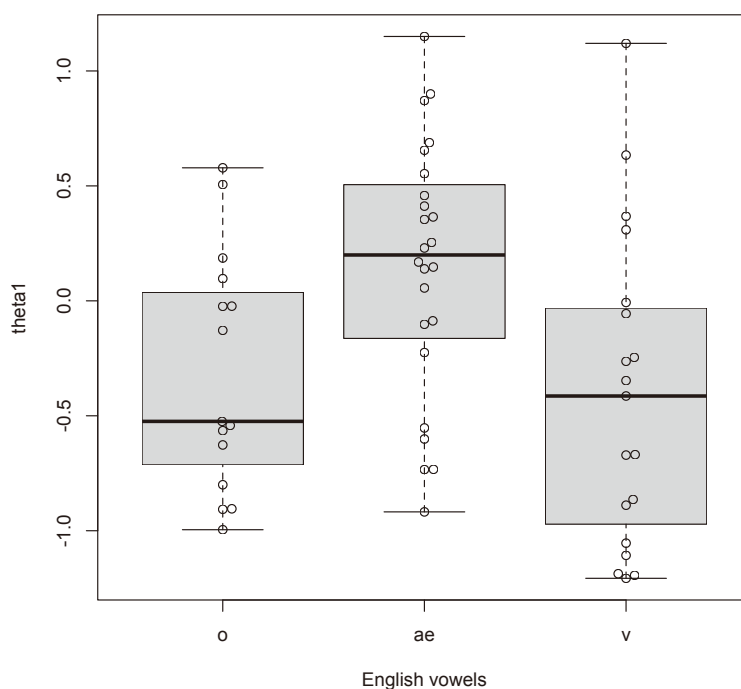


Fig. 2 Vowel Tenseness Indicator θ_1 of English Vowels /ɑ:/, /æ/, and /ʌ/

4. Discussion and Conclusion

Ishizaki (2020, 2021, 2022, 2023, 2025a, 2025b) quantified vowel tenseness using θ_1 as an indicator, and the differences in these tendencies may indicate differences in vowel tenseness. A tendency toward negative θ_1 values was observed for /ɑ:/ and /ʌ/, whereas /æ/ showed a tendency toward positive values.

Figure 3 presents the θ_1 values for the English vowels /i:/, /ɪ/, /u:/, /ʊ/, /ɑ:/, /æ/, and /ʌ/. According to Ishizaki (2020, 2021, 2022, 2023, 2025a, 2025b), /i:/ and /u:/ tend to show negative θ_1 values and may be interpreted as tense vowels, whereas /ɪ/ and /ʊ/ tend to show positive values and may be interpreted as lax vowels.

If it is assumed that the interpretation of the sign of θ_1 can be applied uniformly across vowels regardless of whether they are open or close, it becomes possible to formulate a hypothesis concerning the tenseness classification of /ɑ:/, /æ/, and /ʌ/. This hypothesis is presented in Table 1.

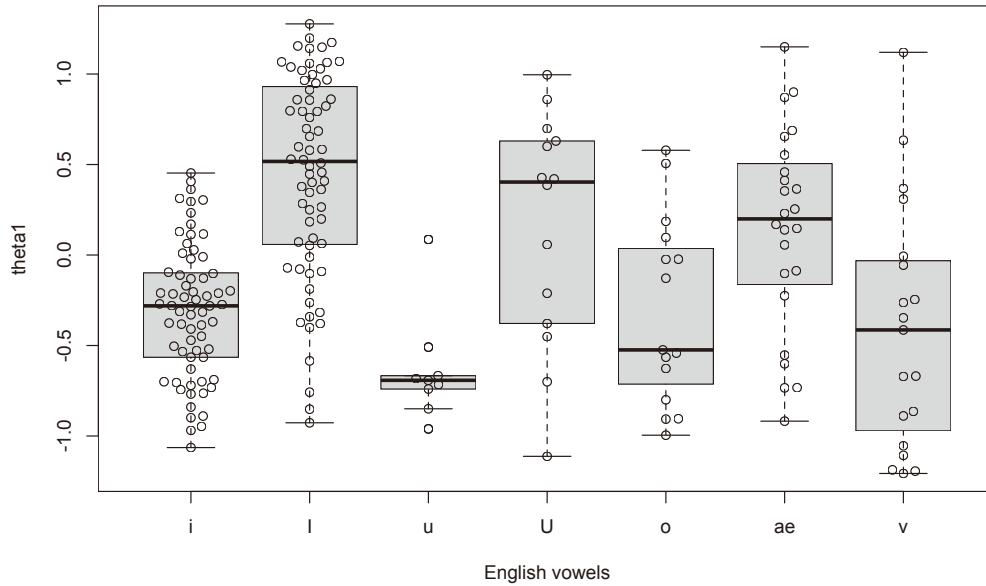


Fig. 3 Vowel Tenseness Indicator θ_1 of English Vowels
 /i:/, /ɪ/, /u:/, /ʊ/, /ɑ:/, /æ/, and /ʌ/

As shown in Table 1, /i:/, /u:/, /ɑ:/, and /ʌ/ exhibit negative tendencies and may be grouped as potentially tense vowels, whereas /ɪ/, /ʊ/, and /æ/ exhibit positive tendencies and may be grouped as potentially lax vowels. This hypothesis differs from that proposed in Ishizaki (2025b) and is based on the assumption described above. In the present study, negative θ_1 values are interpreted as indicating tense, and positive θ_1 values as indicating lax. The tenseness classification of the English vowels /i:/, /ɪ/, /u:/, /ʊ/, /ɑ:/, /æ/, and /ʌ/ is therefore provisionally presented as shown in Table 1.

Table 1 Proposed tenseness classification based on the sign of θ_1

Vowel	Sign of θ_1	Tenseness (based on θ_1)	Tenseness (Phonology)
/i:/	—	Tense	Tense
/ɪ/	+	Lax	Lax
/u:/	—	Tense	Tense
/ʊ/	+	Lax	Lax
/ɛ/	Not analyzed	Not analyzed	Lax
/æ/	+	Lax	Lax
/ʌ/	—	Tense	Lax
/ɑ:/	—	Tense	Tense

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