교육학석사 학위논문

Korean EFL Learners' Intra-Speaker Variability and Perceptual Sensitivity of Three American English Vowel Pairs: [i-ɪ], [ɛ-æ], [u-ʊ]

한국인 EFL 학습자의
세 가지 미국 영어 모음 쌍
[i-ɪ], [ɛ-æ], [u-ʊ]에 나타나는
발화자 내 변이성과 인지적 민감성에 대한 연구

2022 년 8 월

서울대학교 대학원

외국어교육과 영어전공

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Korean EFL Learners' Intra-Speaker Variability and Perceptual Sensitivity of Three American English Vowel Pairs: [i-ɪ], [ɛ-æ], [u-ʊ]

by

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A Thesis Submitted to
the Department of Foreign Language Education
in Partial Fulfillment of the Requirements
for the Degree of Master of Arts in Education

At the
Graduate School of Seoul National University

August 2022

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지도교수 안 현 기

이 논문을 교육학석사 학위논문으로 제출함

2022 년 8 월

서울대학교 대학원
외국어교육과 영어전공
최 세 연

최세연의 교육학석사 학위논문을 인준함
2022 년 8 월

위 원 장 ______________________ (인)

부위원장 ______________________ (인)

위 원 ______________________ (인)

Abstract

Korean EFL Learners'

Intra-Speaker Variability and Perceptual Sensitivity of

Three American English Vowel Pairs: [i-ɪ], [ɛ-æ], [u-ʊ]

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This study investigated 30 high-intermediate level Korean EFL participants' intra-speaker variability and perceptual sensitivity of three English vowel pairs [i-ɪ], [ɛ-æ], and [u-ʊ], replicating and expanding the previous study on intra-speaker variability by Smith et al. (2019). The intra-speaker variability in this study was operationalized as the indicator of language learners' L2 speech learning processes. It was based on the basic assumption of the speech learning model (SLM) (Flege, 1995) that one's language system is adjustable throughout the lifetime. Three research questions about intra-speaker variability and perceptual sensitivity were under investigation. Firstly, whether high-intermediate Korean participants demonstrate nativelike intra-speaker variability was examined with Welch's *t*-test. Secondly, whether there was a difference in intra-speaker variability between "new" sounds [ɪ, æ, ʊ] and "similar" sounds [i, ɛ, u] in each pair was analyzed using matched pair *t*-test. Lastly, whether perceptual sensitivity affects the degree of intra-speaker variability was explored by utilizing simple linear regression method. Intra-speaker variability was quantified as the coefficient of variation (CV) while perceptual sensitivity was assessed by a categorical discrimination task (A' score). In most cases, the differences or relationships between variables were not statistically significant throughout the three analyses. As a result, it was concluded that almost all high-intermediate level Korean EFL participants had nativelike degrees of intra-speaker variability across all three English vowel pairs. In addition, the English vowel pair [ɛ-æ] was found to be the most difficult one for Korean learners to discriminate. Lastly, high-intermediate level Korean EFL participants were at the stabilization stage in their L2 speech learning processes about the target English pairs, despite their low level or lack of perceptual sensitivity. This study has contributed to expanding the understanding of learner language related to L2 speech learning by examining language learners' intra-speaker variability from a pedagogical point of view.

Keywords: English vowel pairs, intra-speaker variability, perceptual sensitivity, "new" sounds and "similar" sounds, Korean learners of English, L2 speech learning, speech learning model, SLM, learner language, A' score, categorical discrimination task

Student Number: 2019-29809

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Chapter 1. Introduction

1.1. Background of the Study

Studies have revealed that the impact of segmental errors in communication is great in speech intelligibility (Derwing et al., 1998; Bent et al., 2007). Among the segmental errors in English, vowels play a more pivotal role than consonants in speech intelligibility (Levis, 2018; Bent et al., 2007; Fogerty & Kewley-Port, 2009). This is because vowels bear coarticulatory information of the adjacent consonants as well as their own phonological information, even in a simple English word like *pat*; that is, vowels contain more information than consonants (Levis, 2018, Bent et al., 2007). For example, Bent et al. (2007) reported that the accurate production of vowels is the most important factor in intelligibility judgment after investigating the intelligibility of Mandarin Chinese speakers' productions. Research also has revealed that several English vowel pairs are particularly difficult for Korean learners to perceive (Hong, 2007, 2012; Yang, 2008; Kim & Kim, 2003). In this respect, Korean learners' perception and production of English vowels deserve to receive undivided attention.

Language learners' difficulties in learning the second language (L2) sounds can be predicted with two perceptual models of second language learning — the perceptual assimilation model (PAM) (Best, 1995) and the speech learning model (SLM) (Flege, 1995). Studies based on these two models have reported that Korean learners tend to assimilate the three English vowel pairs /i-ɪ/, /ɛ-æ/, and /u-ʊ/ into a single Korean vowel /i/, /ɛ/, and /u/, respectively (Yang, 1996; Tsukada et al., 2007; Hong, 2012; Hong, 2007; Ingram & Park, 1997; Silva, 2004). Moreover, the SLM assumed that language learners are more likely to categorize "new" sounds /ɪ, æ, ʊ/ better than "similar" sounds /i, ɛ, u / as learning progresses (Flege, 1995; Lee & Rhee, 2019; Lee & Cho, 2015). In this respect, this study focused on three English vowel pairs, /i-ɪ/, /ɛ-æ/, and /u-ʊ/, which are reported to be challenging for Koreans in particular (Hong, 2007; Ingram & Park, 1997; Kim & Kim, 2003; Silva, 2004; Tsukada et al. 2007).

Language experience is also significant in L2 speech learning (Flege, 1995). Best and Tyler (2007), who briefly synthesized the previous studies on language experience, suggested a fairly low cutoff line for the length of L2 experience (about 6-12 months of L2 experience) for significant L2 perceptual learning to take place successfully. Still, Korean learners in an English as a Foreign Language (EFL) setting have relatively insufficient and limited language experience. This is because "English has no special status or internal function, and … its communicative use is of low priority" (Nayar, 1997, p. 29). Similarly, Best and Tyler (2007) used the term *functional monolinguals* to describe those who do not actively learn or use an L2. Research has shown that it is challenging for *functional monolinguals* to categorize and differentiate many non-native phonetic contrasts, consonants and vowels, which are not used to distinguish lexical items in their first language (L1) (Best & Tyler, 2007; Goto, 1971; Polka & Werker, 1994). In this respect, L2 speech learning by language learners in an EFL context needs to be examined in terms of language learning processes.

1.2. Purpose of the Study

One of the main characteristics of a learner language is variability (Warner & Tucker, 2011; Verspoor et al., 2008). However, little research has been conducted on intra-speakers' phonetic variability of a sound observed in a language learning process, especially that of non-native speakers of English (Eckman, 2017; Smith et al., 2019). In fact, what constitutes variability in language learning is vague (Bley-Vroman, 1983; Sosa & Stoel-Gammon, 2006); there is no consensus on the definition of the term. It may partly result from difficulty differentiating normal patterns of variability from the typical developmental progression of variability (Bley-Vroman, 1983).

Against this background, to empirically contradict the secondary assumption that L2 speakers might exhibit greater intra-subject variability than L1 speakers do in an ESL context, Smith et al. (2019) attempted to define *intra-speaker variability*. According to Smith et al. (2019, p. 159), intra-speaker variability is about "how consistent a given L2 speaker is in achieving a particular production pattern relative to the "stability" shown by native speakers." Based on this definition, the intra-speaker variability of contrastive English vowel pairs (/i-ɪ/, /e-ɛ/, and /u-ʊ/) by Korean, Mandarin, and Spanish L2 speakers of English was compared to that of native English speakers. Each speaker's vowel productions were classified according to the four-scenario framework reflecting phonetic intra-speaker variability and mean formant of L1 and L2 speakers' speech. The four scenarios by Smith et al. (2019) are as follows:

> "(1) L2 speakers might be similar to L1 speakers in terms of both their vowel formants and the variability of those productions;
> (2) L2 speakers might produce vowel formants similar to those of L1 speakers, but be more variability in their productions;
> (3) L2 speakers might produce different vowel formants than L1 speakers, but be no more variable in their productions;
> (4) L2 speakers might produce different formants than L1 speakers and also be more variable in their productions" (Smith et al., 2019, p. 142).

Among these scenarios, the first and the third ones represent the native-like degree of intra-speaker variability. The nativelikeness of vowel formant (Hertz) and intra-speaker variability (coefficient of variation (CV)) depended on whether non-native speakers' productions were within the range of ± two standard deviation difference from the native norm (Smith et al., 2019). The result showed that irrespective of the nativelikeness of formant values, almost 80% (79%) of non-native speakers demonstrate the native-like degree of intra-speaker variability. Smith et al. 's (2019) research contributed to empirically proving that language learners do not necessarily show a greater degree of intra-speaker variability even though they failed to achieve nativelike productions of a sound.

Notwithstanding, it appears that the following three points need to be further investigated in Smith et al.'s (2019) study. Firstly, their study was not based on a theoretical framework. Thus, the target English vowel contrasts were chosen without any consideration of the learners' first languages (L1). This is important because, depending on the listeners' first language, the relative ease or difficulty of a non-native contrast varies (Best & Tyler, 2007). Thus, this study narrows down the scope of non-native participants' L1 background to Korean only. Besides, English vowel contrasts challenging for Korean learners are extracted from the research based on the two L2 perception models. Secondly, the non-native speakers' actual perception of target English vowel pairs was not investigated. Therefore, one of the probable sources of the degree of deviations found in English vowel productions by non-native speakers is missing. Lastly, they overlooked 21% of participants who showed a nonnative-like degree of intra-speaker variability. One of the possible reasons for the great degree of intra-speaker variability is participants' different proficiency levels. In fact, studies have reported that learners of different proficiency levels demonstrate different behaviors in speech learning processes (Chen & Yang, 2007; Kong & Yoon, 2013; Mehrpour & Makki, 2011; Saito et al., 2016). Thus, the language proficiency levels of language learners should be taken into account to examine one of the possible sources of the non-nativelike degree of intra-speaker variability in Smith et al.'s (2019) study.

This study aims at replicating and expanding the study by Smith et al. (2019). The primary interest of this study is in investigating Korean EFL learners' intra-speaker variability and perceptual sensitivity in the production of three American English vowel pairs /i-ɪ/, /ɛ-æ/, and /u-ʊ/. To this end, Korean EFL learners' productions of each English vowel pair were acoustically analyzed, and the perceptual sensitivity was assessed using a categorical discrimination task (A' score).

1.3. Organization of the Thesis

The current thesis consists of five chapters. This chapter illustrates the background and purpose of this study and the organization of the thesis. Chapter 2 lays out previous literature about the perception and production of the second language (L2) speech learning by comparing English vowels to Korean vowels. Besides, the concept of intra-speaker variability is discussed in terms of learner language. Chapter 3 delineates participants, procedures, stimuli, and statistical analyses. It includes how vowel formant frequencies, intra-speaker variability and perceptual sensitivity were obtained and quantified. The results from the statistical analyses are displayed in Chapter 4. The statistical results are further discussed in Chapter 5 in relation to the previous literature. Chapter 6 encapsulates major findings from the study, presenting pedagogical implications and the limitations of this study.

Chapter 2. Review of Literature

In this chapter, relevant studies and literature are reviewed. Firstly, comparisons of modern English vowels to modern Korean vowels are presented. Then, the theoretical background of the target English vowel pairs of this study is addressed. Secondly, the relationship between learner language and intra-speaker variability in terms of the intelligibility principle is discussed. Lastly, the relationship between perception and production in L2 speech learning is dealt with.

2.1. Perception of L2 Sounds: English Vowel Pairs for Korean EFL Learners

2.1.1. Modern English Vowels

American English vowels can be characterized as including 11 nonrhotic segments: five front unrounded ones (/i, ɪ, e, ɛ, æ/), a mid-low and a low back unrounded ones (/ʌ, ɑ/), and four back rounded ones (/u, ʊ, o, ɔ/) (Strange et al., 2007; Reetz & Jongman, 2009). Moreover, markedly, the mid front and back vowels (/e, o/) are realized as diphthongized ones ([eɪ], [oʊ]) (Strange et al., 2007). English vowels can be phonemically characterized in terms of tongue height, tongue backness, tenseness, and lip rounding (Giegerich, 1992). Tongue height — roughly high, mid, and low — is diverged within front and back vowels (Giegerich, 1992; Strange et al., 2007).

Vowels are discriminated by tenseness quality as well (Giegerich, 1992). Along with the qualitative trait (tenseness) of a vowel, a quantitative trait (length) of tense vowels is considered to be important as well. American English vowels systematically and intrinsically display longer duration in tense vowels (/i, e, u, o/) (Strange et al., 2007). However, vowel length is considered a redundant distinctive feature in English vowel description since the agreed absolute criteria for vowel length comparison are absent (Giegerich, 1992). Moreover, there is a dominant tendency for listeners' reliance on vowel quality than its duration when distinguishing tense-lax vowel sounds (Giegerich, 1992). Lastly, lip rounding in English vowels is only observed in back vowels like /u, ʊ, o, ɔ/ (Giegerich, 1992; Ladefoged & Johnson, 2014).

2.1.2. Modern Korean Vowels

The number of Korean vowels can be analyzed to be either eight — /ɪ, e, ɛ, a, ʌ, o, ɨ, u/ (Kang, 1996; Lee & Zhi, 1983; Tsukada et al., 2005), or 10, if /y/ and /ø/ are included (Lee & Ramsey, 2000; Sohn, 2001; Yang, 1996). However, these are not likely to be exhaustive lists because two major ongoing sound changes are being observed in modern Korean vowels (Tsukada et al., 2005). Firstly, due to the raising of /ɛ/ (Kang, 1996; Lee & Ramsey, 2000), the places of articulation of /e/ and /ɛ/ are getting merged (Ingram & Park, 1997; Yang, 1996). Secondly, phonemic contrast of the vowel length, once traditionally present between /i/ and /i:/, is disappearing

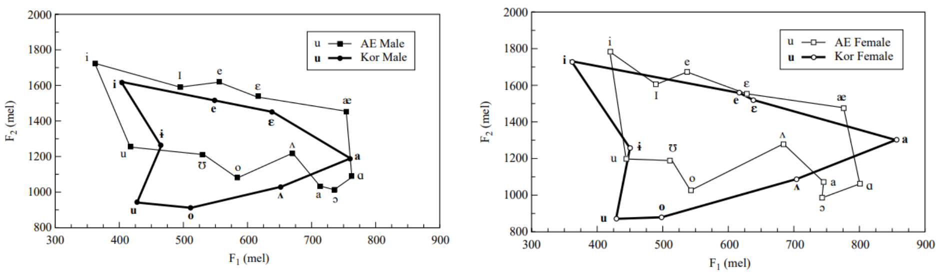
(Lee & Ramsey, 2000; Magen & Blumstein, 1993). Consequently, Koreans have a growing tendency that two Korean front vowels, /i/ and /e/, are mainstreamed, while the use of their counterparts, /i:/ and /ɛ/, respectively, are diminishing.

2.1.3. Different Characteristics of the Sounds between English and Korean

Languages generally differ in segmental inventories and phonetic realizations due to language-specific factors (Flege, 1987). English has tense and lax vowel pairs such as /i-ɪ/ and /u-ʊ/ that are distinct in quality and quantity (Giegerich, 1992). On the other hand, the Korean vowel system does not have a tenseness quality in discriminating vowel phonemes. Thus, Korean learners of English frequently struggle with native language (L1) influence when producing English sounds absent in Korean sound systems (Franklin, 2009; Lee & Rhee, 2019). On top of that, vowel spaces for American English vowels and standard Korean vowels are also distinct (Yang, 1996). Yang (1996) examined 13 American English vowels in /hVd/ for American English and 10 Standard Korean vowels in /hVda/ for Korean. The productions of four groups of 10 speakers – Korean males, Korean females, American males, and American females – were under analysis after the normalization process. In general, he found that "the Korean vowel space appears wedge-shaped with [i, a, u] at the corners; the American English vowel space looks more rectangular with [i, u, æ, ɑ]" (Yang, 1996, p. 258) as represented in Figure

2.1 (From Yang (1996, pp. 257-258)). The figures clearly show that none of the productions of English and Korean vowels are perfectly overlapping. Still, one of the most intriguing findings was that the English back vowel [u] almost overlaps Korean [ɨ] instead of Korean [u]. A similar tendency was also observed in Tsukada et al.'s (2005) first experiment, in which the second most frequently categorized Korean vowel for English vowel [u] was the sound [ɨ] followed by Korean [u]. Thus, it could be inferred that some Koreans may subsume English [u] under the Korean [ɨ] category. This result indicates that there is a chance that English [u] does not always assimilate into Korean [u] for Korean EFL learners.

Figure 2.1 *Normalized Vowel Spaces of American English and Korean by Male (left) and Female Speakers (right)*



Note. From Yang (1996, pp. 257-258)

English vowel articulations involve complex movements of muscles in the oral cavity, including tongue height, tongue advancement, lip rounding, and muscular tension (Giegerich, 1992). Among them, the tongue position —

high/low and front/back — is what differentiates the English vowels (Ladefoged & Disner, 2012).

These complex muscular movements are important because they make qualitative (spectral) differences in vowel productions. For example, when pronouncing /i/, the tongue root is substantially brought forward, making a relatively large back cavity in the mouth. This movement leads to the low first formant (F1) of /i/. The tongue root moves gradually backward as /ɪ/, /ɛ/, and /æ/ are pronounced in sequence. It makes a smaller body of air pass through the back of the oral cavity, resulting in higher F1 in order. On the other hand, a small cavity behind the front teeth on the pronunciation of /i/ generates a high second formant (F2). As /ɪ/, /ɛ/, and /æ/ are pronounced in sequence, the front cavity of a mouth gets larger, resulting in lower F2. Therefore, F1 indicates the traditional description of vowel *height*. Specifically, "the first formant frequency is inversely related to vowel height" (Ladefoged & Johnson, 2014). Unlike a comparatively straightforward characteristic of F1, however, F2 is not directly related to the front-back dimension of vowels because it is influenced by lip rounding as well as tongue advancement (Ladefoged & Johnson, 2014). Therefore, in order to exclude some of the lip-rounding effects in F2, the vowel advancement can be represented in terms of the difference between F1 and F2 (i.e., F2-F1); the narrower the distance between F1 and F2, the more 'back' a vowel becomes (Ladefoged & Johnson, 2014). In addition to tongue movements, muscular tension also affects English vowel production. Thus, language learners whose native language lacks tense-lax distinction, like Chinese or Korean, can have difficulty differentiating English tense-lax vowel pairs (Ingram & Park, 1997; Wang & van Heuven, 2006; Yang, 2008).

Studies have revealed that Koreans use temporal rather than spectral cues to perceive and produce English vowels (Flege et al., 1997; Franklin, 2009; Lee & Rhee, 2019; Yang, 2008). Yang (2008) reported in his study of American and Korean male speakers that both groups kept the contrast in temporal aspects in producing front English vowel contrasts /i-ɪ/ and /ɛ-æ/. However, Koreans did not show spectral differences in the productions of the same vowel pairs, indicating that Koreans may have difficulties differentiating English vowel pairs in terms of qualitative aspect, which is an *essential* distinctive feature in vowel discrimination (Giegerich, 1992).

2.1.4. Perceived Similarity between L1 and L2: English Vowels for Korean EFL Learners

Language distance is one of several factors that could explain the crosslinguistic influence of L1 on L2 sound perception and production (Gass et al., 2013; Ellis, 2015; Kellerman, 1983). It is not necessarily about the actual physical distance but rather a learner's *perceived* distance between L1 and L2 (Gass et al., 2013; Strage & Shafer, 2008). Sjoholm (1976), for example, examined which linguistic resource was primarily used in learning English by studying Finnish-Swedish and Swedish-Finnish bilinguals whose dominant languages were Finnish and Swedish, respectively. The result revealed that irrespective of their L1, both groups tended to rely more on Swedish than Finnish. This tendency showed that the learner's decision on which linguistic resource is more likely to be operated in learning L2 appears to play a significant role in the language learning process (Gass et al., 2013). In other words, learners' own judgment on a similarities between Swedish and English affected their decision on learning resources to be used.

The perceived phonetic similarity between L1 and L2, and L2 sound categorization has been explained by two perceptual L2 speech learning models in the field — the speech learning model (SLM) (Flege, 1995) and the perceptual assimilation model (PAM) (Best, 1995). These two models attempt to disclose the difficulties non-native listeners experience with sounds of a language other than their native language.

On the one hand, the PAM posits six different pairwise assimilation scenarios based on the gestural similarity between the languages, and three of them are related to L2 sound perceptual patterns in relation to a native category — Two-Category, Category-Goodness Difference, and Single Category (Best, 1995). Firstly, two distinct L2 sounds can be mapped into two different L1 sounds, respectively (Two-Category [TC Type]) (Best, 1995; Best et al., 2001). Secondly, two distinct L2 sounds can be mapped into a single native category, with one L2 sound being acceptable and the other L2 sound being deviant from the native *ideal* (Category-Goodness Difference [CG Type]) (Best, 1995; Best et al., 2001). Thirdly, two distinct L2 sounds can be mapped into a single L1 sound, with both L2 sounds equally either acceptable or deviant (Single Category [SC Type]) (Best, 1995). The PAM predicts that the TC type displays excellent discrimination, followed by CG type (moderate to very good) and SC type (poor) in sequence (Best, 1995). Assimilation patterns that lead to poor discrimination may be associated with high degrees of similarity between two foreign categories (Best & Tyler, 2007).

On the other hand, the SLM postulates that L2 learners perceive L2 phones as either “new,” “similar,” or “identical” to their L1 phones (Flege, 1987). If L2 learners fail to find L1 phones corresponding to L2 ones, the L2 sounds are “new” to L2 learners (Flege, 1987). On the other hand, an L2 phone that is perceived to be “similar” to a certain L1 sound is categorized as the perceptually closest L1 sound (Flege, 1987). The sound appears to be found in both L1 and L2, but in fact, there is a systematic difference between them (Flege, 1987). Lastly, L2 learners may perceptually analyze L2 sounds as being included in L1 categories; the perceptual identification of L1 and L2 sounds into a single L1 phonic category (Flege, 1995), the phenomenon of which is also referred to as “diaphones” by Weinreich (1957, p. 8). The SLM points out that the more similarity between L1 and L2 is perceived by learners, the more challenging it is for learners to establish a separate category for the L2 sounds (Flege, 1987). In other words, the degree of perceived similarity between L1 and L2 inversely correlates with the possibility of forming a new category for the L2 sound (Flege, 1995, 2003).

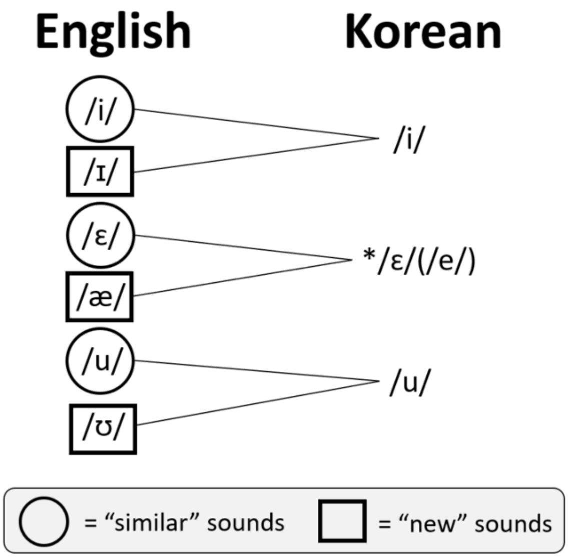
Two kinds of tasks, *discrimination* and *identification*, are experimentally utilized for assessing the perception of phonetic contrasts (Strange & Shafer, 2008). While discrimination tasks force a listener to decide on whether the recorded stimuli present the same or different sounds (Baker et al., 2002; Tsukada et al., 2005; Hong, 2007), identification tasks require a listener to make a decision on which item corresponds to the recorded stimulus (Lee & Cho, 2015, Lee & Shin, 2015).

Studies on Korean learners' perception of English vowel contrasts have revealed that Korean learners have difficulty in learning English vowel contrasts /i-ɪ/, /ɛ-æ/, and /u-ʊ/ (Hong, 2007; Ingram & Park, 1997; Kim & Kim, 2003; Silva, 2004; Tsukada et al. 2007). Kim and Kim (2003) reported that Korean EFL learners failed to distinguish the English vowel pairs like /i-ɪ/ and /ɛ-æ/. Likewise, Tsukada et al. (2005) examined Korean learners' actual perceptual sensitivity toward English vowel pairs /i-ɪ/, /e-ɛ/, /ɛ-æ/, and /ɑ-ʌ/, utilizing a categorical discrimination test (A' score) (Snodgrass et al., 1985; Flege et al., 1999; Flege & MacKay, 2004; Frieda & Nozawa, 2007). The result showed that Korean adult learners generally demonstrated low A' scores (low perceptual sensitivity) across the four English vowel pairs. Among the English pairs, the pair /ɛ-æ/ was found to be the most difficult one to discriminate for both Korean children and adults (Tsukada et al., 2005). This perceptual reduction of English front adjacent vowels /ɛ-æ/ by native Korean adults was also found in Korean female subjects' production in Yang's (1996) study. It appears to be attributed to the *merging* phenomenon in the Korean vowel pair /e-ɛ/. Ingram and Park (1997) also found that Korean learners tend to assimilate Australian English vowel pairs /ɛ-æ/ to Korean /ɛ/ (/e/). Hong (2007) showed that Korean learners of English tend to assimilate two distinct English vowels like /i-ɪ/, /ɛ-æ/, and /u-ʊ/ to a single Korean vowel like /i/, /e/, and /u/, respectively. A similar assimilation pattern was also observed in Silva's (2004) L1 and L2 sound mapping study. Silva (2004) conducted a contrastive analysis of English and Korean by analyzing the assimilation patterns of front vowels observed in Korean loanwords from English. This analysis was based on the belief that Korean loanwords from English fully reflect the host language's phonology (Silva, 2004). She revealed that English sounds /i/ and /ɪ/ are assimilated to Korean /i/ and English vowels /ɛ/ and /æ/ is to an on-going merging Korean vowel /ɛ/ (/e/) (Silva, 2004). Consequently, she concluded that there is no feasible way to represent the tense-lax distinction in Korean. In general, it appears that English vowel contrasts /i-ɪ/, /ɛ-æ/, and /u-ʊ/ are challenging for Korean learners to learn. In the PAM terms, Korean learners of English display a Single Category pattern (Best, 1995) toward English vowel pairs /i-ɪ/, /ɛ-æ/, and /u-ʊ/, leading to poor discrimination of the sounds (Lee & Cho, 2015). Still, these three English vowel pairs do not display the same degree of difficulty for Korean learners. Studies revealed that Korean learners discriminate English vowels /i-ɪ/ better than /ɛ-æ/ or /u-ʊ/ (Tsukada et al., 2005) and /u-ʊ/ better than /ɛ-æ/ (Hong, 2012; Kahng, 2006). For example, Tsukada et al. (2005) reported that both Korean adults and children showed higher A’ scores (perceptual sensitivity) toward the English vowel pair /i-ɪ/ than /ɛ-æ/. As a result, it can be assumed that Korean learners have difficulty discriminating English vowel pairs in the order of /i-ɪ/, /u-ʊ/, and /ɛ-æ/.

English and Korean have /i, e, ɛ, o, u, ʌ/ in common, though not the same, while there is no /ɪ, æ, ʊ, ɑ/ in Korean at all (Lee & Rhee, 2019; Lee & Cho, 2015). Yang (1996) acoustically analyzed Korean learners’ production of English vowels. He found that Korean /u/ is closer to English /u/ than /ʊ/. Besides, his analysis also displayed that Korean /i/ is more closely related to English /i/ than /ɪ/, and Korean /ɛ/ is to English /ɛ/ than /æ/. Likewise, Han et al. (2011), in their study on interlanguage speech intelligibility benefit, also classified /ɪ, æ/ as non-match sounds and /i, ɛ/ as match sounds for Korean learners. In the SLM term, between the sounds in each English vowel pair /i-ɪ/, /ɛ-æ/, and /u-ʊ/, the former sounds of each pair are “similar” sounds, and the latter ones of each pair are “new” sounds for Korean EFL learners (Lee & Cho, 2015; Suh, 2019). Lee and Cho (2015) found that the perception of “new” /ɪ, æ, ʊ/ sounds was more accurate than that of “similar” sounds, /i, ɛ, u/, in the forced-choice identification test, which corroborates what the SLM predicts. Thus, despite the relatively high degree of difficulty in perceiving “new” sounds (Escudero, 2009), L2 learners are more likely to successfully form a distinct category for “new” sounds in each pair than “similar” sounds in their own phonetic space (Flege, 1995, 2003; Milenova, 2015).

Taken together, two tense-lax English vowel pairs and one lax English vowel pair — /i-ɪ/, /u-ʊ/, and /ɛ-æ/ — are selected as target pairs for this study. A schematic representation of Korean learners' perceptual mapping pattern is summarized in Figure 2.2. These vowels are reported to be particularly difficult for Koreans due to the perceptual assimilation of two distinct English sounds to a single Korean sound. Between the sounds in each pair, one L2 sound is perceived as more "similar" to the corresponding L1 sound than the other ("new").

Figure 2.2 *Korean Learners' Perceptual Mapping Pattern of Six English Vowels to Three Korean Vowels*



Note. * Merging of the two Korean sounds is underway.

Notably, the English mid front tense vowel /e/ in the pair /e-ɛ/ in Smith et al.'s (2019) study is replaced with another monophthong vowel /æ/ in this study. This is because the lax counterpart in the original tense-lax pair, /ɛ/, is undoubtedly a monophthong, whereas /e/ takes on a diphthongized trait as [eɪ]. Owing to its diphthongized characteristic, /e/ becomes more salient than /ɛ/ to Koreans, resulting in Koreans' relative well-discrimination between the two (Tsukada et al., 2005). Besides, several studies revealed that /ɛ-æ/ is much more difficult to discriminate for Koreans than /e-ɛ/ (Hong, 2012; Tsukada et al., 2005). Thus, the English pair /ɛ-æ/ takes the place of /e-ɛ/ in this study.

Among the sounds in each target pair, literature has reported that when an L2 sound is phonetically close to an L1 category, the learner is less likely to establish a relevant phonetic category (Flege, 1995; Flege, 2003; Milenova, 2015). That is, learners have distinct perceptual mapping mechanisms for "new" and "similar" sounds, respectively (Escudero, 2009). Escudero (2009) argued that learners *create* a novel category for "new" sounds, whereas they *adjust* their perceptual mappings and category boundaries for "similar" sounds. Therefore, as a way of examining the different perceptual mapping mechanisms between the two sounds in each English vowel pair, the degree of intra-speaker variability between the two sounds in each pair can be compared.

The research based on the SLM has uncovered the anticipated difficulties of L2 sound contrasts for language learners of different L1's. However, these studies mainly focused on the status quo of L2 learners' speech learning products at the moment so that the general learning tendency of L2 learners can be identified. Thus, whether learners are in the process of L2 speech learning or not is unclear. This is important because the fundamental presumption of the SLM is that L2 speech learning is a continual process. More specifically, the SLM assumes that "the phonetic systems used in the production and perception of vowels and consonants *remain adaptive over the life span*, and that phonetic systems reorganize in response to sounds encountered in an L2 through the addition of new phonetic categories, or through the modification of old ones" (Flege, 1995, p. 233; italics in original). In other words, L2 learners are struggling to find proper perceptual targets in order to ultimately create a new category for an L2 sound. In this respect, language learners' L2 speech learning deserves to be seen as a process rather than a result that is invariable. Thus, in order to capture an aspect of learners' learning process, the concept of intra-speaker variability by Smith et al. (2019) can be utilized as one of the potential indicators for observing whether learning is in progress. For example, it can be hypothesized as if language learners show greater intra-speaker variability than native speakers do, they are in the process of developing their linguistic skills by testing their own hypotheses about a sound of a language.

2.1.5. Non-native Contrastive Sounds and Relative Functional Load

Research has revealed that the importance of segmental errors to speech intelligibility differs (Catford, 1987; King, 1967; Levis, 2018; Munro & Derwing, 2006). For example, Munro and Derwing (2006) found that two consonant pairs in syllable onset, /l-n/ and /θ-f/, have a different impact on listeners' comprehensibility ratings. The errors in /l-n/ affect listeners' comprehensibility much more than those in /θ-f/. They ascribe the discrepancy of the relative importance of one to another to the distinct functional load of the two sound pairs. Functional load conceptualizes the gravity of errors of contrastive sounds in speech intelligibility. It is defined as follows:

> "The term functional load is customarily used in linguistics to describe the extent and degree of contrast between linguistic units, usually phonemes. In its simplest expression, functional load is a measure of the number of minimal pairs which can be found for a given opposition. More generally, in phonology, it is a measure of the work which two phonemes (or a distinctive feature) do in keeping utterances apart – in other words, a gauge of the frequency with which two phonemes contrast in all possible environments" (King, 1967, p. 831).

This idea has developed by Catford (1987), who calculated Relative Functional Load (RFL). The RFL data was obtained from about 1,000 words, which are everyday vocabulary items encompassing various semantic domains (Koffi, 2021). Then, the analyst narrowly transcribes all the words "and carefully catalogs all the lexical minimal pairs and/or all phonetically similar sounds that occur in the same environment" (Koffi, 2021, p,48). Finally, the RFL is calculated as the percentage of the number of minimal pairs of the target sounds to the number of all the words that the contrasts can occur in word initial, medial, or final positions. The RFL directly corresponds to the degree of intelligibility (Koffi, 2021). The RFL percentages of the target English vowel contrasts for this study are presented in Table 2.1 (Adapted from Koffi (2021, pp. 49-50)).

Table 2.1 *Relative Functional Load (RFL) Percentages and Its Correlations to Intelligibility*

Target Vowel Phonemes in This Study	**RFL (%)**	**Intelligibility Rating (RFL range (%))**
/i-ɪ/	95	Poor intelligibility (75-100)
/ɛ-æ/	53	Mediocre intelligibility (50-74)
/u-ʊ/	7	Good intelligibility (0-24)

Note. Adapted from Koffi (2021, pp. 49-50)

The replacement of /i/ with /ɪ/ has the most detrimental impact on intelligibility because the RFL between /i/ and /ɪ/ is 95%, leading to poor intelligibility. If one substitutes /ɛ/ for /æ/ in the same place in a word, the likelihood of unintelligibility is not bad. This is because the RFL between /ɛ/ and /æ/ is 53%. The substitution of the sounds between /u/ and /ʊ/ has the least harmful effect on intelligibility as the RFL between /u/ and /ʊ/ is just 7%, resulting in good intelligibility. As a result, the gravity of the three target English vowel pairs /i-ɪ/, /ɛ-æ/, and /u-ʊ/ on speech intelligibility differs. The information on the RFL of segmental errors can serve as a reference for setting priorities in pronunciation teaching.

2.2. Production of L2 Sounds: Intra-Speaker Variability of Learner Language

2.2.1. Foreign Accentedness and Intra-Speaker Variability

Discussions on English pronunciation instructions have revolved around two main conflicting principles; the nativeness principle and the intelligibility principle (Levis, 2005). While the nativeness principle aims at making language learners achieve native-like pronunciation, the intelligibility principle simply holds that if learners' utterances are understandable, it does not matter whether they have foreign accents or not (Levis, 2005). These principles have greatly influenced the status of foreign accentedness in the field for a long time.

It has been acknowledged that the nativeness principle presents unrealistic goals for adult learners in L2 pronunciation teaching and learning (Munro & Derwing, 2015b; Saito, Trofimovich, & Isaacs, 2016), as many studies reported that it is absolutely challenging for adult language learners to attain nativelike pronunciation, though not impossible (Abrahamsson & Hyltenstam, 2009; Johnson & Newport, 1989; Levis, 2018). In addition, studies have proved that foreign-accented speech does not always result in communication breakdown (Derwing & Munro, 1997; Munro & Derwing, 1995). Most of all, as Derwing and Munro (1997) noted, foreign accents are just different ways of talking; no accent is superior to any others. In light of this, *English as an international language* (Jenkins, 2000) — the intelligibility principle — is now widely upheld in the field. That is, L2 speech needs to be intelligible not merely from native English speakers' points of view, but from non-native speakers' perspectives as well who are willing to use English to communicate with people from different cultural and linguistic backgrounds (Jenkins, 2000).

Under the intelligibility principle, it has been underscored that L2 speech must be dealt with in terms of three different dimensions; intelligibility, comprehensibility, and accentedness (Derwing & Munro, 1997; Munro & Derwing, 1995). The general understanding of each term is as follows: Intelligibility can be understood as "the extent to which a speaker's message is actually understood by a listener" (Munro & Derwing, 1995, p. 76); Perceived comprehensibility as "judgments on a rating scale of how difficult or easy an utterance is to understand" (Derwing & Munro, 1997, p. 2); And accentedness as "the extent to which native listeners judge their speech to be accented" (Derwing & Munro, 1997, p. 2). Literature has constantly proved that these three elements are closely related but partially independent (Derwing & Munro, 1997; Munro & Derwing, 1995; Munro et al., 2006). Thus, foreign-accented speech does not always have detrimental influences on communication (Derwing & Munro, 1997; Munro & Derwing, 1995). That is, though foreign accents may negatively affect speech intelligibility and comprehensibility to some extent, it is not the only main cause of communication breakdown. Thus, a shift in perspective on foreign-accented speech in pronunciation teaching is called for. That is, the foreign-accented speech needs to be seen within the framework of L2 learners' interlanguage, not as a defective product as it is. Only then can meaningful English pronunciation instruction be given to language learners to facilitate communication.

If language learners' speech learning is viewed as a process rather than a one-off output, phonetic intra-speaker variability observed in speech could illuminate one of the aspects of language learners' speech learning processes. Learner language has been known to demonstrate variability as well as systematicity throughout language learning processes (Ellis, 2015). In fact, language learners generally display systematicity at every level of a language, including morphology, phonology, syntax, semantics, and pragmatics (Tarone, 1999; Bley-Vroman, 1983). However, they also manifest variability in the process, which is one of the major features of *interlanguage* – namely learner's developing second language knowledge (Ellis, 2015; Lightbown & Spada, 2017; Selinker, 1972; Smith et al., 2019; Song, 2012; Verspoor et al., 2008). This is because language learners formulate their own hypothesis regarding the target language and consistently monitor and modify it as they progress (Ellis, 2015; Lightbown & Spada, 2017). This agrees with Widdowson (1978), who also commented that "… change is only the temporal consequence of current variation" (p. 14).

Brown (2007) introduced four stages of learner language development, referring to the insights from the proposed model by Corder (1973). The first phase is called the presystematic stage (Corder, 1973), characterized as experimentation and inaccurate guessing about a language (Brown, 2007). It is a stage of random errors (Brown, 2007). After that, an emergent stage, also referred to as U-shaped learning (Gass et al., 2013), appears. At this stage, a correct form and an incorrect form occurs back and forth, and learners cannot correct the error even if it is pointed out by other people (Brown, 2007). The third stage is a systematic stage where learners display a more internally self-consistent form of a language (Brown, 2007). Learners at this point are capable of correcting their own errors when it is pointed out by others (Brown, 2007). The final stage is referred to as stabilization (Brown, 2007; Long, 2003). Learners at this phase are equipped with a relatively complete system and are able to self-correct the errors without others' help. Some researchers refer to the last stage of interlanguage as fossilization, or the cessation of learning. However, due to its negative connotation, researchers attempt to use the term *stabilization* more often in order to "leave open the possibility for further development at some point in time" (Brown, 2007, p. 270; Long, 2003)

Thus, it can be said that a learner language system generally displays dynamic and systematic changes throughout the language learning process in such a way that free variation (viz. interchangeable use) of a new form gives way to systematic variation (Ellis, 2015; Gass et al., 2013; Lightbown & Spada, 2017; Tarone, 1999). This is in line with the basic assumption of the speech learning model (SLM) (Flege, 1995): Each individual's idiosyncratic *phoneme targets* for each sound, which guide the articulation of a sound, are adaptable throughout the lifetime by virtue of relevant sufficient phonetic input (Cebrian, 2006; Flege, 1987; Smith et al., 2019). More specifically, as language experiences are accumulated, L2 learners' "phonetic systems reorganize in response to sounds encountered in an L2 through the addition of new phonetic categories, or through the modification of old ones" (Flege, 1995, p. 233). If this is the case, L2 learners may display some type of variability in their L2 speech learning processes by testing their own hypothesis, especially for tricky L2 sounds. In this respect, language learners' intra-speaker variability of a sound is worth investigating.

Phonetic variability, nevertheless, has often been considered noise while nativelike spectral or temporal attributes of L2 vowels have been paid much attention in the field (Cebrian, 2006; Flege et al., 1995, 2003; Lee & Rhee, 2019). However, there is a growing consensus among several researchers that the concept of variability must be recast as useful information instead of noise, and this feature must be included in speech perception models as a basic component of spoken word recognition (Clarke & Garrett, 2004; Pisoni, 1997; Nygaard & Pisoni, 1995). This is because perception and production of a sound of a language are inherently flexible to some extent, not invariable (Couper, 2015; Ladefoged & Broadbent, 1957). Even if a single native speaker of a language shows some degree of intra-speaker variability in the same utterances, their messages are generally understood most of the time among L1 speakers (Couper, 2015). Therefore, the perception and production of a sound of a language are not restricted to a fixed abstract range.

Rather, they are adaptable to the surrounding linguistic environments. (Ladefoged & Broadbent, 1957).

2.2.2. Intra-Speaker Variability and Communication

Intra-speaker variability is different from inter-speaker variability in that it is related “to the speech of *individual* L2 speakers and how consistent (i.e., ‘stable’) each person is in his/her own production of L2 speech sounds, as compared to the degree of variability shown by individual native speakers” (Smith et al., 2019, p. 141; italics in original). In this respect, language learners’ intra-speaker variability could be one of the indicators which show whether learners are struggling with L2 sound categorization or not. Then, the standard for the degree of intra-speaker variability needs to be set so that it can be used as a useful tool for exploring learner language in terms of the speech learning process. Regarding this, we can obtain insights from the observations on interlocutors’ role as listeners in communication and the traits of native speakers’ speech patterns.

Firstly, considering communication is a two-way street, foreign-accented speech has been blamed too much for impeding communication (Derwing & Munro, 2009). Moreover, from a different point of view, the negatively biased view on foreign accentedness implicitly disregards listeners’ flexible ability to adapt to unfamiliar sounds. To comprehend a speech successfully, the ability to perceive an individual sound as intended is required despite acoustic variations in the speech stream (Barcroft &

Sommers, 2005). Research on high-variability phonetic training (HVPT) has shown that listeners have flexible competence in adapting to unfamiliar vowel sounds (Iverson & Evans, 2012; Kingston, 2003). The HVPT is an effective training technique where listeners are trained with multiple speech stimuli in various phonetic contexts (Zhang et al., 2021). The studies have reported that listeners are generally adaptive to foreign-accented speech despite the different accents of interlocutors (Clarke & Garrett, 2004; Iverson & Evans, 2012; Kingston, 2003; Zhang et al., 2021). The primary assumption of these studies is that listeners could grasp and leverage phonological *regularities* even from a short foreign-accented speech (Clarke & Garrett, 2004). In other words, listeners could eventually catch up on interlocutors' speech patterns online if their speech sounds are reasonably consistent throughout the communication. Then, it can be assumed that as long as the sound production patterns of a non-native speaker are consistent, speech intelligibility could be relatively enhanced despite unfamiliar sound patterns in communication.

Secondly, given that native speakers of a language can understand each other despite some degree of phonetic variability of a sound, native speakers' degree of variability of a language could offer us a hint to one aspect of successful speech learning for L2 learners. Native speakers of a language also demonstrate some degree of intra-speaker variability of a sound during communication (Barcroft & Sommers, 2005; Couper, 2015; Lindblom, 1990a, 1990b). In fact, "acoustic forms of words and phonemes are different when produced by different speakers" in terms of "speaking rate, degree of stress, the talker's age and gender, and speaking style or clarity" (Couper, 2015, p. 419; Lindblom, 1990a, 1990b). In addition, "they are also different when produced by the same speaker in different occurrences, in different situations, and phonetic contexts" (Couper, 2015, p. 419). For example, Saraclar and Khudanpur (2000) revealed significant pronunciation differences between conversational real-time speech and citation forms in telephone conversations among American English speakers.

Regarding the issue, Lindblom's (1990b) theory of adaptive dispersion calls our attention to an important point in speech perception. According to Lindblom (1990b), speakers tend to keep "sufficient perceptual contrast" among speech sounds of different categories (p. 8). This *sufficient* contrast among sounds appears to be closely related to the perception and production of sounds in a relative manner (Yang, 1995). Indeed, some researchers have proved that L2 sound perception occurs in a relative manner rather than absolute (Clarke & Garrett, 2004; Ladefoged & Broadbent, 1957). Ladefoged and Broadbent (1957) reported that acoustic-phonetic perceptual patterns for a vowel category vary according to the preceding sentence with different frequency ranges. Thus, L1 speakers' speech variability found in L1 production seems to be contained within the extent to which the speakers can sufficiently contrast each speech sound in their phonetic space. Yet, it does not mean each vowel sound of a language has sharply defined phonemic boundaries in speakers' phonetic space. Rather, it means that despite the overlapping parts among sounds in one's phonetic space, successful communication can be achieved in most cases (Fry et al., 1962). In light of this, it can be assumed that the degree of intra-speaker variability of the native speakers of a language can be understood as reasonably consistent to listeners (Smith et al., 2019; Tarone et al., 1976). It might indicate that it is not the manifestation of the variability of a sound per se but the *regular* degree of variability of a sound to the extent to which an interlocutor can extract meaning that matters in communication. In this respect, it can be assumed that if language learners demonstrate a nativelike (regular) degree of intra-speaker variability of a sound in their speech, there is a possibility that they could be understood, if not fully, by interlocutors.

On balance, the regular degree of intra-speaker variability is one of the main characteristics of native speakers of a language, which is beneficial for listeners to adapt to communication. Thus, when it comes to the degree of intra-speaker variability, the terms *regular* and *nativelike* are identified with each other in this study. Consequently, it is hypothesized in this study that if language learners demonstrate nativelike, i.e., regular, degree of intra-speaker variability, their speech could be understood by their interlocutors during the communication.

2.3. A Relationship between Perception and Production

Research has shown that perception is closely related to the production in L2 speech learning (Barry, 1989; Borden et al., 1983; Flege, 1993, 1995; Liberman, 1957; Liberman & Mattingly, 1985; Neufeld, 1988; Zhang et al., 2009). For instance, the SLM (Flege, 1995) posits "that without accurate perceptual *targets* to guide the sensorimotor learning of L2 sounds, production of the L2 sounds will be inaccurate" (p. 238). Similarly, the motor theory of speech perception (Liberman, 1957; Liberman & Mattingly, 1985) assumed that the brain interprets speech information based on articulatory gestures, not acoustic signals. In general, the SLM and the motor theory demonstrate that perception is inextricably linked to speech production.

There are mixed results in the chronological order of perception and production (Escudero, 2007). Some argued perception precedes production (Borden et al., 1983; Flege, 1993; Neufeld, 1988), while others challenged the chronological precedence of perception over production in language learning (Flege & Eefting, 1987; Sheldon & Strange, 1982; Tsukada et al., 2005). For example, Tsukada et al. (2005) reported that the English segmental pairs, which native Korean children failed to discriminate, were successfully produced by the same speakers. Still, as they admitted, it could be ascribed to several methodological limitations; firstly, the tests for assessing perception and production were inherently inadequate; secondly, the difficulty of each test was not properly controlled. Likewise, Escudero (2007) pointed out that other studies reporting counterevidence to the precedence of perception over production appear to have similar methodological shortcomings, including too many controlled task types and/or improperly controlled experimental environments, faulty data analyses, and so on. Consequently, it is generally accepted in the field that perception precedes production in the language learning processes (Ellis, 2015; Escudero, 2007). In light of this, it is necessary to incorporate the perceptual aspect of speech (perceptual sensitivity) into the discussion of intra-speaker variability (production).

The following possibilities can be supposed in relation to intra-speaker variability, perceptual sensitivity, and learner language stages. Table 2.2 displays possible relationships among intra-speaker variability, perceptual sensitivity, and stages of learner language. If language learners with perceptual sensitivity toward English vowel pairs demonstrate a regular (stable) pattern of intra-speaker variability of a sound, they can be said to be at the systematic or stabilization stage (Brown, 2007). Yet, suppose learners

Table 2.2 *Possible Relationships among Intra-Speaker Variability, Perceptual Sensitivity, and Stages of Learner Language*

Intra-Speaker Variability	Perceptual Sensitivity	Stages of Learner Language
Irregular	No	Presystematic
Irregular	Yes	Emergent
Regular	Yes	Systematic or Stabilization
Regular	No	Stabilization (Lack of Knowledge)

who lack perceptual sensitivity toward English vowel pairs demonstrate a stable intra-speaker variability of a sound. In that case, it may reflect the learners' lack of knowledge about L2 sounds that they themselves are unaware of. On the other hand, if learners with perceptual sensitivity toward English vowel pairs display an irregular pattern of intra-speaker variability of a sound, they are likely to test their hypotheses about an L2 sound as U-shaped learning (an emergent stage (Brown, 2007)). Still, if learners with low perceptual sensitivity show irregular intra-speaker variability of a sound, they may lack overall knowledge of L2 sounds (a presystematic stage (Brown, 2007)). In this respect, this study investigates the relationship between perceptual sensitivity toward and the intra-speaker variability of the three English vowel pairs.

2.4. Research Questions

This study aims at replicating and expanding previous research by Smith et al. (2019) on language learners' intra-speaker variability in producing American English vowel pairs. To this end, the following three questions were examined:

1. Do high-intermediate level Korean EFL learners show greater intra-speaker variability than General American English speakers do in the production of each pair /i-ɪ/, /ɛ-æ/, and /u-ʊ/?

2. Do high-intermediate level Korean EFL learners' productions of "new" English sounds [ɪ, æ, ʊ] show a similar degree of intra-speaker variability to "similar" English sounds [i, ɛ, u]?

3. Do high-intermediate level Korean EFL learners with high perceptual sensitivity toward three English vowel pairs, /i-ɪ/, /ɛ-æ/, and /u-ʊ/, demonstrate less degree of intra-speaker variability of the sounds?

Chapter 3. Research Design

3.1. Participants

3.1.1. Native English Speakers

Eight native English speakers speaking general American English from the United States of America (four females and four males) participated in this study. They were recruited by a snowball sampling method. The information on the language experience of participants is collected through a questionnaire. It includes questions about age, gender, parents' L1 and/or spouse's L1, length of residence in Korea, self-reported familiarity with Korean English accents, self-reported familiarity with other foreign accents of English, the highest level of education completed, major, training experience in linguistics, the list of foreign languages studied and self-reported proficiency for each language (Munro & Derwing, 2015b). A summary is presented in Table 3.1. As native English speakers' perceptions toward productions by Korean participants were not investigated by Smith et al. (2019), the information on their current surrounding languages and languages learned were not included.

3.1.2. Korean Learners of English

Thirty-five speakers living in South Korea volunteered for this study. They were recruited referring to their Test of English for International Communication (TOEIC) listening scores using a random sampling method with gender ratio for each group equal (Tannenbaum & Wylie, 2013): elementary (TOEIC listening scores below 275; below CEFR level of B1), intermediate (TOEIC listening scores between 276 and 399; below CEFR level between B1 and B2), and high-intermediate (TOEIC listening scores of 400 or higher; corresponding above CEFL level of B2). The recruitment documents were distributed through the online social network website *Every Time* for about ten universities in Korea and through *SNUlife*. Ultimately, a total of 35 participants volunteered to attend the experiment; 33 high-intermediate level participants, one intermediate level participant, and one elementary level participant were gathered. However, five of them were omitted from the analysis due to the insertion of repetitive noise in recording (1 Female / 1 Male), insincere responses (selecting option number one for all the 64 trials in the perceptual sensitivity task) (1 Male), or the insufficient number of participants for grouping (1 Female (intermediate level) / 1 Male (elementary level)).

Consequently, 30 high-intermediate level participants, 15 males and 15 females, were under analysis. The 30 high-intermediate level participants were undergraduate or graduate students born and raised or who spent most of their lives in Seoul or Kyung-gi province in Korea, thus speaking Standard Korean. Korean learners were asked about their language experience, age, gender, age of starting language learning, the amount of time studying English per week, and experience of studying abroad – country, region, and length of stay (Munro & Derwing, 2015b). Except for 11 participants who had studied abroad in English-speaking countries for two months to six years, the rest of the participants had never lived in English-speaking countries. A summary of the demographic information is presented in Table 3.2.

Table 3.1 *Age, Highest Level of Education Completed, Major, Training Experience in Linguistics, Length of Residence in Korean for Each of the Eight Native English Speakers*

ID1)	**Age**	**Highest level of education completed**	**Major**	**Training experience in linguistics**	**Length of Residence in Korea (year)**
NEF1	23	Bachelor's degree	TESOL	Yes	1.8
NEF2	30	Master's degree	Korean Studies	Yes	6.5
NEF3	24	Bachelor's degree	Journalism, Linguistics, and Global Communication	Yes	2.1
NEF4	28	Bachelor's degree	International Studies and Spanish	No	0
NEM1	29	Bachelor's degree	Asian Languages	Yes	7.7
NEM2	29	Bachelor's degree	Chemical Engineering	No	1.2
NEM3	34	Master's degree	English Education	Yes	12
NEM4	35	Master's degree	English Education	Yes	11

Note. 1) NE = Native English Speakers, F = Female, M = Male

Table 3.2 *Mean TOEIC Listening Score, Mean Age, Mean Age Beginning Learning English, Mean Length of Years Studying English, Mean Studying Hours Studying English Listening or Speaking a Week, and Experience of Studying Abroad for 30 Korean Participants*[1)]

					Experience of studying abroad	
TOEIC Listening Score	**Age**	**Age Beginning learning English**	**Length of studying English (year)**	**Hours studying English listening or speaking a week**	**# of participants**	**Length of residence (LOR) (year)**
467(26)	24(2.9)	7.6(2.5)	16.4(3.4)	1.5(1.8)	11	1.6(1.9)

Note. 1) Standard deviations are in parenthesis.

3.2. Procedure

A single-blind approach was adopted in order for the result to be less biased. Thus, it was expected that the possibility of the participants paying too much conscious attention to the articulation of the target vowels would be prevented to some extent. All the participants were recruited under the blindfolding title “Korean EFL Learners’ Perception and Production of American English Words.” At the very end of the research procedure, all of them were heard and explained the actual title and objective of the study — investigating not words but vowels. Even if they were told their data could be discarded if they did not want their data to be included in the study, none of the participants disapproved of using the data. An example of a debriefing document is available in Appendix A.

Every meeting was basically done one-on-one. Although some people were able to visit a soundproof lab in the early days of the experiment, most of the meetings were carried out through *Zoom client (5.1.2)* (Yuan, 2012). This was because the COVID-19 pandemic got worse as time went by. The researcher met nine out of 40 participants face-to-face. When meeting face-to-face, *Praat (Version 6.1.20beta)* (Boersma & Weenink, 2020) was mainly used in the soundproof lab. In the meantime, if participants cannot visit the lab, the researcher either visits their places or reserves a soundproof room around their living area. In these cases, a portable sound recorder (Tascam DR-100MKII) was used. When it comes to an online meeting, the participants were given guidelines about how to install *Praat* on their gadgets, precautions for recording, and a consent form to participate in the experiment in advance. When recording, they were guided to set to mono, 16-bit, and 41,000 Hz. The whole procedures of each meeting were under the supervision of the researcher. More than half of the participants used *Praat*, but others utilized pre-installed recording applications on their own gadgets because they failed to install *Praat*. The recorders included smartphones (e,g., iPhone, Galaxy, LG phones), tablet computers (e.g., iPad, Galaxy Tab), or personal computers. Though various gadgets were used by participants in this study, thanks to the advancement of technology, researchers have begun to recognize smartphones as a new option for recording sounds for acoustic analyses of speech (Yun et al., 2015; Petrizzo & Popolo, 2020). Thus, they were included in the analysis. Sound file formats that the participants handed in included *mp3* (1), *flac* (1), *m4a* (12), and *wav* (26); the number in parenthesis indicates the number of participants. The data for perceptual sensitivity was collected using *Google Form*. Both Korean and English versions of the perceptual sensitivity test were available in accordance with their own native language.

As for native English speakers, there were two meeting sessions with a time interval of six months. At the first meeting, the recording was carried out. Each participant was given a sheet of paper with a list of seven English sentences to be read. They were asked to produce at least five tokens while trying to provide the best production. At the second meeting, when verifying whether the perceptual sensitivity task worked properly, six out of eight native English speakers participated: one female and one male speaker dropped out because they were lost in touch. Honorariums of 10,000 and 15,000 won were given to native English speakers for the first meeting and the second one, respectively.

When it comes to Koreans, it was a one-off meeting. They recorded the same English sentences as what native English speakers read. Though they additionally produced six Korean vowels related to the target English vowels, they were not analyzed in this study. An honorarium of 10,000 won was given to native Koreans at the end of the experiment.

3.3. Stimuli

Four English vowel pairs were selected for this study. The three English vowel pairs (/i-ɪ/, /ɛ-æ/, /u-ʊ/) that have been found to be difficult to discriminate for most native Korean learners of English are mainly analyzed. The other pair (/i-ɑ/) is added when gauging their perceptual sensitivity toward the three target English vowel pairs (Tsukada et al., 2005). That is, it serves as a control pair to make sure whether the word discrimination task works properly.

Seven words in /hVd/ form are chosen that can elicit the seven English vowels in sequence: *heed, hid, had, head, who'd, hood, hod.* Unlike Smith et al. (2019), the target words were confined to the /hVd/ form to reduce the contextual influence of the coarticulatory effect. This is because the variability can be inflated due to phonetic contexts (Xie & Jeager, 2020). Instead, considering the linguistically restricted contexts of this study, the number of reading the sentences was increased to five times from three times in Smith et al. (2019). A carrier sentence, *"I like to say _______ some of the time"* (Smith et al., 2019), is used to help speakers to keep constant speech speed (Munro, 1993). The corresponding phonemic symbols for each target word were placed right below each word. The syllable onset and the coda in /hVd/ are deliberately chosen. On the one hand, it is because the glottal fricative /h/ is the only consonant that involves the whole vocal tract, from vocal folds to lips, like vowels, in its articulatory process, and therefore is expected to have the least effect on the articulation of the following vowel (Ladefoged & Johnson, 2014). On the other hand, the alveolar stop /d/ is selected as it makes the preceding vowel sound much longer than its voiceless counterpart /t/ (Ladefoged & Johnson, 2014). Thus, it is supposed to increase the chances of getting a longer stable state of each vowel production, even if it makes a minor difference.

3.4. Data Analysis

3.4.1. Acoustic Information of Vowels

A total of 1,140 tokens were analyzed as 38 speakers (eight native English speakers and 30 Korean participants) produced six target vowels five times. The sound file names consist of the initials of participants' nationality (native English speakers (NE) or Korean participants (NK)), gender (female (F) or male (M)), numbers in order (two digits), and the words containing target vowels; for instance, *NKF01had*. Though not considered by Smith et al. (2019), the sound files were sorted into four groups and analyzed with different settings: front and back vowel productions by a male participant and a female participant. This is because it is important to consider gender differences and different acoustic traits of front/back vowels in acoustic analysis.

After meticulously comparing the spectrograms to the recordings, the demarcations of all vowel tokens were manually marked on *Praat (Version 6.1.20 beta)* (Boersma & Weenink, 2020). The first, second, and third formants were taken from the midpoint into the vowel production using an open resource script (Crosswhite, n.d.) for *Praat (Version 6.1.20 beta)* (Boersma & Weenink, 2020) to minimize the co-articulatory effect from the surrounding sounds. If some of the formant values appeared to show atypically large variations, the spectrograms of a token were compared by listening to the recordings. The Burg method with 50 Hz pre-emphasis and window length of 0.025 seconds, which is as good as a Gaussian window duration of 0.050 seconds, was utilized. Referring to Yang (2019), the settings for a maximum number of formants and formant ceiling were adjusted differently in accordance with gender and vowel advancements as follows: 4.0 with a ceiling of 5,500 Hz for the front vowels of female speakers; 5.0

with a ceiling of 5,500 Hz for the back vowels of female speakers; 4.5 with a ceiling of 5,000 Hz for the front vowels of male speakers; and 5 with a ceiling of 5,000 Hz for the back vowels of male speakers.

Bark Difference Metric normalization was performed for all speech samples to adjust the formant differences between males and females (Syrdal & Gopal, 1986), leveraging the website *NORM: Vowel Normalization Suite 1.1* (Thomas & Kendall, 2007). The steps of normalizing the speech data using *NORM* (Thomas & Kendall, 2007) were as follows. Firstly, one should upload the vowel data file of the required template on *NORM*. Then, choose *Bark Difference Metric* at stage *3. Select normalization methods*, and click *Normalize!* at the bottom of the webpage. It is calculated based on the formula: $Z_i=26.81/(1+1960/F_i)-0.53$ (Traunmüller, 1997). As a result, the normalized height dimension is shown as Z_3-Z_1 (Bark), while the normalized front-back dimension is displayed as Z_3-Z_2 (Bark).

3.4.2. Intra-Speaker Variability

Following Smith et al. (2019), a four-scenario framework of formant and intra-speaker variability and coefficient of variation (CV) (Kesteven, 1946) was used to observe the relative intra-speaker variability of the six target vowel productions by 30 Korean participants. Firstly, the nativelikeness in the four-scenario framework meant that the mean formant and CV values of Korean EFL learners “were greater than or less than two standard deviations different from the native speakers’ average formant and

CV values" (Smith et al., p. 153). Secondly, the CV is calculated based on the standard deviation (*sd*) and the mean formant frequency ($\overline{x}$) of five repetitions of each vowel of each speaker utilizing the formula $sd/\overline{x}$ (Smith et al., 2019). The F1 and F2-F1 were normalized into Z_3-Z_1 (Bark) and Z_3-Z_2 (Bark), respectively, and were analyzed in terms of intra-subject variability. The value of CV made it possible to observe the relative dispersion of the speakers' productions (Kesteven, 1946; Smith et al., 2019).

3.4.3. Perceptual Sensitivity

A categorical discrimination task (A' score) (Snodgrass et al., 1985), which involves both change and no-change trials, was used to gauge Korean listeners' perceptual sensitivity toward three English vowel pairs (/i-ɪ/, /ɛ-æ/, /u-ʊ/). In addition to the three English vowel pairs, /i-ɑ/ was also included as a control pair which was found to be relatively easy to distinguish for Koreans (Tsukada et al., 2005). This control pair was used to see whether trials for assessing perceptual sensitivity toward each English vowel pair worked well and whether all participants retained enough working memory capacity to carry out the trials (Tsukada et al., 2005).

There are two types of trials, change trials and no-change trials. While change trials contain one odd element that needs to be distinguished (e.g., stimulus: hid_5 hid_3 $heed_7$; number subscriptions denote different speakers), no-change trials include a single vowel produced by three different speakers (e.g., stimulus: $heed_3$ $heed_5$ $heed_8$). It is based on the assumption that “establishing a phonetic category will increase sensitivity to differences between instances of the newly formed category and other L1 and L2 categories, and will also reduce sensitivity to token-to-token variation *within* the newly formed category” (Tsukada et al., p. 272; italics in original). Put simply, it is based on “the belief that phonetic category formation leads to a decreased sensitivity to within-category differences and an increased sensitivity to differences between the new category and adjacent categories” (Flege, 2003, p. 337).

Words in /hVd/ form were extracted leveraging *Praat* to be used for constructing the perceptual sensitivity items. The edited recording file for each item was created using *Audacity (Version 1.3.4.-beta)* (Audacity Team, 2008). The recordings for each item were constructed in such a way that 800 milliseconds (ms) of silence were attached between each word (Cheour-Luhtanen et al., 1995: Rinne et al., 1999). At the very beginning and at the very end of each recording chunk, 500 ms of silence were attached. The recordings for both trials involve three different tokens spoken by three different native English speakers with a gender ratio balanced out.

Sixty-four questions in total – 16 items for four English vowel pairs, including a control pair /i-ɑ/ – were constructed. Four English vowel pairs (/i-ɑ/, /u-ʊ/, /ɛ-æ/, /i-ɪ/) constituted four sections. Within each section, there were eight items for change and no-change trials, respectively, and the order of the items was randomly shuffled. Although instructions on how the item works were given in advance, the control pair (*heed-hod*) was introduced at the beginning of the test, so listeners could have a chance to get used to the item format better. The other three target pairs – *who'd-hood, had-head*, and *heed-hid* followed the control pair (/i-ɑ/) in order. The same question applies to all the items in common – *Which one is distinct from the others?* There were four options for each item presented only with numbers. The number of each option corresponds to the presenting order of the recordings. As there were three types of words for each item, the last option, number 4, always indicates *none of the above*. To sum up, the answers for the change trials were among numbers 1, 2, or 3, whereas the answers for no-change trials were always number 4. The general settings for perceptual sensitivity items for English speaking participants on *Google Form* can be seen in Appendix B.

A' score is based on the proportion of *hits* (H) and the proportion of *false alarms* (FA) for each English vowel pair in change and no-change trials. The proportion of H is produced based on the number of correct selections in change trials, while the proportion of FA is calculated based on the number of incorrect selections in no-change trials (Tsukada et al., 2005). Three different calculation methods are applied in accordance with the following cases; firstly, if H and FA are found to be the same, the A' score is set to 0.5; secondly, if H surpasses FA, the formula, "A'=0.5+((H-FA)*(1+H-FA)/((4*H)*(1-FA))," is used; and lastly, if H falls behind FA, the formula, "A'=0.5-((FA-H)*(1+FA-H)/((4*FA)*(1-H))," is used (Tsukada et al., 2005, pp. 272-273). A' score ranges from 0 to 1. The maximum score is 1, which displays perfect sensitivity, while a score of 0.5 or below shows a lack of phonetic sensitivity (Flege et al., 1999; Snodgrass et al., 1985; Tsukada et al., 2005). The produced A' scores were all rounded to two decimal places. In this study, participants who scored more than 0.5 were considered to have perceptual sensitivity, and those who scored 0.5 or less were considered to have no perceptual sensitivity. Thus, only three scenarios can be produced: perfect perceptual sensitivity (A' score = 1), some degree of perceptual sensitivity (A' score > 0.5), or lack of perceptual sensitivity (A' score ≤ 0.5).

Participants could listen to the recordings as much as they wanted and were also allowed to guess the answer. In order to see how confident they were in distinguishing the target pairs, the degree of listeners' certainty about their answers for each item was asked. A 6-point Likert scale (0 = totally guessed answer, 1 = almost a guess, 2 = not sure, 3 = sure, 4 = almost certain, 5 = certain) was used (Hasan et al., 1999). The threshold value was set to 2.5, following Hasan et al. (1999). Thus, if the certainty of response index (CRI) was above 2.5, it was considered high certainty about the answer and vice versa (Hasan et al., 1999).

3.4.4. Statistical Analysis

Intra-speaker variability and perceptual sensitivity of the three target English vowel pairs (/i-ɪ/, /ɛ-æ/, /u-ʊ/) by 30 high-intermediate level Korean EFL participants were statistically analyzed leveraging *SPSS (Version 28.0)* (IBM Corp., 2022). In order to examine the research questions of the study, Welch's two-tailed *t*-test, paired samples *t*-test, and simple linear regression were conducted, respectively. The reason for using Welch's *t*-test instead of Student's *t*-test is that the basic assumption of Student's *t*-test about normality and homogeneity of variance is hard to be met in real life, and thus cannot be considered as a default method for statistical tests (Delacre et al., 2017; Erceg-Hurn, & Mirosevich, 2008). Besides, Delacre et al. (2017) warned that if this basic assumption fails to be satisfied, the Student *t*-test produces unreliable results. They also reported that Welch's *t*-test controls the possibility of the type 1 error, which can inflate the false positive. As a result, when comparing the mean of two independent groups, Welch's *t*-test was used in this study.

Firstly, to explore whether high-intermediate level Korean EFL participants demonstrate a larger degree of intra-speaker variability, Welch's two-tailed *t*-test was conducted. Secondly, whether high-intermediate level Korean EFL participants show different degrees of intra-speaker variability in "new" English sounds [ɪ, æ, ʊ] and "similar" English sounds [i, ɛ, u] is examined using paired samples *t*-test for each English vowel pair. Lastly, simple linear regression was carried out to explore how high-intermediate level Korean EFL participants' perceptual sensitivity is related to the degree of intra-speaker variability (CV).

The corresponding effect sizes (Cohen's *d*) were also presented to complement the interpretation of the significance level. The interpretation of the effect size referred to L2 research-specific guidelines proposed by Plonsky and Oswald (2014). They recommended using the benchmark of d = 0.4, d = 0.7, and d = 1.0 for small, medium, and large effects, respectively, for independent samples in second language acquisition research (Plonsky & Oswald, 2014, p. 889).

Chapter 4. Results

4.1. Intra-Speaker Variability of Native English Speakers and Korean Participants

Whether high-intermediate level Korean EFL participants display a nativelike degree of intra-speaker variability was examined using a four-scenario framework by Smith et al. (2019) and independent samples *t*-test.

Firstly, the four scenarios introduced by Smith et al. (2019) were used to observe whether 30 high-intermediate level Korean EFL participants showed nativelike intra-speaker variability in their English vowel productions of each pair /i-ɪ/, /ɛ-æ/, and /u-ʊ/. As native-like production of vowel formants was beyond the scope of this study, I limited myself to focusing on intra-speaker variability in this framework. The first and third scenarios by Smith et al. (2019), in combination, represent the nativelike degree of intra-speaker variability. As can be seen in Table 4.1 (Adapted from Smith et al. (2019, p. 155)) and Table 4.2 (Adapted from Smith et al. (2019, p. 155)), almost all high-intermediate level Korean EFL participants demonstrated nativelike intra-speaker variability in both tongue height (Z_3-Z_1 (Bark) (97% [54% (Scenario 1) + 43% (Scenario 3)]) and tongue advancement (Z_3-Z_2 (Bark)) (94% [32% (Scenario 1) + 62% (Scenario 3)]). It means almost all high-intermediate level Korean EFL participants did not show greater intra-speaker variability than native English speakers did in the production of English sounds.

Table 4.1 *Tongue Height (Z_3-Z_1 (Bark)) Similarities/Differences and Intra-Speaker Variability (CV) Findings across 30 High-Intermediate Level Korean EFL Participants and the Scenarios They Reflect*

	Scenario 1 Similar formants Similar variability	**Scenario2 Similar formants Different variable**	**Scenario 3 Different formants Similar variability**	**Scenario 4 Different formants Different variable**
[i]	18	0	11	1
[ɪ]	13	0	17	0
[ɛ]	24	0	6	0
[æ]	12	0	18	0
[u]	21	1	8	0
[ʊ]	10	1	17	2
Total	**98 (54%)**	**2 (1%)**	**77 (43%)**	**3 (2%)**

Note. Adapted from Smith et al. (2019, p. 155)

Table 4.2 *Tongue Advancement (Z_3-Z_2 (Bark)) Similarities/Differences and Intra-Speaker Variability (CV) Findings across 30 High-Intermediate Level Korean EFL Participants and the Scenarios They Reflect*

	Scenario 1 Similar formants Similar variability	**Scenario2 Similar formants Different variable**	**Scenario 3 Different formants Similar variability**	**Scenario 4 Different formants Different variable**
[i]	18	3	5	4
[ɪ]	0	1	29	0
[ɛ]	15	1	14	0
[æ]	9	1	20	0
[u]	10	0	20	0
[ʊ]	6	1	23	0
Total	**58 (32%)**	**7 (4%)**	**111 (62%)**	**4 (2%)**

Note. Adapted from Smith et al. (2019, p. 155)

Secondly, independent samples *t*-test was performed to compare the degree of intra-speaker variability (CV) between native English speakers and Korean EFL participants. The null hypothesis was that the degrees of intra-speaker variability in all six English vowels between native English speakers and high-intermediate level Korean EFL participants are the same.

Table 4.3 *Means and Standard Deviations of Intra-Speaker Variability (CV) of Tongue Height (Z_3-Z_1 (Bark)) in Six English Vowels by Native English Speakers and Korean Participants*

	[i]	[ɪ]	[ɛ]	[æ]	[u]	[ʊ]
NE(N=8)	0.03(0.01)	0.06(0.04)	0.05(0.03)	0.08(0.08)	0.04(0.04)	0.06(0.08)
NK(N=30)	0.04(0.03)	0.04(0.02)	0.05(0.03)	0.04(0.02)	0.04(0.04)	0.05(0.07)

Note. Standard deviations are in parenthesis; NE = native English speakers; NK = Korean participants

Table 4.4 *A Summary of Welch's t-test about the Comparison of Intra-Speaker Variability (CV) in Tongue Height (Z_3-Z_1 (Bark)) between Native English Speakers and Korean Participants*

					95% Confidence Interval	
English Vowels	***t***	***df***	***p*-value (two-tailed)**	**Cohen's *d***	**Lower**	**Upper**
[i]	0.54	19.05	0.59	0.16	-0.62	0.94
[ɪ]	-1.02	7.80	0.34	-0.61	-1.40	0.19
[ɛ]	0.86	11.20	0.95	-0.26	-0.81	0.75
[æ]	-1.30	7.39	0.23	-0.88	-1.68	-0.71
[u]	-0.22	12.30	0.83	-0.81	-0.86	0.70
[ʊ]	-0.10	9.54	0.92	-0.04	-0.83	0.73

Note. The significance level is .05.

As can be seen in Table 4.3 and Table 4.4 there was not a significant difference in the degree of intra-speaker variability of all six English vowels for tongue height (Z_3-Z_1 (Bark)) between native English speakers and Korean participants ($t(19.95) = 0.54$, $p = 0.59$ ([i]); $t(7.80) = -1.02$, $p = 0.34$ ([ɪ]); $t(11.20) = 0.86$, $p = 0.95$ ([ɛ]); $t(7.39) =-1.30$, $p = 0.23$ ([æ]); $t(12.30) = -0.22$,

p = 0.83 ([u]); t(9.54) = -0.10, p = 0.92 ([ʊ]). Thus, the null hypothesis was adopted for all six vowels of tongue height (Z_3-Z_1 (Bark)), indicating that Korean participants show nativelike degree of intra-speaker variability.

Table 4.5 *Means and Standard Deviations of Intra-Speaker Variability (CV) of Tongue Advancement (Z_3-Z_2 (Bark)) in Six English Vowels by Native English Speakers and Korean Participants*

	[i]	**[ɪ]**	**[ɛ]**	**[æ]**	**[u]**	**[ʊ]**
NE(N=8)	0.08(0.08)	0.11(0.09)	0.08(0.04)	0.07(0.05)	0.11(0.06)	0.07(0.04)
NK(N=30)	0.15(0.10)	0.17(0.13)	0.10(0.06)	0.09(0.05)	0.08(0.06)	0.09(0.08)

Note. Standard deviations are in parenthesis; NE = native English speakers; NK = Korean participants

Table 4.6 *A Summary of Welch's t-test about the Comparison of Intra-Speaker Variability (CV) in Tongue Advancement (Z_3-Z_2 (Bark)) between Native English Speakers and Korean Participants*

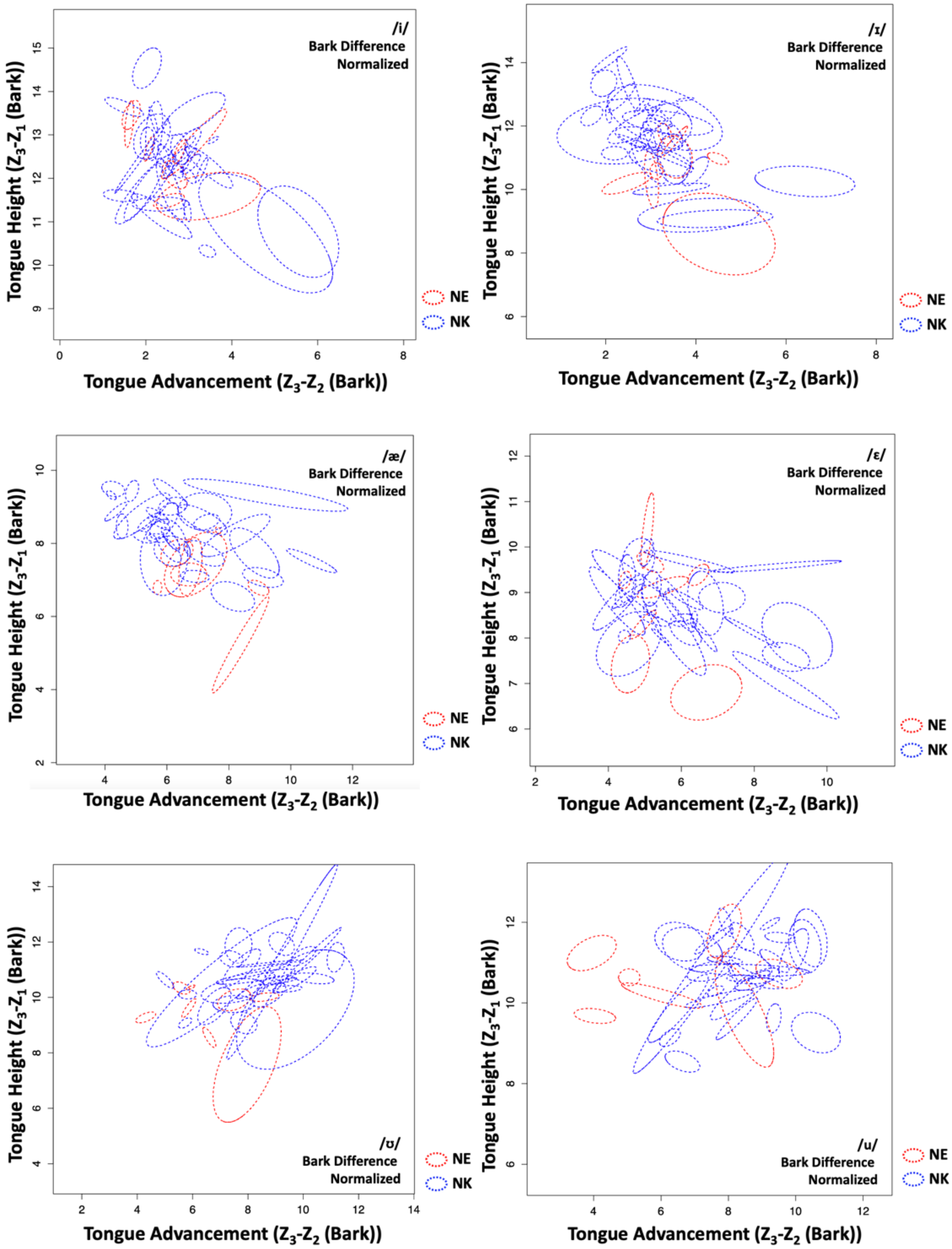
English Vowels	***t***	***df***	***p*-value (two-tailed)**	**Cohen's *d***	**95% Confidence Interval**	
					Lower	**Upper**
[i]	2.25	14.40	0.04*	0.76	-0.47	1.56
[ɪ]	1.15	15.90	0.15	0.49	-0.30	1.28
[ɛ]	0.86	16.15	0.40	0.27	-0.51	1.05
[æ]	0.97	11.77	0.35	0.37	-0.42	1.15
[u]	-1.15	10.46	0.27	-0.48	-1.26	0.31
[ʊ]	1.29	21.70	0.21	0.36	-0.42	1.15

Note. The significance level is .05.

As for tongue advancement (Z_3-Z_2 (Bark)), Table 4.5 and 4.6 shows that there was a significant difference in the degree of intra-speaker variability of the English vowel [i] between native English speakers and Korean participants ($t(14.40) = 2.25$, $p = 0.04$). Except for the [i], however, there was no significant difference in the degree of intra-speaker variability of the other five English vowels for tongue advancement (Z_3-Z_2 (Bark)) between native English speakers and Korean participants ($t(15.90) = 1.15$, $p = 0.15$ ([ɪ]); $t(16.15) = 0.86$, $p = 0.40$ ([ɛ]); $t(11.77) = 0.97$, $p = 0.35$ ([æ]); $t(10.46) = -1.15$, $p = 0.27$ ([u]); $t(21.70) = 1.29$, $p = 0.12$ ([ʊ]). Thus, the null hypothesis was adopted for the five vowels, [ɪ], [ɛ], [æ], [u], and [ʊ], of tongue advancement (Z_3-Z_2 (Bark)), meaning high-intermediate level Korean EFL participants have a similar degree of intra-speaker variability to the native English speakers. Still, when it comes to [i] of tongue advancement (Z_3-Z_2 (Bark)), though the effect size was medium (Cohen's $d = 0.76$, lower limit = -0.47, upper limit = 1.56), the difference in the degree of intra-speaker variability between the native English speakers and Korean participants was not statistically important because the range of the 95% confidence interval passes through zero. According to Lee (2016), "a 95% confidence interval for effect size means a 5% alpha error level for effect size. … If this 95% confidence interval contains *zero*, it indicates *statistical non-significance*" (p. 559). Thus, consequently, it can be understood as Korean EFL participants did not necessarily show a significantly different degree of intra-speaker variability in the production of [i] in terms of tongue advancement (Z_3-Z_2 (Bark)) from that of native English speakers.

Figure 4.1 demonstrates six vowel charts of tongue height (Z_3-Z_1(Bark)) and tongue advancement (Z_3-Z_2(Bark)) converted from the median F1 and F2-F1 values for eight native English speakers and 30 Korean participants. Each ellipse indicates one standard deviation from the mean, displaying a relative degree of intra-speaker variability of a sound by the participants. The red ovals indicate native English speakers, while the blue ones signify Korean participants. The speakers' IDs for each ellipsis in the six vowel charts were all deleted as they greatly interfered with observation, especially for the concentrated areas. Still, whenever any unusual cases were detected, the researcher identified them off the record. The vowel charts in Figure 4.1 generally show that Korean participants did not necessarily demonstrate greater variability than native English speakers. However, as for [i] in tongue advancement, two noticeable outliers were observed. They were spread across 3 to 6 on tongue advancement (Z_3-Z_2 (Bark)). They were identified as one female and one male Korean participant, respectively. Both were classified as high-intermediate level EFL learners according to the classification by Tannenbaum and Wylie (2013). When their data were excluded from the analysis of [i] in tongue advancement (Z_3-Z_2 (Bark)), there was no statistically significant difference between native English speakers and Korean participants ($t(14.62) = 2.03$, $p = 0.61$).

Figure 4.1 *Bark Difference Normalized Vowel Plots with Ellipses by Native English Speakers and Korean Participants*



Note. Ellipses indicate one standard deviation; NE = native English speakers; NK = Korean participants; These plots were drawn from *NORM: Vowel Normalization Suite 1.1* (Thomas & Kendall, 2007)

Thus, their productions of [i] were checked out once again by listening to their recordings several times. Firstly, as for the female speaker, two productions out of five, the second and third productions of [i], where she produced her [ɪ]-like F1 (800 Hz) and F2 (1,815 Hz), were distinctly different from the rest of the three productions, ranging from 511 Hz to 590 Hz for F1 and from 2,050 Hz to 2,247 Hz for F2. These two productions make the F2-F1 values different from other values in her own five productions of [i]. Secondly, the male speaker displayed noticeably distinct F2 in his fifth production of [i] (1,250 Hz). This was similar to one of the F2 values for [ɪ] (1,386 Hz) in his own production as well. Thus, it appears that both of the participants were testing their own hypothesis about /i/ with /ɪ/ during the five times of productions in a row.

Consequently, the results from the four-scenario framework and the *t*-test show that there is little difference, if any not important, in the degree of intra-speaker variability between high-intermediate level Korean EFL participants and English native speakers throughout six English vowels in each pair.

4.2. Intra-Speaker Variability of "New" Sounds and "Similar" Sounds

To examine whether "new" sounds [ɪ, æ, ʊ] and "similar" sounds [i, ɛ, u] demonstrate distinct learning patterns for high-intermediate level Korean

EFL participants, paired samples *t*-test was performed. The coefficient of variation (CV) was compared in pairs between "new" English sounds [ɪ, æ, ʊ] and "similar" English sounds [i, ɛ, u]. The null hypothesis was that the mean difference in the degree of the intra-speaker variability between a "new" sound and a "similar" sound in each pair is zero.

Table 4.7 *Means and Standard Deviations of Intra-Speaker Variability (CV) of Tongue Height (Z_3-Z_1 (Bark)) in Six English Vowels by Korean Participants*

	[i]	**[ɪ]**	**[ɛ]**	**[æ]**	**[u]**	**[ʊ]**
NK(N=30)	0.04(0.03)	0.04(0.02)	0.05(0.03)	0.04(0.02)	0.04(0.04)	0.05(0.07)

Note. Standard deviations are in parenthesis; NK = Korean participants

Table 4.8 *A Summary of Paired Samples t-test about the Comparison of Intra-Speaker Variability (CV) in Tongue Height (Z_3-Z_1 (Bark)) between "New" English Vowels and "Similar" English Vowels for Korean Participants*

English Vowel Pairs	***t***	***df***	***p*-value (two-tailed)**	**Cohen's *d***	**95% Confidence Interval**	
					Lower	**Upper**
[i-ɪ]	-0.35	29	0.73	-0.64	-0.47	0.30
[ɛ-æ]	0.66	29	0.52	0.12	-0.24	0.48
[u-ʊ]	-1.23	29	0.23	0.27	-0.22	1.14

Note. The significance level is .05.

When it comes to tongue height (Z_3-Z_1 (Bark)), Table 4.7 and Table 4.8 shows that there was no significant difference in the intra-speaker variability between "new" English sounds and "similar" English sounds

($t(29) = -0.35$, $p = 0.73$ ([i-ɪ]); $t(29) = 0.66$, $p = 0.52$ ([ɛ-æ]); $t(29) = -1.23$, $p = 0.23$ ([u-ʊ])). Thus, the null hypothesis is adopted for all six vowels of tongue height (Z_3-Z_1 (Bark)), implying that the degree of intra-speaker variability of tongue height is the same between "new" and "similar" sounds in each pair.

Table 4.9 *Means and Standard Deviations of Intra-Speaker Variability (CV) of Tongue Advancement (Z_3-Z_2(Bark)) in Six English Vowels by Korean Participants*

	[i]	**[ɪ]**	**[ɛ]**	**[æ]**	**[u]**	**[ʊ]**
NK(N=30)	0.15(0.10)	0.17(0.13)	0.10(0.06)	0.09(0.05)	0.08(0.06)	0.09(0.08)

Note. Standard deviations are in parenthesis; NK = Korean participants

Table 4.10 *A Summary of Paired Samples t-test about the Comparison of Intra-Speaker Variability (CV) in Tongue Advancement (Z_3-Z_2 (Bark)) between "New" English Vowels and "Similar" English Vowels for Korean Participants*

English Vowel Pairs	***t***	***df***	***p*-value (two-tailed)**	**Cohen's *d***	**95% Confidence Interval**	
					Lower	**Upper**
[i-ɪ]	-0.91	29	0.37	-0.17	-0.53	0.20
[ɛ-æ]	0.81	29	0.43	0.15	-0.21	0.51
[u-ʊ]	-1.21	29	0.24	-0.22	-0.58	0.14

Note. The significance level is .05.

Likewise, as for tongue advancement (Z_3-Z_2 (Bark)), Table 4.9 and Table 4.8 displays that there was no significant difference in the intra-speaker variability between "new" English sounds and "similar" English sounds ($t(29) = -0.91$, $p = 0.37$ ([i-ɪ]); $t(29) = 0.81$, $p = 0.43$ ([ɛ-æ]); $t(29) = -1.21$, $p = 0.24$ ([u-ʊ])). Thus, the null hypothesis is adopted for all six vowels of tongue advancement (Z_3-Z_2 (Bark)), indicating that the degree of intra-speaker variability of tongue advancement is the same between "new" and "similar" sounds in each pair.

On balance, high-intermediate level Korean EFL participants demonstrated a similar degree of intra-speaker variability between "new" and "similar" sounds. This indicates that despite the different learning patterns between the two types of sounds (Escudero, 2009), high-intermediate level Korean EFL participants' speech learning patterns of "new" and "similar" sounds in each pair do not differ from each other.

4.3. Perceptual Sensitivity and Intra-Speaker Variability

To examine whether perceptual sensitivity is related to the degree of intra-speaker variability, a simple regression method was performed.

4.3.1. Perceptual Sensitivity and Certainty of Response Index

Before moving on to the statistical analysis, however, whether trials for A' score worked properly must be checked out. A' score was obtained from a series of categorical discrimination tasks. Under each item, the certainty response index (CRI) of each item was also added in order to observe how much the respondents were sure about their responses. The perfect score of A' score and CRI is 1 (0.5) and 5 (2.5), respectively; the thresholds of each score are in parenthesis.

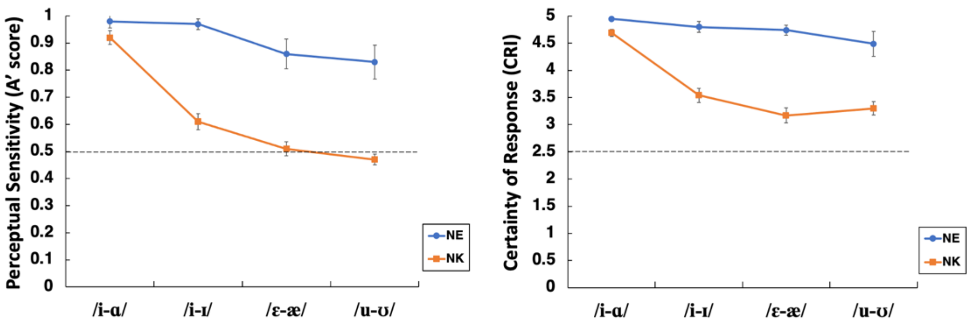
As can be seen in Table 4.11 and Figure 4.2, the task for assessing perceptual sensitivity has worked well based on two observations. Firstly, the average A' score for the control English vowel pair (/i-ɑ/) of both native English speakers (*M* = 0.98, *SD* = 0.05) and Korean participants (*M* = 0.92, *SD* = 0.15) were almost 1.0 (perfect A' score) with a high degree of certainty (CRI) in both native English speakers (*M*= 4.95, *SD* = 0.07) and Korean participants (*M* = 4.69, *SD* = 0.37). Secondly, average A' scores of native speakers across the three target English vowels (*M* = 0.97, *SD* = 0.83 (/i-ɪ/); *M* = 0.86, *SD* = 0.86 (/ɛ-æ/); *M* = 0.83, *SD* = 0.97 (/u-ʊ/)) were generally close to 1.0 (perfect A' score) with a high degree of certainty (CRI) across all three English vowel pairs (*M* = 4.80, *SD* = 0.22 (/i-ɪ/); *M* = 4.74, *SD* = 0.21 (/ɛ-æ/); *M* = 4.49, *SD* = 0.52 (/u-ʊ/)). The result showed that Korean participants possess relatively better perceptual sensitivity toward the English front vowel pairs ((*M* = 0.61, *SD* = 0.15 (/i-ɪ/); *M* = 0.51, *SD* = 0.15 (/ɛ-æ/)) than the English back vowel pair (*M* = 0.47, *SD* = 0.12 (/u-ʊ/)). The perceptual sensitivity of the only two English front vowel pairs (/i-ɪ/ and /ɛ-æ/) by Korean participants was above the threshold of 0.5, which means high-intermediate level Korean EFL participants have perceptual sensitivity toward the front vowel pairs.

Table 4.11 *Means and Standard Deviations of Perceptual Sensitivity (A' Scores) and Certainty Response Index (CRI) of Native English Speakers (NE) and Korean Participants (NK)*

	NE		NK	
	A' score	**CRI**	**A' score**	**CRI**
/i-ɑ/	0.98 (0.05)	4.95 (0.07)	0.92 (0.15)	4.69 (0.37)
/i-ɪ/	0.97 (0.83)	4.80 (0.22)	0.61 (0.15)	3.54 (0.74)
/ɛ-æ/	0.86 (0.86)	4.74 (0.21)	0.51 (0.15)	3.17 (0.79)
/u-ʊ/	0.83 (0.97)	4.49 (0.52)	0.47 (0.12)	3.30 (0.70)

Note. Standard deviations are in parenthesis; NE= native English speakers; NK = Korean participants; The perfect score is 1.0 for A' score while 5.0 for CRI.

Figure 4.2 *Mean and Standard Error of Perceptual Sensitivity (A' Score) (left) and Certainty of Response (CRI) (right) of Native English Speakers (NE) and Korean Participants (NK) across Four English Vowel Pairs*



Note. The error bar encloses ± one standard error; Thresholds of A' score (right) and CRI (left) are presented with a horizontal reference line.

Accordingly, they showed a relatively high degree of certainty about the English high front vowel pairs (M = 3.54, SD = 0.74 (/i-ɪ/); M = 3.17, SD = 0.79 (/ɛ-æ/)). On the other hand, Korean participants were found to lack the perceptual sensitivity toward the English back vowel pair (/u-ʊ/). In the meantime, the intriguing point was observed that Korean participants' A' score (actual perceptual sensitivity) and CRI (their beliefs in discrimination of sounds) toward /ɛ-æ/ and /u-ʊ/ were inversely related.

4.3.2. The Relationship between Perceptual Sensitivity and the Degree of Intra-Speaker Variability

Simple linear regression was used to test if the degree of perceptual sensitivity (A' score) significantly predicted the degree of intra-speaker variability (CV). Since the result from the second research question of this study revealed that there was no significant difference in intra-speaker variability (CV) between "new" sounds and "similar" sounds in each English vowel pair, the mean CVs of each English vowel pair were utilized for this analysis. More specifically, the average CVs of each English vowel pair in tongue height (Z_3-Z_1 (Bark)) and tongue advancement (Z_3-Z_2 (Bark)), a total of six variables, were under analysis. The null hypothesis was that there is no statistically significant relationship between perceptual sensitivity (A' score) and intra-speaker variability in tongue height (Z_3-Z_1 (Bark)) and tongue advancement (Z_3-Z_2 (Bark)) across the three English vowel pairs.

Table 4.12 and 4.13 shows the result of simple linear regression on the relationship between perceptual sensitivity and intra-speaker variability of [i-ɪ] in tongue height (Z_3-Z_1 (Bark)) and tongue advancement (Z_3-Z_2 (Bark)). The overall regression model was not statistically significant for both tongue height (R^2 ($R^2_{adjusted}$) = 0.038 (0.003), $F(1, 28) = 1.098$, $p = 0.304$) and tongue advancement (R^2 ($R^2_{adjusted}$) = 0.01 (-0.025), $F(1, 28) = 0.284$, p =

0.598). Overall, the perceptual sensitivity did not significantly predict intra-speaker variability in the production of [i-ɪ]. The fitted regression model was as follows: *intra-speaker variability (CV) of [i-ɪ] in tongue height (Z_3-Z_1 (Bark)) = 0.05 - 0.02 * perceptual sensitivity (A' score) toward [i-ɪ]* and *intra-speaker variability (CV) of [i-ɪ] in tongue advancement (Z_3-Z_2 (Bark)) = 0.20 - 0.07 * perceptual sensitivity (A' score) toward [i-ɪ]*.

Table 4.12 *A Summary of Simple Linear Regression on the Relationship between Perceptual Sensitivity (A' score) and Intra-Speaker Variability (CV) of [i-ɪ] in Tongue Height (Z_3-Z_1 (Bark))*

A Predictor	Coefficient Beta	R^2 ($R^2_{adjusted}$)	F	Regression df (Residual df)	p
(Intercept)	0.05				
Perceptual Sensitivity (A' score)	-0.02	0.038(0.003)	1.098	1(28)	.304

Note. The significance level is .05.

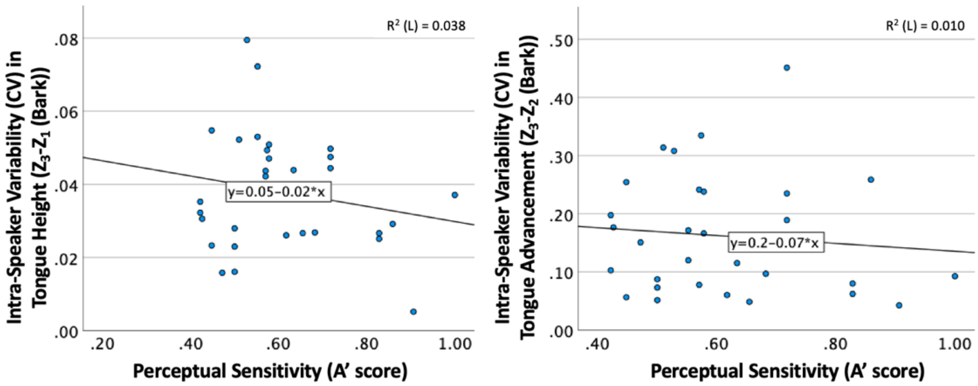
Table 4.13 *A Summary of Simple Linear Regression on the Relationship between Perceptual Sensitivity (A' score) and Intra-Speaker Variability (CV) of [i-ɪ] in Tongue Advancement (Z_3-Z_2 (Bark))*

A Predictor	Coefficient Beta	R^2 ($R^2_{adjusted}$)	F	Regression df (Residual df)	p
(Intercept)	0.20				
Perceptual Sensitivity (A' score)	-0.07	0.01(-0.025)	0.284	1(28)	.598

Note. The significance level is .05.

It indicates that an increase in one perceptual sensitivity corresponds to a decrease in intra-speaker variability of 0.02 for tongue height and 0.07 for tongue advancement. These negative correlations, though very small and not statistically significant, are presented in Figure 4.3 with a diagonal regression line tilted to the right.

Figure 4.3 *Scatter Plots for the Relationship between Perceptual Sensitivity (A' Score) and Intra-Speaker Variability (CV) of [i-ɪ]*



Note. The plots were drawn from *SPSS 28.0* (IBM Corp., 2022)

Figure 4.3 displays scatter plots for the relationship between perceptual sensitivity and intra-speaker variability of [i-ɪ] in tongue height (Z_3-Z_1 (Bark)) and tongue advancement (Z_3-Z_2 (Bark)). This may indicate that the more learners are perceptually sensitive toward non-native contrasting pairs, the clearer phonemic target they have about a sound in their productions.

Table 4.14 and Table 4.15 reports a summarized result from a simple regression on the relationship between perceptual sensitivity and intra-speaker variability of [ɛ-æ] in tongue height (Z_3-Z_1 (Bark)) and tongue advancement (Z_3-Z_2 (Bark)). The perceptual sensitivity did not significantly explain an amount of variance in intra-speaker variability for both tongue height (Z_3-Z_1 (Bark)) (R^2 ($R^2_{adjusted}$) = 0.007(-0.028), F (1, 28) = 0.221, p = 0.649) and tongue advancement (Z_3-Z_2 (Bark)) (R^2 ($R^2_{adjusted}$) = 0.00(-0.036), F (1, 28) = 0.001, p = 0.977).

Table 4.14 *A Summary of Simple Linear Regression on the Relationship between Perceptual Sensitivity (A' score) and Intra-Speaker Variability (CV) of [ɛ-æ] in Tongue Height (Z_3-Z_1 (Bark))*

A Predictor	**Coefficient Beta**	R^2 ($R^2_{adjusted}$)	F	**Regression *df* (Residual *df*)**	p
(Intercept)	0.04				
Perceptual Sensitivity (A' score)	0.01	0.007(-0.028)	0.221	1(28)	0.649

Note. The significance level is .05.

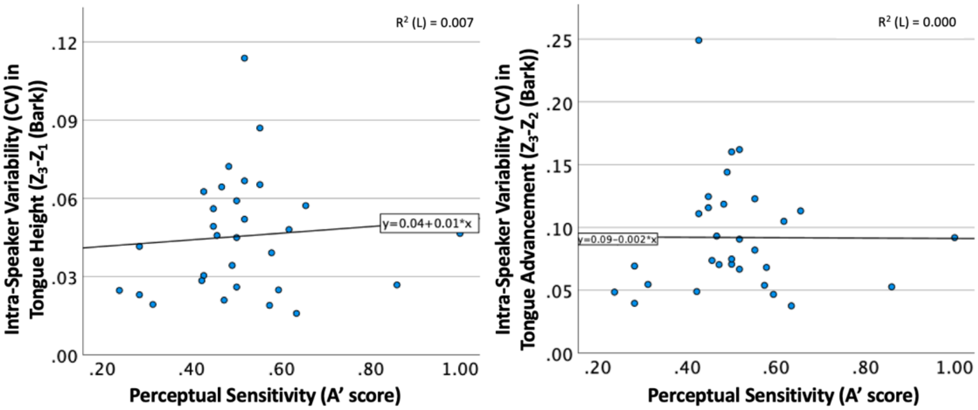
Table 4.15 *A Summary of Simple Linear Regression on the Relationship between Perceptual Sensitivity (A' score) and Intra-Speaker Variability (CV) of [ɛ-æ] in Tongue Advancement (Z_3-Z_2 (Bark))*

A Predictor	**Coefficient Beta**	R^2 ($R^2_{adjusted}$)	F	**Regression *df* (Residual *df*)**	p
(Intercept)	0.09				
Perceptual Sensitivity (A' score)	-0.002	0.00(-0.036)	0.001	1(28)	0.977

Note. The significance level is .05.

The fitted regression model of [ɛ-æ] was as follows: *intra-speaker variability (CV) of [ɛ-æ] in tongue height (Z_3-Z_1 (Bark)) = 0.04 + 0.01 * perceptual sensitivity (A' score) toward [ɛ-æ]* and *intra-speaker variability (CV) of [ɛ-æ] in tongue advancement (Z_3-Z_2 (Bark)) = 0.09 - 0.002 * perceptual sensitivity (A' score) toward [ɛ-æ].* The regression coefficient indicated that an increase in one perceptual sensitivity led to an increase in the degree of intra-speaker of 0.01 for tongue height and a decrease of 0.002 for tongue advancement.

Figure 4.4 *Scatter Plots for the Relationship between Perceptual Sensitivity (A' Score) and Intra-Speaker Variability (CV) of [ɛ-æ]*



Note. The plots were drawn from *SPSS 28.0* (IBM Corp., 2022)

Figure 4.4 shows a tendency of a slight positive correlation for tongue height and almost no correlation for tongue advancement, though not statistically significant. It means whether Korean participants have perceptual sensitivity toward the English vowel pair [ɛ-æ] does not affect whether they have a definite phonemic target in their mental representation.

Table 4.16 *A Summary of Simple Linear Regression on the Relationship between Perceptual Sensitivity (A' score) and Intra-Speaker Variability (CV) of [u-ʊ] in Tongue Height (Z_3-Z_1 (Bark))*

A Predictor	**Coefficient Beta**	R^2 ($R^2_{adjusted}$)	F	**Regression *df* (Residual *df*)**	p
(Intercept)	0.11				
Perceptual Sensitivity (A' score)	-0.14	0.106(0.074)	3.33	1(28)	0.079

Note. The significance level is .05.

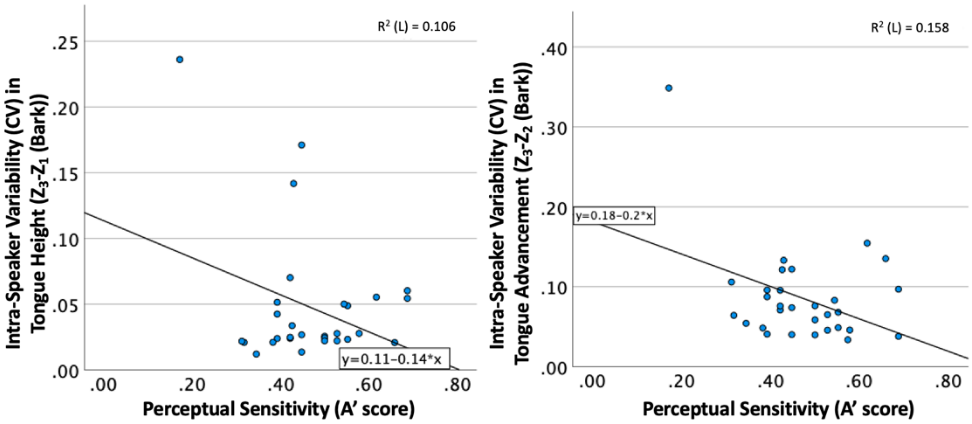
Table 4.17 *A Summary of Simple Linear Regression on the Relationship between Perceptual Sensitivity (A' score) and Intra-Speaker Variability (CV) of [u-ʊ] in Tongue Advancement (Z_3-Z_2 (Bark))*

A Predictor	**Coefficient Beta**	R^2 ($R^2_{adjusted}$)	F	**Regression *df* (Residual *df*)**	p
(Intercept)	0.18				
Perceptual Sensitivity (A' score)	-0.20	0.158(0.128)	5.251	1(28)	0.03*

Note. The significance level is .05.

Table 4.16 and 4.17 display the result from simple linear regression on the relationship between perceptual sensitivity and intra-speaker variability of [u-ʊ] in tongue height (Z_3-Z_1 (Bark)) and tongue advancement (Z_3-Z_2 (Bark)). The regression model was not statistically significant for tongue height (R^2 ($R^2_{adjusted}$) = 0.106 (0.074), F (1, 28) = 3.33, p = 0.079) whereas the perceptual sensitivity explained a significant amount of the variance of intra-speaker variability of tongue advancement toward [u-ʊ] (R^2 ($R^2_{adjusted}$) = 0.158 (0.128), F (1, 28) = 5.251, p = 0.03). Two fitted regression model were as follows: *intra-speaker variability (CV) of [*u-ʊ*] in tongue height (Z_3-Z_1 (Bark)) = 0.11 - 0.14 * perceptual sensitivity (A' score) toward [*u-ʊ*]* and *intra-speaker variability (CV) of [*u-ʊ*] in tongue advancement (Z_3-Z_2 (Bark)) = 0.18 - 0.20 * perceptual sensitivity (A' score) toward [*u-ʊ*]*. It indicates that an increase in one perceptual sensitivity corresponds to a decrease in intra-speaker variability of 0.14 for tongue height (Z_3-Z_1 (Bark)) and 0.20 for tongue advancement (Z_3-Z_2 (Bark)).

Figure 4.5 *Scatter Plots for the Relationship between Perceptual Sensitivity (A' Score) and Intra-Speaker Variability (CV) of [u-ʊ]*



Note. The plots were drawn from *SPSS 28.0* (IBM Corp., 2022)

The negative correlations also can be seen in Figure 4.5 with a slanted regression line to the right. Figure 4.3 shows scatter plots for the negative correlations between perceptual sensitivity and intra-speaker variability of [u-ʊ] in tongue height (Z_3-Z_1 (Bark)) and tongue advancement (Z_3-Z_2 (Bark)). The result indicates that the high-intermediate level Korean EFL participants' perceptual sensitivity is inversely correlated to the degree of intra-speaker variability in the production of [u-ʊ].

On balance, except for the intra-speaker variability of [u-ʊ] in tongue advancement, the null hypotheses were adopted, meaning that the perceptual sensitivity was not found to significantly predict the degree of intra-speaker variability of tongue height and tongue advancement across the rest of the vowels in both dimensions. Still, unlike [ɛ-æ], the disposition of a negative correlation was detected in [i-ɪ] and [u-ʊ] of both dimensions. There were no or even positive correlations between perceptual sensitivity and the degree of intra-speaker variability in the production of [ɛ-æ], indicating that high-intermediate level Korean EFL participants were still in the process of struggling to have their own phonemic target of a sound in their productions.

Chapter 5. Discussion

This study explored high-intermediate level Korean EFL participants' intra-speaker variability and perceptual sensitivity toward three English vowel pairs /i-ɪ/, /ɛ-æ/, and /u-ʊ/. Based on the literature, the degree of intra-speaker variability of a sound was assumed to be one of the signals that a learner is testing their own hypothesis, i.e., learning in progress. The results from this study corroborated the previous studies in several ways.

It was found that high-intermediate level Korean EFL participants did not show greater within-speaker variability than native speakers did, just as found in Smith et al. (2019). Though there was a significant difference in [i] of tongue backness, the range of 95% confidence interval of its effect size (Cohen's *d*) confirmed that it was not a significant difference. In light of this, considering that most high-intermediate level Korean EFL participants demonstrated near nativelike intra-speaker variability, there is a high chance that the 21% of participants in Smith et al. (2019), who showed a greater degree of intra-speaker variability than native English speakers did, were not high-intermediate level learners. Unlike Smith et al. (2019), however, there was some change in the research design. The linguistic context for stimuli was strictly restricted to the */hVd/* form with a rationale. To compensate for the restricted linguistic environment, the number of productions by participants was increased to five times from three. The two participants who demonstrated the non-nativelike degree of intra-speaker variability in the production of /i/ in terms of tongue advancement proved that even this restricted research design works for investigating the intra-speaker variability of a speaker from a pedagogical point of view. It appears that they were testing idiosyncratic hypotheses about an L2 sound, as the SLM predicted language learners' sound system is adaptable throughout their lifetime (Cebrian, 2006; Flege, 1987; Flege, 1995; Smith et al., 2019).

The results also demonstrated that high-intermediate level Korean EFL participants have low perceptual sensitivity toward the three English vowel pairs /i-ɪ/, /ɛ-æ/, and /u-ʊ/, just as previous studies have revealed (Hong, 2007; Ingram & Park, 1997; Kim & Kim, 2003; Silva, 2004; Tsukada et al. 2007). Although high-intermediate level Korean EFL participants were better at discriminating /i-ɪ/ than /ɛ-æ/ and /u-ʊ/ as previous research reported (Hong, 2012; Kahng, 2006; Tsukada et al., 2005), /ɛ-æ/ was found to have higher A' score (better perceptual sensitivity) than /u-ʊ/, contrary to the previous research (Hong, 2012; Kahng, 2006). Still, the examination of the relationship between perceptual sensitivity and intra-speaker variability indicated that, in fact, the result from this study about /ɛ-æ/ is also in line with the previous research by Hong (2012) and Kahng (2006). This is because it was found that Korean participants may have difficulty in establishing their own phonemic targets for /ɛ-æ/ in their mental representations. That is, even high-intermediate level Korean learners of English with some degree of perceptual sensitivity were experiencing confusion about the English vowel pair /ɛ-æ/. This confusion among Korean participants about /ɛ-æ/ appears to stem from the ongoing merging process between Korean /e/ and /ɛ/ (Ingram & Park, 1997; Kang, 1996; Lee & Ramsey, 2000; Silva, 2004; Yang, 1996). Thus, among the target English pairs in this study, the English pair /ɛ-æ/ was found to be the most challenging for Korean learners to learn.

Furthermore, it was found that the relative hierarchy of perceptual sensitivity by Korean participants across the three target English vowel pairs in this study is generally in line with the gravity of Relative Functional Load (RFL) on speech intelligibility, /i-ɪ/, /ɛ-æ/, and /u-ʊ/ in sequence (Catford, 1987; Koffi, 2021), though there were very small differences. Thus, it appears that Korean learners of English may have set a priority in L2 speech learning in a way that has less impact on intelligibility.

The results showed that high-intermediate level Korean EFL participants did not show any difference in their intra-speaker variability between "new" sounds and "similar" sounds as well. However, according to Escudero (2009), L2 speech learning occurs by *creating* a category for "new" L2 sounds and *adjusting* a category for "similar" L2 sounds. Moreover, empirical evidence indicates that a separate phonetic category for "new" L2 sounds is relatively better established than that of "similar" L2 sounds (Flege, 1995, 2003; Milenova, 2015). Regarding the result of this study, two interpretations can be presented. Firstly, Korean participants in this study were mostly at the stabilization stage of their L2 speech learning process. As they demonstrate the native-like degree of intraspeaker variability in common, it is less likely that different learning patterns can be detected. That is, high-intermediate level Korean EFL participants already have their own phonemic target of a sound in their mental representations to guide their productions, regardless of perceptual sensitivity toward non-native contrasting pairs. Secondly, despite the distinct learning mechanisms, there is a possibility that there is no difference in the learner's learning patterns in the acquisition of the two sounds in each pair. This might be because learner language is characterized by systematicity as well as variability (Ellis, 2015). Yet, for a better understanding of the issue, future research can explore the learning patterns of "new" L2 sounds and "similar" L2 sounds with various proficiency level participants.

Moreover, though not the focus of this study, there was an interesting observation regarding language experience. Two Korean female participants with the experience of studying abroad for six years and four and a half years, respectively, displayed almost nativelike perceptual sensitivity toward two English front vowel pairs /i-ɪ/ and /ɛ-æ/, ranging from 0.86 to 1 in A' score. They started learning English when they were five or six years old and self-reported that they do not spend time studying English speaking and listening at all (another aspect of language experience). Thus, their superior perceptual and productive ability compared to the rest of the Koreans' can be partly ascribed to their comparatively longer language experiences in L2 settings. This tendency of participants with an experience of studying abroad for a relatively longer time than others confirmed the previous studies on the influence of the L2 experience on L2 speech learning (Flege et al., 1995, 1997, 1999).

Finally, the results showed that perceptual sensitivity could not explain the degree of intra-speaker variability in most of the cases except for tongue advancement of the English back vowel pair /u-ʊ/, meaning perceptual sensitivity alone might be insufficient to delve into the characteristics of learner language in L2 speech learning. Korean participants in this study generally demonstrated a low level or lack of perceptual sensitivity toward target English vowel pairs. Still, they believed that they could discriminate the sounds in each pair. Moreover, they generally have a regular (nativelike) degree of intra-speaker variability, indicating speech learning is not in progress at the moment. From this observation, it can be assumed that learning appears to take place when learners feel the need to do so. In this respect, learner beliefs appear to come into play. For example, according to Dörnyei (2009), "the *ideal L2 self* is a powerful motivator to learn the L2 because of the desire to reduce the discrepancy between our actual and ideal selves" (p. 29; italics in original). Borrowing this assumption, it can be applied to this study as Korean participants did not appear to have the desire (having regular intra-speaker variability) to reduce the disparity between their actual (having low perceptual sensitivity) and ideal (having a comparatively high degree of certainty) selves. Thus, future research can explore learners' intra-speaker variability in terms of learners' motivation to explain the discrepancy.

Chapter 6. Conclusion

This chapter summarizes the major findings of this study. Then, pedagogical implications and the limitations of the study are discussed.

6.1. Summary of Major Findings

This study investigated 30 high-intermediate level Korean EFL participants' intra-speaker variability and perceptual sensitivity toward three English vowel pairs /i-ɪ/, /ɛ-æ/, and /u-ʊ/. The three major findings of this study are as follows. Firstly, almost all high-intermediate level Korean EFL participants, in general, showed a regular (nativelike) degree of intra-speaker variability, as Smith et al. (2019) revealed. It means that about 20% of participants with a greater degree of intra-speaker variability than native speakers in Smith et al.'s (2019) study might not be high-intermediate level learners of English. Secondly, high-intermediate level Korean EFL participants did not show a different degree of intra-speaker variability between "new" English sounds [ɪ, æ, ʊ] and "similar" English sounds [i, ɛ, u]. The result may indicate that language learners demonstrate systematic variability despite the different mechanisms of sound category formation. Lastly, though not statistically significant, it was found that the more perceptual sensitivity learners have toward a non-native contrasting pair, the less intra-speaker variability they are likely to demonstrate in English vowel pairs /i-ɪ/ and /u-ʊ/. It was motivated by one of the basic assumptions of the

SLM (Flege, 1995), which postulates that accurate perceptual *targets* would lead to the sensorimotor learning of L2 sounds. It means if they could perceptually discriminate the L2 contrasting pairs, they could have a clearer phonemic target of a sound. Still, as for /ɛ-æ/, it was observed that high-intermediate level Korean EFL participants were wrestling with setting their own phonemic target of the sounds by testing their own idiosyncratic hypothesis about the sound. On the whole, it was observed from this study that high-intermediate level Korean EFL participants were at the stabilization stage in their L2 speech learning processes even if they have very low or lack perceptual sensitivity toward English vowel pairs /i-ɪ/, /ɛ-æ/, and /u-ʊ/.

6.2. Pedagogical Implications

Although high-intermediate level Korean EFL participants with high TOEIC listening scores did not show high perceptual sensitivity toward each English vowel pair, it should not be taken as unnecessity to learn English segmental pronunciations at all. There are two reasons for this. Firstly, the skills required for TOEIC listening are not the same as those needed for real-world communication. Communication, which is a two-way street, is one of the main objectives of learning a language. However, the TOEIC listening test takes on the traits of one-way listening in that testees cannot engage in conversations as speakers. As Scovel (1988) stated, pronunciation is distinct from other *cognitive* aspects of a language because it involves physical reality, which is realized with articulators. Secondly, segmental errors indeed can be detrimental to speech comprehensibility. Munro and Derwing (2015a) contended that based on purely theoretical considerations, it is likely that a failure to produce phonemic distinctions between non-native sounds would result in severe communication breakdown, possibly even when contextual details are available (Brown, 1991; Levis & Cortes, 2008). Thus, there is a chance that even learners with high TOEIC listening scores can have difficulty communicating in English in the real world. In this respect, non-native sounds need to be dealt with in the classroom even for high proficiency learners, particularly if they appear to lack the perceptual sensitivity toward contrasting L2 sounds. To this end, teachers can set a priority for English sounds to be addressed in the classroom by referring to the Relative Functional Load (RFL) (Catford, 1987; Koffi, 202l). For example, the result from this study revealed that even high-intermediate level Korean learners of English have difficulty learning /ɛ-æ/ (RFL: 52% (mediocre intelligibility)). Thus, for this kind of learner, voice quality settings (Esling & Wong, 1983) — the postures of speech organs in pronunciation — for English segmental elements should be explicitly taught to Korean learners of English as EFL context "is a fairly impoverished context for L2 learning" (Best & Tyler, 2007, p. 19).

Last but not least, though many teachers consider acoustic phonetics an unfamiliar and hard-to-approach field, it should no longer be an excuse to disregard one of the most useful tools in L2 pronunciation teaching. Teachers must be knowledgeable about many aspects of phonetics and phonology to teach L2 pronunciation beyond mere mimicry of a native norm (Koffi, 2021). In this respect, acoustic phonetics can elucidate one of the potential realms for efficient teaching and learning of L2 sounds under the intelligibility principle. As Koffi (2021) emphasized, “both teachers and students can benefit from acoustic phonetics because it gives them the opportunity to visualize certain aspects of pronunciation in ways that International Phonetic Alphabet (IPA) symbols or other method symbols cannot” (p. 18).

6.3. Limitations and Suggestions for Future Study

Although this study contributed to understanding high-intermediate level Korean EFL learners’ learning of non-native vowel contrasts in terms of intra-speaker variability and perceptual sensitivity, several limitations should be addressed for future research.

Firstly, the sample size was much smaller than the researcher initially intended at the outset, mainly due to a failure to recruit intermediate and lower-level participants. It seems that Korean EFL learners with relatively lower linguistic proficiency levels were unwilling to come forward voluntarily. Thus, future study needs to use a different sampling method or thoroughly ponder how to encourage the lower proficiency level learners to participate in the study before designing research.

In addition, the task for collecting speech data was too decontextualized and unnatural. The participants' speech was somewhat detached from the real world. Thus, future studies can use speech samples from real-world conversations or more meaningful tasks to explore various aspects of English vowel contrasts.

Finally, this study mainly depended on acoustic analyses of non-native vowel contrasts. Kang and Pickering (2013), however, cautioned about overreliance on acoustic measures because, unlike human ratings, they involve precise calibration, which often generates conflicting results than humans' actual perception. In a similar vein, Munro and Derwing (2015b) underscored that "without listener data, acoustic measures themselves are of little or no value" (p. 14). Hence, future studies can use both human ratings and acoustic measures of a sound, placing machine analysis as supplementary data for human scores (Hincks, 2015; Kang & Pickering, 2013).

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Appendices

Appendix 1. Debriefing for Native English Speakers

Debriefing (For native English speaker participants)

Research Title: Korean EFL Learners' Intra-speaker Variability and Perceptual Sensitivity in Producing Three American English Vowel Pairs

Principal Investigator: Seyeon Choe (a graduate students majored in English education, SNU)

Good morning/afternoon. First of all, thank you very much for participating in this study.

The original purpose of this study is to examine Korean EFL learners' intra-speaker variability and perceptual sensitivity in producing three American English vowel pairs (/i-ɪ/, /ɛ-æ/, /u-ʊ/). As these three pairs of American English vowels in particular are the main concern of this study, the more general title ("Korean EFL learners' perception and production of American English *words*") was used throughout the whole process in order to obtain more objective result. The sentences you read at the first meeting contained target vowels in 'hVd' forms (e.g., heed, hid, etc.). Besides, a listening test with 64 items was carried out for the purpose of understanding your phonetic sensitivity towards each target vowel pair contrast. The foreign accentedness and comprehensibility ratings you gave to each word were in fact to examine the foreign accentedness and comprehensibility of each vowel. Therefore, this study will mainly investigate the vowels only, not the words as a whole, in your speech and responses to the recordings.

If you do not wish to use the results of this experiment in this research, please let the researcher know (Seyeon Choe, a graduate students majored in English education, SNU, 010-5339-0214). In this case, the data obtained from you will not be used for data analysis and will be deleted immediately.

Thanks to your participation, I can learn more about Koreans' perception and production of English vowels. Thank you for taking the time to participate in this research and for your sincere participation.

Your signature documents your permission to take part in this research.

Signature of participant ____________ Date ____________

Name of participant ____________

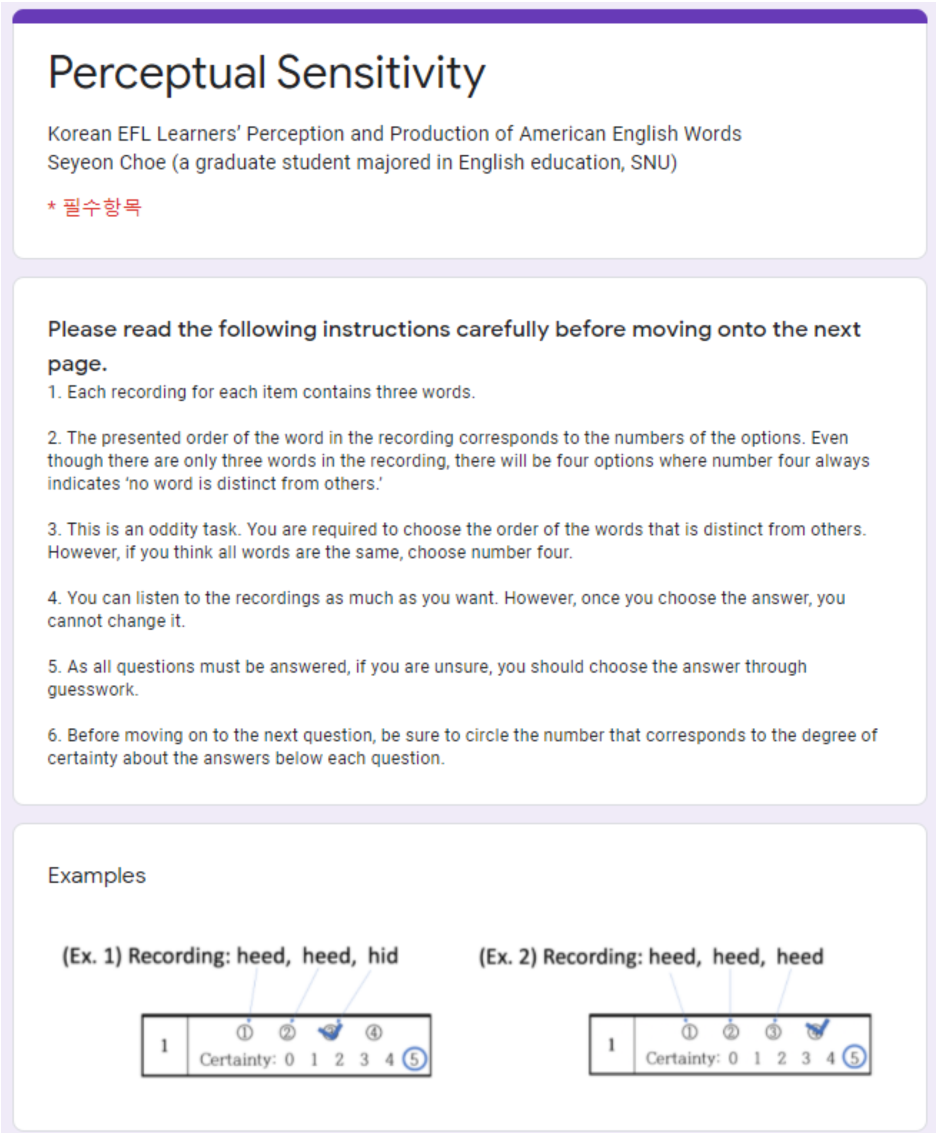
Signature of person obtaining consent ____________ Date ____________

Name of person obtaining consent ____________

Version 1.1(2020.07.23.)

Appendix 2. Perceptual Sensitivity Trials Constructed on *Google Form*

<Main Front Page>



Perceptual Sensitivity

Korean EFL Learners' Perception and Production of American English Words
Seyeon Choe (a graduate student majored in English education, SNU)

* 필수항목

Please read the following instructions carefully before moving onto the next page.

1. Each recording for each item contains three words.

2. The presented order of the word in the recording corresponds to the numbers of the options. Even though there are only three words in the recording, there will be four options where number four always indicates 'no word is distinct from others.'

3. This is an oddity task. You are required to choose the order of the words that is distinct from others. However, if you think all words are the same, choose number four.

4. You can listen to the recordings as much as you want. However, once you choose the answer, you cannot change it.

5. As all questions must be answered, if you are unsure, you should choose the answer through guesswork.

6. Before moving on to the next question, be sure to circle the number that corresponds to the degree of certainty about the answers below each question.

Examples

(Ex. 1) Recording: heed, heed, hid

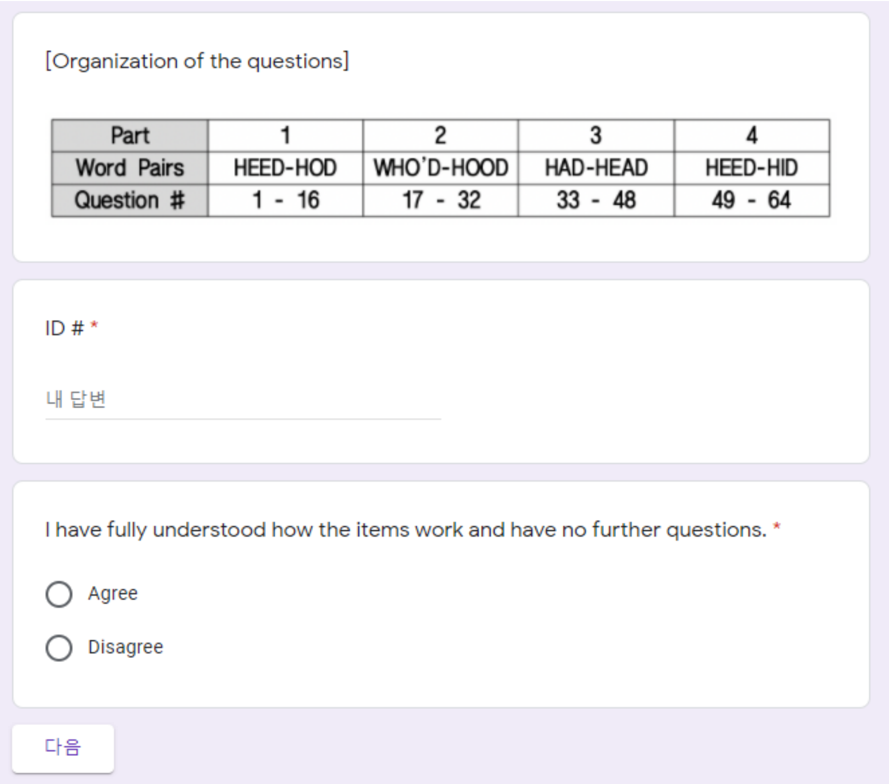
1	① ② ③ ④ Certainty: 0 1 2 3 4 5

(Ex. 2) Recording: heed, heed, heed

1	① ② ③ ④ Certainty: 0 1 2 3 4 5

(Continued)

<Main Front Page>



[Organization of the questions]

Part	1	2	3	4
Word Pairs	HEED-HOD	WHO'D-HOOD	HAD-HEAD	HEED-HID
Question #	1 - 16	17 - 32	33 - 48	49 - 64

ID # *

내 답변

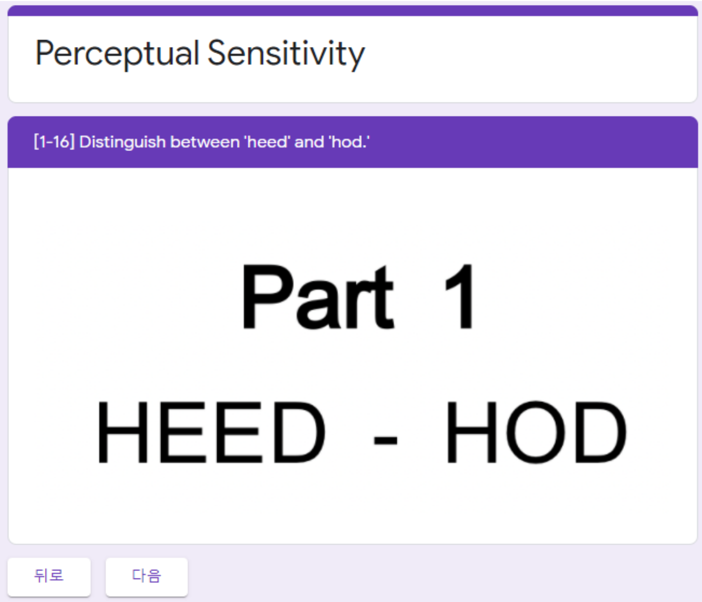
I have fully understood how the items work and have no further questions. *

○ Agree

○ Disagree

다음

<Preliminary Front Page for the Trials of Each Pair>



Perceptual Sensitivity

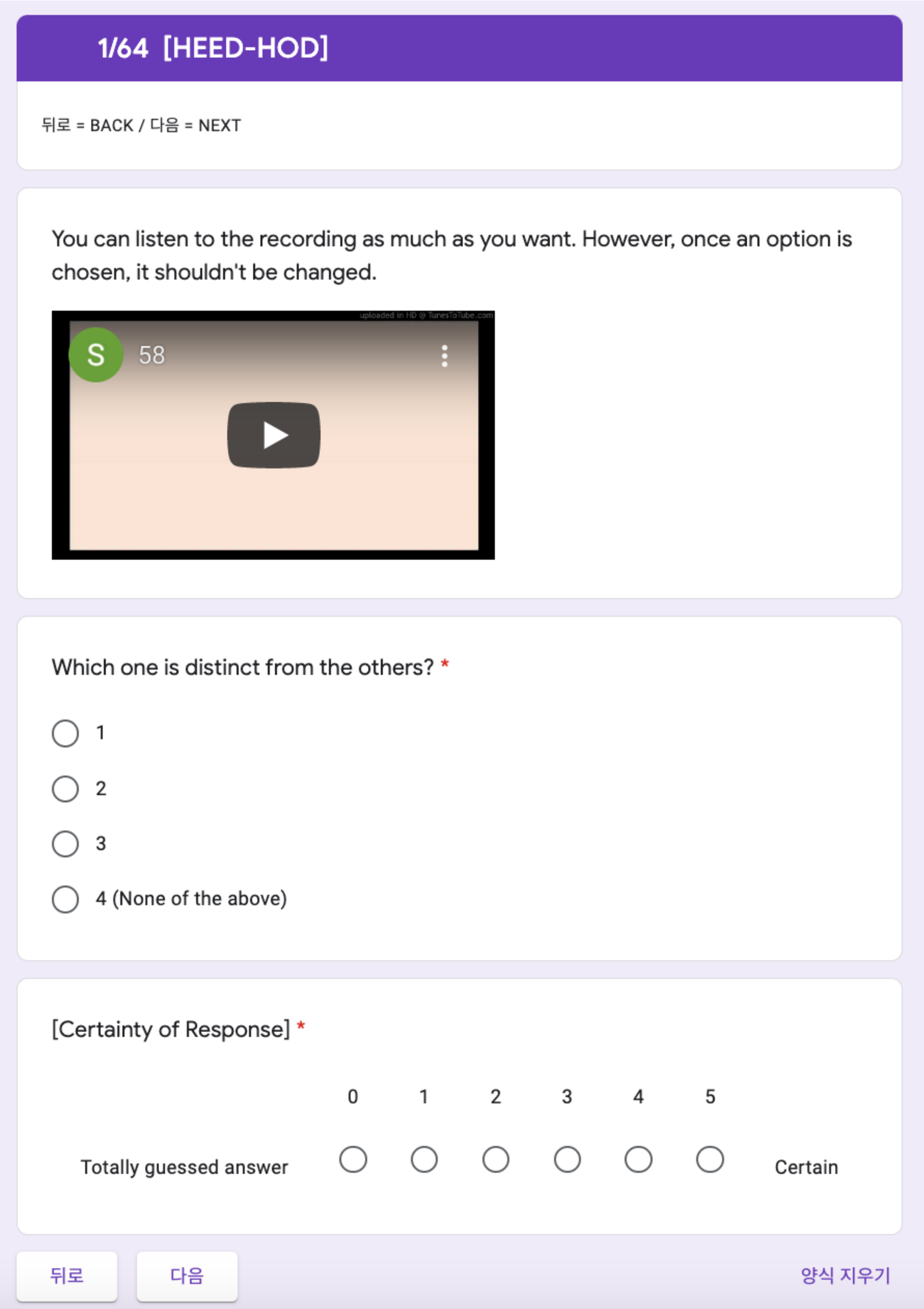
[1-16] Distinguish between 'heed' and 'hod.'

Part 1

HEED - HOD

뒤로 다음

<A Trial for the Perceptual Sensitivity and 6-Point Likert Scale for the Certainty of Response>



1/64 [HEED-HOD]

뒤로 = BACK / 다음 = NEXT

You can listen to the recording as much as you want. However, once an option is chosen, it shouldn't be changed.

Which one is distinct from the others? *

1
2
3
4 (None of the above)

[Certainty of Response] *

	0	1	2	3	4	5	
Totally guessed answer	○	○	○	○	○	○	Certain

뒤로 다음 양식 지우기

국 문 초 록

본 연구는 30명의 높은 영어 수준을 가진 한국인 참가자의 세 개의 영어 모음 쌍 [i-ɪ], [ɛ-æ], [u-ʊ]에 대한 인지적 민감성과 발화자 내 변이성에 대해 분석했다. 본 연구의 설계는 Smith et al, (2019)의 발화자 내 변이성에 대한 이전 연구 설계를 반복하고 확장하였다. 본 연구에서의 발화자 내 변이성은 언어 학습자의 L2 음소 학습 과정으로 정의되었다. 이는 L2 학습자의 언어 시스템이 평생 동안 조정 가능하다는 음성 학습 모델(speech learning model) (Flege, 1995)의 기본 가정에 기초했다. 본 연구에서는 발화자 내 변이성과 인지적 민감성에 대한 세 가지 연구 질문이 설정되었다. 첫째, 높은 영어 수준의 한국인 참가자들이 영어 원어민 정도의 발화자 내 변이성을 보이는지를 살펴보기 위해 Welch *t* 검정을 활용했다. 둘째, 각 모음 쌍에서 모국어인 한국어에 대해 "새로운" [ɪ, æ, ʊ] 소리와 "유사한" [i, ɛ, u] 소리 발화에서 발화자 내 변이성에 차이가 있는지 여부를 대응표본 *t* 검정을 사용하여 분석했다. 마지막으로, 인지적 민감성이 발화자 내 변이성의 정도에 영향을 미치는지 여부를 탐구하기 위해 단순 선형 회귀 분석을 실시했다. 발화자 내 변이성은 변동계수(coefficient of variation)로, 인지적 민감성은 영어 대조 모음

식별 과제를 통해 A’ 점수로 수치화 되었다. 총 세 가지의 통계 분석 결과 거의 대부분의 분석에서 통계적으로 유의미한 차이 또는 관계가 검출되지 않았다. 결론적으로, 거의 모든 높은 영어 수준의 한국어 EFL 학습자들은 원어민과 비슷한 수준의 발화자 내 변이성을 보인다는 것이 밝혀졌다. 또한, 한국인 학습자들은 영어 모음 쌍 [ɛ-æ] 학습을 가장 어려워하는 것으로 나타났다. 높은 영어 수준의 한국인 학습자들은 각 영어 모음 쌍에 대해 인지적 민감성이 매우 낮거나 부족함에도 불구하고, 세 가지 영어 모음 쌍 [i-ɪ], [ɛ-æ], [u-ʊ]의 학습이 학습자 언어 단계 측면에서 안정화 단계에 접어든 것으로 관찰되었다. 이 연구는 교육학적 관점에서 언어 학습자의 발화자 내 변이성을 살펴봄으로써 L2 소리 학습과 관련된 학습자 언어에 대한 이해의 폭을 넓히는 데에 도움을 준다.

주요어: 영어 모음 쌍, 발화자 내 변이성, 인지적 민감성, "새로운" 소리와 "유사한" 소리, 한국인 영어 학습자, L2 음성 학습, 음성 학습 모델, 학습자 언어, A' 점수, 범주형 변별 과제

학 번: 2019-29809