PERCEPTION AND RECOVERABILITY OF MODIFIED ENGLISH L2 CODAS

by

Ali S. Alelaiwi
A Dissertation
Submitted to the
Graduate Faculty
of
George Mason University
in Partial Fulfillment of
The Requirements for the Degree
of
Doctor of Philosophy
Linguistics

Committee:

_____	Director
_____	
_____	
_____	Department Chairperson
_____	Program Director
_____	Dean, College of Humanities and Social Sciences

Date: 05 / 01 / 2020

Spring Semester 2020
George Mason University
Fairfax, VA

Perception and Recoverability of Modified English L2 Codas

A Dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at George Mason University

by

Ali S. Alelaiwi
Master of Arts
California State University, Fresno, 2014
Bachelor's Degree
King Faisal University, 2010

Director: Steven H. Weinberger, Associate Professor
George Mason University

Spring Semester 2020
George Mason University
Fairfax, VA

DEDICATION

To my Mother

ACKNOWLEDGEMENTS

First of all, I would like to express my deep and sincere gratitude to my family. They are the reason I am here right now, writing these words. I would not have been able to go this far without their infinite, boundless support. For that, I will be eternally grateful. Specifically, I would like to thank my mother for her love, patience, sacrifices, encouragement and for tolerating the absence of her son. There is nothing I could say or do that could express my gratitude. I love you all, and I wish my father were here to witness this moment with us.

In addition, I would like to thank my committee members Steven Weinberger, Douglas Wulf and Harim Kwon for their time and insightful comments and suggestions. Special thanks to Steven for being an awesome advisor. I was first introduced to the notion of recoverability while taking one of your courses, and your prior work was what inspired me to write this dissertation. Thank you for your guidance, hospitality and kindness. Thank you for supporting my multidisciplinary curiosity and being hopeful even when I was not.

This section would not be complete without mentioning Charlie Jones. I wish he were here to share this moment with us. I am grateful that I had the chance to meet such a great man. I would also like to thank Chris Golston because he showed me that being a great linguist does not mean that you cannot be a multifaceted scientist. Also, special thanks to my data analyst, Debby Kermer, without whom I would not have been able to do the statistical analysis.

Thank you, also, to my amazing boss, Kathy Rossell, for her understanding and flexibility and for believing in me and giving me the great opportunity to work as an LRC Specialist while doing my PhD. In addition, I would like to thank Ahmed Alhuwayshil for being my friend throughout all of this, listening to all of my unusual yet fantastic ideas and sharing all of my sad and happy moments even though we were away from each other. Finally, I would like to thank all my friends, my teachers, my students, my anonymous participants and everyone who helped me at any point to complete this dissertation.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

PERCEPTION AND RECOVERABILITY OF MODIFIED ENGLISH L2 CODAS

Ali S. Alelaiwi, Ph.D.

George Mason University, 2020

Dissertation Director: Dr. Steven H. Weinberger

Previous studies have shown that when L2 learners are faced with structures that are illegal in their L1, they tend to simplify such structures (Weinberger, 1987; Benson, 1988; Sato, 1984; Wang, 1995; Hansen, 2004; Yavaş, 2011; among others). This dissertation examines two different strategies of syllable structure simplification, namely, deletion and epenthesis, using two perception experiments. Specifically, this dissertation investigates the recoverability principle (Weinberger, 1994), which suggests that epenthesis is functionally superior to deletion since it results in relatively less ambiguous structures. Even though both deletion and epenthesis convert the relatively complex CVC syllables into simple CV syllables, their outcomes differ in terms of the degree of lexical ambiguity. If we examine a word with a CVC syllable structure such as *lead*, the following are possible simplification outcomes:

(1) Target word	Deleted form	Epenthesized form
lead [lid]	[li]	[lidə]

We can see that the deleted form results in more ambiguity since it could be interpreted as *Lee, leaf, leave, lean, lead, leak, leash, lease*, etc. The epenthesized form [lidə], on the

other hand, results in less potential ambiguity because it can only be interpreted as *lead* or *leader* – the word can only be interpreted as *leader* if the listener's dialect involves final [ɹ] deletion. This study hypothesizes that words modified by epenthesis should be chosen more frequently by listeners since epenthesis is better when it comes to meaning preservation (Weinberger, 1994). Thus far, all research dealing with this notion of recoverability has been done with production data. This study attempts to document the perception of recoverability by native and non-native listeners of English and examine the implications of the recoverability principle which cannot be examined in production studies. In the first experiment, listeners from three different language backgrounds were recruited - English, Japanese and Spanish. The participants were presented with monosyllabic words with codas modified by either deletion or epenthesis accompanied by pictures of what the words denote, and they were instructed to choose the modified form of each word that best matched the picture based on their judgment. A mixed model regression test was conducted to see if the listeners' L1 and the sonority of coda consonants significantly influenced the choice of repair strategy (deletion vs. insertion). The findings revealed that epenthesis was significantly preferred over deletion regardless of the listeners' L1, which provides support to the recoverability principle. The results showed that the choice of strategy (epenthesis vs. deletion) was significantly influenced by the participants' L1. Furthermore, the choice of strategy was significantly influenced by the sonority profile. And finally, the interaction between language and sonority was also statistically significant. In Experiment 2, listeners from three different language backgrounds were recruited: English, Japanese and Spanish. In addition to the same

monosyllabic words presented in Experiment 1, the participants were presented with bisyllabic words to test whether the findings in Experiment 1 are based on the recoverability principle or an overall preference for bisyllabic forms (Wang, 1995). Our findings revealed that the choice of strategy was significantly influenced by the sonority profile, number of syllables, age of onset, vowel duration and word frequency. Even though epenthesis was significantly preferred over deletion regardless of the listeners' L1, the findings of the two experiments show that the preference for a specific modification strategy cannot be explained only by the recoverability principle or a preference for bisyllabicity; rather, there is a constellation of factors that influence the modification strategy.

CHAPTER ONE

1.1. Introduction

Previous studies have shown that when L2 learners are faced with structures that are illegal in their L1, they tend to simplify such structures (Sato, 1984; Weinberger, 1994; Osburne, 1996; Abrahamsson, 2003; Hansen, 2004; Yavaş, 2011; among others). This paper examines two different strategies of syllable structure simplification, namely, consonant deletion and vowel epenthesis, from a perspective of lexical access. Specifically, this paper investigates *the Recoverability Principle* (Weinberger, 1994), which suggests that epenthesis is functionally superior to deletion since it results in relatively less ambiguous structures. Even though both deletion and epenthesis convert the relatively complex CVC syllables into simple CV syllables, their outcomes differ in terms of the degree of lexical ambiguity. If we examine a word with a CVC syllable structure such as *lead*, the following are possible simplification outcomes:

(1) Target word	Deleted form	Epenthesized form
lead [lid]	[li]	[lidə]

We can see that the deleted form results in more ambiguity since it could be interpreted as *Lee (proper name), leaf, leave, lean, lead, leak, leash, lease*, etc. The epenthesized form [lidə], on the other hand, results in less potential ambiguity because it can only be interpreted as *lead* or *leader* if the person speaks a variety of English where the deletion

of final [ɹ] is acceptable. This example illustrates that epenthesis is better when it comes to meaning preservation (Weinberger, 1994).

This dissertation is organized as follows. Chapter 1 provides the necessary theoretical background. It discusses the prevalence of the CV syllable structure, and it introduces the relevant sonority principles and other factors that will be explored in this dissertation. Chapter 2 relates the current study with previous literature. It introduces the recoverability principle and reviews the relevant previous studies on coda modifications. Chapter 3 discusses the first experiment. It elaborates on the participants in this study, the stimuli used, the predictions of the study and the results. Chapter 4 discusses the second experiment. It elaborates on the participants in this study, the stimuli used, the predictions of the study and the results. Finally, chapter 5 discusses the results of both experiments with regard to the predictions and presents conclusions.

1.2. Preference for CV syllable structure

Previous studies have suggested that the CV syllable is universally preferred in the languages of the world (Blevins, 1995; Cairns & Feinstein, 1982; Clements, 1990; Greenberg, 1965; Hulst & Ritter, 1999; Vennemann, 1987). Evidence for the preference of the CV syllable is provided from various phonological processes from many languages, which reduce complex codas and onsets by vowel epenthesis or consonant deletion. For example, Vennemann (1987) provides data from Early Old High German in which CCV syllables are reduced to CV syllables. Early Old High German used to have complex onsets consisting of /h/ followed by a consonantal sonorant. In Late Old High German, the initial /h/ disappeared resulting in one-member onsets shown in (2):

(2) Early Old High German → Late Old High German (as cited in Carlisle, 2001)

[hnigan] → [nigan] "*to bow*"

[hlur] → [lur] "*loud*"

[hruofan] → [ruofan] "*to call*"

[hwiz] → [wiz] "*white*"

Furthermore, Vennemann (1987) provides another example of CCV syllables being reduced to CV syllables from the historical development of Pali, in which two-member onsets were reduced to one-member onsets as in the following:

(3) Pali (as cited in Carlisle, 2001)

[srotas] → [sota] "*stream*"

[svapna] → [soppa] "*sleep*"

[sjandana] → [sandana] "*wagon*"

This tendency of obtaining CV syllables by eliminating segments is not exclusive in onsets, however. Vennemann (1987) provides example from Italian in which CVC syllables have been reduced to CV syllables by deleting the one-member coda as shown in (4):

(4) Historical Italian (as cited in Carlisle, 2001)

[cantat] → [canta] "*(he) sings*"

[fac] → [fa] "*make!*"

[dic] → [di] "*say*"

These examples clearly demonstrate the universal preference for CV syllables.

1.3. Sonority

It is fairly well established that, cross-linguistically, the segments within a syllable pattern in a certain manner based upon sonority (Tropf, 1987; Clements, 1990; Carlisle, 1991, 2001; Broselow & Finer, 1991; Hansen, 2001; Parker, 2002). The syllables in which the nucleus is the most sonorous constituent and the segments comprising the onset and coda continuously fall in sonority outward from the nucleus are universally preferred. This organization of segments within a syllable is referred to as *the Sonority Sequencing Principle* (SSP) (Hooper, 1976; Kiparsky, 1979; Clements, 1990; Parker, 2002; among others). It is formally expressed in (5):

(5) Between any member *x* of a syllable and the syllable peak *p*, only sounds of higher sonority rank than *x* are permitted (Kar, 2010).

One-member onsets and codas by definition must adhere to the sonority sequencing principle since they must be comprised of segments that are less sonorant than the nucleus (Carlisle, 2001). However, one-member onsets and codas differ dramatically from each other according to which segments are preferred. If an onset consists of one segment, there is a universal tendency for this segment to be low in sonority, which results in obstruents being preferred over sonorants in that position. The reverse is true for codas where one-member codas that are high in sonority are preferred. This generalization is referred to as *the Sonority Dispersion Principle* (SDP) (Clements, 1990). This principle requires sonority to be maximally dispersed in the initial demisyllable and minimally dispersed in the final demisyllable (Clements, 1990). This is to say that the sharper the rise in sonority from beginning of the syllable to the nucleus,

the better the syllable. The opposite is true for the end of the syllable in which the fall of sonority from the nucleus needs to be minimal.

A number of different sonority scales have been proposed in the literature, but in this paper, the scale in (6) will be used as a starting point. Each of the segments forming the syllable will take its place on this scale, according to its sonority properties.

(6) Stops < Fricatives < Nasals < Liquids < Glides < Vowels (Morelli, 2003)

However, since affricates are not included in the above scale, they will be treated as a separate category. Affricates are not usually included in most common scales of sonority due to their complex nature. Some researchers suggest that they have the same sonority profile as stops (Bolinger, 1962; Cardona, 1988). Others suggest that affricates are between stops and fricatives, as in (7).

(7) Stops < Affricates < Fricatives (Goldsmith, 1990; Katamba, 1989; Puppel, 1992).

In our analysis, affricates are treated as a separate sonority group due to their debatable classification.

This paper investigates two simplification strategies, namely vowel epenthesis and consonant deletion, employed by L2 learners when encountering codas illegal in the learner's L1 that exhibit various sonority profiles. Different sonority profiles are examined because the hypothesis is that, based on the sonority dispersion principle (Clements, 1990), different sonority profiles may result in different modification strategies. That is, if the original word ends on segment with low sonority (e.g., [t]), listeners will prefer the form modified by epenthesis. This is because epenthesis creates

another syllable in which the segment previously in coda will be now the onset of the new syllable, and onsets with low sonority are preferred. In contrast, if the original word ends on a segment with high sonority, listeners will prefer the form modified by deletion.

For example, the English word *meal* can be modified by epenthesis as [milə] or deletion as [mi], and the word *book* can be modified by epenthesis as [bʊkə] or deletion as [bʊ]. Based on Clements (1990), it may be supposed that for [mil], deletion will be preferred since it results in a more optimal structure, whereas the other possibility [mi.lə] results in an onset with high sonority, which violates SDP. For the word [bʊk], on the other hand, it may be assumed that epenthesis will be preferred since it results in a low-sonority onset that satisfies the sonority dispersion principle.

1.4. Other factors

In addition to investigating the recoverability principle and the effects of sonority, other factors will also be examined in this dissertation to see if they have any effects on the choice of the modification strategy. These factors are self-reported English proficiency, word frequency, bisyllabicity – which will be discussed in section 2.2 – and vowel duration.

Weinberger (1987) examined the production of one-member, two-member, and three-member word-final codas by four intermediate Mandarin speakers of English. He found that the Mandarin participants exhibited 50% epenthesis and 50% deletion. Weinberger suggested that this was due to the difference in the participants' overall English proficiency. He argued that adult L2 learners with a more developed knowledge of the target lexicon tend to be more sensitive to the recoverability principle. In other

words, advanced learners will typically show a greater degree of epenthesis than less advanced learners.

Thus, in this study, self-reported English proficiency will be examined to see if it has any effects on the choice of the modification strategy. Based on Weinberger (1987), this study predicts that listeners with higher self-reported English proficiency will choose words modified by epenthesis more frequently, whereas listeners with lower self-reported English proficiency will choose words modified by epenthesis less frequently.

Additionally, age of onset will be treated as one of the measures for English proficiency. This is because several studies have shown that age of onset plays a significant role in learners' performance and overall L2 proficiency (Patkowski, 1980; Flege et al. 1995). For example, Stevens (1999) indicates that regardless of how many years of exposure or opportunities to learn L2, it seems that only those who begin L2 learning as young children are capable of achieving native-like attainment. He further adds that the age-related loss in ability appears to persist through childhood, and perhaps through adolescence. However, this loss is not an abrupt one-time event. Rather, it is a gradual event because L2 learners who start after the age of six or seven often become communicatively fluent, but they often retain measurable accents in phonology.

Furthermore, length of residency will also be treated as one of measures for English proficiency. According to Steven (1999), length of residence in the U.S. can be a simple and direct measure of immigrants' exposure to opportunities to learn the language. He indicates that immigrants who have been in the country for longer periods of time report or demonstrate higher levels of overall proficiency in English. Similarly,

Espenshade & Fu (1997) indicate that exposure to the English language, which is frequently measured by the length of stay, along with age at migration, can be viewed as the most important factor that determines immigrants' acquisition of English. Thus, this study predicts that listeners who reported longer length of residency will choose words modified by epenthesis more frequently, whereas listeners who reported shorter length of residency will choose words modified by epenthesis less frequently.

Moreover, since we are examining real English words modified by two modification strategies (epenthesis and deletion), the effects of word frequency will also be explored as a factor. Previous studies have shown that word frequency can have an influence on learners' performance. For example, Fidelholtz (1975) showed that vowel reduction in initial syllables in English was significantly correlated with frequency where more frequent words were more likely to have a reduced vowel. Bybee (2002) indicates that word frequency and context frequency are factors that can affect variation and should be taken into account when investigating variation and change. Similarly, Bybee (2007) indicates that high-frequency words are affected earlier by vowel and consonant reduction or assimilation processes, whereas infrequent words are the most resistant to phonetically motivated change.

Lastly, the length of the epenthetic vowel will also be measured and included as a factor to see if it has any influence on the choice of modification strategy. Steriade (2001) points out that the schwa is preferentially inserted in many languages because it is the closest thing to no epenthesis at all. The schwa has a short duration, and it is unstressable in many languages such as in Dutch, Indonesian and French. This makes it the closest

thing in a vowel system to no segment at all. Moreover, Shoji & Shoji (2014) indicate that the epenthesized segment should be the one that is the least intrusive, the most unmarked and perceptually the closest to zero (or silence) in the recipient languages. They further add that epenthetic vowels with minimal salience would result in a smaller perceptual change between the input and output. Thus, this study predicts that listeners should choose epenthesis more frequently in words with shorter vowel duration.

CHAPTER TWO

2. Literature review

Previous research shows that when speakers are faced with illegal codas in their native language, they tend to modify such structures, as mentioned above, by two common modification strategies – epenthesis and deletion.[1] The motivation for the two strategies is clear since both deletion and epenthesis result in a change toward CV syllables. They have the effect of transforming the form that would be an impossible syllable structure in a certain language to one that is a legal syllable structure. For example, the English word *rose* [ɹoʊz] has [z] in its syllable coda which is an illegal structure in many languages such as Japanese. If deletion or epenthesis are applied, the resulting forms are [roʊ] and [roʊzə], respectively. Both [ɹoʊ] and [ɹoʊzə] avoid this illicit coda structure. However, one could still wonder why one would be preferred over the other.

2.1. The recoverability principle

Weinberger (1987) suggests that the recoverability principle (Hankamer, 1973; Kaye, 1974) accounts for this asymmetry. He proposes that this principle is used to account for the ambiguity that results from such phonological operations. As in the previous example, repeated here as (8), the deletion process results in unrecoverable forms.

[1] There are other strategies as well, such as devoicing, which are used to modify illegal structures. However, the other strategies are beyond the scope of this paper because we are interested in syllable structure changes rather than feature changes.

(8) Target word	Deleted form	Epenthesized form
lead [lid]	[li]	[lidə]

In other words, deletion will lead to an increased lexical ambiguity since there are various possible forms from which the listener could choose, whereas epenthesis results in relatively easily recoverable structures since it limits the possibilities. Thus, the recoverability principle can be formalized as:

(9) Modifications resulting in recoverable outputs are preferred over modifications resulting in nonrecoverable outputs.

Weinberger (1994) suggests that this principle is part of universal grammar that matures according to a preset schedule. He argues that children do not employ epenthesis as a simplification strategy because the recoverability principle is not yet active due to their limited lexicon. By the time it becomes active, children whose native language allows coda consonants are already capable of producing the complex structures. Based on this claim, it can be predicted that adult L2 learners will employ epenthesis as their predominant simplification strategy since the recoverability principle is presumably active. However, studies investigating cluster simplification strategies show that this is not always the case (Heyer, 1986; Weinberger, 1987; Riney, 1990; Abrahamsson, 2003; among others). This could be due to the learners' proficiency and lexicon size. That is, beginners may not be aware of any potential ambiguity due to their yet to be developed small lexicon. Thus, it is possible that epenthesis becomes the strategy of choice when learners develop the adequate linguistic knowledge of the target lexicon, which would

lead them to being aware of such lexical ambiguity. This is because ambiguity is operational only if the interpreter has the requisite lexical knowledge.

2.2. Previous Studies on codas

Several studies have investigated the production of English codas by L2 learners. However, all have focused on production. For example, Sato (1984) conducted a longitudinal study, examining the production of two-member codas in spontaneous speech samples of two Vietnamese children at three different time points during a time period of 10 months. The results showed that, at time 1, the codas were produced 10.10% accurately, while 89.89% were non-target productions. Of these non-target productions, 3.37% were cases of feature change, 78.65% were cases of cluster reduction, where one member was deleted, and 17.97% were cases of cluster deletion, where both members of the coda were deleted. At time 2, 5.88% of the productions were target like, whereas 94.11% were non-target productions. Of these non-target productions, 1.13% were cases of feature change, 85.79% were cases of cluster reduction and 13.06% were cases of cluster deletion. Finally, at time 3, 19.70% of the productions were target like, while 80.29% consisted of non-target productions. Of these non-target forms, 2.43% were modified by feature change, 84.14% were modified by cluster reduction, and 13.41% were modified by cluster deletion. The results are summarized in Table 1.

Table 1: Epenthesis vs. deletion in Sato (1984).

Time	Epenthesis	Cluster Reduction	Cluster Deletion
Time 1	0%	78.65%	17.97%
Time 2	0%	85.79%	13.06%
Time 3	0%	84.14%	13.41%

Sato pointed out that there were only two instances of vowel insertion, both of which were cases of prothesis, which is outside the scope of this paper. Sato concluded that native speakers of Vietnamese tend to modify codas by single consonant deletion rather than epenthesis or deletion of the entire cluster.

Similarly, Benson (1988) examined the production of monosyllabic English words in informal conversations by two Vietnamese speakers of English. The results showed that the first participant had 396 attempted productions of monosyllabic closed syllable target words (CVC), of which 67 cases (16.91%) were modified by deletion. The second participant had 141 attempted productions of monosyllabic closed syllable target words (CVC), of which 25 cases (17.7%) were modified by deletion. The results are shown in Table 2.

Table 2: Epenthesis vs. deletion in Benson (1988).

Participant	Epenthesis	Deletion
Participant 1	0%	16.91%
Participant 2	0%	17.7%

Similar to Sato's study, Benson (1988) pointed out that none of the two participants used epenthesis as a modification strategy. Benson concluded that the errors made by those Vietnamese participants are due to transfer from their native language.

Both Sato (1984) and Benson (1988) examined coda productions of Vietnamese speakers of English, and they both found that deletion was the predominant strategy. Based on their findings, one could predict that our Vietnamese participants will also choose words modified by deletion more frequently. Nevertheless, this is against the recoverability principle which suggests that deletion will lead to increased lexical ambiguity.

Hansen (2004) did a longitudinal study in which she collected data from two adult native speakers of Vietnamese three times over a year. Data were elicited through interviews and word list reading. When codas were grouped by length, the overall results showed that accuracy was higher for singleton codas over CC codas and for CC codas over CCC codas. Unlike Sato (1984) and Benson (1988), Hansen's results for singleton codas showed that, at time 1, the codas were produced 48% accurately, 25% were

modified by deletion, 8% modified by epenthesis, 16% modified by feature change and 3% modified by two or more strategies. At time 2, codas were 43% target-like, 30% modified by deletion, 9% by epenthesis, 15% modified by feature change and 2% modified by two or more strategies. And at time 3, codas were 48% target-like, 19% modified by deletion, 11% by epenthesis, 19% modified by feature change and 3% modified by two or more strategies. The results are summarized in Table 3.

Table 3: Epenthesis vs. deletion in Hansen (2004).

Time	Epenthesis	Deletion
Time 1	8%	25%
Time 2	9%	30%
Time 3	11%	19%

Unlike Sato (1984) and Benson (1988), she concluded that there was not a preferred production type, after considering various factors such as individual preference, coda length, and linguistic environment. For instance, she indicated that one participant slightly disfavored deletion, whereas the other participant slightly favored deletion.

Weinberger (1987) examined the production of one-member, two-member, and three-member word-final codas by four intermediate Mandarin speakers of English. The frequency of modification was dependent on the length of the coda. The longer the codas, the more frequently they were modified. There was 5.5% modification of one-member

codas, 29.8% of two-member codas and 42% of three-member codas. This suggests that the more marked the syllable, the more frequent the simplification processes. With regard to the modification strategies, the Mandarin participants in his study exhibited 50% epenthesis and 50% deletion.

Weinberger suggested that this was due to the difference in the participants' overall English proficiency. Adult L2 learners with a more developed knowledge of the target lexicon tend to be more sensitive to the recoverability principle. That is, once the adult language learner is aware that ambiguity is a real possibility, he/she should utilize epenthesis significantly more often than deletion. In other words, advanced learners will typically show a greater degree of epenthesis than less advanced learners.

Thus, this dissertation will also investigate the influence of proficiency on the choice of modification strategy. Based on the Weinberger (1987), we predict that listeners with higher self-reported English proficiency will choose words modified by epenthesis more frequently, whereas listeners with lower self-reported English proficiency will choose words modified by epenthesis less frequently.

Another study that only focused on production is Yavaş (2011). He investigated the acquisition of two-member English coda clusters by native speakers of Spanish. He looked at the production of 24 monosyllabic and mono-morphemic English words by 19 native speakers of Spanish. All the tested words exhibited coda clusters that obeyed the sonority sequencing principle. He observed that when adult Spanish learners of English were faced with English coda clusters, they typically simplified the target by deleting one member of the cluster. The results showed that his participants only modified these target

words by deletion. There were 139 cases of deletion out of 456 possible cases (30% deletion). It is worth pointing out that Yavaş (2011) did not mention anything regarding the learners' overall English proficiency. Furthermore, Yavaş (2011) only investigated two-member English coda clusters. One could cautiously predict that when Spanish speakers are faced with illegal codas, they exclusively modify these codas by deletion. This prediction will be tested in Experiment 1 in chapter 3. Also, it will be seen whether his findings can be generalized to singleton codas.

Wang (1995) investigated the pronunciation of English syllable codas by native speakers of both Mandarin and Taiwanese. Taiwanese permits only voiceless obstruents in the coda and Mandarin permits no coda obstruents. She found that most of the participants employed both epenthesis and deletion[2] to transform the target structures into structures that conform to their native language syllable coda types or at least into less marked structures. She argues that the choice of simplification strategy is dependent upon the target word's number of syllables such that there is an overall preference for bisyllabic forms. This is to say, epenthesis is favored in monosyllable stimuli because the output is a bisyllabic word, whereas other strategies, such as deletion which do not add a syllable, are favored in bisyllabic stimulus forms. In fact, she found that monosyllabic words were significantly more likely to undergo epenthesis (CVC → CVCV), while bisyllabic words were significantly more likely to undergo deletion (CVCVC → CVCV).

Based on the findings of Wang (1995), for a monosyllabic word such *rose* [roʊz], epenthesis should be preferred over deletion of the final consonant because epenthesis

[2] Some employed devoicing as well, but it is outside the scope of this paper.

will transform this monosyllabic form [roʊz] into a bisyllabic form [roʊ.zə], whereas deletion of the final consonant would yield a monosyllabic output. Wang's proposal provides an alternative explanation for choosing epenthesis over deletion as a simplification strategy. However, what about the results of Yavaş's study? All the words tested were monosyllabic words. This actually represents a challenge for the generalizability of both Wang's and Weinberger's proposals. If we apply Wang's proposal to an English word with two-member coda cluster used in Yavaş's study such as *milk* [mɪlk], we should end up with something like [mɪl.kV]. Alternatively, if we apply Weinberger's proposal to the same word, we should end up with [mɪl.kV] or [mɪ.lV.kV]. Nevertheless, the outcomes of both proposals were not found in Yavaş (2011), in which participants mainly showed deletion.

We could argue that Spanish speakers do not value the bisyllabic constraint, and thus, the participants in Yavaş's study employed deletion more often. It is also possible that they were non-advanced learners. Consequently, at that time, it is possible that they still had not developed the adequate linguistic knowledge of the target lexicon which would lead them to employ the recoverability principle. Nevertheless, the possibility cannot be ignored that Spanish learners have a general preference for coda deletion as a simplification strategy. That is to say, regardless of the number of syllables in the target words or their overall English proficiency level, it is possible to predict, based on Yavaş's findings, that they will choose deletion as the main strategy when faced with illegal codas.

The tendency of a certain language to systematically apply one repair strategy over another is not entirely unusual. For example, it has been observed that the English interdentals [θ, ð] are replaced either by [t] or [s], depending on the speaker's L1. Generally, the segment used for substitution is consistent for speakers of a given language. For example, speakers of German are reported to use [s], whereas Russian speakers use [t] systematically (Lombardi, 2003). Based on such observation, we will test the possibility that one language may systematically employ a particular modification strategy. Specifically, we will examine whether Spanish and Vietnamese show a preference for employing deletion (Yavaş, 2011; Sato, 1984; Benson, 1988), and whether Japanese shows a preference for epenthesis (Dupoux et al., 1999).

2.3. Languages under examination

In this dissertation, we examine the perception of structures modified by either epenthesis or deletion by listeners of four different languages in two experiments. The first is Japanese; Japanese listeners have been found to report perceiving a vowel when presented with words containing illegal structures even when the vowel was not actually present (Dupoux et al., 1999). The hypothesis is that Japanese speakers would prefer epenthesis over deletion because they have been found to report perceiving a vowel when presented with words containing illegal structures even when the vowel was not actually present. Dupoux et al. (1999) examined two groups of listeners: French listeners, whose native languages allows for complex syllabic structures, and Japanese listeners, whose native language disallows complex structures. The listeners were presented with different variants of the nonword "*ebzo*" some of which contained no vowel, and others had

various pitch/length modifications of the vowel [u] between [b] and [z]. Both French and Japanese participants were asked to decide whether or not the vowel [u] was present in the stimuli. The results showed that the French listeners were able to judge that the vowel was absent in the "*ebzo*" case and present in the "*ebuzo*" case. However, the Japanese listeners predominantly judged that the vowel was present regardless of the presence of the vowel in the acoustic stimuli. Even when the vowel was non-existent in the stimulus, the Japanese listeners still reported that the vowel was present in more than 70% of the cases. It is worth pointing out that the Japanese participants were not learners, nor were they perceiving real words. However, we want to see if the findings of Dupoux et al. (1999) can be extended to Japanese learners of English.

Furthermore, this preference for inserting a vowel is also found in loanwords:

(10) Japanese loanwords from English (Itô and Mester,1995)

"fight" → [faito]

"festival" → [fesɯtibarɯ]

"sphinx" → [sɯfiIkɯsɯ]

Furthermore, Japanese is more restrictive in the range of coda consonants it allows compared to English. Japanese has very restricted codas such that it only allows for codas in two cases. Codas are allowed if the segment is a nasal, or if it is the first part of a geminate which can only appear word-medially. It is worth pointing out that not all Japanese consonants can be geminated. The ones that can be geminated are shown in (11):

(11) [p, t, k, s, ʃ, ts, tʃ] (Tsuchida, 1995).

The second language is Spanish, which has been shown to favor deletion when it comes to modifying illegal codas with two consonants in production studies (Yavaş, 2011). Since Yavaş (2011) only examined two-member coda clusters in a production study, this dissertation investigates whether the findings can be generalized to the perception of singleton codas. Similar to Japanese, Spanish has a very limited set of coda possibilities. It only allows for five consonants in the coda position [d, s, n, ɾ, l] (Nunez, Rafael and Morales, 1999). English, on the other hand, allows for a much larger set. Most English consonants can occur in the coda position [p, b, t, d, k, g, m, n, ŋ, f, v, θ, ð, s, z, ʃ, ɹ, l, dʒ, tʃ] (Gregová, 2010).

The third is language is Vietnamese. Vietnamese has a CVC syllable structure, and it allows for three unreleased voiceless obstruents [p̚, t̚, k̚] and three nasals [m, n, ŋ]. We are targeting Vietnamese speakers because Vietnamese is similar to Japanese in terms of syllable structure; nevertheless, it seems to behave differently in terms of the choice of modification strategy.

Vietnamese has been shown to favor deletion when it comes to modifying illegal codas (Sato, 1984; Benson, 1988). Moreover, Nguyen & Dutta (2017) indicate that consonant deletion is the most frequent strategy employed to modify foreign consonant clusters in the coda position. In fact, they indicate that in French loanwords in Vietnamese, deletion is the only strategy that is applied.

It is worth pointing out that, unlike Dupoux et al. (1999) on Japanese perception, as far as we know, no studies have investigated the preferred modification strategy of Vietnamese listeners. Thus, we want to see if Vietnamese listeners will show the same

tendency when they are presented with monosyllabic and bisyllabic words with single codas.

The fourth and final language is English. Since the stimuli will consist of English words that have been modified by either epenthesis or deletion, the perception of English listeners will be examined as a control group. Since the recoverability principle suggests that speakers employ the strategy that results in the least ambiguity, native listeners' judgments of both modified structures will be informative. Table 4 summaries our predictions with regard to each examined language.

Table 4: Predictions with regard to each examined language.

Language	Preference
Japanese	Epenthesis
Spanish	Deletion
Vietnamese	Deletion

2.4. The current study

This dissertation examines the preference between two strategies (epenthesis and deletion) of syllable structure simplification using a perceptual task. Previous studies that examined learners' production found that the results vary depending on the type of the task employed (Eckman, 1991; Edge, 1991; Boudaoud & Cardoso, 2009). Learners have been found to exhibit a greater number of errors in more spontaneous conversations,

whereas they show a greater level of accuracy when performing more controlled tasks such as reading word lists and/or passages. For example, Boudaoud & Cardoso (2009) compared the production of onset clusters by Farsi speakers across two tasks. The formal task involved reading a list of sentences containing the target clusters, whereas the other task was an informal picture-based interview in which the participants were presented with pictures containing the target clusters. They found that participants exhibited a higher proportion of target-like productions in the formal task, but they exhibited more errors in the informal task.

As far as we know, no previous study has examined the difference between two epenthesis and deletion using a perceptual task. By conducting a perception experiment, it is possible to address the gap in the literature (no perception studies investigating recoverability), and to avoid the issues associated with production experiments such as the varying results based of the production task employed. Abrahamsson (2003) indicates that, based on functional approaches to phonology and phonetics, speakers are governed by two conflicting forces. The first is their tendency to minimize articulatory effort, and the second is their need to maximize intelligibility (e.g., Boersma, 1998; Donegan & Stampe, 1979; Kiparsky, 1982). The tendency to minimize articulatory complexity is based on the speaker, and this manifests itself in phonological processes that result in unmarked structures. The other force, which manifests itself in the need to maintain distinctness and understandability, is oriented towards the needs of the listener. When it comes to the processes under examination (deletion & epenthesis), if adult speakers are to minimize articulatory complexity, deletion should be the strategy of choice. If, however,

adult speakers ultimately want to be understood, they should employ epenthesis rather than deletion since it accommodates the listeners' needs by maintaining relevant information and avoiding ambiguous forms, as predicted by the recoverability principle (Weinberger, 1994). Nevertheless, as evidenced from the previously mentioned production studies, epenthesis is not always the strategy of choice by adult speakers.

A perception experiment was conducted because we want to examine the implications of the recoverability principle which cannot be examined in production studies. Production studies only examine one part of the equation. Successful communication requires both a speaker and a listener. So far, it is just an assumption that speakers will choose epenthesis as a modification strategy because they want to be understood. As far as we know, no one has asked the listeners about their actual preferences. We hypothesize that if the recoverability principle is at work, listeners should always view the structures modified by epenthesis as less ambiguous compared to those modified by deletion. In this study, we try to answer this question: do listeners prefer epenthesis which results in easily recoverable structures regardless of their native language? Or do they follow their NL preferences based on what found in earlier production studies?

CHAPTER THREE

3.1. Experiment 1

Previous studies have shown that when L2 learners are faced with structures that are illegal in their native language, they tend to simplify such structures (Weinberger, 1987; Benson, 1988; Sato, 1984; Wang, 1995; Hansen, 2004; Yavaş, 2011; among others). The purpose of Experiment 1 is to examine two different strategies of syllable structure simplification, namely, deletion and epenthesis, using a perceptual task. Specifically, this dissertation investigates the recoverability principle (Weinberger, 1994), which suggests that epenthesis is functionally superior to deletion since it results in relatively less ambiguous structures. Up until this point, all research dealing with this notion of recoverability has been done with production data. This study attempts to document the perception and recoverability by native and non-native listeners of English modified words. Even though both deletion and epenthesis convert the relatively complex CVC syllables into simple CV syllables, their outcomes differ in terms of the degree of lexical ambiguity. We hypothesize that words modified by epenthesis should be chosen more frequently by listeners since epenthesis is better when it comes to meaning preservation (Weinberger, 1994).

3.2. Methodology

3.2.1. Stimuli

The stimuli used in Experiment 1 consisted of 38 monosyllabic English nouns with CVC syllable structure experimental words. In each session, the participants were

presented with two modified forms of each word of the original 38 words, one with epenthesis (CVCV) and the other with deletion (CV). This means that they listened to 76 (38x2) forms of the experimental words, and they had to choose one variant per question.

The experimental words were chosen to cover all consonants that can occur in the English coda position. Nineteen different coda consonants were included: [p, b, t, d, k, ɡ, f, v, θ, s, z, ʃ, tʃ, dʒ, m, n, ŋ, l, ɹ]. One consonant, the voiced fricative [ð], was not included because it was not found in coda positions in monosyllabic nouns. Each of the coda consonants appeared twice in two different words. This resulted in a total of 38 target words per participant. In addition, the participants were presented with 15 nonexperimental words (fillers), which can be seen in Appendix A3. These fillers consisted of words with onset clusters, such as *flake*, for which each question contained two forms: the original form [fleɪk] and another that was modified by deleting one member of the cluster [leɪk]. Of these 15 fillers, three were used in a brief training session.

All words can be seen in Appendix A1 and A3. All of these words were produced by a phonetically-trained male native speaker of English. The speaker's age was 62. He was born in Pittsburgh, PA, USA, and he reported a knowledge of Mandarin. The speaker was asked to produce two forms of each word. For the words modified by deletion, he was asked to drop the coda. For the words modified by epenthesis, he was asked to add the vowel [ə]. The duration of the inserted vowel for all words is shown in Appendix B. The words were recorded with a 44.1 khz sampling rate using Zoom H2 Handy Recorder in the Acoustics Lab at George Mason University.

3.2.2. Participants

Experiment 1 examined listeners who identified themselves to be from three different language backgrounds: English, Japanese and Spanish. A total of 137 listeners were recruited for this study. The participants were recruited via Amazon Mechanical Turk and were given $1.50 for compensation. Participants who reported having hearing or speaking issues were excluded from this study. In addition, Japanese and Spanish participants were asked to self-rate their English proficiency and frequency of English use using a five-point scale in which 1 indicates very low proficiency/frequency of use, and 5 indicates high proficiency/frequent language use. The percentages were calculated by summing up all the proficiency scores for each language group and then dividing the actual outcome by the total possible proficiency score for that particular language. The obtained decimal value was then multiplied by 100 to get the percentage. Table 5 summarizes the background information about the participants in this study and also provides average scores converted into percentages.

Table 5: Experiment 1 participants' demographic information.

Participants	Total number	Age	Gender	Age of onset	Length of residency	English proficiency	English frequency
English	51	(21 – 70) mean=29.47	M=27, F=24	NA	NA	NA	NA
Japanese	38	(18 – 43) mean=31.83	M=21, F=17	(3 – 21) M=8.39	(0 – 35) M=11.1	84.73%	70.52%
Spanish	48	(19 – 52) mean=31.58	M=34, F=14	(1 – 25) M=7.71	(0 – 25) M=2.16	82.5%	48.75%

In Table 5, it can be seen that all language groups are similar in terms of the listeners' mean age. The English participants had an average age of 29.47, whereas the Japanese and Spanish participants had age averages of 31.83 and 31.58, respectively. In addition, both non-native groups, Japanese and Spanish, had a similar age of onset where Japanese had an average of 8.39 years and Spanish 7.71 years. An independent-samples t-test was conducted to compare the average age of onset for the Japanese and Spanish groups. There was no significant difference between the Japanese (M=8.39, SD=4.99) and Spanish (M=7.71, SD=4.18) groups; t (74)=0.648, p = 0.519.

Self-reported English proficiency was similar in the Japanese and the Spanish participants, which were 84.73% and 82.5%, respectively. An independent-samples t-test revealed that this difference is not statistically significant: Japanese (M=4.24, SD=0.542) and Spanish (M=4.18, SD=0.766) groups; t (74)=0.346, p = 0.731. When it comes to the self-reported frequency of using English, however, the Japanese participants had a higher frequency (70.52%) compared to the Spanish participants (48.75%). An independent-samples t-test revealed that this difference is statistically significant: Japanese (M=3.53, SD=0.830) and Spanish (M=2.50, SD=0.191) groups; t (37)= -5.29, p < .001. This could be the result of their length of residency in an English-speaking country. The Japanese participants had an average of 11.13 years compared to only 2.35 years in the Spanish sample. An independent-samples t-test revealed that this difference was statistically significant: Japanese (M=11.1, SD=8.25) and Spanish (M=2.16, SD=4.69) groups; t (74)=5.69, p < .001.

3.2.3. Task

In Experiment 1, each participant listened to the two forms of each word accompanied by a picture. For example, for the English word *couch*, participants were shown a picture of a couch, and they heard the two modified forms [kaʊʧə] and [kaʊ]. All of these words were nouns. Listeners were presented with each of these words accompanied by a picture of what the word denotes, and they were instructed to choose the word that best matches the picture based on their judgment. All pictures used can be seen in Appendix A, where Appendix A1 shows the monosyllabic experimental words, A2 shows the bisyllabic experimental words, and A3 shows the fillers.

3.2.4. Procedure

The experiment was designed in Qualtrics, and then it was linked to Amazon Mechanical Turk. All participants first completed a consent form. At the end of the consent form, they had to click "*accept*" if they agreed to participate. Once they agreed, they were asked to provide some demographic information: native language, age, gender, English proficiency, English frequency, length of residency, age of onset, place of birth and method of learning English (naturally or academically). All questions are listed in Appendix B. Participants who did not meet the requirements for the study, such as those who reported having hearing problems, were excluded from the analysis. In addition, since this was a perception experiment, the participants were required to wear headsets. Participants were required to enter the model name of the headset they were using. Those who failed to provide this information were excluded from the study.

Once they completed the background information, they were presented with three stimuli containing filler words as part of a training session. The purpose was to familiarize the participants with the experiment. After the familiarization trials, the actual experiment started. Experiment 1 was self-paced, and each participant was presented with 50 stimuli containing 38 experimental words and 12 fillers with corresponding pictures in a randomized order.

3.2.5. Predictions

Based on the previous studies, this study hypothesizes that:

1. The recoverability principle operates in grammar: Words modified by epenthesis should be chosen more frequently by listeners of all languages (Weinberger, 1994).
2. Sonority of the coda consonant will influence the modification strategy: If the original word ends on a segment with low sonority (e.g., [t]), listeners will choose the word modified by epenthesis. This is because epenthesis creates another syllable in which the segment previously in coda will be the onset of the new syllable, and onsets with low sonority are preferred. However, if the original word ends on a segment with high sonority, listeners will choose the word modified by deletion (Clements, 1990).
3. There will be native language bias: Based on previous studies, it was found that certain languages have a tendency of employing a particular repair strategy (epenthesis or deletion). Thus, in this experiment, we want to see if the results of Yavaş (2011), which is a production study, and Dupoux et al. (1999), which is a study examining the perception of native speakers of Japanese who are not actively learning the target language, can be extended to the perception of L2 leaners of modified English codas. Spanish listeners are

predicted to choose words modified by deletion more often, whereas Japanese listeners are predicted to choose words modified by epenthesis (Dupoux et al., 1999; Yavaş, 2011).

4. Proficiency matters: Listeners with higher English proficiency will choose words modified by epenthesis more frequently (Weinberger, 1994).

3.4. Results and discussion

3.4.1. Statistical analysis for all languages

Overall, the results showed both epenthesis and deletion activity. In this section, we will report and discuss the results and the ratios found. We used Jamovi (2018) to perform the statistical analyses. A mixed model regression test was conducted to see if the listeners' native language and the sonority of coda consonants significantly influenced the choice of repair strategy (deletion vs. insertion). In this model, deletion was set as the dependent variable; language, sonority, and sonority*language, which explores the interaction between language and sonority, were the fixed factors; participant and word were the random structures.

Overall, the results show that the choice of strategy (epenthesis vs. deletion) was significantly influenced by the participants' native language [$F(2,142) = 14.12$, $p < .001$]. Furthermore, the choice of strategy was significantly influenced by the sonority profile [$F(4,33) = 2.86$, $p = 0.038$]. And finally, the interaction between language and sonority was also statistically significant [$F(8,5024) = 4.88$, $p < .001$].

In order to examine the combined performance of all groups in relation to specific sonority profiles, a Bonferroni post-hoc analysis was conducted. The results showed that

liquid was the only sonority level that significantly exhibited deletions ($p = 0.005$) compared to other sonority levels. Furthermore, when we examine the performance of a specific language in relation to specific sonority profiles compared to the other languages, we find that Spanish participants had a significant tendency for deleting stops ($p < .001$), fricatives ($p = 0.017$), nasals ($p = 0.008$), and liquids ($p = 0.018$). Moreover, Japanese participants had a significant tendency for deleting stops ($p = 0.017$) and nasals ($p = 0.027$). The results are shown in Table 6.

Table 6: Experiment 1 mixed model results.

Fixed Effect Omnibus tests

	F	Num df	Den df	p
Language	14.12	2	141.6	< .001
Sonority	2.86	4	33.1	0.038
Language ✻ Sonority	4.88	8	5024.0	< .001

Fixed Effects Parameter Estimates

				95% Confidence Interval				
Names	**Effect**	**Estimate**	**SE**	**Lower**	**Upper**	**Df**	**t**	**p**
(Intercept)	(Intercept)	0.09186	0.01405	0.06433	0.11939	98.8	6.540	< .001
Language1	Japanese - (English, Japanese, Spanish)	0.03884	0.01554	0.00839	0.06929	141.6	2.500	0.014
Language2	Spanish - (English, Japanese, Spanish)	0.03766	0.01463	0.00898	0.06634	141.6	2.573	0.011
Sonority1	fricative - (affricate, fricative, liquid, nasal, stop)	-0.02292	0.01589	-0.05406	0.00822	33.1	-1.443	0.158
Sonority2	liquid - (affricate, fricative, liquid, nasal, stop)	0.07049	0.02356	0.02430	0.11667	33.1	2.991	0.005
Sonority3	nasal - (affricate, fricative, liquid, nasal, stop)	-0.01505	0.02010	-0.05444	0.02434	33.1	-0.749	0.459
Sonority4	stop - (affricate, fricative, liquid, nasal, stop)	0.00872	0.01589	-0.02242	0.03986	33.1	0.549	0.587

Fixed Effects Parameter Estimates

Names	Effect	Estimate	SE	95% Confidence Interval		Df	t	p
				Lower	Upper			
Language1 ✻ Sonority1	Japanese - (English, Japanese, Spanish) ✻ fricative - (affricate, fricative, liquid, nasal, stop)	0.00406	0.00881	-0.01321	0.02133	5024.0	0.461	0.645
Language2 ✻ Sonority1	Spanish - (English, Japanese, Spanish) ✻ fricative - (affricate, fricative, liquid, nasal, stop)	-0.01979	0.00830	-0.03606	-0.00352	5024.0	-2.384	0.017
Language1 ✻ Sonority2	Japanese - (English, Japanese, Spanish) ✻ liquid - (affricate, fricative, liquid, nasal, stop)	0.00276	0.01307	-0.02286	0.02838	5024.0	0.211	0.833
Language2 ✻ Sonority2	Spanish - (English, Japanese, Spanish) ✻ liquid - (affricate, fricative, liquid, nasal, stop)	0.02917	0.01231	0.00503	0.05330	5024.0	2.369	0.018
Language1 ✻ Sonority3	Japanese - (English, Japanese, Spanish) ✻ nasal - (affricate, fricative, liquid, nasal, stop)	0.02470	0.01115	0.00285	0.04655	5024.0	2.216	0.027
Language2 ✻ Sonority3	Spanish - (English, Japanese, Spanish) ✻ nasal - (affricate, fricative, liquid, nasal, stop)	-0.02766	0.01050	-0.04824	-0.00708	5024.0	-2.634	0.008
Language1 ✻ Sonority4	Japanese - (English, Japanese, Spanish) ✻ stop - (affricate, fricative, liquid, nasal, stop)	-0.02100	0.00881	-0.03827	-0.00373	5024.0	-2.383	0.017
Language2 ✻ Sonority4	Spanish - (English, Japanese, Spanish) ✻ stop - (affricate, fricative, liquid, nasal, stop)	0.03364	0.00830	0.01737	0.04991	5024.0	4.053	< .001

Figure 1 demonstrates the deletion frequency for all examined languages across all sonority profiles. In the following sections, we discuss the results of each language group in more details.

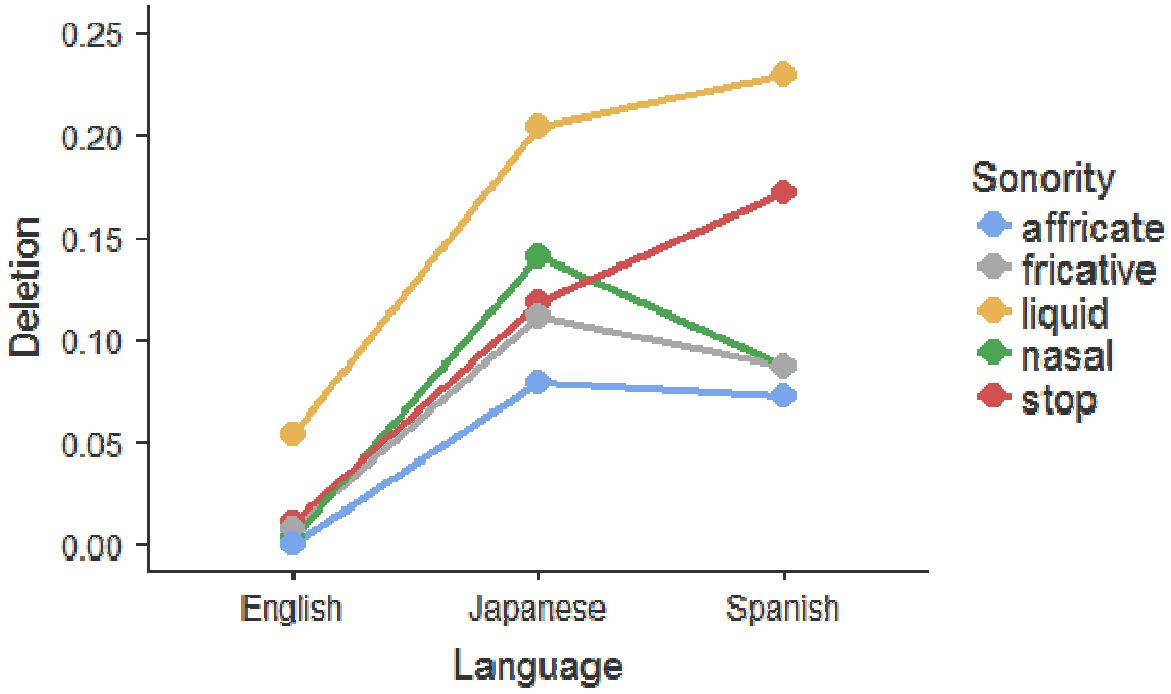


Figure 1: Experiment 1 deletions based on language and sonority.

3.4.2. English Participants

Our main prediction was that if the recoverability principle is at work in the grammars of these L2 listeners, words modified by epenthesis should be chosen more frequently by listeners of all examined languages. A total of 51 native speakers of English participated in this study. They were each presented with 38 experimental words

and had to choose between words that were modified by epenthesis or deletion. This results in a total of 1,938 tokens. Out of 1,938 tokens, words modified by epenthesis were chosen 1,914 times, which amounts for 98.76%. Words modified by deletion, on the other hand, were only chosen 24 times, which amounts for 1.23%.

The results show that native speakers of English had a dominant preference for words modified by epenthesis. This provides support for the recoverability principle that words modified by epenthesis are easier to disambiguate. Based on these findings, we could argue that in real communication, with all else being equal, native English speakers would find words modified by epenthesis, at least monosyllabic words, preferable to those modified by deletion.

We also examined the specific segments in the coda position. Based on a sonority perspective, we predicted that if the coda has a segment with low sonority, listeners will choose the word modified by epenthesis since the original coda is transformed into an onset where segments with lower sonority are preferred. By contrast, if the original word ends on a segment with high sonority, listeners will choose the word modified by deletion based on the sonority dispersion principle.

Table 7: Experiment 1 total epenthesis vs. deletion based on sonority profile.

Sonority	Total	Epenthesis	Deletion
Stops	12x51= 612	605 (98.85%)	7 (1.14%)
Affricates	4x51= 204	204 (100%)	0 (0%)

Fricatives	12x51= 612	607 (99.18%)	5 (0.81%)
Nasals	6x51= 306	305 (99.67%)	1 (0.32%)
Liquids	4x51= 204	193 (94.60%)	11 (5.69%)
Totals	1938	1914 (98.76%)	24 (1.23%)

Table 7 shows the exact number of epenthesis and deletion instances in addition to the overall percentages. The column labeled "*Total*" indicates the total number of tokens for each sonority profile. This number is the result of the original number of words ending in segments in a particular sonority profile multiplied by the number of participants. We can see in Table 7 that epenthesis was predominantly more frequent as mentioned previously. When it comes to sonority, liquids exhibited the greatest number of deletions totaling 5.69%. So, we further examined the 11 cases of liquids deletions. We found that out of the 11 cases, 10 cases (90.9%) were instances of [ɹ] deletions. This higher percentage of [ɹ] deletions compared to other consonants could be attributed to the acceptability of [ɹ] deletions in many dialects of English.

To see if the differences between the sonority profiles was statistically significant or not, a post-hoc test was performed. The results are shown in Table 8.

Table 8: Experiment 1 Post Hoc Comparisons - English ✻ Sonority.

Comparison									
Language	**Sonority**		**Language**	**Sonority**	**Difference**	**SE**	**test**	**df**	**pbonferroni**
English	liquid	-	English	nasal	0.05065	0.0394	1.2848	Inf	1.000
English	liquid	-	English	stop	0.04248	0.0353	1.2047	Inf	1.000

Table 8: Experiment 1 Post Hoc Comparisons - English ✻ Sonority.

Comparison									
Language	**Sonority**		**Language**	**Sonority**	**Difference**	**SE**	**test**	**df**	**pbonferroni**
English	nasal	-	English	stop	-0.00817	0.0305	-0.2675	Inf	1.000
English	affricate	-	English	liquid	-0.05392	0.0432	-1.2485	Inf	1.000
English	affricate	-	English	nasal	-0.00327	0.0394	-0.0829	Inf	1.000
English	affricate	-	English	stop	-0.01144	0.0353	-0.3244	Inf	1.000
English	affricate	-	English	fricative	-0.00817	0.0353	-0.2317	Inf	1.000
English	fricative	-	English	liquid	-0.04575	0.0353	-1.2974	Inf	1.000
English	fricative	-	English	nasal	0.00490	0.0305	0.1605	Inf	1.000
English	fricative	-	English	stop	-0.00327	0.0249	-0.1311	Inf	1.000

Table 8 shows that the English participants generally preferred epenthesis regardless of the sonority profile. Table 8 also shows that the slightly higher parentage of liquid deletions is not statistically significant. Based on these findings, we can conclude that native English speakers find monosyllabic words modified by epenthesis preferable regardless of sonority.

3.4.3. Japanese Participants

As for Japanese, there was a total of 38 participants in this study. Each participant was presented with 38 experimental words and had to choose between words that were modified by epenthesis or deletion. This resulted in a total of 1,444 tokens. Out of 1,444, words modified by epenthesis were chosen 1,264 times, which amounts for 87.53%. Words modified by deletion, on the other hand, were chosen 180 times, which amounts for 12.46%.

The results clearly show that the Japanese participants had a preference for words modified by epenthesis. It was predicted that, based on the recoverability principle, words modified by epenthesis should be chosen more frequently (Weinberger, 1994), which was supported by the results. However, based on Dupoux et al. (1999), which examined the perception of native speakers of Japanese, it was also predicted that Japanese may have a bias of employing epenthesis as a modification strategy. Thus, based on the performance of Japanese participants alone, it cannot be concluded with absolute certainty that this is preference is solely due to the recoverability principle. The performance of participants of other languages need to be examined to reach such definite conclusions.

We also examined the specific segments that had undergone deletion, which are shown below.

Table 9: Experiment 1 Japanese: Total epenthesis vs. deletion based on sonority profile.

Sonority	Total	Epenthesis	Deletion
Stops	12x38= 456	402 (88.15%)	54 (11.84%)
Affricates	4x38= 152	143 (94.07%)	12 (7.89%)
Fricatives	12x38= 456	405 (88.81%)	51 (11.18%)
Nasals	6x38= 228	196 (85.96%)	32 (14.03%)
Liquids	4x38= 152	121 (79.60%)	31 (20.39%)
Totals	1444 (100%)	1264 (87.53%)	180 (12.46%)

Table 9 shows that epenthesis was predominantly more frequent across all sonority types, which is similar to what was found in the English sample. When we examine the frequency of deletions, we find that the most sonorous categories, namely liquids and nasals, had slightly higher deletions compared to fricatives and stops. Specifically, liquids exhibited the highest percentage (20.39%), and nasals came immediately after (14.03%). A post-hoc test was conducted to see if there was a significant interaction between deletions and sonority.

Table 10: Experiment 1 Post Hoc Comparisons - Japanese ✻ Sonority.

Comparison									
Language	**Sonority**		**Language**	**Sonority**	**Difference**	**SE**	**Test**	**df**	**pbonferroni**
Japanese	liquid	-	Japanese	nasal	0.06360	0.0414	1.5355	Inf	1.000
Japanese	liquid	-	Japanese	stop	0.08553	0.0370	2.3088	Inf	1.000
Japanese	nasal	-	Japanese	stop	0.02193	0.0321	0.6836	Inf	1.000
Japanese	affricate	-	Japanese	liquid	-0.12500	0.0454	-2.7552	Inf	0.616
Japanese	affricate	-	Japanese	nasal	-0.06140	0.0414	-1.4826	Inf	1.000
Japanese	affricate	-	Japanese	stop	-0.03947	0.0370	-1.0656	Inf	1.000
Japanese	affricate	-	Japanese	fricative	-0.03289	0.0370	-0.8880	Inf	1.000
Japanese	fricative	-	Japanese	liquid	-0.09211	0.0370	-2.4864	Inf	1.000
Japanese	fricative	-	Japanese	nasal	-0.02851	0.0321	-0.8886	Inf	1.000
Japanese	fricative	-	Japanese	stop	-0.00658	0.0262	-0.2512	Inf	1.000

As it can be seen from Table 10, the Japanese participants' rate of deletion was not significantly influenced by the sonority profile. This indicates that, similar to English, Japanese speakers find words modified by epenthesis preferable regardless of sonority.

If we examine the Japanese sample in comparison to the English sample, we will see that the English sample had a relatively greater preference for epenthesis. The English

participants chose epenthesis 98.76% of the time compared to 87.53% in the Japanese sample. A post-hoc test showed that this difference is statistically significant ($p < .001$). This could be attributed to the fact that the non-native Japanese participants do not possess the same linguistic proficiency as the English participants which enables them to employ the recoverability principle as frequently. In fact, this is clearly indicated by their self-reported English proficiency, which was equal to an average of 84.73%. Even though the Japanese participants chose epenthesis slightly less than their English counterparts, the fact still remains that there is a significant preference for epenthesis over deletion for these monosyllabic words, which also provides evidence in favor of the recoverability principle.

3.4.4. Spanish Participants

As for the Spanish sample, there was a total of 48 participants in this study. Each participant was presented with 38 experimental words and had to choose between words that were modified by epenthesis or deletion. This resulted in a total of 1,824 tokens. Out of these 1,824, words modified by epenthesis were chosen 1,593 times, which amounts for 87.33%, whereas words modified by deletion were chosen 231 times, which amounts for 12.66%.

Similar to what was found in the English and Japanese groups, the results clearly show that the Spanish participants had a preference for words modified by epenthesis. It was predicted that, based on the recoverability principle, words modified by epenthesis should be chosen more frequently (Weinberger, 1994). The results actually provide support of the recoverability principle.

Moreover, based on Yavaş (2011), which is a production study, it was predicted that Spanish listeners would choose words modified by deletion more often. Nevertheless, the results of Experiment 1 do not provide support for this prediction. One possible explanation is that the findings of Yavaş (2011) production study cannot be generalized to the perception of Spanish participants. That is, it is possible that Spanish employ deletion as repair strategy in production; however, when it comes to perception, listeners prefer words modified by epenthesis since they are easier to recover, which provides additional support for the recoverability principle that words modified by epenthesis are easier to disambiguate.

We also examined the specific segments that had undergone deletion, which are shown in Table 11.

Table 11: Experiment 1 Spanish: Total epenthesis vs. deletion based on sonority profile.

Sonority	Total	Epenthesis	Deletion
Stops	12x48= 576	477 (82.81%)	100 (17.36%)
Affricates	4x48= 192	178 (92.70%)	14 (7.29%)
Fricatives	12x48= 576	527 (91.49%)	48 (8.33%)
Nasals	6x48= 288	263 (91.31%)	25 (8.68%)
Liquids	4x48= 192	148 (77.08%)	44 (22.91%)
Totals	1824	1593 (87.33%)	231 (12.66%)

Table 11 shows that epenthesis was the most frequent choice, regardless of the sonority profile. This is consistent with what was found in the English and Japanese samples. Similar to the other groups, when we closely examine the frequency of deletions, we find that liquids exhibited the highest percentage of deletions (22.91%). To see whether liquids deletion rate was significant or not, a post-hoc test was conducted. The results are shown in Table 12.

Table 12: Experiment 1 Post Hoc Comparisons - Spanish ✻ Sonority.

Comparison									
Language	**Sonority**		**Language**	**Sonority**	**Difference**	**SE**	**Test**	**df**	**pbonferroni**
Spanish	liquid	-	Spanish	nasal	0.14236	0.0398	3.5772	Inf	0.036
Spanish	liquid	-	Spanish	stop	0.05729	0.0356	1.6095	Inf	1.000
Spanish	nasal	-	Spanish	stop	-0.08507	0.0308	-2.7596	Inf	0.608
Spanish	affricate	-	Spanish	liquid	-0.15625	0.0436	-3.5841	Inf	0.036
Spanish	affricate	-	Spanish	nasal	-0.01389	0.0398	-0.3490	Inf	1.000
Spanish	affricate	-	Spanish	stop	-0.09896	0.0356	-2.7801	Inf	0.571
Spanish	affricate	-	Spanish	fricative	-0.01389	0.0356	-0.3902	Inf	1.000
Spanish	fricative	-	Spanish	liquid	-0.14236	0.0356	-3.9994	Inf	0.007
Spanish	fricative	-	Spanish	nasal	-1.60e−15	0.0308	-5.19e−14	Inf	1.000
Spanish	fricative	-	Spanish	stop	-0.08507	0.0252	-3.3798	Inf	0.076

The results show that the Spanish participants deleted liquids significantly more than nasals (p = 0. 036), fricatives (p = 0. 007) and affricates (p = 0. 036). However, there was no significant difference between liquids and stops. A possible explanation for the

high frequency of liquid deletions could be due to the acceptability of [ɹ] deletions in many English dialects. If we examine these deletions, we find that out of 44 deletions, 38 cases (86.36%) were instances of [ɹ] deletions compared to only 6 (13.63%) instances of [l] deletions. Overall, epenthesis was the most frequent strategy across all sonority profiles including liquids for a total of (87.33%).

It is worth pointing out that in the Spanish group, unlike Japanese, nasal was not the coda type with the second most deletions. In Spanish, stop deletions amount for 17.36%, which comes immediately after liquids (22.91%). This difference was not statistically significant when compared to other sonority profiles. It approached significance only when compared to fricatives ($p = 0.076$). This is interesting because, based on sonority, stops would not be expected to be the second highest to exhibit deletions since they make ideal onsets.

This could be because stops are the least marked segments (de Lacy, 2002). Unmarked segments may be easier to produce due to their articulatory simplicity, yet they have less perceptual salience. Such features make unmarked segments subject to change. Hume (2004) points out that phonologically unmarked segments in a system are considered to be the least stable phonetically. That is, they are most likely to undergo processes such as reduction, deletion and assimilation.

We also looked at the results of the Spanish participants epenthesis frequency in comparison to the other two samples. The results are shown in Table 13.

Table 13: Experiment 1 epenthesis vs. deletion preference in all samples.

Listeners	Epenthesis	Deletion
English	98.76%.	1.25%.
Japanese	87.53%.	12.46%
Spanish	87.33%.	12.66%

Table 13 shows the results of epenthesis vs. deletion in all examined languages. If we examine the Spanish listeners in comparison to the English listeners, we find that Spanish participants had a relatively lower epenthesis frequency (87.33%) compared to the English sample (98.76%). A post hoc-test showed that the difference between the Spanish and English samples is statistically significant ($p < .001$). The results are shown in Table 14.

Table 14: Experiment 1 Post Hoc Comparisons – Language.

Comparison							
Language		**Language**	**Difference**	**SE**	**test**	**df**	**pbonferroni**
English	-	Japanese	-0.11534	0.0262	-4.4080	Inf	< .001
English	-	Spanish	-0.11415	0.0246	-4.6489	Inf	< .001
Japanese	-	Spanish	0.00119	0.0265	0.0448	Inf	1.000

Similarly, if we examine the Japanese listeners in comparison to the English listeners, we find that, similar to the Spanish listeners, Japanese participants had a

relatively lower epenthesis frequency (87.53%) compared to the English sample (98.76%). The post hoc-test in Table 14 showed that the difference between the Japanese and English samples is statistically significant ($p < .001$).

This could be attributed to the difference in proficiency levels since both Spanish and Japanese participants had very similar average English proficiency values: 82.5% and 84.73% respectively. Based on these findings, it seems that the proficiency influences the choice of modification strategy employed. These findings are consistent with previous studies (Weinberger, 1987).

Moreover, we looked at the performance of the Spanish group in comparison to the Japanese group. The Spanish group employed epenthesis 87.33% of the time, whereas the Japanese group employed it 87.53% of the time. This slight difference did not turn out to be statistically significant. This is interesting because we predicted that Spanish participants would choose deletion more frequently since in Yavaş (2011), Spanish participants predominantly chose deletion to modify two-member coda clusters. It is possible that this is because this study is a perception study, whereas Yavaş's is a production study. It is also possible that the findings of Yavaş (2011) cannot be extended to singleton codas. That is, Spanish speakers' choice of strategy is dependent upon the length of the coda such that singleton codas are modified by epenthesis whereas two-member codas are modified by deletion. Another possible explanation is that, since both Japanese and Spanish listeners have a similar English proficiency, it is possible that they have reached the same level of competence that is needed to exploit the recoverability

principle. That is, it is possible that the participants in Yavaş (2011) had an overall lower English proficiency than our current sample.

In conclusion, the findings of Experiment 1 do not provide support for the hypothesis that Spanish uses deletion as a default repair strategy. Rather, the results show that when listeners are presented with monosyllabic words with singleton codas that are modified by epenthesis and deletion, words modified by epenthesis are preferred, presumably because they result in a significantly lesser degree of ambiguity.

3.5. Interim Conclusion

The purpose of Experiment 1 was to examine the preference between two common modification strategies, epenthesis and deletion, using a perception experiment. As far as we know, no one has previously examined these two strategies in a perception experiment. We have done so because we wanted to test the implications of the recoverability principle. Specifically, we hypothesized that if the recoverability principle plays a role in determining the modification strategy employed, epenthesis will be significantly more preferred by listeners compared to deletion. To test this hypothesis, we targeted participants from three different linguistic backgrounds – English, Japanese and Spanish – resulting in a total of 137 participants. Our results showed that epenthesis was significantly more preferred in all examined languages.

Furthermore, we hypothesized that there would be native language bias. That is, Spanish listeners would choose words modified by deletion more often, whereas Japanese listeners would choose the ones modified by epenthesis (Dupoux et al., 1999; Yavaş,

2011). Nevertheless, our findings did not support these predictions. All examined languages showed a preference to epenthesis.

We also wanted to test the hypothesis that sonority would influence the choice of the modification strategy; however, our findings did not show such effects. Only liquids were found to behave according to our hypothesis. Nevertheless, this could be attributed to the fact that liquid deletions are acceptable in various English dialects.

Finally, Experiment 1 suggests that linguistic proficiency may influence the choice of modification strategy as our non-native samples had slightly, but significantly, higher rate of deletion than native English speakers. In future research, it will be interesting to examine the performance of non-native samples with different English proficiency levels.

Based on the recoverability principle, we argued that if it is active in the grammar of L2 listeners, words modified by epenthesis should be chosen more frequently since it results in structures that are easily recovered. Deletion, on the other hand, should not be used as often since it leads to an increased lexical ambiguity. Overall, these findings provide evidence in favor of the recoverability principle since all examined groups were found to favor epenthesis over deletion.

However, we could argue that these findings could be also explained by an overall preference for bisyllabic forms (Wang, 1995). Since the stimuli used consisted of only monosyllabic words, epenthesis would result in two syllable words. Because Experiment 1 only tested monosyllabic words, it is not possible to be certain that listeners have a preference for bisyllabic words. This possibility will be investigated in

Experiment 2 in which we will include bisyllabic words such as *magic* [mæ.ʤɪk]. Epenthesis would result in something like [mæ.ʤɪ.kə], whereas deletion would result in a two-syllable word [mæ.ʤɪ]. Experiment 2 could reveal whether listeners show a preference for epenthesis or for bisyllabicity.

CHAPTER FOUR

Experiment 1 examined the perception of English structures modified by either epenthesis or deletion by listeners of three different languages. In Japanese, epenthesis is used as a default strategy. Japanese listeners have been found to perceive a vowel even when it is not actually present (Dupoux et al., 1999). Spanish has been shown to favor deletion when it comes to modifying illegal codas with two consonants (Yavaş, 2011). As a control, the perception of English listeners was also examined. Experiment 1 had four main predictions:

1) The recoverability principle operates in grammar: Words modified by epenthesis should be chosen more frequently than words modified by deletion by listeners of all languages (Weinberger, 1994).

2) The sonority value of the coda consonant will influence the modification strategy: Epenthesis is preferred when the input coda has lower sonority. This is because epenthesis creates another syllable in which the segment previously in coda will be the onset of the new syllable, and onsets with low sonority are preferred. By contrast, deletion is preferred when the input coda has higher sonority (Clements, 1990).

3) There will be native language bias: Spanish listeners will choose words modified by deletion more often, whereas Japanese listeners will choose the ones modified by epenthesis (Dupoux et al., 1999; Yavaş, 2011).

4) Proficiency matters: Listeners with higher English proficiency will choose words modified by epenthesis more frequently (Weinberger, 1994).

As for our first prediction, the results from Experiment 1 showed that epenthesis was significantly preferred in all examined languages, which provides support to the recoverability principle (Weinberger, 1994). As for sonority, our findings showed that it did not influence the choice of the modification strategy. Only liquids were found to behave according to our hypothesis. As for the prediction that individual languages would show a preference of a particular strategy, the results of the previous experiment did not show any support. All examined languages favored epenthesis over deletion. Finally, the findings of the previous study suggest that linguistic proficiency may influence the choice of modification strategy. The non-native samples showed slightly, but significantly more preference for deletion than English speakers.

4.1. Experiment 2

Experiment 2 will extend the same line of inquiry while addressing the shortcomings of the previous experiment. The findings of Experiment 1 provided evidence in favor of the recoverability principle since all examined groups were found to favor epenthesis over deletion. However, one could argue that the findings could also be explained by an overall preference for bisyllabic forms (Wang, 1995). That is, since the stimuli used consisted only of monosyllabic words, epenthesis would result in two syllable words. Because Experiment 1 only tested monosyllabic words, we cannot exclude the possibility that listeners have a preference for bisyllabic words.

In order to address this issue, our new stimuli will include bisyllabic words as well as monosyllabic words. For a bisyllabic word such as *magic* [mæ.ʤɪk], we are interested in two possible outcomes. Deletion would result in [mæ.ʤɪ], which would

satisfy the bisyllabicity requirement. Epenthesis, on the other hand, would result in [mæ.ʤɪ.kə], which would satisfy the recoverability principle.

Furthermore, in addition to bisyllabicity, we will be examining two more factors – word frequency and the duration of the epenthetic vowel – to see if these factors have any effects on the choice of the modification strategy. Thus, in addition to the four predictions we examined in Experiment 1, we will be examining three additional predictions in Experiment 2, which are listed in section 4.2.5

4.2. Methodology

4.2.1. Stimuli

The stimuli for Experiment 2 consisted of two sets of words. All the words were nouns, and all of them had the same stress, which is on the first syllable. However, not all the words used have the same frequency. The reason is that we wanted to include all possible segments in the coda position. Thus, instead of controlling for word frequency, we decided to explore its influence on the choice of the modification strategy. The frequency of words was based on the Corpus of Contemporary American English (COCA) (Davies, 2008). The frequencies can be seen in the Appendix A1 and A2.

The first set consisted of 38 monosyllabic English words with CVC syllable structure. These words were the same words used in Experiment 1. Participants were presented with two modified forms of each word of the original 38 words, one with epenthesis (CVCV) and the other with deletion (CV). This means that they listened to 76 (38x2) forms of the experimental words, and they had to choose one variant per question. The experimental words were chosen to cover all consonants that can occur in the

English coda position. Nineteen different coda consonants were included: [p, b, t, d, k, ɡ, f, v, θ, s, z, ʃ, tʃ, dʒ, m, n, ŋ, l, ɹ]. One consonant, the voiced fricative [ð], was not included because it was not found in coda positions in monosyllabic nouns. Each of the coda consonants appeared twice in two different words. This resulted in a total of 38 target words per participant.

The second set consisted of 28 bisyllabic words. Similarly, participants were presented with two modified forms of each word of the original 28 words, one with epenthesis (CVCVCV) and the other with deletion (CVCV). This means that they listened to 56 (28x2) forms of the experimental words, and they had to choose one variant per question. These 28 experimental words covered all segments possible in the coda position of CVCVC words. Thus, fourteen different coda consonants were included: [p, t, d, k, f, v, s, z, ʃ, dʒ, m, n, l, ɹ]. In addition to the voiced fricative [ð], which was not included in the monosyllabic set, five additional consonants, [b, ɡ, θ, tʃ, ŋ], were not included in the bisyllabic set. This was because either no CVCVC English words had them in the coda position, or we could not find nouns ending in such segments or have same stress pattern.

Thus, the total number of experimental words was 66 words. In addition, 34 nonexperimental words (fillers) were included. Of these 34 fillers, four were used in a brief training session. All words can be seen in Appendix A, where Appendix A1 shows the monosyllabic words, Appendix A2 shows the bisyllabic words and Appendix A3 shows the fillers. All of the words in Experiment 2 were pronounced by the same person who pronounced the words in Experiment 1. For the words modified by epenthesis, he

was asked to add the vowel [ə]. The duration of the inserted vowel for all words is shown in Appendix C. The words were recorded using an Apogee MiC 96k microphone, which was attached to an iPhone. The words were recorded at 44.1 khz 16 bit mono, and all of them were normalized at -3 db.

4.2.2. Participants

In Experiment 2, listeners who identified themselves to be from three different language backgrounds were examined – English, Japanese and Vietnamese. It is worth pointing out that – unlike Experiment 1 where we targeted Spanish speakers – we are targeting Vietnamese speakers because, similar to Spanish, they have been found to predominantly employ deletion in productions studies. Thus, we want to see if the results found in the Spanish group in Experiment 1 can be extended to the Vietnamese group.

A total of 137 listeners were recruited for this study. The participants were recruited via Amazon Mechanical Turk and were given $1.50 for compensation. Participants who reported having hearing or speaking issues were excluded from this study. Table 15 summarizes the background information about the participants in Experiment 2. In addition, Japanese and Vietnamese participants were asked to rate their English proficiency and frequency of English use using a five-point scale in which 1 indicates very low proficiency/frequency of use, and 5 indicates high proficiency/frequent language use. The percentages were calculated by summing up all the proficiency scores for each language group and then dividing the actual outcome by the total possible proficiency score for that particular language. The obtained decimal

value was then multiplied by 100 to get the percentage. The average scores converted into percentage are shown in Table 15.

Table 15: Experiment 2 participants' demographic information.

Participants	Total number	Age	Gender	Age of onset	Length of residency	English proficiency	English frequency
English	71	(24 – 59) mean=36.25	M=40, F=31	NA	NA	NA	NA
Japanese	32	(18 – 67) mean=30.12	M=18, F=14	(0 – 15) M=6.75	(0 – 37) M=15.74	88.12%	71.87%
Vietnamese	34	(19 – 48) mean=30.5	M=21, F=13	(0 – 20) M=6.64	(0 – 48) M=19.55	88.82%	75.29%

From Table 15, we can see that all language groups are similar in terms of the listeners' mean age with a slightly higher average for the English participants. The English participants had an average age of 36.25, whereas the Japanese and Vietnamese participants had age averages of 30.12 and 30.5, respectively. In addition, both non-native groups, Japanese and Vietnamese, had a similar age of onset where Japanese had an average of 6.75 years and Vietnamese 6.64 years. An independent-samples t-test was conducted to compare the average age of onset for the Japanese and Vietnamese groups. The results of the t-test showed that the difference was not statistically significant: Japanese (M=6.75, SD=4.47) and Vietnamese (M=6.64, SD=4.81) groups; t (64)=0. 0.0898, p = 0.929. Self-reported English proficiency was slightly different between the Japanese and the Vietnamese participants, which were 88.12% and 88.82.%, respectively. An independent-samples t-test revealed that this difference was not statistically significant: Japanese (M=4.41, SD=0.712) and Vietnamese (M=4.44, SD=0.613) groups; t (64)=-0.214, p = 0.731. Furthermore, when it comes to the self-reported frequency of using English, likewise, both groups seemed to have similar reported frequency: Japanese participants (71.87%) compared to the Vietnamese participants (75.29%). An independent-samples t-test revealed that this difference was not statistically significant: Japanese (M=15.7, SD=9.90) and Vietnamese (M=19.6, SD=12.0) groups; t (64)=-1.40, p = 0.165.

4.2.3. Task

As in Experiment 1, all participants listened to the two forms of each he two forms of each word accompanied by a picture. For example, for the English word *couch*,

participants were shown a picture of a couch, and they heard the two modified forms [kaʊʧə] and [kaʊ]. All the experimental words were nouns with the same stress pattern. Listeners were presented with each of these words accompanied by a picture of what the word denotes, and they were instructed to choose the word that best matches the picture based on their judgment. All pictures used can be seen in Appendix A, where Appendix A1 shows the monosyllabic experimental words, A2 shows the bisyllabic experimental words, and A3 shows the fillers.

4.2.4. Procedure

As in Experiment 1, Experiment 2 was designed by Qualtrics (2019), and then it was linked to Amazon Mechanical Turk (2019). All participants first completed a consent form. At the end of the consent form, they had to click "*accept*" if they agreed to participate. Once they agreed, they were asked to provide some demographic information about their native language, age, gender, English proficiency, English frequency, length of residency, age of onset, place of birth and method of learning English (naturally or academically). All questions are listed in Appendix B.

Participants who did not meet our requirements, such as those who reported having hearing problems, were excluded from the analysis. In addition, since this was a perception experiment, the participants were required to wear headsets. Participants were required to enter the model name of the headset they were using. Those who failed to provide this information were excluded from the study. Once they completed the background information, they were presented with four stimuli containing filler words as part of a training session. The purpose was to familiarize the participants with the

experiment. After the familiarization trials, the actual experiment started. The experiment was self-paced and each participant was presented with 96 stimuli containing the experimental words and fillers with corresponding pictures, in a randomized order.

4.2.5. Predictions

1) Based on the recoverability principle (Weinberger, 1994), if the recoverability principle is active, then:

a) Listeners will prefer words modified by epenthesis in monosyllabic stimuli.

b) Listeners will prefer words modified by epenthesis in bisyllabic stimuli.

2) Based on (Wang, 1995), if there is a preference for bisyllabic forms, then:

a) Listeners will prefer words modified by epenthesis in monosyllabic stimuli.

b) Listeners will prefer words modified by deletion in bisyllabic stimuli. (This is crucial to reveal whether listeners show a preference for epenthesis or for bisyllabicity).

3) Vietnamese listeners will prefer words modified by deletion regardless of stimuli type, whereas Japanese listeners will prefer words modified by epenthesis regardless of stimuli type (Sato, 1984; Benson, 1988; Dupoux et al., 1999).

4) Listeners with higher English proficiency will choose words modified by epenthesis more frequently than those with lower English proficiency (Weinberger, 1994).

5) Word frequency: Deletion will be chosen more frequently in words with higher frequency, whereas words with lower word frequency will exhibit more instances of epenthesis (Bybee, 2002, 2007).

6) Vowel duration: Listeners will choose epenthesis more frequently in words with shorter vowel duration, whereas words with longer vowel duration will exhibit more instances of deletion (Steriade, 2001; Shoji & Shoji, 2014).

7) Sonority of the coda consonant will influence the modification strategy (Clements, 1990).

4.3. Results and discussion

4.3.1. Statistical analysis for all languages

Overall, the results showed both epenthesis and deletion activity. In this section, we will report and discuss the results and the ratios found. Jamovi (2019) was used to perform the statistical analyses. A mixed model regression test was conducted to see if the listeners' native language and the sonority of coda consonants significantly influenced the choice of repair strategy (deletion vs. insertion). In addition, we wanted to see if the number of syllables, the frequency of words and vowel duration significantly influenced the choice of repair strategy. In this model, deletion was set as the dependent variable; language, sonority and syllables were the fixed factors; participant and word were the random structures; age of onset, English proficiency, length of residency, vowel duration and word frequency were covariates.

For each examined language, the raw data reported by the participants for age of onset, English proficiency and length of residency was included in the model. As for vowel duration, the duration of the epenthetic vowel in each of the words was measured in milliseconds using Praat (Boersma, 2001). As for word frequency, all words had to be normalized prior to the analysis because they had some disparities. That is, some words

were very frequent such as the word *love*, which had a frequency value of 192472. There were other words, on the other hand, that were significantly less frequent such as the word *cupid*, which had a frequency value of 547. In other words, the frequencies of words were not normally distributed. To solve this issue, the original word frequencies were listed in one column, and Jamovi function LN (Frequency) was used to perform a log transformation, creating a new frequency column with normally distributed data. Applying the log transformation made the data more normal – and thus interpretable.

Overall, the results show that the choice of strategy (epenthesis vs. deletion) was not influenced by the participants' native language [$F (2, 84) = 1.774$, $p = 0.176$], nor self-reported English proficiency [$F (1, 102.0) = 2.339$, $p = 0.129$], nor length of residency [$F (1, 125.9) = 0.344$, $p = 0.559$]. Nevertheless, the choice of strategy was significantly influenced by the sonority profile [$F (4, 8863) = 35.702$, $p < .001$], number of syllables [$F (1, 8863) = 200.555$, $p < .001$], age of onset [$F (2, 121.0) = 14.710$, $p < .001$], vowel duration [$F (1, 8863.1) = 5.420$, $p = 0.020$] and word frequency [$F (1, 8863) = 6.834$, $p = 0.009$].

And finally, the interactions between Language ✻ Syllables [$F (2, 8863) = 3.433$, $p = 0.032$] and Syllables ✻ Sonority [$F (4, 8863) = 8.327$, $p < .001$] were also statistically significant. However, the interactions between Language ✻ Sonority [$F (8, 8863) = 1.103$, $p = 0.358$] and Language ✻ Syllables ✻ Sonority [$F (8, 8863) = 0.292$, $p = 0.969$] were not statistically significant. The results are shown in Table 16.

Table 16: Experiment 2 mixed model results.

Fixed Effect Omnibus tests

	F	Num df	Den df	p
Frequency	6.834	1	8863.0	0.009
Syllables	200.555	1	8863.0	< .001
Sonority	35.702	4	8863.0	< .001
AgeofOnset	14.710	1	121.0	< .001
English Proficiency	2.339	1	102.0	0.129
LengthofResidency	0.344	1	125.9	0.559
Vowel Duration	5.420	1	8863.1	0.020
Language	1.774	2	84.0	0.176
Syllables ✻ Sonority	8.327	4	8863.0	< .001
Syllables ✻ Language	3.433	2	8863.0	0.032
Sonority ✻ Language	1.103	8	8863.0	0.358
Syllables ✻ Sonority ✻ Language	0.292	8	8863.0	0.969

Fixed Effects Parameter Estimates

Names	Effect	Estimate	SE	95% Confidence Interval		df	t	p
				Lower	Upper			
(Intercept)	(Intercept)	0.78600	0.01611	0.75443	0.81757	91.4	48.79379	< .001
Frequency	Frequency	-0.00747	0.00286	-0.01307	-0.00187	8863.0	-2.61416	0.009
Syllables1	2 - 1	-0.15978	0.01128	-0.18189	-0.13766	8863.0	-14.16173	< .001
Sonority1	affricate - fricative	0.04553	0.01610	0.01397	0.07708	8863.0	2.82789	0.005
Sonority2	stop - fricative	-0.07255	0.01048	-0.09309	-0.05201	8863.0	-6.92329	< .001
Sonority3	liquid - fricative	-0.11908	0.01392	-0.14638	-0.09179	8863.0	-8.55201	< .001
Sonority4	nasal - fricative	5.92e-5	0.01361	-0.02662	0.02674	8863.0	0.00435	0.997
AgeofOnset	AgeofOnset	-0.00645	0.00168	-0.00974	-0.00315	121.0	-3.83541	< .001
English Proficiency	English Proficiency	0.04201	0.02747	-0.01182	0.09585	102.0	1.52952	0.129
LengthofResidency	LengthofResidency	-5.26e−4	8.97e-4	-0.00228	0.00123	125.9	-0.58632	0.559
Vowel Duration	Vowel Duration	-0.41613	0.17875	-0.76647	-0.06579	8863.1	-2.32804	0.020
Language1	japanese - english	0.07907	0.04214	-0.00352	0.16166	77.2	1.87637	0.064
Language2	vietnamese - english	0.03079	0.04170	-0.05095	0.11253	80.2	0.73832	0.462
Syllables1 ✻ Sonority1	2 - 1 ✻ affricate - fricative	0.12863	0.03419	0.06163	0.19563	8863.0	3.76264	< .001
Syllables1 ✻ Sonority2	2 - 1 ✻ stop - fricative	-0.05451	0.02190	-0.09744	-0.01158	8863.1	-2.48853	0.013
Syllables1 ✻ Sonority3	2 - 1 ✻ liquid - fricative	-0.01985	0.02830	-0.07531	0.03562	8863.0	-0.70138	0.483
Syllables1 ✻ Sonority4	2 - 1 ✻ nasal - fricative	0.02359	0.02605	-0.02747	0.07465	8863.0	0.90547	0.365

Fixed Effects Parameter Estimates

Names	Effect	Estimate	SE	95% Confidence Interval		df	t	p
				Lower	Upper			
Syllables1 ✻ Language1	2 - 1 ✻ japanese - english	-0.04890	0.02210	-0.09220	-0.00559	8863.0	-2.21293	0.027
Syllables1 ✻ Language2	2 - 1 ✻ vietnamese - english	-0.04401	0.02166	-0.08645	-0.00156	8863.0	-2.03220	0.042
Sonority1 ✻ Language1	affricate - fricative ✻ japanese - english	0.00940	0.03718	-0.06348	0.08228	8863.0	0.25270	0.801
Sonority2 ✻ Language1	stop - fricative ✻ japanese - english	-0.02103	0.02409	-0.06825	0.02619	8863.0	-0.87274	0.383
Sonority3 ✻ Language1	liquid - fricative ✻ japanese - english	-0.04223	0.03185	-0.10465	0.02020	8863.0	-1.32586	0.185
Sonority4 ✻ Language1	nasal - fricative ✻ japanese - english	0.01226	0.02982	-0.04618	0.07070	8863.0	0.41117	0.681
Sonority1 ✻ Language2	affricate - fricative ✻ vietnamese - english	0.00966	0.03643	-0.06174	0.08107	8863.0	0.26529	0.791
Sonority2 ✻ Language2	stop - fricative ✻ vietnamese - english	-0.04304	0.02362	-0.08933	0.00326	8863.0	-1.82203	0.068
Sonority3 ✻ Language2	liquid - fricative ✻ vietnamese - english	0.00818	0.03121	-0.05298	0.06934	8863.0	0.26209	0.793
Sonority4 ✻ Language2	nasal - fricative ✻ vietnamese - english	0.01513	0.02926	-0.04222	0.07249	8863.0	0.51712	0.605
Syllables1 ✻ Sonority1 ✻ Language1	2 - 1 ✻ affricate - fricative ✻ japanese - english	-0.02337	0.07437	-0.16913	0.12239	8863.0	-0.31421	0.753
Syllables1 ✻ Sonority2 ✻ Language1	2 - 1 ✻ stop - fricative ✻ japanese - english	-0.00112	0.04818	-0.09557	0.09332	8863.0	-0.02335	0.981
Syllables1 ✻ Sonority3 ✻ Language1	2 - 1 ✻ liquid - fricative ✻ japanese - english	-0.03597	0.06370	-0.16081	0.08888	8863.0	-0.56464	0.572
Syllables1 ✻ Sonority4 ✻ Language1	2 - 1 ✻ nasal - fricative ✻ japanese - english	0.03287	0.05964	-0.08401	0.14976	8863.0	0.55124	0.581

Fixed Effects Parameter Estimates

Names	Effect	Estimate	SE	95% Confidence Interval		df	t	p
				Lower	Upper			
Syllables1 ✻ Sonority1 ✻ Language2	2 - 1 ✻ affricate - fricative ✻ vietnamese - english	-0.07836	0.07286	-0.22117	0.06445	8863.0	-1.07550	0.282
Syllables1 ✻ Sonority2 ✻ Language2	2 - 1 ✻ stop - fricative ✻ vietnamese - english	-0.01799	0.04724	-0.11059	0.07460	8863.1	-0.38088	0.703
Syllables1 ✻ Sonority3 ✻ Language2	2 - 1 ✻ liquid - fricative ✻ vietnamese - english	-0.03681	0.06241	-0.15913	0.08552	8863.0	-0.58973	0.555
Syllables1 ✻ Sonority4 ✻ Language2	2 - 1 ✻ nasal - fricative ✻ vietnamese - english	0.01817	0.05852	-0.09653	0.13288	8863.0	0.31051	0.756

4.3.2. All Languages

We looked at the overall percentages of epenthesis and deletion in all examined languages. The results are shown in Table 17.

Table 17: Experiment 2 epenthesis vs. deletion preference in all samples.

Listeners	Epenthesis	Deletion
English	79.96%	20.03%
Japanese	79.30%	20.69%
Vietnamese	74.46%	25.53%

Table 17 shows the results of epenthesis vs. deletion in all examined languages. We can see that all languages have very comparable results. To see whether these differences were statistically significant or not, a post-hoc test was performed. The results are shown in Table 18.

Table 18: Experiment 2 post Hoc Comparisons - Language

Comparison							
Language		**Language**	**Difference**	**SE**	**t**	**df**	**$p_{bonferroni}$**
Japanese	-	Vietnamese	0.0485	0.0434	1.117	59.7	0.806
English	-	Japanese	-0.0802	0.0445	-1.803	81.9	0.225
English	-	Vietnamese	-0.0317	0.0435	-0.728	82.4	1.000

Table 18 shows that there were no significant differences among our three samples. This could be attributed to the proficiency levels. We hypothesized that listeners with higher English proficiency would choose words modified by epenthesis more frequently than those with lower English proficiency. However, Table 18 does not show any differences between the groups. If we go back to Table 15, we see that self-reported English proficiency was very similar between the Japanese and the Vietnamese participants, which were 88.12% and 88.82%, respectively. An independent-samples t-test revealed that this difference was not statistically significant: Japanese (M=4.41, SD=0.712) and Vietnamese (M=4.44, SD=0.613) groups; t (64)=-0.214, p = 0.731. Thus, the similar results found could be due to the fact that both samples had participants with significantly similar self-reported English proficiency.

4.3.3. Production vs. perception

One of the main reasons for conducting this research was to examine the preference between two strategies (epenthesis and deletion) of syllable structure simplification using a perceptual task. Abrahamsson (2003) indicates that, based on functional approaches to phonology and phonetics, speakers are governed by two conflicting forces. The first is their tendency to minimize articulatory effort, and the second is their need to maximize intelligibility (e.g., Boersma, 1998; Donegan & Stampe, 1979; Kiparsky, 1982). The tendency to minimize articulatory complexity is based on the speaker, and this manifests itself in phonological processes that result in unmarked structures. The other force, which manifests itself in the need to maintain distinctness and

understandability, is oriented towards the needs of the listener. When it comes to the processes under examination (epenthesis and deletion), if adult speakers are to minimize articulatory complexity, deletion should be the strategy of choice. If, however, adult speakers ultimately want to be understood, they should employ epenthesis rather than deletion since it accommodates the listeners' needs by maintaining relevant information and avoiding ambiguous forms, as predicted by the recoverability principle (Weinberger, 1994). Nevertheless, as evidenced from the previously mentioned production studies, epenthesis is not always the strategy of choice by adult speakers.

The only method to actually examine the implications of the recoverability principle is by a perception study. Thus, it is hypothesized that if the recoverability principle is at work, listeners should always view the structures modified by epenthesis as less ambiguous compared to those modified by deletion. This hypothesis, in fact, was supported. The data shows that, overall, epenthesis was preferred in all examined languages. These findings suggest that, when it comes to the choice of modification strategies, perception is not the same as production. This suggests that listeners prefer words modified by epenthesis because, unlike deletion, more information is retained by this modification strategy, which makes the listeners' task of disambiguating a particular word easier.

4.3.4. Proficiency

We wanted to examine the effects of proficiency in order to see if there is any influence on the modification strategy. Three measures were examined, namely self-reported English proficiency, age of onset, and length of residency. The results of our

mixed model regression test showed that the choice of strategy (epenthesis vs. deletion) was not influenced by self-reported English proficiency [F (1, 102.0) = 2.339, p = 0.129], nor length of residency [F (1, 125.9) = 0.344, p = 0.559]. The choice of strategy, however, was significantly influenced by age of onset [F (2, 121.0) = 14.710, p < .001]. The following plot shows the effects of age of onset on the degree of epenthesis for each language.

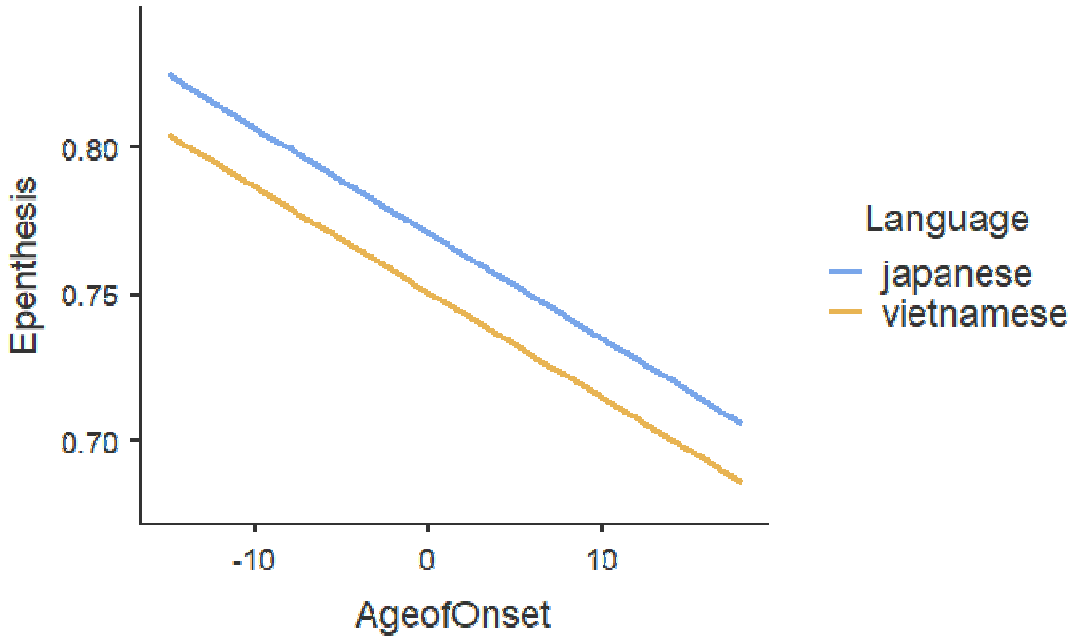


Figure 2: Experiment 2 age of onset effects on the degree of epenthesis for each language.

The Y-axis stands for the degree of epenthesis. A higher point means more cases of epenthesis, whereas a lower point means fewer cases of epenthesis – thus, more cases of deletion. The X-axis, on the other hand, stands for age of onset, where a higher point

means higher age of onset. It is worthy of note that even though the X-axis shows a negative value, the raw data did not include any negative values. The reason why the plot shows a negative number is that it was based on the regression test rather than actual raw data. Therefore, it is normal for the line to extend past actual values since it is about prediction.

We can see from Figure 2 that the lower the age of onset, the more cases of epenthesis and vice versa. That is, deletion was chosen more frequently by participants with higher age of onset. This observation was found in all examined languages represented by different colors in Figure 2. These findings provide partial support to our prediction because only age of onset was statistically significant. Based on the recoverability principle, we predicted that listeners with higher English proficiency would choose words modified by epenthesis more frequently. Weinberger (1987) suggested that adult L2 learners with a more developed knowledge of the target lexicon tend to be more sensitive to the recoverability principle. That is, once the adult language learner is aware that ambiguity is a real possibility, he/she should utilize epenthesis significantly more often than deletion. In other words, advanced learners will typically show a greater degree of epenthesis than less advanced learners.

Self-reported English proficiency may not be a significant predicter of the choice of modification strategy. However, several studies have shown that age of onset plays a significant role in learners' performance and overall target language proficiency (Patkowski, 1980; Flege et al. 1995). To illustrate, Stevens (1999) indicates that regardless of how many years of exposure or opportunities to learn L2, it seems that only

those who begin L2 learning as young children are capable of achieving native-like attainment. He further adds that the age-related loss in ability appears to persist through childhood, and perhaps through adolescence. However, this loss is not an abrupt one-time event. Rather, it is a gradual event because L2 learners who start after the age of six or seven often become communicatively fluent, but they often retain measurable accents in phonology. Thus, this could possibly explain why age of onset was the only measure that actually influenced the choice of the modification strategy. This also suggests that age of onset is a better predictor than self-reported proficiency when it comes to L2 learners' knowledge of the lexicon.

4.3.5. Syllables

Experiment 1 provided evidence in favor of the recoverability principle since all examined groups were found to favor epenthesis over deletion. However, our stimuli merely consisted of monosyllabic words. It is possible that this preference for epenthesis is due an overall preference for bisyllabic forms (Wang, 1995). Therefore, we have included both monosyllabic and bisyllabic words in the stimuli of Experiment 2. We hypothesized that if the recoverability principle is active, then listeners will prefer words modified by epenthesis in both monosyllabic bisyllabic stimuli. Nevertheless, if there is a preference for bisyllabic forms, then listeners will show a preference for words modified by epenthesis only in monosyllabic stimuli, but when it comes to bisyllabic stimuli, listeners will prefer words modified by deletion to maintain bisyllabicity. To see if the differences between monosyllabic and bisyllabic words were statistically significant or not, a post-hoc test was performed. The results are shown in Table 19.

Table 19: Experiment 2 post Hoc Comparisons – Syllables

Comparison							
Syllables		**Syllables**	**Difference**	**SE**	**t**	**df**	$p_{bonferroni}$
1	-	2	0.160	0.0113	14.2	8863	< .001

Table 19 shows that there was indeed a significant difference between monosyllabic and bisyllabic words ($p < .001$). To further investigate this difference, we looked at the instances of epenthesis and deletion across all samples for each syllable type. The results are shown in Table 20.

Table 20: Experiment 2 total epenthesis vs. deletion based on number of syllables.

Language	**Total**	**Monosyllabic**			**Bisyllabic**		
		Total	epenthesis	deletion	Total	epenthesis	deletion
English	4686	2698	2309 (85.58%)	389 (14.41%)	1988	1438 (72.33%)	550 (27.66%)
Japanese	2112	1216	1056 (86.84%)	160 (13.15%)	896	619 (69.08%)	277 (30.91%)

Vietnamese	2244	1292	1054 (81.57%)	238 (18.42%)	952	617 (64.81%)	335 (35.18%)

Table 20 shows epenthesis and deletion instances across all samples for each syllable type. Overall, we can see that all participants from all samples tended to choose epenthesis more often in monosyllabic words compared to bisyllabic words. When we look at the English participants, we find that epenthesis was chosen 85.58% in monosyllabic words compared to 72.33% in bisyllabic words. On the other hand, deletion was chosen 14.41% in monosyllabic words compared to 27.66% in bisyllabic words.

Similarly, the Japanese participants had a total of 86.84% epenthesis in monosyllabic words compared to 69.08% in bisyllabic words. On the other hand, deletion was chosen 13.15% in monosyllabic words compared to 30.91% in bisyllabic words. Finally, the Vietnamese participants, similar to the English and Japanese samples, had a higher preference for epenthesis in monosyllabic words 81.57% compared to 64.81% in bisyllabic words. On the other hand, deletion was chosen 18.42% in monosyllabic words compared to 35.18% in bisyllabic words.

Overall, we can see that, across all language groups, deletion was chosen more frequently in bisyllabic words compared to monosyllabic words. In fact, the percentage of deletion in bisyllabic words was almost double the percentage of deletion in monosyllabic words. To see if the differences between monosyllabic and bisyllabic words in each language were statistically significant or not, a post-hoc test was performed. The results are shown in Table 21.

Table 21: Experiment 2 Post Hoc Comparisons - Language ✻ Syllables

Comparison									
Syllables	Language		Syllables	Language	Difference	SE	t	df	$p_{bonferroni}$
1	Japanese	-	2	Japanese	0.17770	0.0194	9.184	8863.0	< .001
1	Vietnamese	-	2	Vietnamese	0.17282	0.0188	9.171	8863.0	< .001
1	English	-	2	English	0.12881	0.0138	9.360	8863.0	< .001

Table 21 shows that the differences between epenthesis and deletion instances across all samples were statistically significant. Going back to our hypothesis, we predicted that if modifications were governed by the recoverability principle, then listeners would prefer words modified by epenthesis in both monosyllabic and bisyllabic stimuli. This is actually what was found. The results show that epenthesis was preferred overall regardless of the number of syllables across all samples.

It was also hypothesized that if there is a preference for bisyllabic forms, then listeners will show a preference for words modified by epenthesis only in monosyllabic stimuli, but when it comes to bisyllabic stimuli, listeners will prefer words modified by deletion to maintain bisyllabicity. This prediction was not fully supported because listeners did not show an overall preference for deletion over epenthesis in bisyllabic words to maintain bisyllabicity. However, the fact that deletions were significantly higher in bisyllabic words across all samples could be explained be some preference for bisyllabic forms (Wang, 1995).

It is also possible that this is due to the essentially different informational content between both types of stimuli. Bisyllabic words have two syllables, which means that they inherently carry more information compared to monosyllabic words. Consequently, deletion might be slightly more tolerable when it occurs in bisyllabic words. That is, even if we know that deletion results in unrecoverable forms, based on the differences we found between monosyllabic and bisyllabic forms, it seems that there is a degree of ambiguity.

To illustrate, the consequences of deletion for a monosyllabic word like *rose* [ɹoʊz]→ [ɹoʊ], are more severe than for a bisyllabic word like *minus* [maɪnəs] → [maɪnə]. This is because, even though in both cases deletion results in the loss of information, bisyllabic words still have more information even after the deletion of the coda, which makes it slightly easier for the listener to recover the meaning compared to monosyllabic words with deleted information. This could be the reason why we saw slightly, yet significantly, more cases of deletion in bisyllabic words.

4.3.6. Frequency

The frequency of words was based on the Corpus of Contemporary American English (COCA) (Davies, 2008). The frequencies can be seen in Appendix A. The mixed model regression shows that word frequency was statistically significant [F (1, 8863) = 6.833, p = 0.009]. Figure 3 shows the effects of word frequency on the choice of modification strategy for each language.

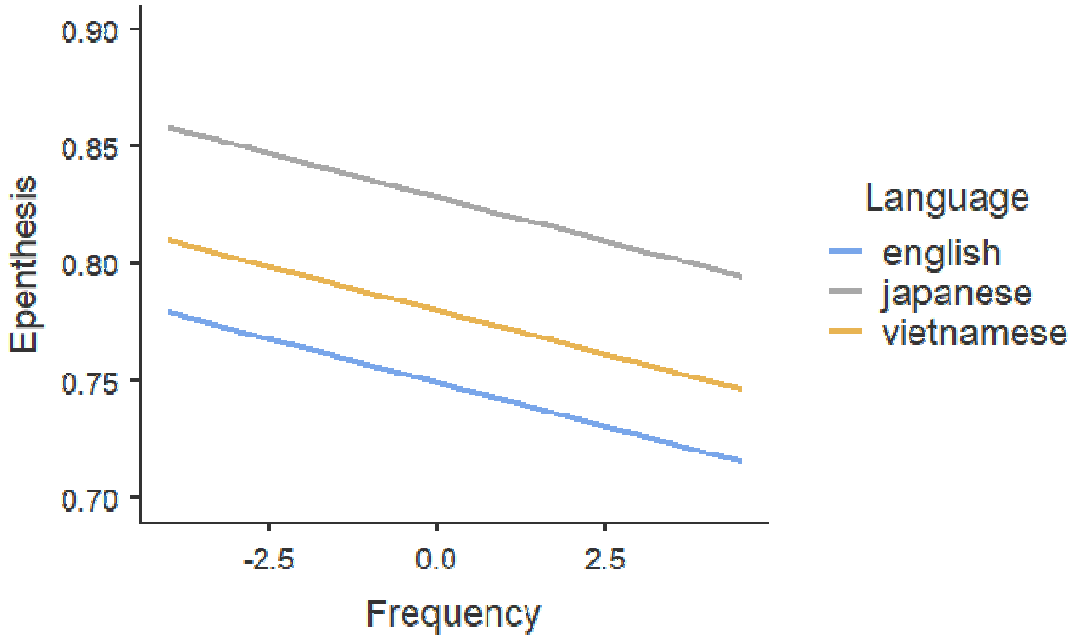


Figure 3: Experiment 2 word frequency effects on the degree of epenthesis for each language.

The Y-axis stands for the degree of epenthesis. A higher point means more cases of epenthesis, whereas a lower point means more cases of deletion. The X-axis, on the other hand, stands for frequency, where a higher point means higher word frequency. We can see from Figure 3 that, overall, the higher the frequency, the more cases of deletion and vice versa. That is, epenthesis was chosen more frequently in words with lower frequency. This observation was found in all examined languages. These findings suggest that word frequency in fact influences the choice of the modification strategy.

This is consistent to what has been found in previous studies. Specifically, the finding that higher word frequency is associated with more cases of deletion. For example, Fidelholtz (1975) showed that vowel reduction in initial syllables in English

was significantly correlated with frequency where more frequent words were more likely to have a reduced vowel. Bybee (2002) indicates that word frequency and context frequency are factors that can affect variation and should be taken into account when investigating variation and change. Similarly, Bybee (2007) indicates that high-frequency words are affected earlier by vowel and consonant reduction or assimilation processes, whereas infrequent words are the most resistant to phonetically motivated change.

4.3.7. Vowel duration

We also measured the duration of each epenthetic vowel in our stimuli words to see if the duration of the vowel influences the choice of modification strategy. The vowel duration for each word can be seen in Appendix C. The mixed model regression shows that vowel duration had statistically significant effects on the choice of the modification strategy [$F(1, 8863.1) = 5.419$, $p = 0.020$]. The following plot shows the effects of vowel duration on the choice of modification strategy for each language.

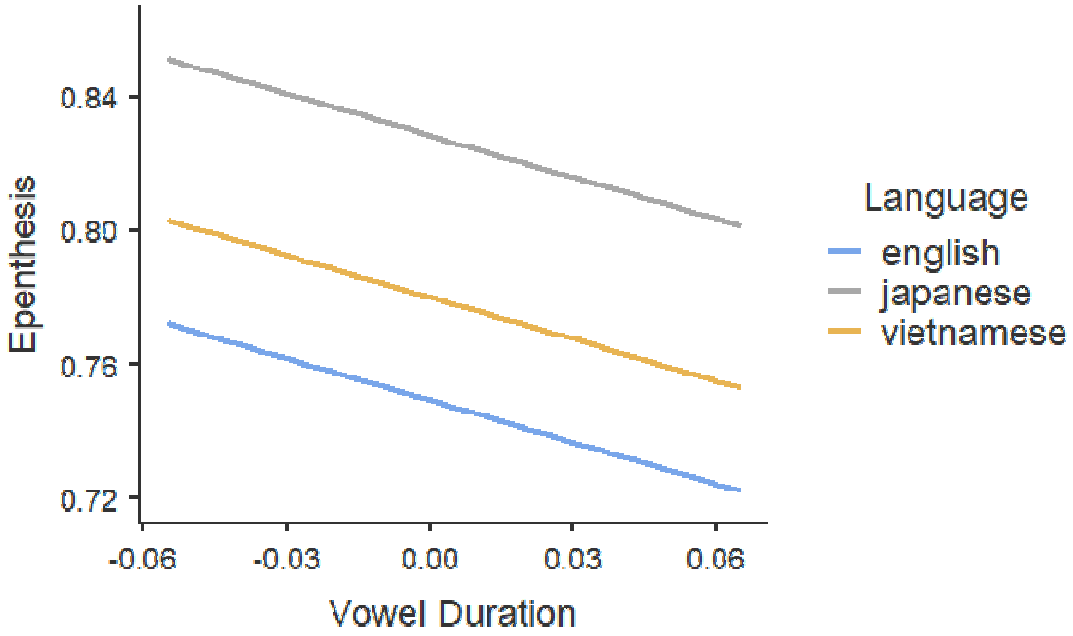


Figure 4: Experiment 2 word duration effects on the degree of epenthesis for each language.

The Y-axis stands for the degree of epenthesis. A higher point means more cases of epenthesis, whereas a lower point means more cases of deletion. The X-axis, on the other hand, stands for vowel duration, where a higher point means higher longer duration. Overall, we can see from Figure 5 that the longer the vowel duration, the more cases of deletion and vice versa. That is, epenthesis was chosen more frequently in words with shorter vowels. This observation was found in all examined languages. These findings suggest that vowel duration in fact influences the choice of the modification strategy.

Steriade (2001) points out that that schwa is preferentially inserted in many languages because it is the closest thing to no epenthesis at all. The schwa has a short

duration, and it is unstressable in many languages such as in Dutch, Indonesian and French. This makes it the closest thing in a vowel system to no segment at all. Moreover, Shoji & Shoji (2014) indicate that the epenthesized segment should be the one that is the least intrusive, the most unmarked and perceptually the closest to zero (or silence) in the recipient languages. They further add that epenthetic vowels with minimal salience would result in a smaller perceptual change between the input and output.

Thus, the finding that longer vowel duration resulted in fewer cases of epenthesis could be explained by the compromised status of the schwa. That is, with longer vowels, the status of the schwa as the least intrusive was changed, resulting in a greater perceptual change between what the listeners were presented with and with what they target form is, leading to the avoidance of such modified words. Basically, it can be concluded that the shorter the epenthesized vowel is, the more tolerable it is, whereas words with longer vowels are less tolerable than deletion. This suggests that the two modification strategies under investigation – epenthesis and deletion – are sensitive to the notion of perceptual salience – particularly with respect to the phonetic feature of vowel length.

4.3.8. Sonority

Figure 5 demonstrates the modifications for all examined languages across all sonority profiles. Each sonority profile is shown a different color. The X-axis shows the three languages under investigation, whereas the Y-axis shows the frequency of epenthesis/deletion – the higher the point, the more cases of epenthesis. In the following sections, we discuss the results of each language group in more details.

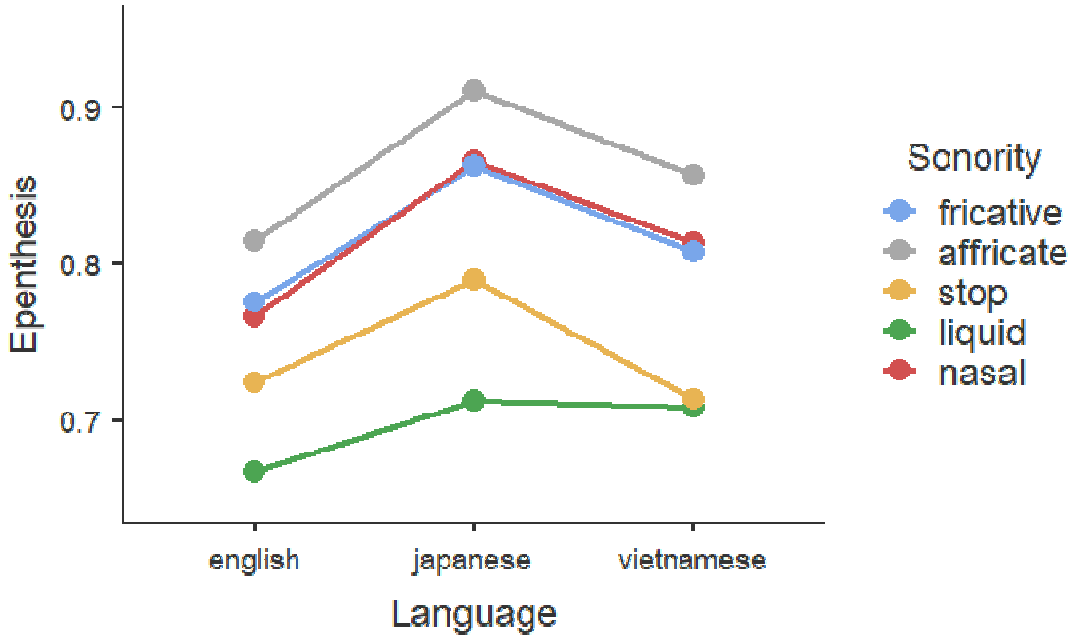


Figure 5: Experiment 2 modifications based on language and sonority.

4.3.8.1. English Participants

Our main prediction was that if the recoverability principle is active in the grammars of these L2 listeners, words modified by epenthesis should be chosen more frequently by listeners of all examined languages. A total of 71 native speakers of English participated in this study. They were each presented with 66 experimental words and had to choose between words that were modified by epenthesis or deletion. This resulted in a total of 4,686 tokens. Out of 4,686 tokens, words modified by epenthesis were chosen 3,747 times, which amounts for 79.96%. Words modified by deletion, on the other hand, were only chosen 939 times, which amounts for 20.03%. Comparable to Experiment 1, English had a dominant preference for words modified by epenthesis. This

provides support for the recoverability principle that words modified by epenthesis are easier to disambiguate. Based on these findings, we could argue that in real communication, with all else being equal, native English speakers would find words modified by epenthesis preferable to those modified by deletion.

We also examined the specific segments in the coda position. Based on a sonority perspective, we predicted that if the coda has a segment with low sonority, listeners will choose the word modified by epenthesis since the original coda is transformed into an onset where segments with lower sonority are preferred. By contrast, if the original word ends on a segment with high sonority, listeners will choose the word modified by deletion based on the sonority dispersion principle.

Table 22: Experiment 2 English: Total epenthesis vs. deletion based on sonority profile.

Sonority	Total	Epenthesis	Deletion
Stops	20x71= 1420	1113 (78.38%)	307 (21.61%)
Affricates	6x71= 426	364 (85.44%)	62 (14.55%)
Fricatives	22x71= 1562	1295 (82.90%)	267 (17.09%)
Nasals	10x71= 710	574 (80.84%)	136 (19.15%)
Liquids	8x71= 568	401 (70.59%)	167 (29.40%)
Totals	4686	3747 (79.96%)	939 (20.03%)

Table 22 shows the exact number of epenthesis and deletions in addition to the overall percentages. The column labeled "*Total*" indicates the total number of tokens for each sonority profile. This number is the result of the original number of words ending in segments in a particular sonority profile multiplied by the number of participants. We can see in Table 22 that epenthesis was predominantly more frequent as mentioned previously. When it comes to sonority, liquids exhibited the greatest percentage of deletions totaling 29.40%. We further examined the 167 cases of liquids deletions. We found that out of the 167 cases, 115 cases (68.86%) were instances of [ɹ] deletions. This higher percentage of [ɹ] deletions compared to other consonants could be attributed to the acceptability of [ɹ] deletions in many dialects of English.

Immediately after liquids, came stops 21.61% followed by nasals 19.15%, fricatives, 17.09%, and finally affricates 14.55%. To see if the differences between the sonority profiles were statistically significant or not, a post-hoc test was performed. The results are shown in the following table.

Table 23: Experiment 2 post Hoc Comparisons - English ✻ Sonority.

Comparison									
Language	**Sonority**		**Language**	**Sonority**	**Difference**	**SE**	**T**	**Df**	$p_{bonferroni}$
liquid	english	-	nasal	english	-0.09866	0.0206	-4.7809	8863.0	< .001
stop	english	-	liquid	english	0.05654	0.0181	3.1266	8863.0	0.186
stop	english	-	nasal	english	-0.04212	0.0172	-2.4470	8863.0	1.000
affricate	english	-	liquid	english	0.14691	0.0240	6.1162	8863.0	< .001
affricate	english	-	nasal	english	0.04824	0.0233	2.0691	8863.0	1.000
affricate	english	-	stop	english	0.09037	0.0210	4.2967	8863.0	0.002
fricative	english	-	liquid	english	0.10773	0.0180	6.0004	8863.0	< .001
fricative	english	-	nasal	english	0.00907	0.0173	0.5251	8863.0	1.000

Table 23: Experiment 2 post Hoc Comparisons - English ✻ Sonority.

Comparison									
Language	**Sonority**		**Language**	**Sonority**	**Difference**	**SE**	**T**	**Df**	$p_{bonferroni}$
fricative	english	-	stop	english	0.05119	0.0136	3.7775	8863.0	0.017
fricative	english	-	affricate	english	-0.03917	0.0209	-1.8775	8863.0	1.000

Table 23 shows that native speakers of English deleted liquids significantly more than nasals ($p < .001$), fricatives ($p < .001$) and affricates ($p < .001$). However, there was no significant difference between liquids and stops ($p = 0.186$). Thus, since stops did not behave according to the sonority scale, we cannot conclude that sonority influences the modification strategy. However, it is worthy of note that, except for stops, the modification strategy in other sonority profiles seemed to behave according to the sonority scale. That is, when the original word ended in segment with lower sonority, English listeners showed a gradual preference for the words modified by epenthesis. This is because epenthesis creates another syllable in which the segment previously in coda will be now the onset of the new syllable, and onsets with lower sonority are preferred.

Nevertheless, something needs to be said about stops. Stops have the least sonority; thus, based on what we hypothesized, they make better onsets. As a result, they should not be deleted as often. Table 23 shows that native speakers of English deleted stops significantly more than fricatives ($p = 0.017$) and affricates ($p = 0.002$). One explanation could be based on markedness. According to de Lacy (2002), stops are the least marked segments. Unmarked segments may be easier to produce due to their articulatory simplicity, yet they have less perceptual salience. Such features make

unmarked segments subject to change. Hume (2004) points out that phonologically unmarked segments in a system are considered to be the least stable phonetically. That is, they are most likely to undergo processes such as reduction, deletion and assimilation.

We also wanted to see if the number of syllables influenced the modification strategy in each sonority profile. Table 24 shows the total of each modification strategy based on sonority and number of syllables.

Table 24: Experiment 2 English: Total epenthesis vs. deletion based on based on sonority profile and number of syllables.

Sonority	Total epenthesis	Epenthesis/ monosyllabic	Epenthesis/ bisyllabic	Total Deletion	Deletion/ monosyllabic	Deletion/ bisyllabic
Stops	1113 (78.38%)	729 (65.49%)	384 (34.50%)	307 (21.61%)	123 (40.06%)	184 (59.93%)
Affricates	364 (85.44%)	243 (66.75%)	121 (33.24%)	62 (14.55%)	41 (66.12%)	21 (33.87%)
Fricatives	1295 (82.90%)	756 (58.37%)	539 (41.62%)	267 (17.09%)	96 (35.95%)	171 (64.04%)
Nasals	574 (80.84%)	363 (63.24%)	211 (36.75%)	136 (19.15%)	63 (46.32%)	73 (53.67%)
Liquids	401 (70.59%)	218 (54.36%)	183 (45.63%)	167 (29.40%)	66 (39.52%)	101 (60.47%)
Totals	3747 (79.96%)	2309 (61.62%)	1438 (38.37%)	939 (20.03%)	389 (41.42%)	550 (58.57%)

Table 24 shows that English listeners exhibited a tendency of choosing epenthesis more frequently in monosyllabic words. This is found in stops 65.49%, affricates, 66.75%, fricatives, 58.37%, nasals, 63.24% and liquids 54.36%. When it comes to deletion, the opposite was true. In other words, deletion was chosen more frequently in bisyllabic words. This is found in almost all sonority profiles: stops 59.93%, fricatives 64.04%, nasals 53.67% and liquids 60.47%. The only exception was affricates where deletion was higher in monosyllabic words 66.12%. To see whether these differences were statistically significant or not, a post-hoc test was performed. The results are shown in Table 25.

Table 25: Experiment 2 post Hoc Comparisons - English ✻ Syllables ✻ Sonority.

Comparison											
Language	**Syllables**	**Sonority**		**Language**	**Syllables**	**Sonority**	**Difference**	**SE**	**t**	**Df**	**$p_{bonferroni}$**
english	1	liquid	-	english	2	liquid	0.14948	0.0316	4.7280	8863.0	0.001
english	1	nasal	-	english	2	nasal	0.14731	0.0297	4.9611	8863.0	< .001
english	1	stop	-	english	2	stop	0.20202	0.0211	9.5624	8863.0	< .001
english	1	affricate	-	english	2	affricate	-0.00865	0.0375	-0.2306	8863.0	1.000
english	1	fricative	-	english	2	fricative	0.15388	0.0199	7.7439	8863.0	< .001

Table 25 shows that the differences between monosyllabic and bisyllabic words were statistically significant in stops ($p < .001$), fricatives ($p < .001$), nasals ($p < .001$), and liquids ($p = 0.001$). Nevertheless, there was not a significant difference between monosyllabic and bisyllabic words when it comes to affricates ($p = 1.000$). One possible explanation for the general preference towards epenthesis in affricates could be based on their phonetic properties. Affricates have longer and louder fricative like releases in English often accompanied with lip rounding.

Another possible explanation could be based on the fact that there was not an equivalent number of monosyllabic and bisyllabic stimuli ending in affricates. The stimuli used consisted of two words per each segment. When it comes to monosyllabic words, there were four words – couch [kaʊʧə], peach [piʧə], badge [bæʤə] and ridge[ɹɪʤə] – that ended in affricates. However, in the bisyllabic stimuli, the only two words that fit the inclusion criteria were college [kɑlɪʤ] and courage [kɜrɪʤə]. This lack of equivalency in addition to the fact that English does not have many affricates – which could reconcile this lack of equivalency – may have led to this insignificant result.

Initially, we predicted that if modifications are governed by the recoverability principle, then listeners would prefer words modified by epenthesis in both monosyllabic and bisyllabic stimuli. In section 4.3.5, we found that epenthesis was preferred regardless of the number of syllables across all samples, which provides support for the recoverability principle. On the other hand, if there is a preference for bisyllabic forms, we hypothesized that listeners will show a preference for words modified by epenthesis only in monosyllabic stimuli, but when it comes to bisyllabic stimuli, listeners will prefer

words modified by deletion to maintain bisyllabicity. The findings in section 4.3.5 provide partial support to Wang (1995) since there was slightly, yet significantly, more cases of deletion in bisyllabic words.

Furthermore, even though the results show that epenthesis was preferred regardless of the number of syllables, when divided based on sonority profile, we can also see that the English participants exhibited significant differences between monosyllabic and bisyllabic words. Based on these findings, it can be suggested that both the recoverability principle and a partial preference for bisyllabicity influence the choice of the modification strategy. Sonority, on the other hand, does not seem to play a role since stops did not behave according to the sonority scale.

4.3.8.2. Japanese Participants

As for Japanese, there was a total of 32 participants in this study. Each participant was presented with 66 experimental words and had to choose between words that were modified by epenthesis or deletion. This resulted in a total of 2,112 tokens. Out of 2,112, words modified by epenthesis were chosen 1,914 times, which amounts for 90.62%. Words modified by deletion, on the other hand, were chosen 198 times, which amounts for 9.37%. Similar to the English participants, the Japanese participants had a dominant preference for words modified by epenthesis. This provides support for the recoverability principle that words modified by epenthesis are easier to disambiguate. Based on these findings, we could argue that in real communication, with all else being equal, Japanese listeners would find words modified by epenthesis preferable to those modified by deletion.

We also examined the specific segments in the coda position. The results are shown in Table 26.

Table 26: Experiment 2 Japanese: Total epenthesis vs. deletion based on sonority profile.

Sonority	Total	Epenthesis	Deletion
Stops	20x32= 640	491 (76.71%)	149 (23.28%)
Affricates	6x32= 192	168 (87.5%)	24 (12.5%)
Fricatives	22x32= 704	584 (82.95%)	120 (17.04%)
Nasals	10x32= 320	263 (82.18%)	57 (17.81%)
Liquids	8x32= 256	169 (66.01%)	87 (33.98%)
Totals	2112	1675 (79.30%)	437 (20.69%)

Table 26 shows that epenthesis was predominantly more frequent across all sonority types, which is similar to what was found in the English sample. When we examine the frequency of deletions, we find that liquids, which is the most sonorous category, exhibited the greatest percentage of deletions totaling 33.98%. Immediately after liquids, came stops 23.28% followed by nasals 17.81%, fricatives, 17.04%, and finally affricates 12.5%. To see if the differences between the sonority profiles were statistically significant or not, a post-hoc test was performed. The results are shown in Table 27.

Table 27: Experiment 2 post Hoc Comparisons - Japanese ✻ Sonority

Comparison									
Language	**Sonority**		**Language**	**Sonority**	**Difference**	**SE**	**T**	**df**	**$p_{bonferroni}$**
liquid	japanese	-	nasal	japanese	-0.15315	0.0307	-4.9904	8863.0	< .001
stop	japanese	-	liquid	japanese	0.07774	0.0269	2.8848	8863.0	0.412
stop	japanese	-	nasal	japanese	-0.07541	0.0254	-2.9658	8863.0	0.318
affricate	japanese	-	liquid	japanese	0.19853	0.0358	5.5491	8863.0	< .001
affricate	japanese	-	nasal	japanese	0.04538	0.0346	1.3112	8863.0	1.000
affricate	japanese	-	stop	japanese	0.12079	0.0313	3.8591	8863.0	0.012
fricative	japanese	-	liquid	japanese	0.14996	0.0266	5.6365	8863.0	< .001
fricative	japanese	-	nasal	japanese	-0.00319	0.0252	-0.1265	8863.0	1.000
fricative	japanese	-	stop	japanese	0.07222	0.0201	3.5954	8863.0	0.034
fricative	japanese	-	affricate	japanese	-0.04857	0.0310	-1.5684	8863.0	1.000

Table 27 shows that the Japanese participants deleted liquids significantly more than nasals ($p < .001$), fricatives ($p < .001$) and affricates ($p < .001$). However, just like what was found in the English group, there was no significant difference between liquids and stops ($p = 0.412$). Table 27 shows that the Japanese participants deleted stops significantly more than affricates ($p = 0.012$) and fricatives ($p = 0.034$). Again, this could be due to the fact that stops are the least marked segments, which makes them most likely to undergo processes such as reduction, deletion and assimilation. From these findings, we cannot conclude that sonority influences the modification strategy.

We also wanted to see if the number of syllables influenced the modification strategy in each sonority profile. Table 28 shows the total of each modification strategy based on sonority and number of syllables.

Table 28: Experiment 2 Japanese: Total epenthesis vs. deletion based on based on sonority profile and number of syllables.

Sonority	Total epenthesis	Epenthesis/ monosyllabic	Epenthesis/ bisyllabic	Total Deletion	Deletion/ monosyllabic	Deletion/ bisyllabic
Stops	491 (76.71%)	329 (67.00%)	162 (32.99%)	149 (23.28%)	55 (36.91%)	94 (63.08%)
Affricates	168 (87.5%)	115 (68.45%)	53 (31.54%)	24 (12.5%)	13 (54.16%)	11 (45.83%)
Fricatives	584 (82.95%)	348 (59.58%)	236 (40.41%)	120 (17.04%)	36 (30%)	84 (70%)
Nasals	263 (82.18%)	167 (63.49%)	96 (36.50%)	57 (17.81%)	25 (43.85%)	32 (56.14%)
Liquids	169 (66.01%)	97 (57.39%)	72 (42.60%)	87 (33.98%)	31 (35.63%)	56 (64.36%)
Totals	1675 (79.30%)	1056 (63.04%)	619 (36.95%)	437 (20.69%)	160 (36.61%)	277 (63.38%)

Similar to the English sample, Table 28 shows that the Japanese listeners had a tendency of choosing epenthesis more frequently in monosyllabic words. This is found in

stops 67.00%, affricates, 68.45%, fricatives, 59.58%, nasals, 63.49% and liquids 57.39%. When it comes to deletion, the opposite was true. That is, deletion was chosen more frequently in bisyllabic words. This is found in almost all sonority profiles: stops 63.08%, fricatives 70%, nasals 56.14% and liquids 64.36%. The only exception was affricates where deletion was higher in monosyllabic words 54.16%. To see whether these differences were statistically significant or not, a post-hoc test was performed. The results are shown in the following table.

Table 29: Experiment 2 post Hoc Comparisons - English ✻ Syllables ✻ Sonority.

Comparison											
Language	**Syllables**	**Sonority**		**Language**	**Syllables**	**Sonority**	**Difference**	**SE**	**t**	**df**	**$p_{bonferroni}$**
japanese	1	liquid	-	japanese	2	liquid	0.22882	0.0461	4.9587	8863.1	< .001
japanese	1	nasal	-	japanese	2	nasal	0.15782	0.0426	3.7039	8863.0	0.093
japanese	1	stop	-	japanese	2	stop	0.24652	0.0302	8.1565	8863.0	< .001
japanese	1	affricate	-	japanese	2	affricate	0.05809	0.0556	1.0448	8863.0	1.000
japanese	1	fricative	-	japanese	2	fricative	0.19726	0.0284	6.9438	8863.0	< .001

Table 29 shows that the differences between monosyllabic and bisyllabic words were statistically significant in stops ($p < .001$), fricatives ($p < .001$), nasals ($p = 0.093$), and liquids ($p < .001$). Nevertheless, there was not a significant difference between monosyllabic and bisyllabic words when it comes to affricates ($p = 1.000$), which is similar to what was found in the English sample.

4.3.8.3. Vietnamese Participants

As for the Vietnamese sample, there was a total of 34 participants in this study. Each participant was presented with 66 experimental words and had to choose between words that were modified by epenthesis or deletion. This resulted in a total of 2,244 tokens. Out of these 2,244, words modified by epenthesis were chosen 1,671 times, which amounts for 74.46%, whereas words modified by deletion were chosen 573 times, which amounts for 25.53%. Similar to the English and Japanese samples, the Vietnamese participants had a dominant preference for words modified by epenthesis. This provides support for the recoverability principle that words modified by epenthesis are easier to disambiguate.

We also examined the specific segments that undergone deletion, which are shown in Table 30.

Table 30: Experiment 2 Vietnamese: Total epenthesis vs. deletion based on sonority profile.

Sonority	Total	Epenthesis	Deletion

Stops	20x34= 680	473 (69.55%)	207 (30.44%)
Affricates	6x34= 204	170 (83.33%)	34 (16.66%)
Fricatives	22x34= 748	584 (78.07%)	164 (21.92%)
Nasals	10x34= 340	263 (77.35%)	77 (22.64%)
Liquids	8x34= 272	181 (66.54%)	91 (33.45%)
Totals	2244	1671 (74.46%)	573 (25.53%)

Table 30 shows that epenthesis was the most frequent regardless of the sonority profile. This is consistent to what was found in the English and Japanese samples. Similar to the other groups, when we closely examine the frequency of deletions, we find that liquids exhibited the highest percentage of deletions (33.45%). Immediately after liquids, came stops 30.44% followed by nasals 22.64%, fricatives 21.92%, and finally affricates 16.66%. To see if the differences between the sonority profiles were statistically significant or not, a post-hoc test was performed. The results are shown in Table 31.

Table 31: Experiment 2 post Hoc Comparisons - Vietnamese ✻ Sonority.

Comparison									
Language	**Sonority**		**Language**	**Sonority**	**Difference**	**SE**	**T**	**df**	**$p_{bonferroni}$**
liquid	vietnamese	-	nasal	vietnamese	-0.10562	0.0298	-3.5422	8863.1	0.042
stop	vietnamese	-	liquid	vietnamese	0.00532	0.0262	0.2036	8863.0	1.000
stop	vietnamese	-	nasal	vietnamese	-0.10029	0.0247	-4.0548	8863.0	0.005
affricate	vietnamese	-	liquid	vietnamese	0.14839	0.0347	4.2754	8863.0	0.002
affricate	vietnamese	-	nasal	vietnamese	0.04278	0.0336	1.2724	8863.1	1.000
affricate	vietnamese	-	stop	vietnamese	0.14307	0.0304	4.7103	8863.0	< .001
fricative	vietnamese	-	liquid	vietnamese	0.09956	0.0258	3.8540	8863.0	0.012

Table 31: Experiment 2 post Hoc Comparisons - Vietnamese ✻ Sonority.

Comparison									
Language	**Sonority**		**Language**	**Sonority**	**Difference**	**SE**	**T**	**df**	**$p_{bonferroni}$**
fricative	vietnamese	-	nasal	vietnamese	-0.00606	0.0245	-0.2470	8863.0	1.000
fricative	vietnamese	-	stop	vietnamese	0.09423	0.0195	4.8277	8863.0	< .001
fricative	vietnamese	-	affricate	vietnamese	-0.04884	0.0301	-1.6248	8863.0	1.000

Table 31 shows that the Vietnamese participants deleted liquids significantly more than nasals ($p = 0.042$), fricatives ($p = 0.012$) and affricates ($p = 0.002$). However, similar to the English and Japanese samples, the difference between liquids and stops was not statistically significance ($p = 1.000$). When we look at stops, Table 31 shows that the Vietnamese participants deleted stops significantly more than nasals ($p = 0.005$), fricatives ($p < .001$) and affricates ($p < .001$). Again, this could be attributed to markedness since phonologically unmarked segments in a system are considered to be the least stable phonetically. That is, they are most likely to undergo processes such as reduction, deletion and assimilation.

We also wanted to see if the number of syllables influenced the modification strategy in each sonority profile. The following table shows the total of each modification strategy based on sonority and number of syllables.

Table 32: Experiment 2 Vietnamese: Total epenthesis vs. deletion based on based on sonority profile and number of syllables.

Sonority	Total epenthesis	Epenthesis/ monosyllabic	Epenthesis/ bisyllabic	Total Deletion	Deletion/ monosyllabic	Deletion/ bisyllabic
Stops	473 (69.55%)	319 (67.44%)	154 (32.55%)	207 (30.44%)	89 (42.99%)	118 (57.00%)
Affricates	170 (83.33%)	118 (69.41%)	52 (30.58%)	34 (16.66%)	18 (52.94%)	16 (47.05%)
Fricatives	584 (78.07%)	347 (59.41%)	237 (40.58%)	164 (21.92%)	61 (37.19%)	103 (62.80%)
Nasals	263 (77.35%)	167 (63.49%)	96 (36.50%)	77 (22.64%)	37 (48.05%)	40 (51.94%)
Liquids	181 (66.54%)	103 (56.90%)	78 (43.09%)	91 (33.45%)	33 (36.26%)	58 (63.73%)
Totals	1671 (74.46%)	1054 (63.07%)	617 (36.92%)	573 (25.53%)	238 (41.53%)	335 (61.96%)

Similar to the English and Japanese samples, Table 32 shows that the Vietnamese listeners had a tendency of choosing epenthesis more frequently in monosyllabic words. This is found in stops 67.44%, affricates, 69.41%, fricatives, 59.41%, nasals, 63.49% and liquids 56.90%. The opposite was true when it comes to deletion. That is, deletion was chosen more frequently in bisyllabic words. This is found in almost all sonority profiles: stops 57.00%, fricatives 62.80%, nasals 51.94% and liquids 63.73%. Just like the English and Japanese samples, the only exception was affricates where deletion was higher in monosyllabic words 52.94%. To see whether these differences were statistically significant or not, a post-hoc test was performed. The results are shown in Table 33.

Table 33: Experiment 2 post Hoc Comparisons - Vietnamese ✻ Syllables ✻ Sonority.

Comparison											
Language	**Syllables**	**Sonority**		**Language**	**Syllables**	**Sonority**	**Difference**	**SE**	**t**	**df**	$p_{bonferroni}$
vietnamese	1	liquid	-	vietnamese	2	liquid	0.20729	0.0448	4.6263	8863.0	0.002
vietnamese	1	nasal	-	vietnamese	2	nasal	0.15015	0.0415	3.6143	8863.0	0.032
vietnamese	1	stop	-	vietnamese	2	stop	0.24102	0.0294	8.1926	8863.1	< .001
vietnamese	1	affricate	-	vietnamese	2	affricate	0.09072	0.0540	1.6813	8863.0	1.000
vietnamese	1	fricative	-	vietnamese	2	fricative	0.17490	0.0277	6.3211	8863.1	< .001

Table 33 shows that the differences between monosyllabic and bisyllabic words were statistically significant in stops ($p < .001$), fricatives ($p < .001$), ($p = 0.032$) and liquids ($p = 0.002$). Nevertheless, there was not a significant difference between monosyllabic and bisyllabic words when it comes to affricates ($p = 1.000$), which is similar to what was found in the English and Japanese samples.

4.4. Review of predictions

In Experiment 2, we had seven predictions. Our first prediction was that if the recoverability principle is active, then listeners will prefer words modified by epenthesis in both monosyllabic and bisyllabic stimuli. Our findings provide support for this prediction. All participants showed a preference for epenthesis in both monosyllabic and bisyllabic words regardless of their English proficiency or linguistic background. This provides support for the recoverability principle that words modified by epenthesis are easier to disambiguate.

Our second prediction stated that if there is a preference for bisyllabic forms, then listeners will prefer words modified by epenthesis in monosyllabic stimuli, but they will prefer words modified by deletion in bisyllabic stimuli. However, if modifications are governed by the recoverability principle, then listeners will prefer words modified by epenthesis in both monosyllabic and bisyllabic stimuli. Overall, the findings show that epenthesis was preferred regardless of the number of syllables across all samples.

However, we could conclude that there is an interaction between recoverability and bisyllabicity. This is due to the fact that epenthesis in monosyllabic words also results in bisyllabicity. In addition, when we examined bisyllabic words closely, even

though there was no overall preference for deletion over epenthesis in bisyllabic words to maintain bisyllabicity, we found that deletions in bisyllabic words were significantly higher than deletions in monosyllabic words across all samples, which could be due to some preference for bisyllabic forms (Wang, 1995).

It is also possible that this is due to the essentially different informational content between both types of stimuli. Bisyllabic words have two syllables, which means that they inherently carry more information compared to monosyllabic words. Consequently, deletion might be slightly more tolerable when it occurs in bisyllabic words. That is, even if we know that deletion results in unrecoverable forms, based on the differences we found between monosyllabic and bisyllabic forms, it seems that there is a degree of ambiguity.

Moreover, based on Vietnamese production studies (Sato, 1984; Benson, 1988), Japanese non-learners research (Dupoux et al., 1999) and the tendency of some languages of using different segments for substitution as a repair strategy systematically (Lombardi, 2003), it was predicted that there would be native language bias. That is, Vietnamese listeners will prefer words modified by deletion regardless of stimuli type, whereas Japanese listeners will prefer words modified by epenthesis regardless of stimuli type. However, the findings did not support this prediction. All participants showed a preference for epenthesis in both monosyllabic and bisyllabic words regardless of linguistic background. This suggests that, when it comes to perception of a language the listeners know, it seems there is clear evidence that structures modified by epenthesis are easier to recover regardless of learners' L1. Furthermore, these findings suggest that the

preferred modification strategy in a perceptual task cannot be predicated based on the modification strategies used by L2 learners in productions studies or a study done on non-learners.

Furthermore, we predicted that listeners with higher English proficiency would choose words modified by epenthesis more frequently than those with lower English proficiency. In order to test this prediction, three measures of proficiency were examined, which were self-reported English proficiency, age of onset and length of residency. The results of Experiment 2 showed that English proficiency and length of residency did not have a significant effect on the choice of strategy. The choice of strategy, however, was significantly influenced by age of onset. This is consistent with previous studies (Patkowski, 1980; Flege et al. 1995; Stevens, 1999).

Moreover, we predicted that deletion would be chosen more frequently in words with higher frequency, whereas words with lower word frequency would exhibit more instances of epenthesis (Bybee, 2002, 2007). Our results supported this prediction. We found that higher word frequency resulted in more cases of deletion, whereas lower word frequency led to more instances of epenthesis. These findings provide evidence that that word frequency in fact influences the choice of the modification strategy.

Additionally, when it comes to vowel duration, it was predicted that listeners would choose epenthesis more frequently in words with shorter vowel duration, whereas words with longer epenthetic vowel duration would exhibit more instances of deletion. The findings provided support for this prediction. It was found that the duration of the epenthetic vowel significantly influenced the modification strategy. Specifically, in all

examined languages, it was found that words with longer vowel duration exhibited more cases of deletion, whereas words with shorter vowels had more cases of epenthesis.

Finally, we predicted that the sonority of the coda consonant would influence the modification strategy. That is, if the original word ends on a segment with low sonority (e.g., [t]), listeners will choose the word modified by epenthesis. On the contrary, if the original word ends on a segment with high sonority, listeners will choose the word modified by deletion. Our findings showed that, except for stops, words ending with higher sonority were modified by deletion more frequently. It was found in all samples that when the sonority decreases, the frequency of deletion decreases as well. Nevertheless, since stops did not behave according to the sonority scale, we cannot conclude that sonority influences the modification strategy.

Stops was the only sorority profile that did not behave in accordance with our prediction. Stops have the least sonority; thus, based on what we hypothesized, they make better onsets. As a result, they should not be deleted as often. We suggest that this due to markedness. de Lacy (2002) indicates that stops are the least marked segments. Unmarked segments are relatively easier to produce due to their articulatory simplicity, yet they have less perceptual salience. Such features make unmarked segments subject to change. Furthermore, Hume (2004) points out that phonologically unmarked segments in a system are considered to be the least stable phonetically. That is, they are most likely to undergo processes such as reduction, deletion and assimilation.

Another possible explanation could be based on perceptual salience. Hume et al. (1999) indicates that perceptual salience may explain several phonological processes.

Specifically, she states that acoustically less salient segments are more likely to be targets of such processes. According to Jun's (1995) ranking of salience, coronals are the least salient. Kochetov & So (2005) indicate that coronals are highly susceptible to phonological processes such place assimilation compared to labials and dorsals because of their poorer acoustic cues since they tend to be unreleased in a syllable-final position. Thus, the fact that stops did not behave as predicted could be explained based on their relatively low perceptual salience, making them more prone to deletion.

In addition, we wanted to see if the number of syllables influenced the modification strategy in each sonority profile. We found that all groups had a tendency of choosing epenthesis more frequently in monosyllabic words regardless of sonority. This was found in stops, affricates, fricatives, nasals and liquids. When it comes to deletion, however, the results were not as consistent. It was found that all samples had a tendency of choosing deletion more frequently in bisyllabic words. Nevertheless, this was not found in all sonority profiles. It was found in stops, fricatives, nasals and liquids but not affricates.

The fact that affricates in codas showed a preference for epenthesis overall could be attributed to their phonetic properties. That is, affricates have longer and louder fricative like releases in English often accompanied with lip rounding, which makes them resistant to deletion, leading to more cases of epenthesis. The behavior of affricates provides evidence that phonetic features could influence the modification strategy. Another piece of evidence that the choice of the modification strategy can be phonetically motived comes from the behavior of stops since they did not behave as we predicted

based on sonority. In sum, given the findings about affricates, the unexpected behavior of stops and the effects of vowel duration on the choice of the modification strategy, it seems that phonetic properties influence the choice of the modification strategy to some extent.

CHAPTER FIVE

5. Review of both experiments and conclusions

The purposes of this dissertation were to examine the difference between two strategies of syllable structure simplification (epenthesis & deletion) that are used by L2 learners when faced with structures that are illegal in their L1 using a perceptual task. Several studies have investigated the strategies of modifying illegal structures (Weinberger, 1987; Benson, 1988; Sato, 1984; Wang, 1995; Hansen, 2004; Yavaş, 2011); nevertheless, as far as can be determined, no one has investigated these two strategies using perception experiments. By conducting such perception experiments, this gap in the literature is addressed. Moreover, we are actually testing the implications of the recoverability principle, which cannot be examined in production studies.

We examined the perceptual preference of words modified by either epenthesis or deletion by listeners of four different languages in two experiments. Our main hypothesis was based on the recoverability principle (Weinberger, 1987). It was predicted that if the recoverability principle determines the modification strategy employed, epenthesis will be significantly more preferred by listeners compared to deletion. This hypothesis was supported in both Experiment 1 and Experiment 2. Our results showed that epenthesis was significantly more preferred in all examined languages in general. This finding provides support for the recoverability principle. Weinberger (1987) suggested that the two modification strategies are not equal because their outcomes differ in the degree of ambiguity. That is, deletion results in an increased lexical ambiguity because there are

various possible forms from which the listener could choose, whereas epenthesis results in relatively easily recoverable structures since it limits the possibilities. Up to this point, no one could verify such assumptions since no perception studies have investigated this hypothesis. Since all of the language groups in both perception experiments were significantly found to prefer epenthesis over deletion, it can be safely be concluded that epenthesis in fact results in structures that are easier for listeners to disambiguate.

Nevertheless, since only monosyllabic words were tested in Experiment 1, it could be argued that the findings could also be explained by an overall preference for bisyllabic forms (Wang, 1995). That is, since the stimuli used consisted only of monosyllabic words, epenthesis would result in two syllable words. Because Experiment 1 only tested monosyllabic words, the possibility that listeners had a preference for bisyllabic words could not be excluded. In order to address the shortcomings of Experiment 1, Experiment 2 included bisyllabic words as well as monosyllabic words, and we had a new set of predictions based on Weinberger (1987) and Wang (1995). We predicted that if the recoverability principle was active, then listeners would prefer words modified by epenthesis in monosyllabic stimuli as well as in bisyllabic stimuli. On the other hand, if there was a preference for bisyllabic forms, then listeners would prefer words modified by epenthesis in monosyllabic stimuli. However, listeners would prefer words modified by deletion in bisyllabic stimuli.

Our findings showed that, even in bisyllabic stimuli, where we predicted that listeners would prefer words modified by deletion to maintain bisyllabicity, there was a preference for epenthesis across all samples. Nevertheless, deletions were significantly

higher in bisyllabic words compared to monosyllabic words across all samples, which provides partial support for a preference for bisyllabic forms (Wang, 1995). Thus, based on the fact that deletions were significantly higher in bisyllabic words compared to monosyllabic words across all samples and the fact that epenthesis in monosyllabic words also results in bisyllabic forms, it can be concluded that there is an interaction between recoverability and bisyllabicity.

In addition to a partial preference for bisyllabic forms, we suggest that this could be due to the essentially different informational content between both types of stimuli. Bisyllabic words have two syllables, which means that they inherently carry more information compared to monosyllabic words. As a result, deletion might be slightly more tolerable when it occurs in bisyllabic words. In other words, even if we know that deletion results in unrecoverable forms, based on the differences we found between monosyllabic and bisyllabic forms, it seems that there is a degree of ambiguity. This is because, even though in both cases deletion results in the loss of information, bisyllabic words still have more information even after the deletion of the coda, which makes it slightly easier for the listener to recover the meaning compared to monosyllabic words with deleted information. This could be the reason why we found slightly, yet significantly, more cases of deletion in bisyllabic words. In sum, these findings show that both the recoverability principle and bisyllabicity influenced the listeners' choices, suggesting that neither the recoverability principle nor bisyllabicity could solely account for the choice of the modification strategy.

We also predicted that the sonority of the coda consonant would influence the modification strategy. Specifically, if the original word ends on a segment with low sonority (e.g., [t]), listeners will choose the word modified by epenthesis. This is because epenthesis creates another syllable in which the segment previously in coda will be the onset of the new syllable, and onsets with low sonority are preferred. By contrast, if the original word ends on a segment with high sonority, listeners will choose the word modified by deletion (Clements, 1990).

In Experiment 1, it was found that epenthesis was the most frequent regardless of the sonority profile in all language groups – English, Japanese and Spanish. Thus, our findings did not show evidence that sonority influenced the modification strategy. Only liquids were found to behave according to our hypothesis. However, this could be attributed to the fact that liquid deletions are acceptable in various English dialects.

In Experiment 2, however, some sonority profiles seemed to behave according to our hypothesis. In all examined languages – English, Japanese and Vietnamese – participants deleted liquids significantly more than nasals, fricatives and affricates. Stops were the only exception. We suggest that it is due to either the fact that stops are the least marked segments or the fact that they are perceptually less salient. Both of these properties could explain why they exhibited more cases of deletion. Overall, looking at the results of both experiments together, it can be concluded that sonority does not influence the choice of the modification strategy.

In addition, we wanted to see if the number of syllables influenced the modification strategy in each sonority profile. It was found that all groups had a tendency

of choosing epenthesis more frequently in monosyllabic words regardless of sonority. This was found in stops, affricates, fricatives, nasals and liquids. When it comes to deletion, however, the results were not as consistent. It was found that all samples had a tendency of choosing deletion more frequently in bisyllabic words. Nevertheless, this was not found in all sonority profiles. It was found in stops, fricatives, nasals and liquids, but not in affricates. It is possible that this is because the monosyllabic and bisyllabic stimuli did not include the same number of words ending in affricates, which may have led to the lack of significant difference between deletion in monosyllabic and bisyllabic words when it comes to affricates. It is also possible that this because of affricates phonetic properties. This finding in addition to the behavior of stops suggest that phonetic properties may influence the choice of the modification strategy.

Moreover, based on Vietnamese production studies (Sato, 1984; Benson, 1988), Japanese non-learners research (Dupoux et al., 1999) and the tendency of some languages of using different segments for substitution as a repair strategy systematically (Lombardi, 2003), we predicted that there would be native language bias. That is, Spanish and Vietnamese listeners would choose words modified by deletion more often, whereas Japanese listeners would choose the ones modified by epenthesis. However, there was no evidence to support this prediction. The results showed a significant preference for epenthesis over deletion regardless of the native language. This is actually interesting because it suggests that, unlike production studies and the study done on non-learners (Dupoux et al., 1999), where it was found that L2 learners with different native languages

may employ different modification strategies, when it comes to perception, it seems there is clear evidence that structures modified by epenthesis are easier to recover.

Furthermore, we predicted that listeners with higher English proficiency would choose words modified by epenthesis more frequently because advanced learners were found to show a greater degree of epenthesis than less advanced learners (Weinberger, 1994). In Experiment 1, it was found that linguistic proficiency may influence the choice of modification strategy as the Japanese and the Spanish samples had slightly, but significantly, higher rate of deletion than native English speakers. Nevertheless, in Experiment 2, there were not any significant differences among the three samples.

Additionally, in Experiment 2, three measures of linguistic proficiency were included in the analysis, which were self-reported English proficiency, age of onset and length of residency. The results showed that the only measure that influenced the choice of modification strategy (epenthesis vs. deletion) was age of onset. It was found that the lower the age of onset, the more cases of epenthesis and vice versa. In other words, deletion was chosen more frequently by participants with higher age of onset. This was found in all examined languages.

It has been shown that linguistic abilities are sensitive to the age of exposure to language. That is, late learners, particularly those who were exposed to a language after late infancy through puberty, do not generally achieve the same level of proficiency as very young learners (Patkowski, 1980; Flege et al. 1995; Birdsong, 1999; Johnson and Newport, 1989; ; Perani et al., 2003; among others). Combing the results of both Experiment 1 and Experiment 2, we can conclude that listeners with higher English

proficiency will choose words modified by epenthesis more frequently. This is consistent with the recoverability principle, which suggests that adult L2 learners with a more developed knowledge of the target lexicon tend to be more sensitive to the recoverability principle. That is, once the adult language learner is aware that ambiguity is a real possibility, he/she should utilize epenthesis significantly more often than deletion. It is also possible that, since they are adult L2 learners, the recoverability principle is already active from their L1 experience. However, it is worthy of note that since self-reported English proficiency was not a significant predicter of the choice of modification strategy, a future study could utilize a standardized tool to evaluate English proficiency. This could avoid the subjective nature of self-reporting, leading, potentially, to more accurate proficiency-based generalizations.

We also wanted to see if the duration of the epenthetic vowel in our stimuli words influenced the choice of modification strategy. It was found that the longer the vowel duration, the more cases of deletion and vice versa. In other words, epenthesis was chosen more frequently in words with shorter vowels. The fact that longer vowel duration resulted in fewer cases of epenthesis could be explained by the compromised status of the schwa. Steriade (2001) indicates that, since the schwa has a short duration – in addition to other features that are outside the scope of this dissertation – it is preferentially inserted in many languages because it is the closest thing to no epenthesis at all. Thus, a longer vowel duration compromises the ideal status of the schwa as an epenthetic vowel, making deletion more tolerable in words with longer vowels.

Even though Experiment 2 showed evidence that vowel duration influences the modification strategy, in a future study, the duration of the epenthetic vowel should be controlled to see if the same results can be reached with less variability. For instance, two sets of stimuli could be designed where one contains words modified by epenthesis with inserted vowels with consistent short duration, and another set of stimuli containing words modified by epenthesis with relatively yet significantly longer inserted vowels. In such data sets, if the results of Experiment 2 can be extended, we could expect listeners to prefer epenthesis in the set with shorter vowel duration.

Finally, we wanted to see if word frequency influenced the choice of modification strategy. Experiment 2 showed that the higher the frequency, the more cases of deletion and vice versa. That is, epenthesis was chosen more frequently in words with lower frequency. Regardless of the listeners' native language and sonority profile, it was found that higher word frequency resulted in more cases of deletion, whereas lower word frequency led to more instances of epenthesis. These findings suggest that word frequency in fact influences the choice of the modification strategy.

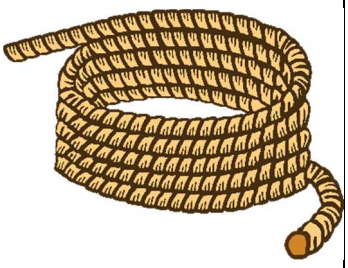
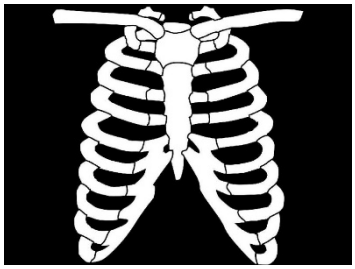
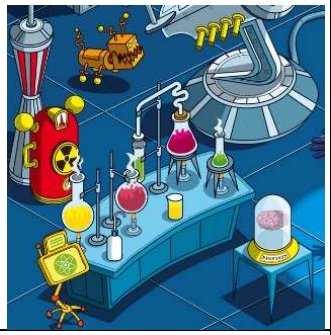
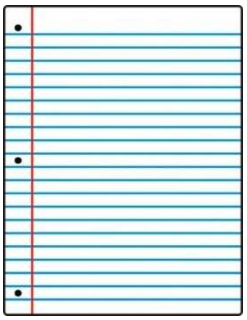
The significance of this research is that it contributed to the body of knowledge in Linguistics by examining the implications of the recoverability principle using a perceptual perspective. Furthermore, it has shown that the two modification strategies of epenthesis and deletion are not equal when examined form the perspective of listeners. Even though both result in CV syllables, listeners were found to prefer words modified by epenthesis since they are easier to disambiguate, which suggests that meaning preservation and maintaining distinctness are essential to listeners. Furthermore, this

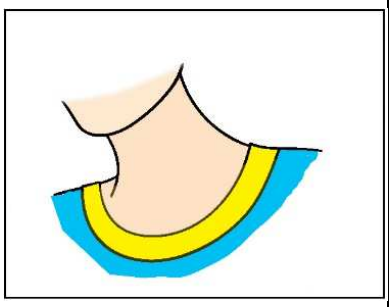
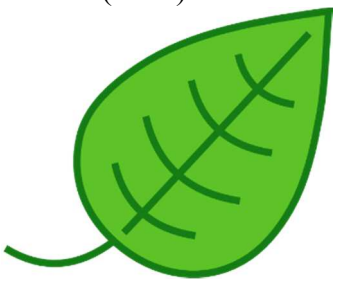
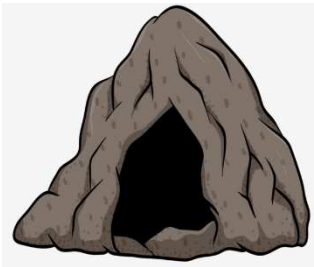
dissertation has shown that recoverability and bisyllabicity are not mutually exclusive because both have been found to significantly influence the choice of the modification strategy.

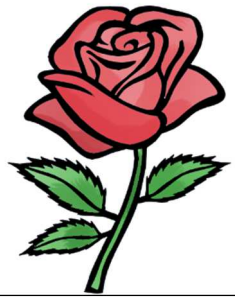
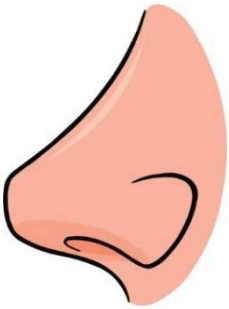
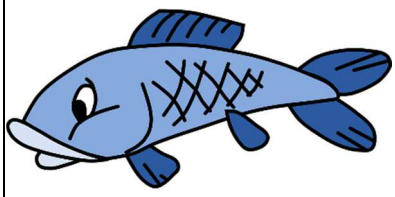
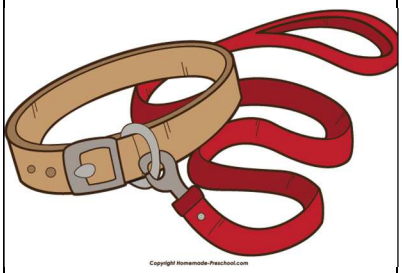
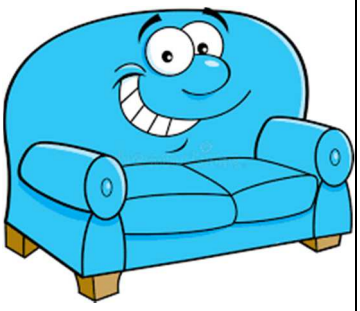
Interestingly, although examined listeners showed a greater preference for easily recoverable forms, there was a constellation of other factors that significantly influenced their choice. This dissertation has shown that the two modification strategies – epenthesis and deletion – are not purely phonologically motivated since, based on the results of Experiments 1 and 2, it could not be concluded that sonority influenced the choice of the modification strategy. It was shown that there are other phonetic factors that significantly influenced the modification strategy such as the phonetic properties of particular segments and the duration of the epenthetic vowel. A future study could examine the effects of such properties in more depth. Additionally, since this dissertation only focused on epenthesis and deletion in isolated words, a future study could examine the recoverability of structures modified by other simplification strategies employed by L2 learners such as devoicing, assimilation and substitution in context-based tasks in order to try to recreate even more realistic environments.

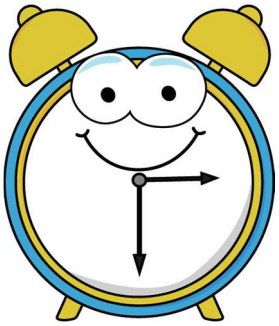
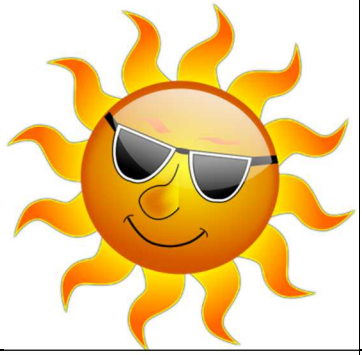
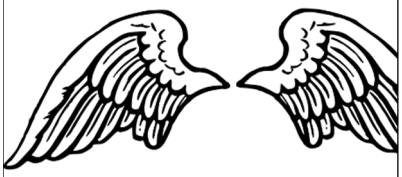
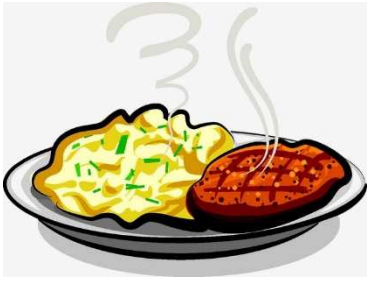
APPENDIX

(A) Stimuli words used in the study.
(A1) Monosyllabic Experimental words.

1. [ɹoʊpə] - [ɹoʊ] (9570) 	2. [supə] - [su] (13201) 	3. [ɹɪbə] - [ɹɪ] (2572) 
4. [læbə] - [læ] (19197) 	5. [butə] - [bu] (7966) 	6. [ʃitə] - [ʃi] (17413) 
7. [bɛdə] - [bɛ] (72819) 	8. [lɪdə] - [lɪ] (6159) 	9. [bʊkə] - [bʊ] (148303) 

10. [nɛkə] - [nɛ] (34522) 	11. [lɛgə] - [lɛ] (26026) 	12. [wɪgə] - [wɪ] (2055) 
13. [lifə] - [li] (9297) 	14. [ɹifə] - [ɹi] (3115) 	15. [lʌvə] - [lʌ] (192472) 
16. [keɪvə] - [keɪ] (9234) 	17. [dɛθə] - [dɛ] (119740) 	18. [maʊθə] - [maʊ] (51969) 

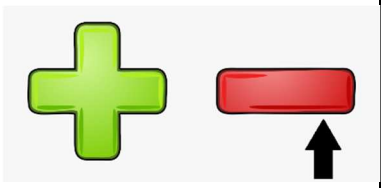
19. [aɪsə] - [aɪ] (46597) 	20. [ɹeɪsə] - [ɹeɪ] (71356) 	21. [ɹoʊzə] - [ɹoʊ] (50723) 
22. [noʊzə] - [noʊ] (27952) 	23. [fɪʃə] - [fɪ] (57923) 	24. [liʃə] - [li] (1782) 
25. [kaʊʧə] - [kaʊ] (12381) 	26. [piʧə] - [pi] (3431) 	27. [bædʒə] - [bæ] (3193) 

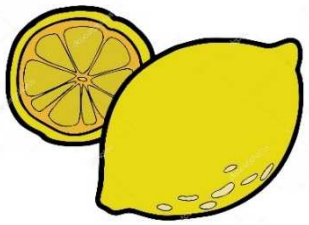
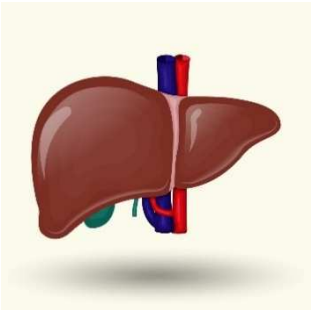
28. [ɹɪʤə] - [ɹɪ] (12289) 	29. [hoʊmə] - [hoʊ] (332004) 	30. [taɪmə] - [taɪ] (908345) 
31. [sʌnə] - [sʌ] (64986) 	32. [munə] - [mu] (30776) 	33. [ɹɪŋə] - [ɹɪ] (26970) 
34. [wɪŋə] - [wɪ] (13606) 	35. [silə] - [si] (8830) 	36. [milə] - [mi] (18154) 

37. [ʃɔɹə] - [ʃɔ] (14668)	38. [fɔɹə] - [fɔ] (57923)
	

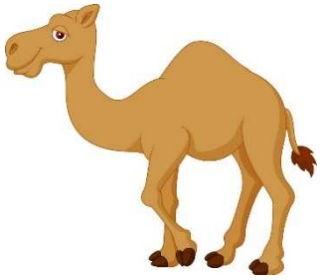
(A2) Bisyllabic Experimental words.

1. [paɪlətə] – [paɪlə] (20200) 	2. [ʤækɪtə] – [ʤækə] (17992) 	3. [kjupɪdə] – [kjupə] (547) 
4. [sælədə] – [sælə] (14504) 	5. [sɪrəpə] – [sɪrə] (4915) 	6. [tulɪpə] – [tulə] (930) 
7. [mjuzɪkə] – [mjuzə] (149233) 	8. [pænɪkə] – [pænə] (10714) 	9. [məʊzɪzə] – [məʊzə] (4223) 

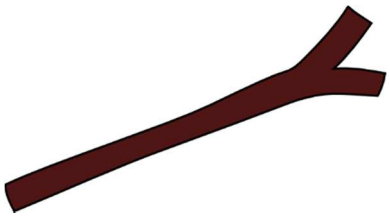
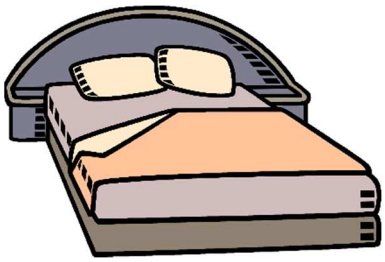
10. [maɪnəsə] – [maɪnə] (3785) 	11. [toʊpæzə] – [toʊpə] (442) 	12. [natʃozə] – [natʃə] (323) 
13. [rʌbɪʃə] – [rʌbə] (1002) 	14. [rædɪʃə] – [rædə] (487) 	15. [ʃerɪfə] – [ʃerə] (15060) 
16. [dikæfə] – [dikə] (376) 	17. [ɑlɪvə] – [ɑlə] (15410) 	18. [neɪtɪvə] – [neɪtə] (40365) 

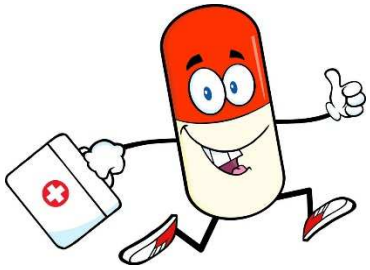
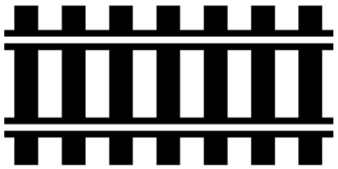
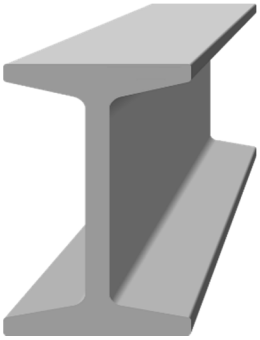
19. [denəmə] – [denə] (2061) 	20. [modəmə] – [modə] (4262) 	21. [lemənə] – [lemə] (13659) 
22. [kæbınə] – [kæbə] (11708) 	23. [kɑlıʤə] – [kɑlə] (130988) 	24. [kɜrıʤə] – [kɜrə] (12483) 
25. [ʃʊgərə] – [ʃʊgə] (33435) 	26. [lıvərə] – [lıvə] (7485) 	27. [dɛvələ] – [dɛvə] (9130) 

28. [kæmələ] – [kæmə]
(2464)



(A3) Fillers

1. [stɪk-tɪk] 	2. [brɛd-bɛd] 
3. [kreɪn-keɪn] 	4. [kreɪn-keɪn] 
5. [glæs-gæs] 	6. [swɪŋ-wɪŋ] 
7. [skɑɪ -kɑɪ] 	8. [stɔɪ-sɔɪ] 

9. [spɪl-pɪl] 	10. [snoʊ-noʊ] 
11. [slɪp-lɪp] 	12. [tɹæk-ɹæk] 
13. [fleɪk-leɪk] 	14. [dɹeɪk-ɹeɪk] 
15. [stil-sil] 	16. [sneɪl-neɪl] 

17. [klɑk-lɑk] 	18. [bɹum-ɹum] 

Appendix B

Background Questionnaire

Please provide the following information. The purpose is to gather information about your language history.

1. You will need to use earphones during this study. Please provide the name/model of your earphones below.

……

2. Do you have any hearing difficulties? If yes, please explain.

……

2. How old are you?

……

3. What is your gender?

……

4. Where were you born? (city and/or province and country of birth)

……

5. What is your native language?

……

6. Do you speak other languages? If yes, what are they?

……

7. How old were you when you first began to learn English?

……

8. How did you learn English? (academically or naturalistically)

……

9. How long have you lived in an English-speaking country? Which country?

……

10. Please rate your ability in speaking English.

0%
25%
50%
75%
100%

11. How often do you speak English in a typical day?

0% of the time
25% of the time
50% of the time
75% of the time
100% of the time.

Appendix C
(C1) Duration of vowel in monosyllabic stimuli words

Word	Vowel duration (sec.)
1. [ɹoʊpə]	0.093
2. [supə]	0.131
3. [ɹɪbə]	0.125
4. [læbə]	0.102
5. [butə]	0.146
6. [ʃĩtə]	0.129
7. [bɛdə]	0.159
8. [lɪdə]	0.125
9. [bʊkə]	0.102
10. [nɛkə]	0.071
11. [lɛgə]	0.114
12. [wɪgə]	0.125
13. [lifə]	0.086
14. [ɹifə]	0.092
15. [lʌvə]	0.088
16. [keɪvə]	0.159
17. [dɛθə]	0.090
18. [maʊθə]	0.091

19. [aɪsə]	0.082
20. [ɹeɪsə]	0.072
21. [ɹoʊzə]	0.141
22. [noʊzə]	0.091
23. [fɪʃə]	0.105
24. [liʃə]	0.059
25. [kaʊʧə]	0.073
26. [piʧə]	0.065
27. [bædʒə]	0.133
28. [ɹɪdʒə]	0.118
29. [hoʊmə]	0.120
30. [taɪmə]	0.127
31. [sʌnə]	0.152
32. [munə]	0.116
33. [ɹɪŋə]	0.126
34. [wɪŋə]	0.151
35. [silə]	0.115
36. [milə]	0.101
37. [ʃɔɹə]	0.125
38. [fɔɹə]	0.163

(C2) Duration of vowel in bisyllabic stimuli words

Word	Vowel duration
1. [paɪlətə]	0.064
2. [ʤækɪtə]	0.085
3. [kjupɪdə]	0.071
4. [sælədə]	0.113
5. [sɪrəpə]	0.047
6. [tulɪpə]	0.055
7. [mjuzɪkə]	0.091
8. [pænɪkə]	0.072
9. [maɪnəsə]	0.096
10. [məʊzɪzə]	0.060
11. [toʊpæzə]	0.085
12. [natʃozə]	0.095
13. [rʌbɪʃə]	0.086
14. [rædɪʃə]	0.093
15. [ʃerɪfə]	0.053
16. [dikæfə]	0.048
17. [ɑlɪvə]	0.079
18. [neɪtɪvə]	0.094
19. [denəmə]	0.077
20. [modəmə]	0.069
21. [lemənə]	0.101

22. [kæbɪnə]	0.098
23. [kɑlɪʤə]	0.071
24. [kɜrɪʤə]	0.116
25. [ʃʊgərə]	0.078
26. [lɪvərə]	0.083
27. [dɛvələ]	0.091
28. [kæmələ]	0.057

REFERENCES

Abrahamsson, N. (2003). Development and recoverability of L2 codas: A longitudinal study of Chinese-Swedish interphonology. *Studies in second language acquisition*, *25*(3), 313-349.

Birdsong, D. (1999). *Second language acquisition and the critical period hypothesis*. Routledge.

Bybee, J. (2002). Word frequency and context of use in the lexical diffusion of phonetically conditioned sound change. *Language variation and change*, *14*(3), 261-290.

Bybee, J. (2007). *Frequency of use and the organization of language*. Oxford University Press on Demand.

Benson, B. (1988). Universal preference for the open syllable as an independent process in interlanguage phonology. Language Learning, 38,221-242.

Best, C. T. (1995). A Direct Realist View of Cross-Language Speech Perception. *Speech perception and linguistic experience: Issues in cross-language research*, 171-204.

Blevins, J. (1995). The syllable in phonological theory. In J. Goldsmith (Ed.), *The Handbook of*

Phonological Theory (pp. 206-244). Cambridge, MS: Blackwell.

Boersma, P. (1998). *Functional phonology: Formalizing the interactions between articulatory and perceptual drives*. The Hague: Holland Academic Graphics.

Boersma, P. (2001). Praat, a system for doing phonetics by computer. *Glot International* 5:9/10, 341-345.

Bolinger, D. L. (1962). Binomials and pitch accent. *Lingua*, *11*, 34-44.

Boudaoud, M., & Cardoso, W. (2009). *Vocalic [e] epenthesis and variation in Farsi-English interlanguage speech* (Vol. 2, pp. 1-34). Concordia Working Papers in Applied Linguistics.

Broselow, E., & Finer, D. (1991). Parameter setting in second language phonology and syntax. *Second Language Research*, 7, 35-59.

Brown, C. A. (1998). The role of the L1 grammar in the L2 acquisition of segmental structure. *Second Language Research*, *14*(2), 136-193.

Cairns, C. E., & Feinstein, M. H. (1982). Markedness and the theory of syllable structure. *Linguistic Inquiry*, 193-225.

Campbell, J. (1982). *Grammatical man: Information, entropy, language, and life*. New York: Simon and Schuster.

Cardona, G. (1988). *Pāṇini, His Work and Its Traditions: Background and Introduction* (Vol. 1). Motilal Banarsidass.

Carlisle, R. S. (2001). Syllable structure universals and second language acquisition. *International Journal of English Studies*, *1*(1), 1-19.

Clements, G. N. (1990). The role of the sonority cycle in core syllabification. *Papers in laboratory phonology*, *1*, 283-333.

Davies, M. (2008) *The Corpus of Contemporary American English (COCA): 600 million words, 1990-present*. Available online at https://www.english-corpora.org/coca/.

De Lacy, P. (2002). The formal expression of markedness. Doctoral disertation, University of Massachusetts.

Dijkstra, T., Roelofs, A., & Fieuws, S. (1995). Orthographic effects on phoneme monitoring. *Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale*, *49*(2), 264.

Donegan, P., & Stampe D. (1979). The study of natural phonology. In D. Dinnsen (Ed.), *Current approaches to phonological theory* (pp. 126–173). Bloomington: Indiana University Press.

Dupoux, E., Kakehi, K., Hirose, Y., Pallier, C., & Mehler, J. (1999). Epenthetic vowels in Japanese: A perceptual illusion?. *Journal of experimental psychology: human perception and performance*, *25*(6), 1568.

Eckman, F. R. (1991). The structural conformity hypothesis and the acquisition of consonant clusters in the interlanguage of ESL learners. *Studies in Second Language Acquisition*, *13*(1), 23-41.

Edge, B. A. (1991). The production of word-final voiced obstruents in English by L1 speakers of Japanese and Cantonese. *Studies in Second Language Acquisition*, *13*(3), 377-393.

Espenshade, T. J., & Fu, H. (1997). An analysis of English-language proficiency among US immigrants. *American Sociological Review*, 288-305.

Fidelholtz, J. L. (1975). Word frequency and vowel reduction in English. In *Chicago Linguistic Society* (Vol. 11, pp. 200-213).

Flege, J. E. (1995). Second language speech learning: Theory, findings, and problems. *Speech perception and linguistic experience: Issues in cross-language research*, *92*, 233-277.

Goldsmith, J. A. (1990). *Autosegmental and metrical phonology* (Vol. 1). Basil Blackwell.

Greenberg, J. H. (1965). Some generalizations concerning initial and final consonant sequences. *Linguistics*, *3*(18), 5-34.

Gregová, R. (2010) A Comparative Analysis of Consonant Clusters in English and in Slovak. *Bulletin of the Transilvania University of Brasov*, Vol. 3, No. 52, 2010. 79-84.

Hallé, P. A., Chéreau, C., & Segui, J. (2000). Where is the/b/in "absurde"[apsyrd]? It is in French listeners' minds. *Journal of Memory and Language*, *43*(4), 618-639.

Hansen, J. G. (2001). Linguistic constraints on the acquisition of English syllable codas by native speakers of Mandarin Chinese. *Applied Linguistics* 22(3):338–365.

Hansen, J. G. (2004). Developmental sequences in the acquisition of English L2 syllable codas. *Studies in Second Language Acquisition*, 26, 85–124.

Hume, E. (2004). Markedness: A predictability-based approach. In *Annual Meeting of the Berkeley Linguistics Society* (Vol. 30, No. 1, pp. 182-198).

Hume, E., Johnson, K., Seo, M., Tserdanelis, G., & Winters, S. (1999). A cross-linguistic study of stop place perception. In *Proceedings of the XIVth international congress of phonetic sciences* (Vol. 9, pp. 2069-2072).

Jamovi [Computer software]. (2018). Retrieved from https://www.jamovi.org/

Jamovi [Computer software]. (2019). Retrieved from https://www.jamovi.org/

Johnson, J. S., & Newport, E. L. (1989). Critical period effects in second language learning: The influence of maturational state on the acquisition of English as a second language. *Cognitive psychology*, *21*(1), 60-99.

Jun, J. (1995). *Perceptual and articulatory factors in place assimilation: An Optimality Theoretic approach* (Doctoral dissertation, Univ. Los Angeles).

Katamba, F. (1989). *An introduction to phonology* (Vol. 48). London: Longman.

Kar, S. (2010). *Syllable structure of Bangla: An optimality-theoretic approach*. Newcastle upon Tyne: Cambridge Scholars Pub.

Kiparsky, P. (1982). *Explanation in phonology*. Dordrecht: Foris.

Kochetov, A., & So, C. K. (2005). Investigating the relation between place of articulation markedness and perceptual salience. In *Proceedings of the 2005 Annual Conference of the Canadian Linguistic Association* (pp. 1-11).

Lombardi, L. (2003). Second language data and constraints on manner: Explaining substitutions for the English interdentals. *Second Language Research*, *19*(3), 225-250.

Nunez C, Rafael A. & Alfonso M. (1999). Fonologia generative contemporanea de la lengua espanola. Washington, DC: Georgetown University Press.

Osburne, A. G. (1996). Final cluster reduction in English L2 speech: A case study of a Vietnamese speaker. *Applied Linguistics, 17*, 164–181.

Parker, S. G. (2002). *Quantifying the sonority hierarchy* (Doctoral dissertation, University of Massachusetts at Amherst).

Perani, D., Abutalebi, J., Paulesu, E., Brambati, S., Scifo, P., Cappa, S. F., & Fazio, F. (2003). The role of age of acquisition and language usage in early, high-proficient bilinguals: An fMRI study during verbal fluency. *Human brain mapping*, *19*(3), 170-182.

Puppel, S. (1992). The sonority hierarchy in a source-filter dependency framework. *Phonological investigations*, *38*, 467.

Riney, T. (1990). Age and open syllable preference in interlanguage phonology. In H. Burmeister & P. Rounds (Eds.), Variability in second language acquisition: Proceedings of the tenth meeting of the second language research forum: Vol. II (pp. 655-666). Eugene, OR: Dept. of Linguistics, University of Oregon.

Sato, C. (1984). Phonological processes in second language acquisition: Another look at interlanguage syllable structure. Language Learning, 34,43-57.

Sato, C. (1984). Task variation in interlanguage phonology. *University of Hawai'i Working Papers in English as a Second Language 3 (1)*.

Shoji, S., & Shoji, K. (2014, March). Vowel epenthesis and consonant deletion in Japanese loanwords from English. In *Proceedings of the Annual Meetings on Phonology* (Vol. 1, No. 1).

Stevens, G. (1999). Age at immigration and second language proficiency among foreign-born adults. *Language in society*, *28*(4), 555-578.

Steriade, D. (2001). The phonology of perceptibility effects: the P-map and its consequences for constraint organization. *Ms., UCLA*.

Tropf, H. (1987). Sonority as a variability factor in second language phonology. In A.R. James and J. Leather (eds.) *Sound Patterns in Second Language Acquisition*. Dordrecht: Foris. 173-192.

Tsuchida, A. (1995). English loans in Japanese: Constraints in loanword phonology. *Working Papers of the Cornell Phonetics Laboratory*, *10*, 145-164.

Van der Hulst, H., & Ritter, N. A. (1999). Theories of the syllable. *The syllable: Views and facts*, *13*, 52.

Vennemann, T. (1987). Preference laws for syllable structure: And the explanation of sound change with special reference to German, Germanic, Italian, and Latin. Walter de Gruyter.

Weinberger, S. H. (1987). The influence of linguistic context on syllable simplification. In G. L. Ioup and S. Weinberger (Eds.), *Interlanguage phonology,* pp. 401-417. Rowley, Massachusetts: Newbury House Publishers.

Weinberger, S. H. (1994). Functional and phonetic constraints on second language phonology. In M. Yavas (Ed.), First and second language phonology (pp. 283–302). San Diego, CA: Singular Publishing Group.

Yavas, M. (2011). The role of sonority in the acquisition of interlanguage coda clusters. In: Wrembel, M.; Kul, M.; Dziubalska-Kolaczyk, K. (Eds.). *Achievements and perspectives in SLA of speech*: new sounds 2010. Peter Lang, 2011.

BIOGRAPHY

Ali S. Alelaiwi received his Bachelor of Arts in English from King Faisal University in 2010. He received his Master of Arts in Linguistics from California State University, Fresno in 2014. He was employed as an LRC Specialist at INTO Mason in Fairfax, VA for four years.