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THE PERCEPTION OF ENGLISH WORD-FINAL /l/  
BY BRAZILIAN LEARNERS

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**ABSTRACT**

THE PERCEPTION OF ENGLISH WORD-FINAL /L/ BY BRAZILIAN LEARNERS

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UNIVERSIDADE FEDERAL DE SANTA CATARINA  
2008

Supervising Professor: Dr. Barbara Oughton Baptista

Very little research exists on Brazilians concerning English word-final /l/ beyond noting that they generally produce [u] (Baptista, 2001) or [w] (Avery & Ehrlich, 1992). Perception of this word-final consonant is also little researched. To attempt to address these gaps in the literature, this study investigated Brazilian ESL students' perception of English word-final /l/ (dark /l/).

Two groups of 20 Brazilian learners of English (intermediate and advanced) and one group of native speakers of English participated in the experiment. Three pairs of tests – two Categorical Discrimination Tests, two discrimination tasks, and two identification tests – examined perception of word-final /l/. The first test of each pair assessed word-final contrasts in both Portuguese and English; the second examined English-only contrasts. All results were analyzed by overall error rate, error rate per vowel context and error rate per test. Demographic data and total error rate were explored for correlations.

No significant differences were found between the two groups of Brazilian students. Only for the vowel contexts /o/ and /ɔ/ did native speakers perform significantly better than Brazilians. Native and non-native error rates were very low for vowel contexts /aɪ/ and /eɪ/ and quite high for /aʊ/.

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**RESUMO**

THE PERCEPTION OF ENGLISH WORD-FINAL /L/ BY BRAZILIAN LEARNERS

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2008

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Há pouca pesquisa com brasileiros a respeito da pronúncia do /l/ final de palavras inglesas, além da observação de que geralmente é produzido como [u] (Baptista, 2001) ou [w] (Avery & Ehrlich, 1992). A percepção dessa consoante também é pouco pesquisada. Para tentar preencher essas lacunas na literatura, o objetivo desta pesquisa foi investigar a percepção do /l/ no final de palavras inglesas (“dark /l/”) por brasileiros estudantes de inglês como língua estrangeira.

Dois grupos de 20 estudantes brasileiros de inglês (dos níveis intermediário e avançado) e um grupo de falantes nativos de inglês participaram neste experimento. Três pares de testes – dois Testes de Discriminação Categórica, dois Testes de Discriminação, e dois Testes de Identificação – aferiram a percepção do /l/ no final de palavras. O primeiro teste de cada par examinou contrastes finais em palavras do português brasileiro e do inglês; o segundo examinou contrastes somente em palavras inglesas. Os resultados foram analisados por índice de erro global, de erro por vogal, e

de erro por teste. Dados demográficos e índice de erro global foram explorados para investigar correlações.

Nenhuma diferença significativa foi encontrada entre os grupos de brasileiros. O menor índice de erro do resultado dos falantes nativos de inglês foi estatisticamente significativo somente nos contextos de /o/ e /ɔ/. O índice de erro de todos os grupos foi muito baixo nos contextos de /aɪ/ e /eɪ/ e muito alto em /aʊ/.

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## Chapter 1

### 1.1 Introduction

“Then said they unto him, Say now Shibboleth: and he said Sibboleth: for he could not frame to pronounce it right. Then they took him, and slew him at the passages of Jordan: and there fell at that time of the Ephraimites forty and two thousand.”

Judges 12:6, King James Bible

While phonological ignorance and phonetic imprecision no longer carry consequences so grave as those that befell the Ephraimites, one wrong sound in the wrong word can still make a strong impression. It is not for trivial reasons that learners of English are early advised to distinguish a) the word for the stretch of sand between scrub and ocean from b) a strong pejorative term for a woman. Similarly, students of Portuguese must either learn to say “pão” or run the risk of ridicule at the *padaria*. Most errors, of course, are not so serious. Context informs the listener of the difference between *bed* and *bad* even when a non-native speaker’s vowel does not. Nevertheless, discrimination against those with “funny” accents persists.

Among native speakers of English, anyway, non-standard pronunciation is associated with a variety of responses, from pride to parody. For example, many speakers of African-American Vernacular English adopt its well-documented pronunciation of *the* as “da” for informal spelling and in commercial contexts. On the other hand, Chicago sports fans were gently mocked in Saturday Night Live spoofs of the 1990s for their pronunciations “da Bulls” and “da Bears.” And native-speaker

mispronunciation of word-final /l/ as /w/ has been played for laughs for years by Warner Brothers with its cartoon character Elmer Fudd.

Such exaggerated /l/ mispronunciation is rightly considered a speech disorder, but less extreme pronunciations of /l/ have been scorned in the past, among them the following. A well-noted feature of many dialects of English is the realization of /l/ as “clear” and “dark” allophones. Roughly speaking, clear /l/ occurs before vowels and /j/, while dark /l/ occurs everywhere else (Bladon & Al-Bamerni, 1976). Years ago, Daniel Jones (1958) made known a tradition of dark /l/ discrimination among teachers of voice and singing. Most voice coaches were once of foreign origin, and Jones posits that they were nonplussed by the murk of English dark /l/. Thus, they taught that solely the clear /l/ should be used in singing and on the stage. Earlier still, George Philip Krapp advised his readers in *The Pronunciation of Standard English in America* (1919) that the dark /l/ was a sound best avoided, lest the speaker be mistaken for one of the rabble. Now the opposite holds, and a word-final vocalized /l/ instead of a dark /l/ is somewhat stigmatized in both the US and in England (Wells, 1982). Some speech therapists even consider vocalized /l/ an error and worthy of intervention (Ball & Müller, 2005, p. 240).

Very little research has been done on Brazilian speakers of English with regard to English words ending in /l/ beyond noting that they generally produce [u] (Baptista, 2001) or [w] (Avery & Ehrlich, 1992). Perhaps this is simply because the English final /l/ is a difficult sound to master, particularly for Brazilians. In *Teaching Pronunciation*, Celce-Murcia, Brinton and Goodwin (1996) call /l/ one of the most pedagogically challenging consonants in English. After mentioning the difficulties some Asians and Europeans have with the sound, she counsels the instructor to expect problems when teaching American post-vocalic /l/ to Brazilians in particular, due to their penchant to produce a vowel similar to /o/ or /u/. In fact, due to the acknowledged articulatory

difficulty four English consonants present for Brazilians, Baptista and Silva Filho chose not to study /θ/, /ð/, /r/, and /l/ production in an experiment concerning Brazilian English students' pronunciation of English word-final consonants (Baptista & Silva Filho, 1997). Only very recently, Baratieri (2005) completed what may be the first in-depth study of Brazilian production of English /l/.

Even less is known about Brazilians' perception of English word-final consonants. Recent studies in Portuguese-English interphonology have begun to address this. Kluge (2004) investigated perception of word-final nasals, while Bettoni-Techio's study (2005) concerned word-final alveolar stops. In fact, little is known about non-native perception of English word-final consonants at all – Flege's review (1995) purported to cover research of their perception but cited only studies of production.

Furthermore, although production and vocalization of dark /l/ have been studied a fair amount (cf. Sproat & Fujimora, 1975; Hardcastle & Barry, 1989; Recasens, 1996; Johnson & Britain, 2003; Baratieri, 2006), there have been very few studies of the perception of dark /l/. Although there are many perception studies concerning initial and medial /l/ and /r/ among Asian learners of English (see Aoyama, Flege, Guion, Akahane-Yamada & Yamada, 2004, for a review of previous studies concerning Japanese learners), only a few, such as Sheldon and Strange (1982) and Henly and Sheldon (1986), also study their perception of English word-final liquid consonants. And as for studies which investigate final /l/ perception by native English speakers, extensive searches found only Cooper, Delattre, Liberman, Borst and Gerstman (1952), which briefly discusses perception of synthesized word-final /l/ in English words, and Gesuato (1996), which investigates misperception of dark /l/ as /w/. This study aims to contribute new data and new insights to existing research into English word-final /l/, to

interphonology studies in Brazil, and, more broadly, to the study of final-consonant perception in phonology.

## **1.2 Contents of the document**

This thesis is composed of six chapters, of which you are reading the first. Chapter 2 reviews the relevant scholarly literature concerning the phonology and phonetic realization of liquid consonants in English and Brazilian Portuguese. There is also a discussion of second language acquisition theory as it relates to perception of new phonetic categories. Chapter 3 describes in detail the methodology of the experiment, including information on the participants and the instruments used to assess their perception. Chapters 4 and 5 present and discuss at great length the results of the experiment and the subsequent statistical analysis. Chapter 6 concludes the thesis with notes on the findings and limitations of the study and adds suggestions for further research.

## Chapter 2 - Review of Literature

### 2.1 Introduction

Brazilian Portuguese is noted for having only two word-ending consonants that are produced as consonants: /s/ and /r/. A third word-ending consonant<sup>1</sup>, /l/, is generally pronounced as [u] or [w]<sup>2</sup> at the ends of words in Brazilian Portuguese (Baptista, 2001; Mateus & d'Andrade, 2000; Cristóforo Silva, 2002), a pronunciation known as *vocalization* of /l/ (Carr, 1999). This presents a problem for Brazilian learners of English, since English final /l/ is often pronounced with the back of the tongue raised and with the lips unrounded as the so-called “dark L,” which, except for a few Southern dialects (Mateus & d'Andrade, 2000; Cristóforo Silva, 2002), Brazilian Portuguese does not have. In some cases, producing /l/ as [w] in English words can lead to confusion in native English speakers, as with common words such as *go/goal*, *toll/tow/toe*, *roll/row*, *bowl/bow*, *you/you'll*, *call/cow* and so on. Personal observation and the observation of other English teachers has shown that this characteristic is persistent, although much less noticeable, in learners with high levels of experience with English, possibly partly due in some vowel contexts to a more native-like vowel quality in the pronunciation of more advanced learners. This chapter presents an overview of the relevant literature concerning laterals, their realizations in Portuguese and English, and phonological processes that affect them. The study of acquisition of second language sounds is also explored to provide a theoretical context for the experiment to follow.

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<sup>1</sup> Câmara, Jr. also posits a word-ending archiphoneme /N/ (1970).

<sup>2</sup> In this paper, quoted material has kept the original format and notation for phonetic transcriptions (normally brackets) and underlying representation (normally slashes). Sources differ on their notation of the final sound produced by Brazilians for words ending in /l/, with some transcribing [w], some [u], and some [ʊ]. This is not a significant difference and sources are cited as they chose to transcribe it. In fact, Cristóforo Silva (2002) explicitly states “The symbol [w] corresponds to an articulation with the vocalic quality **u**” (my translation).



## 2.2 The lateral sounds

In traditional phonetic descriptions, the most common laterals - voiced lateral approximants - have been classified together with r-sounds (rhotics) as liquids because of their phonetic and phonological similarities. They both often form “a special class in the phonotactics of a language” (Ladefoged & Maddieson, 1996, p. 182) which allows them to figure in a large number of consonant clusters. Their similarities are such that many languages, such as Korean and Japanese, have only one liquid phoneme which has lateral [l] and [r] allophones. In Korean, this liquid’s realization ranges from an ‘l’ like sound to an ‘r’ like sound depending on its position within the syllable. In some dialects of Japanese, [l] and [r] alternate in free allophony. This alternation associates the classes naturally (p. 243). Laterals and rhotics, along with the other approximants /y/ and /w/, are also among the most sonorous of consonants.

Laterals considered on their own are usually described as distinguished by a mid-sagittal occlusion within the vocal tract around which air flows. Ladefoged and Maddieson broaden this characterization somewhat: a lateral is produced by contracting the tongue so that more air flows past one or both of its sides than over its center (p. 182). However, they go on to note that most laterals do not, in fact, allow air to pass over the tongue’s center at all. Although in most of the world’s languages, a dental or alveolar central occlusion is a central feature of laterals, it is important to note that as Ladefoged and Maddieson define *lateral*, a central occlusion is not a requirement.

In most of the world’s languages in which they occur, laterals are produced with the tip of the tongue creating an occlusion in the dental or alveolar region (Maddieson, 1984, cited in Ladefoged & Maddieson). The occlusion typically extends no farther back than the premolars. Behind it, the body of the tongue is “relatively low in the mouth,” which permits air to flow laterally. Other, less common realizations of voiced

lateral approximants are articulated by creating the medial occlusion with the blade or the body of the tongue, by placing the occlusion farther back towards the soft palate, with the tongue curled back, or with an incomplete closure. More unusually, the occlusion can occur between the tongue body and the velum.

Ladefoged and Maddieson claim that whatever the places of articulation, voiced lateral approximants appear to vary greatly with phonetic context and from speaker to speaker within a language (p. 191). Consonantal and vocalic environment both assert a goodly coarticulatory effect, partly because of the “vowel-like” quality that voiced laterals possess (p. 192). One of the most extreme coarticulatory effects results in a “lateral,” called dark /l/, nearly or completely lacking a central occlusion, as occurs in syllable-final /l/ in English and European Portuguese.

### **2.3 Clear /l/ and dark /l/**

A particularly strong coarticulatory effect for /l/ can be found in a number of the world’s languages. Recasens (1996, p. 63), in a paper investigating dark /l/ in Romance languages, says that “two different varieties of /l/ are traditionally distinguished in the phonetics literature, that is, velarized, dark /l/ and non-velarized, clear /l/.” He offers a diagram of German clear /l/ (from Ladefoged & Maddieson, 1986) and shows it to be articulated with the tip of the tongue at the alveolar ridge and with the body of the tongue in a low-mid, or neutral, position. Dark /l/, from Russian, is diagrammed beside clear /l/ showing the rear of the tongue body retracted and raised toward the velum while, as with clear /l/, the tip maintains alveolar contact just behind the teeth.

In studies which pay particular attention to dark /l/, researchers are not so unambiguous about its velarization. Recasens is explicitly critical of the traditional description of dark /l/ as “velarized.” Rather, he points out that though not all varieties

of dark /l/ in the languages in which it occurs involve the raising of the tongue's dorsum towards the velum, all share a movement of the tongue towards the back of the mouth. Recasens cites studies of a variety of European languages that have dark /l/ including Russian, Polish, Czech and English, stating that the back of the tongue body is often retracted towards the upper pharynx rather than the velum (p. 64). Because the tongue body retraction can be towards either the velum or the upper pharynx, Recasens prefers to classify the sound based on its acoustical qualities.

Sproat and Fujimura (1993, p. 292), in a widely cited acoustic and articulatory study of English /l/, describe dark /l/ without mentioning velarization, writing only that "in dark /l/s the body of the tongue is more retracted than in light /l/s." Ultimately, they find the clear/dark dichotomy too simplistic. The authors suggest that because of the wide variety of articulations between lighter and darker varieties of /l/ that the light and dark allophones should not be treated as distinct, but rather as a continuum (p. 301). They also argue that temporal aspects of final /l/ play an important part in the distinction between the clear and dark poles of the continuum (p. 306). Their articulatory measurements showed that in clear /l/, the tip of the tongue reaches its most extreme forward position slightly before the tongue body is fully retracted, whereas in dark /l/, the tongue tip's forwardmost position follows the dorsal retraction. Finally, supporting Recasens' reservations regarding velarization, they state categorically that they found no evidence of the dorsum raising towards the velum in the English dark /l/ produced by their British and American speakers (p. 309).

In addition to the allophony of /l/ that occurs relative to word position, the acoustic characteristics of clear and dark /l/ also vary with the vowel context in which they are found (Bladon & Al-Bamerni, 1975). To study the effect of syllable-initial and syllable-final /l/ on the syllable nucleus, Lehiste (1964) first analyzed more than 1200 recordings

of CNC<sup>3</sup> utterances produced by five speakers of Midwestern American English, then analyzed multiple recordings of 12 isolated monophthongal or mildly diphthongal vowels produced by one speaker of the same dialect. This was done to set a standard for vowels from which to judge variation. Through acoustic analysis of the five speakers' production of 20 CNC words beginning with /l/ and 15 CNC words ending in /l/, she found that syllable-initial /l/ usually raised the first formant of the following vowel, raised the third formant slightly, and had a negligible effect on F2. The effect of syllable-final /l/ on the preceding vowel was much stronger, consistently lowering the vowel's second formant a substantial amount. Lehiste remarks that the effect was unusually strong for the diphthongs /aɪ/ and /ɔɪ/ followed by dark [ɫ]. Both diphthongs were produced with a "strongly centralized sound" (p. 26) and were measured to have a slightly higher F1 and a substantially lower F2 than average.

Allophones of /l/ were also investigated acoustically by Bladon and Al-Bamerni (1975) in a study of four speakers of British RP. Their study concerned /l/ in 12 monophthongal and 8 diphthongal vowel contexts in a great variety of word positions: word-initially, -medially and -finally, adjacent to vowels in initial and final clusters, and between words. In contrast to Lehiste, they found greater variation in pre-vocalic /l/ than in post-vocalic, whether /l/ was alone or part of a consonant cluster.

## 2.4 The English lateral

Clear and dark /l/ have been recognized as distinct variations of English /l/ since at least 1919, when George Philip Krapp wrote in his *Pronunciation of Standard English in America* that the dark, or "thick" *l* was "to be avoided in cultivated speech" (p. 25). That /l/ realization varies with vowel context was noted by Krapp as well, but it is not

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<sup>3</sup> The words were primarily CVC, but included "layer" and "lower."

entirely clear that the sound existed at all in English before the mid 19<sup>th</sup> century. In a survey of historical literature on pronunciation, Johnson and Britain (2003) find almost no mention of variation in the realization of /l/, and indeed find assertions to the contrary. They cite Wright (1905, p. 215), who wrote that “l has gen. remained unchanged initially, medially and finally.”

By the mid-twentieth century, though, clear/dark allophony was well established. Daniel Jones, in *The Pronunciation of English* (1958, p. 87-90) describes three varieties of /l/ “analogous to the positions of vowels” – clear and dark, which correspond to front vowel resonances and back vowel resonances, and neutral, which corresponds to /ə/. Continuing, he describes the clear and dark /l/ of various dialects of English, but does not discuss neutral /l/ further. More recent writings on English phonetics and phonology (Yallop, 1995; Giegerich, 1992; Carr, 1999; Ladefoged & Maddieson, 1996) and pronunciation (Celce-Murcia et al, 1996; Cruttenden & Gimson, 2001) are unanimous in noting the two types of English /l/, though their descriptions of dark /l/ vary. Giegerich and Cruttenden and Gimson describe a dark /l/ in which the tongue tip maintains contact with the alveolar ridge. Ladefoged and Maddieson claim the contrary, that the tip does not make alveolar contact, and add that it may be tucked behind the lower front teeth. Celce-Murcia et al (p. 46) hew to the middle, stating that the tongue tip “may or may not remain in contact with the alveolar ridge.” Many of the authors note that due to loss of apical contact with the alveolar ridge, syllable-final /l/ shows a tendency to vocalize in some dialects. This will be discussed at length in a later section.

## 2.5 The Portuguese lateral

Concerning European Portuguese, Andrade (1999) says that for the past twenty years, /l/ has been “categorically associated with a non-velarized (‘clear’) allophone in syllable onset” (p. 543). In Brazilian Portuguese, too, the syllable initial /l/ is the clear allophone, simply described as a “laminodental voiced lateral” in Azevedo (1981, p. 36).

In contrast, word-final /l/ in European Portuguese is described by Mateus and d’Andrade (2000) as a lateralized velar consonant which is “systematically velarized [ɫ],” similar to the English version. Andrade concurs, describing a velarized (‘dark’) /l/ in coda position in EP. But in Brazilian Portuguese, final /l/ is realized as “the velar glide [w], and therefore, for example, “*mal* ‘evil, badly’ is realized as [máɫ] in EP and as [máw] in BP” (Mateus & d’Andrade, p. 12). This tendency is widely noted with regard to Brazilians’ production of final /l/ in Portuguese, variously transcribed as [u], [w] or [ɯ] by Baptista (2001), Mateus and d’Andrade, and Ladefoged and Maddieson (1996), respectively. This is a characteristic specific to Brazilian Portuguese and it is shared by a majority of its speakers.

Mateus and d’Andrade go on to note that in some southern dialects of Brazilian Portuguese, final /l/ is pronounced as in Portugal and, curiously, that in some Northern continental parts of Portugal, final /l/ is pronounced as in the majority of Brazil (p. 12).

## 2.6 Vocalization of word final /l/

It is important to note that the process of /l/ converting to [w] is not unique to Brazilian Portuguese. Sproat and Fujimura (1993) point out that in languages or dialects that have both clear and dark /l/, clear /l/ occurs only in syllable-initial position and dark /l/ only in syllable-final position (p. 309). The sound change of /l/ to a more vowel-like

segment is not limited to syllable-final position, however. Vocalization of /l/ in syllable-initial, syllable-final or word-final position has occurred historically or continues to occur in languages as varied as Dutch, Czech, Polish, Catalan, French and Italian (Recasens, 1996; Jones, 2005) as well as in a large number of dialects of British, Australian, New Zealand and American English (Johnson & Britain, 2003). In fact, several recent studies have been concerned with a trend towards vocalization of syllable-final /l/ among native speakers of various dialects of English in the United Kingdom, Australia and the United States (Johnson & Britain, 2003; various articles in Foulkes, 1999; Wells, 1994; Horvath & Horvath, 2002), many focusing on the recent development of “Estuary English” in England<sup>4</sup>. Among the Romance languages studied by Recasens, the distinction is made that word-final vocalization is rarer than syllable-final, preconsonantal vocalization. Both syllable-final and word-final /l/ are vocalized in the majority of dialects of Brazilian Portuguese.

A number of explanations have been proposed to account for vocalization of dark /l/ in the Romance languages and in English. One possibility is misperception. Concerning Romance languages in general, Recasens cites von Essen (1964), stating that dark /l/ might be misperceived as [w] because of the “spectral affinity between the two consonants.” Recasens also cites a spectral description from Lehiste (1964) showing that “F1 and F2 frequencies for word-final /w/ coincide to a large extent with those for word-final /l/” (p. 70). Ladefoged and Maddieson (1986) point out that Feldman (1972) finds Portuguese final /l/ similar acoustically to [ʊ]. And Ladefoged (2001, p. 184) goes so far as to say that when final laterals lose alveolar contact, they essentially *become* back unrounded vowels.

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<sup>4</sup> Many of these studies, even though they concern various dialects in several native English speaking countries, point out the social undesirability or stigma among other native speakers of producing /l/ as [u] or [w].

Another possibility cited by Recasens is that vocalization is the result of an articulatory error, taking place when there is a loss of apical contact at the alveolar ridge, which, according to Grammont (1971, p. 204), leads to a tongue configuration like that of a high back vowel and, consequently, a /u/ like sound. Interestingly, Ladefoged and Maddieson again cite Feldman (1972) in noting that final /l/ in Brazilian Portuguese includes a “vestigial” raising of the tip of the tongue towards the alveolar ridge in addition to raising the back (p.193).

## **2.7 Phonological development in children**

It is also worthwhile to consider phonological development in children. According to David Crystal (1997), children show a preference for using [w] in the place of /l/. He also claims that /l/ is typically one of the later consonants to appear in children’s phonological development, with some instances of /l/ “posing problems” at age 4. Some children, on the other hand, produce /w/ successfully before the age of 2, and all children produce /w/ by 3 years, 4 months (p. 242).

Though Crystal is not specific about the position of /l/ regarding its acquisition, many studies of elicited children’s speech do not consider a phoneme acquired until it is properly produced in multiple word positions. For instance, Arlt and Goodban (1976) cite similar ages of acquisition to Crystal’s for /l/ and /w/ in a study of 240 children’s production of English consonants in all possible positions within the syllable. In their study, /l/ was typically acquired by 75% of the children by age 4, and /w/ by age 3. Consider, too, Smit (1986), which juxtaposes the results of Prather, Hedrick, and Kern (1975) and Templin (1957). It is important to point out that Prather et al determined that a sound was acquired when 75% of their participants produced it correctly in initial and final position, whereas Templin’s less permissive criterion was 75% correct production



in three word positions - initial, medial, and final. Despite differing criteria, both studies found that /w/ was acquired at age three or younger for most data sets, but differed greatly on age of /l/ acquisition. The more recent study found that /l/ was acquired as early as three years, four months, but includes a note stating “a reversal occurs in older age groups” (p. 181) without further explanation. Templin’s 1957 study, however, found that /l/ was not acquired until age 6.

Johnson and Britain (2003) also indicate that children learning English show a strong tendency to produce /w/ or /u/ instead of dark /l/ and attribute this to the simpler articulatory structure of /w/ (p. 7). Even more interesting, according to the authors, is that regardless of the language being learned, if the phonological system features dark /l/ in rhyme children “almost invariably appear to vocalise it” (p. 15). In contrast, Cruttenden (1979, p. 18) offers a broader account of acquisition of a number of similar phones. “The development of distinctions among... /lrwj/ varies considerably.” He claims a “common pattern of development is for an [l] *and/or* [my emphasis] a [w] to occur first, [w] subsequently splitting into [w] and [ɹ], and [l] into [l] and [j].” Similarly, Ferguson, Menn and Stoel-Gammon (1992), largely basing their chart (“Age of Mastery of Consonants of American English”) on data from Sander (1972) indicate that [w] typically develops by age 3, with [r] and [l] appearing by age 6. Only some fricatives and affricates develop later. The late development of [r] and [l] is attributed to motoric difficulty experienced by younger children.

## **2.8 Previous research on the perception of English word-final /l/**

Despite that many researchers partially attribute vocalization of dark /l/ to perceptual factors, exceedingly little research appears to exist with regard to its perception. There is certainly not much research on perception of English word-final /l/,

and as noted in the introduction, what little there is tends to focus on perception by speakers of Asian languages which lack word-final liquid phonemes.

Many of these studies investigate Japanese. Despite their well-known difficulty distinguishing /l/ and /r/ in initial and medial positions, Japanese speakers have no apparent difficulty perceiving English word-final /l/ and /r/. Lively, Pisoni, Yamada, Tohkura, and Yamada (1994), for example, studied /l/ and /r/ perception among native Japanese speakers in depth, investigating the phonemes in five environments using two-alternative forced choice tests. They found that their participants identified /l/ and /r/ more accurately in post-vocalic syllable-final position than in any other phonetic context. In fact, participants correctly identified English word-final /l/ and /r/ at a rate of approximately 96%. In an earlier study, Sheldon and Strange (1982, cited in Henly & Sheldon, 1986) reported an even more impressive error rate of only 2% on both phonemes in word-final position using a forced choice test.

Cantonese speakers, like Japanese speakers, are reported to have difficulty with English /r/ and /l/ (Henly & Sheldon, 1986). Interestingly, Henly and Sheldon found that, in contrast to Japanese speakers, Cantonese speakers had more difficulty distinguishing English word final /l/ than word-final /r/ in a forced choice test. They also found that /l/ was more difficult to distinguish word-finally than /l/ or /r/ in any position they studied: word-initial or medial, or in consonant clusters. The 21% error rate for word-final /l/ was in fact the highest error rate they found.

Concerning English speakers, Cooper, Delattre, Liberman, Borst and Gerstman (1952) investigated the perception of some speech sounds using a machine that converted spectrographic images to artificial speech more than fifty years ago. They reported their results with the stop consonants /p, t, k, b, d, g/ in depth and also touched on their preliminary investigations into the nasals /m, n, and ŋ/. While not intending to

investigate /l/, the researchers found that in some cases, syllable-final /m/ was perceived as /l/. They attributed this to:

(a) the rate of transition of the final formant—a gradual transition favors *l*, a rapid transition favors *m*; (b) the frequency position of the low formant of the resonant portion—*l* is favored by a higher frequency; and (c) the behavior of the second formant in passing from vowel to resonance—if the second formant of the resonant portion forms a plausible continuation of the second formant of the vowel, one tends to hear *l*, whereas a sudden discontinuity contributes to an *m* impression (p. 603).

The authors were very cautious to point out that these results were tentative and exploratory.

In 1996, Gesuato investigated 20 native and 3 quasi-native<sup>5</sup> English speakers' perception of word-initial and word-final /l/ in eight monophthongal vowel contexts using an unusual method involving reversed recordings. Because she was unable to find a native English speaker who could reliably produce dark /l/ at the beginning of CVC words, she chose to record words ending in dark /l/ and play them backwards. Through forced choice tests participants were reported to accurately perceive [ɫ] in word-final position, and to misperceive [ɫ] as [w] in word-*initial* position (where it does not occur naturally in English). Misperception rates ranged from close to 14% before the vowel /i/ to approximately 23% before the vowel /æ/.

## 2.9 Theoretical context

English-speaking children's tendency to realize /l/ as [w] as they learn their native language and the tendency of dark /l/ to vocalize in languages in which it appears lend strong support to the idea that /l/ is a more marked sound than /w/. Markedness is the idea that certain sounds and patterns in the world's languages are more "natural" than

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<sup>5</sup> In the US since kindergarten.

others (Katamba, 1989). More marked sounds will occur in fewer languages, and when the sounds of a language change, they will tend to change towards less marked sounds. The fact that /l/ has been subject to a process of vocalization in a number of languages also supports the notion of markedness. One of the least marked linguistic structures is the open CV syllable, which, according to Carlisle (1994), occurs in all of the world's languages. If the sounds of a language change towards the less marked, then it would be natural for more marked CVC syllables such as those ending in /l/ to change into CVV or CV syllables by realizing /l/ as the semi-vowel [w], the vowel [u], or for the /vowel-l/ syllable to become a diphthong such as /au/ or /ou/.

As stated earlier, English word-final /l/ is generally realized by Brazilians as [w]. To attempt to address the reasons for this realization, the broader issue of foreign accent in non-native speakers must be considered. Over the years, a number of theories have been proposed to account for foreign accent, with it being attributed to misperception, articulatory difficulty, or a combination of the two (Rochet, 1995). Many of the theories employ the psychological concept of equivalence classification (Leather & James, 1996). Possibly, the most complete of these is Flege's Speech Learning Model (SLM). In discussing equivalence classification, Flege (1995) states that "bilinguals tend to interpret sounds encountered in an L2 through the 'grid' of their L1 phonology" (p. 237, citing Wode, 1978). He goes on to state that this "virtually assures that non-native speakers will perceive at least some L2 vowels and consonants differently than do native speakers." These ideas make their way into the SLM's first and fifth hypotheses which deal with the nature of phonetic perception (H1) and the interference of L1 on L2 through equivalence classification (H5). The hypotheses state (Flege, 1995, p. 239):

H1: Sounds in the L1 and L2 are related perceptually to one another at a position-sensitive allophonic level, rather than at a more abstract phonemic level.

H5: Category formation for an L2 sound may be blocked by the mechanism of equivalence classification. When this happens, a single phonetic category will be used to process perceptually linked L1 and L2 sounds (diaphones). Eventually, the diaphones will resemble one another in production.

But how does the theory explain the fact that accent improvement occurs over time?

The SLM attributes this change to experience with the new language, and to the idea that improved perception leads to improved production. At first, a sound will be assimilated to an L1 category, but with sufficient exposure to the new language, some differences will be perceived. H3 states (Flege, 1995, p.239):

H3: The greater the perceived phonetic dissimilarity between an L2 sound and the closest L1 sound, the more likely it is that phonetic differences between the sounds will be discerned.

This can be likened to learning to distinguish the difference in appearance between identical twins or learning to recognize the voice of a new acquaintance on the telephone<sup>6</sup>. Best (1995) says that the perceptual system becomes “attuned” and cites the work of James and Eleanor Gibson, two ground breaking psychologists who studied visual perception in support (p. 184). As relates to the sounds of a language, more exposure leads to more sensitivity to new sounds and to changes in their mental representation. Flege believes that eventually, production of the new sounds reflects these changes. In particular, note the following hypotheses (Flege, 1995, p.239):

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<sup>6</sup> The author has also noted the perhaps less usual experiences of learning to make finer distinctions among Asian facial features while traveling in Japan and the development over several years of a sensitivity to subtle variations in typeface design. It would be interesting to consider improvements in discrimination resulting from increased exposure over time in other sensory modes to investigate how universal such a cognitive process might be, as psychologists James and Eleanor Gibson have done with visual perception.

H2: A new phonetic category can be established for an L2 sound that differs phonetically from the closest L1 sound if bilinguals discern at least some of the phonetic differences between the L1 and L2 sounds.

H7: The production of a sound eventually corresponds to the properties represented in its phonetic category representation.

Using these hypotheses and others of the SLM as a framework, research can be designed to investigate acquisition and change in second language phonology.

## **Chapter 3 - Method**

### **3.1 Introduction**

The experiments described in this chapter were conducted in order to investigate the perception of English word-final /l/ by Brazilian students of English as a foreign language and to discover whether their perception of this phoneme improves with more exposure to, and advanced study of, English. To aid in this endeavor, two groups of Brazilians from extracurricular English classes at the Universidade Federal de Santa Catarina (UFSC) volunteered as participants, one group drawn from intermediate classes and another group from advanced. For the control group, native speakers of English from the US and England familiar with Brazilian Portuguese were found. For a variety of reasons detailed later, participants were informed of the purpose of the study.

This study is an expanded and elaborated version of a pilot study conducted in late 2005. The earlier study (Moore, 2005), like the current one, investigated the perception of a range of monosyllabic words ending in English [ɫ] or [u] versus Brazilian Portuguese [w], varying only the preceding context. Results of that study were inconclusive, but promising, and led to the current study's refinements, among which are a more exhaustive range of English and Portuguese words, and better recordings to improve the consistency of the stimulus. The test was also expanded to explore the contrasts in different ways. In addition to the perception test, a survey was designed to investigate the participants' language backgrounds and exposure.

### **3.2 Objective of the study**

To research the perception of English word-final /l/ by Brazilian learners of English, an experiment consisting of three tests of English-Portuguese and three of English-English contrasts between word-final /l/ and back vowels was designed. Through this experiment, the following research questions will be investigated:

1. Whether native speakers of English and Intermediate and Advanced Brazilian learners of English all have difficulty perceiving a difference between English dark /l/ and various back vowels and diphthongs.
2. Whether Brazilians perceive differences less frequently than Native Speakers, since dark /l/ does not exist in the great majority of modern Brazilian Portuguese dialects.
3. Whether Advanced students perceive dark /l/ more accurately than Intermediate students.
4. Whether some phones before dark /l/ and /w/ make these word-final distinctions harder to discern than others.
5. Whether correlations exist between demographic data and test results.

### **3.3 Participants**

For this study, twenty intermediate and twenty advanced students of English from UFSC's extracurricular language courses (described below) volunteered to participate as the experimental groups. For the control group, nine Portuguese-speaking native English speakers from the United States and England volunteered. All Brazilian participants were students of a native speaker of North American English. All participants were compensated only with the experimenter's effusive expressions of



gratitude and a piece or two of candy or a can of fine English beer after the data was collected.

### **3.3.1 Questionnaire**

To collect information about the participants, a questionnaire was developed for the two groups of Brazilians (See Appendix 1). Participants were asked their name, age, place of origin, regional accent, accents heard in youth, how they had learned their L2, whether they spoke languages other than Portuguese and English, experiences in foreign countries, exposure to L2 outside the classroom, etc. The questionnaire included items about potential influences on participants' "ear" for the sounds of their L2. Brazilians were asked about whether they had studied with teachers who were native speakers of English and whether they had been instructed specifically in the pronunciation of English word-final /l/, among many other questions. Since the focus of this study was perception of English dark /l/, Brazilians were asked if they had had much contact with Portuguese as spoken by older people from the state of Rio Grande do Sul, where the dark word-final /l/ of Continental Portuguese is stated by some authors (Mateus & d'Andrade, 2000; Azevedo, 1981) to persist.

Portuguese-speaking native speakers of English were asked their age, city and country of origin, regional accent, and time spent in Brazil.

### **3.3.2 Extracurricular English at UFSC**

Among several other languages, courses in English as a second language are offered at UFSC to high school and university students, public servants, and members of the community in general. A highly successful program, "Extra," as it is called, boasts in the neighborhood of 80 English classes per semester, each of which meets for one and a

half hours twice a week, for a total of 45 classroom hours per semester. The majority of English teachers are students pursuing undergraduate or postgraduate degrees in English and quite often the teachers ask their students to participate as subjects in their research. The pool of students is quite large - more than 1200 students currently enroll in English classes per semester.

The instructional levels range from beginner to advanced, including courses in TOEFL preparation, advanced conversation and reading and interpretation of texts. More specifically, classes are offered at 8 sequentially numbered levels: levels 1, 2, and 3 (basic), levels 4, 5, and 6 (pre-intermediate), levels 7 and 8 (intermediate), followed by two advanced levels, Advanced 1 and 2. Despite the Extracurricular program's description of level 6 as "pre-intermediate," a student who entered at level one and continued studying at "Extra" through level 6 would be in his or her 3<sup>rd</sup> year of study and would have received approximately 270 hours of classroom instruction by the end of the semester. Furthermore, the book used at this level, *Interchange 3<sup>rd</sup> Edition*, book 3, the last in a four book series, is described on Cambridge's website<sup>7</sup> as appropriate for "high-intermediate" students. Advanced 1 and 2 classes are the ninth and tenth levels of Extra's instructional sequence and correspond to between 405 and 450 hours of classroom instruction at completion.

When students enroll in English classes at Extra, they are required to take a written placement test and undergo an evaluation of their speaking skills. A combination of scores on these two measures is used to assign the student to a level of English. Thereafter, there is no new formal evaluation by the program unless the student desires. No matter the level at which they enter, they may progress to the next level if they perform satisfactorily at the level at which they are initially assigned. This results in a

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<sup>7</sup> <http://www.cambridge.org/elt/catalogue/catalogue.asp?cid=1>

potentially inconsistent student body, as one student enrolled, say, in Advanced 1, might have studied for four years in the Extracurricular course, while another might have entered the program at that level. Furthermore, the minimum score required to pass from one level to another is 6 out of 10, although teachers are encouraged to hold students back at their discretion. Students are not locked into their assigned levels, however. Those who have not been assigned to a level of English appropriate to their abilities can, with the cooperation of the teachers involved, move to a level they feel is more suitable.

In this study, to address the potential variability in the level of students' abilities, their teacher rated all Brazilian students very good, normal, or weak for their level. This additional information will be explored in the analysis of correlations.

### **3.3.3 Intermediate Group**

The intermediate group was composed of 11 male and 9 female students from two level six English courses. They ranged in age from 15 to 53, with a mean age of 25.1 and a median age of 21.5. However, only three of the students were older than 26, and only two were younger than 20. Most reported no or very little (a few days to a few weeks) experience in an English speaking country, while four reported having spent more than three months in the US or England. Curiously, two of the students with significant experience in the United States were reported by their professor to be weak students for their level. They were also two of the oldest. Twelve of the twenty were from the Brazilian state of Santa Catarina, four from the state of São Paulo, and one each of the remaining four from the states of Minas Gerais, Bahia, Mato Grosso do Sul, and Rio de Janeiro. The student from Mato Grosso do Sul moved to Florianópolis when

she was 9 years old. Most participants reported Portuguese accents that corresponded to their state of origin, with three reporting an “indeterminate” accent.

### **3.3.4 Advanced Group**

The advanced group was made up of 12 female and 8 male students taken from Advanced 1 and Advanced 2 English classes at “Extra.” In this group, students ranged in age from 18 to 65 with a mean age of 29.9, and a median age of 23. Fourteen of the students were between the ages of 18 and 30. Sixteen of these students are from the state of Santa Catarina, two from Paraná, and two from Rio Grande do Sul. Again, most students described their accent as that of their state of origin, although three described their accents as indeterminate. In contrast to the intermediate group, 8 of the students reported having spent more than 3 months in an English speaking country, while three had visited for short periods of time.

### **3.3.5 Control Group**

Florianópolis is a popular tourist destination, has several universities, and a large number of private English schools. As a result, it was not an immense challenge to find native speakers of English locally. However, finding native speakers with a large amount of exposure to Brazilian Portuguese proved to be more difficult. Finding native speakers of English with similar linguistic backgrounds was, practically speaking, impossible.

The final control group was made up of nine native speakers of English, three women and two men from the United States, and four men from England. They ranged in age from 20 to 60 and all had been living in Brazil for at least three months at the time of the data collection. Importantly, all reported themselves to be competent

speakers of Brazilian Portuguese. None of the speakers from England described themselves as speakers of “Estuary English,” a dialect noted, like Brazilian Portuguese, for its vocalization of word-final /l/.

### 3.4 Listening Tests

#### 3.4.1 Listening Tests - General

To investigate Brazilians’ ability to distinguish English final dark [ɫ] from Portuguese final [w] and from English final [u], three pairs of tests were devised – a Categorical Discrimination Test, a Same/Different Test, and an Identification Test. Each test was made in a version that compared words ending in English [ɫ] to phonetically similar words ending in Portuguese [w], and a version that compared words ending in English [ɫ] to words ending in English [u] or [w]. This was done based on similarities between the English and Portuguese monophthongs /i/, /ɛ/, /ɔ/, /o/, /u/, and the diphthongs /aɪ/, /aʊ/ and /eɪ/. The phones differ slightly in their realizations (cf. Azevedo, 1981; Baptista, 2001), but are similar enough to facilitate comparisons across the two languages with words that are distinct mainly in their final segment.

To prepare the tests, three exhaustive lists of phonetically similar one-syllable words were made, one of English words ending in [ɫ], one of English words ending in [u], and one of Portuguese words ending in [w] (see Appendix 4). The lists were combined to try to find ideal sets of words such as:

English	English	Portuguese
bile	bayou	baio
/baɪl/	/baʊ/	/baʊ/

Using various dictionaries<sup>8</sup> as guides, only “real” words or syllables were selected (with one exception), although many of the words are not common. Where common words could be used, of course, they were preferred. For the English/Portuguese pairs, words such as *feel* and *fio* were contrasted, while for the English-only pairs, words such as *tow* and *toll* were compared. Because final *l*, and final unstressed *o* and *u* in Brazilian Portuguese can all be realized as [w] after vowels, it is possible to use words ending in all three of these letters. The tests did not use all possible words because of concerns about length of the test and because only words with good recordings were selected. The final list of words included English *bayou, bile, cawl, cell, feel, fell, foal, foe, foo, fool, go, goal, pal, peel, pile, poo, pool, pow, shale, toll, tow, vow* and *vowel*. Portuguese words were *baio, céu, cheio, fel, fio, ful, gol, kol* (from *Skol*), *paio* and *piu*.

### 3.4.2 Recording procedure

Normally, different speakers are used to record the words or sounds (“tokens”) used in speech perception tests, the idea being that variations across speakers will be disregarded and respondents will focus on the phonemic contrasts at hand. Catch trials reinforce this by varying only the speaker and not the token spoken. For this experiment, however, only one speaker was used, both because of the very subtle difference between the sounds to be examined, and because of the difficulty of finding people who are native speakers of both English and Portuguese with native accents in both languages. Furthermore, it was the opinion of the author that because of the subtle differences between the target sounds of [ɸ], [w], and [u], variation in the speaker could even become a distraction to listeners and interfere with the experiment’s aim. To offset

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<sup>8</sup> Dicionário Aurélio Eletrônico, versão 3, 1999 and DIC Michaelis UOL, 2001 for Portuguese; Merriam-Webster’s Online Dictionary, Cambridge Dictionary of American English, and the Oxford English Dictionary on Compact Disc, Second Edition for English.

the limitation of using only a single speaker's speech, at least three recordings were made for each word. Thus, in any particular sequence of words, even in the catch trials, all three tokens were different recordings.

To investigate contrasts between Portuguese and English with a minimum of irrelevant phonetic interference, a single person who was a native speaker of both English and Portuguese was required, a "true" bilingual. An acquaintance of the researcher was found to be ideal for the experiment and agreed to participate.

Born in 1977 in Allentown, Pennsylvania in the United States, the speaker lived there to the age of five. In 1983, he moved to Florianópolis, Santa Catarina, Brazil, with his mother, where he took 3 months of Portuguese lessons, after which he continued learning Portuguese naturally while speaking primarily English at home. The speaker left Florianópolis in 1996 to attend college in Providence, Rhode Island in the northeastern United States. After graduation, he moved to Portland, Oregon, where he remained for three years. In 2003, the speaker returned to Florianópolis and has lived there since returning. In the opinion of the experimenter, his accent in English is General American. His accent also clearly features dark /l/ in final position. In Portuguese, despite growing up in Florianópolis, his accent, as judged by several native speakers of Brazilian Portuguese, is not the stereotypical and distinctive accent of that city, but rather a more general Catarinense, the accent from the state of Santa Catarina. His final /l/ in Portuguese is the typical, rounded [w].

Monophonic recordings were made by the bilingual speaker on a Macintosh G5 in a quiet environment in the speaker's home at a sampling rate of 44.1 kHz and a resolution of 16 bits. All words were recorded at least three times using the sentence "a palavra é \_\_\_\_" in Portuguese, and "the word is \_\_\_\_" in English. All Portuguese examples were recorded first, followed by the English examples. The experimenter edited the

recordings using Peak DV software on a Macintosh Powerbook G4, removing all sounds but the words to be used in the perception tests, and selecting the three best examples of the words when there were more than three good examples to choose among. All words were saved as individual files.

To put the words in the order in which they would be presented, another audio editing program, Cubase X, was used. First, each sound file was imported into Cubase. Next, each contrast to be investigated was ordered appropriately according to a randomization of the tokens in Microsoft Excel. Ordering was performed first for the CDT, then for the same/different and identification tests. More detail is provided in the descriptions of the individual tests.

After ordering, six files, one each for the six sections of the test, were exported from Cubase. In addition, for the CDT only, an introductory training file was created with words not used elsewhere, to demonstrate the four possible choices participants would have on the CDT and to give them a small amount of practice. These seven files were re-imported to Cubase, compressed slightly to minimize volume differences, normalized and exported again, and finally recorded on a CD.

### **3.4.3 Tests 1 and 2 - Categorical Discrimination Tests**

The Categorical Discrimination Test (CDT) was originally designed to investigate vowel contrasts, but in this experiment it is used to investigate syllable-final phoneme contrasts, as has been done previously at UFSC (Koerich, 2002; Kluge, 2004). Significantly, to the author's knowledge, until now the CDT has primarily, if not exclusively, been used to investigate contrasts in a single language. One variation of the CDT used in this experiment differs from Flege's CDT in that phonemic contrasts across two languages were studied, rather than contrasts within a single language. This



is similar to many perception studies which ask participants to distinguish between “native-like” and “non native-like” contrasts.

As in the 2005 pilot study, a Categorical Discrimination Test (Flege, Munro & Fox, 1994) was used. In the CDT, to determine whether a listener perceives a contrast between two phonemes, minimal pairs are played in groups of three. Change trials consist of both items in one of six possible orders, while catch trials repeat only one of the items three times. For instance, a listener might hear the minimal pair “beat/bit” in the sequence “beat, beat, bit” for a change trial, and in the sequence “bit, bit, bit” for a catch trial.

For the Categorical Discrimination Tests used in this experiment, more words were used than in the pilot study. In the Portuguese/English CDT, the vowels compared were the diphthongs /eɪ/ and /aɪ/, and the monophthongs /i/, /ɛ/, /ɔ/, /o/ and /u/, featuring the following words or syllables, with Portuguese first: *cheio/shale*, *baio/bile*, *fio/feel*, *céu/sell*, *kol/cawl*, *gol/goal*, and *ful/fool*. In the English only section, the diphthongs were /aɪ/ and /aʊ/ and the monophthongs were /o/ and /u/. The contrasted words were *bile/bayou*, *vowel/vow*, *toll/tow* and *fool/foo(fu)*<sup>9</sup>.

Each group of contrasts to be investigated was ordered into the eight possible orders that three options afford: AAA, BBB, ABA, BAB, ABB, BBA, BAA, AAB. This resulted in a total of 56 sets of three words for the English/Portuguese section, and 32 sets for the English section. When assembling the sets, the beginnings of the words were separated from the ends of previous words by 1.2 seconds. When placing the sets of three in their final presentation order, a pause of 2 seconds was placed between the third word of one set and the first word of the subsequent set. In other words, there was

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<sup>9</sup> Although the syllable /fu/ is not necessarily a “proper” English word, it can be justified here on the following bases: it is the second syllable of the word *kung fu*; *foo* is widely used in computer science as an example variable name; it makes up part of the name of a popular band, the Foo Fighters; and as of August 19, 2007, Google finds almost 4 million web pages in English that contain the word *foo*.

a 1.2 second inter-token pause and a 2 second inter-trial pause. The length of the pauses was determined subjectively, based on the researcher's trials and modifications during the preparation of the tests. To place the sets in their final order, a list of random numbers for all sections was generated using Microsoft Excel's random number generator, and the sets were sorted according to those random numbers. This was done separately for the six sections of the task.

#### **3.4.4 Tests 3 and 4 – Same/Different Tests**

In these tests, participants heard two words and were asked to identify whether they were the same word or different words. The words used in these tests were the same as in the CDTs. As with the CDTs, the first contrasts presented were between English and Portuguese, varying only the word-final phone. In the second same/different Test, the contrasts were between English-only words ending in dark /l/ and [u/w].

#### **3.4.5 Tests 5 and 6 – Forced Choice Identification Tests**

The identification tests allowed for the use of more tokens, since only one good recording was needed for each item. Although both tests 5 and 6 are forced choice identification tests, they are not identically structured. Test 5 presented similar words in English and Portuguese, and participants were asked which language they heard. In addition to the words used in the first and third tests, this test added the English *pile*, *peel*, and *fell*, and the Portuguese *paio*, *pio*, and *fel*. The English-only test (Test 6) in this case featured words that ended in either [ɫ] or [u/ʊ], and participants were instructed to identify the final sound as “L” or “Not L.” The words *pow*, *pal*, *vow*, *vowel*, *bile*, *bayou*, *foe*, *foal*, *toe*, *toll*, *poo*, *pool*, *fool*, and *foo* were used one time each.

### 3.4.6 Instructions and Answer Sheet

A three-page answer sheet was provided for participants to mark their responses. For each test, columns were labeled appropriately for responses to that test. For the CDT, for example, the columns were labeled *1*, *2*, *3*, and *Same*. All participants were also provided with an instruction sheet (see Appendices 2 and 3).

Unlike other answer sheets the experimenter has seen used in phonology experiments, this experiment's answer sheet has blank spaces for students to fill in with an *X* for their responses. In other versions, response sheets contained rows of numbers, one for each trial, with numbers which participants were to circle, as in the following example:

1.	1	2	3	0
2.	1	2	3	0
3.	1	2	3	0

For the present study, based on the human ability to subitize, or grasp numbers up to four without using numeric words (Wiese, 2003), it was decided to number only a header row, and thereby minimize distractions to participants.

	<b>1</b>	<b>2</b>	<b>3</b>	<b>Same</b>
1.				
2.				
3.				

Numerous studies on adults and children over the past sixty years have shown that humans have an innate, preverbal ability to grasp small numbers of items without having to use language. In simple terms, this means that if someone sees three dots on a page, she can say without hesitation and with absolute accuracy that there are three

dots. Through a process called subitizing, we recognize cardinal numbers up to three or four “automatically, accurately and without conscious attention” (Wiese, 2003, p. 95). Through studies of infants using techniques similar to those used in studies of infant speech perception, it has been demonstrated that this ability is present as early as the first week of life.

### **3.5 Data**

#### **3.5.1 Data collection**

All participants were given instructions on paper in both English and Portuguese and were asked to fill in a three-page paper response sheet. Due to the great phonetic similarity between some back vowels and dark /l/, to Brazilians’ known tendency to vocalize syllable-final English /l/, and to well-documented developmental substitution of /w/ for /l/ in children whose L1 is English, the instructions pointed out that the subject of the study was word-final English /l/. Data was collected from the Brazilian participants in four half-hour sessions at UFSC’s language lab, one session for each of the four classes from which the participants were drawn. In the language lab, each participant used headphones to hear the audio, and all participants in each session heard the audio at the same time. All native English-speaking participants were met with individually for data collection, and all also used headphones to listen to the audio.

#### **3.5.2 Data compilation**

Responses from each answer sheet were manually entered into a Microsoft Excel spreadsheet, then verified for accuracy. Calculations in the spreadsheet compared the responses to a key to evaluate them, then placed an *X* where an incorrect response was recorded. Non-responses were entered as *nr*. As discussed below, because some tests

included a high number of non-responses, they were eliminated from calculations on a systematic basis using an objective standard. Totals were calculated for correct, incorrect, and nr responses per test, per vowel, and for total error on all tests. Non-responses were dealt with in the calculations using pairwise deletion, a common method used by SPSS and Minitab. From these totals, percentage correct was figured per test, and per vowel, and for all tests combined.

Responses to the questionnaire were entered as well, and codified to facilitate statistical analysis.

### **3.5.3 Non-responses on the tests**

Eight of the twenty intermediate respondents and nine of the twenty advanced respondents had at least one non-response on at least one of the six tests. Some of these non-responders had small numbers of non-responses. These low *nr* participants had at most two non-responses on any given test, and no more than a total of 5 non-responses (about 3%) out of the six tests' total of 168 questions.

In some cases, however, test-takers failed to respond to a much larger number of items. When they failed to respond to more than 20% of the items on any single test, the responses to the entire test in question were removed from the data set. The researcher believed that high non-response rates indicated confusion on the part of the test-taker. For the various tests, the following numbers of tests were removed:

Test 1: 4 tests removed, nr rates of 100%, 60.71%, 42.86%, 26.79%  
 Test 2: 2 tests removed, nr rates of 59.38%, 84.38%  
 Test 5: 3 tests removed, nr rates of 80%, 35%, 35%  
 Test 6: 1 tests removed, nr rate of 75%

In the principal statistical analysis, non-responses and removed tests were addressed through pairwise deletion. This is one of two common techniques used by many statistical software packages, such as SPSS and Minitab, the software used for analysis in this study. Pairwise deletion works by simply eliminating any data point with missing data in calculations.

The other main technique, listwise deletion, deals with missing data in a sample by removing all data from a participant with any missing data above a certain low threshold, which here, as is typical in SPSS, was one percent. Listwise deletion was used for a secondary analysis. Both listwise and pairwise deletion can lead to bias (Allison, 2002), but “pairwise deletion may be necessary when overall sample size is small or the number of cases with missing data is large” (Garson, 2007). Since neither method for dealing with missing data is ideal, it was felt that if conclusions from both analyses were the same, the conclusions could be considered more robust.

Overall non-response rates, excluding tests that were entirely removed, were as follows:

Test 1: 0.50%	Test 4: 0.16%
Test 2: 0.25%	Test 5: 0.68%
Test 3: 0.36%	Test 6: 1.44%

Among the Native Speakers, there was only one non-response. It occurred in Test 2, the CDT of all English words. The Native Speaker’s single non-response fell below the one percent cutoff used for the tests with listwise deletion.

#### **3.5.4 Outliers**

Among tests which included very few non-responses, there were also some instances of very high error rates on some tests that were objectively identified as

outliers using Grubb's test and by making boxplots in the statistical software Minitab 15. High error rates, too, could indicate a high level of confusion, especially when a participant's error rate on other tests was not greatly different from other participants' error rates on the same tests. However, because there was no apparent measurement error, outliers were not removed from the data set.

### **3.6 Data Analysis**

Data analysis was performed in a variety of ways using the statistical software Minitab 15, choosing appropriate tests based on the variables to be analyzed. According to Brown (1988) and Rumsey (2007), when comparing error rates, which are interval scale variables, against participant groups, which are nominal scale variables, both the one-way ANOVA and the Kruskal-Wallis test are appropriate, depending on the distribution of data in the interval scale variable.

To prepare for analysis of total error rate, error rates by vowel, and error rates by test, the distribution of responses for each sample on each test was analyzed using the Ryan-Joiner test for normality. As with other normality tests, the null hypothesis is that the distribution is normal. A  $p$  value of less than the typical alpha of 0.05 means the null hypothesis should be rejected, and that the distribution is not normal (Spiegel & Stephens, 1999). If the sample passed the normality test, a one-way ANOVA was used. If any group for a particular vowel or test failed the normality test, the distributions were plotted and compared visually. If the distributions were found to be roughly similar, the Kruskal-Wallis analysis of variance was used.

Both ANOVA and Kruskal-Wallis test only for whether differences exist among groups compared (Brown, p. 174-176). If either test finds significant differences, further tests are carried out. For significant ANOVA results, Tukey's test was chosen to

analyze the data for differences, and for significant Kruskal-Wallis tests, the Mann-Whitney test was chosen. Both compare each pair separately and report significant differences between them.

For exploration of possible correlations between demographic data and Total Error Rates, most data could be compared with Pearson's product-moment correlation coefficient. This procedure, better known as Pearson's  $r$ , tests two independent, natural interval scale variables that are normally distributed to discover how similarly they vary (Brown, p. 132, 136-37). For true dichotomous data vs. Total Error Rate, the point-biserial correlation coefficient was employed. In assumptions and interpretation, this test is similar to Pearson's  $r$  (Brown, p. 150). ANOVA tests were also performed to look into possible correlations in demographic data when a correlation coefficient was not appropriate, for instance, when comparing regional accent or region of origin.



## Chapter 4 – Comparison of Vowel Contexts and Tests: Results and Analysis

### 4.1 Introduction

Because of the much higher number of responses that could be analyzed, results using all respondents' data with pairwise deletion are reported as the principal results. All groups' distribution of data were tested for normality with the Ryan-Joiner test, and the great majority were found to be normal at  $p > 0.100$ . As this is the most common finding, it will not be further noted in the text when discussing results. However, in a very few cases the  $p$  value was between 0.055 and 0.100. These will be noted in the text, but did not affect the decision to analyze with one-way ANOVA. In another few cases,  $p$  was found to be  $< 0.050$  for one of the groups under consideration. As this would violate the normal distribution condition of ANOVA, after histograms were examined to compare data distribution shapes, Kruskal-Wallis was used instead. This, too, will be further noted as appropriate.

Results for each analysis will be presented in a table to facilitate comparisons and ease understanding. The table will first present the mean error rate by group in two columns. The first column, labeled "Principal" will contain the mean error rate with non-responses handled with listwise deletion. The second column, labeled "No NRs" will contain the mean error rate with results that contained more than 1% non-responses removed entirely from the analysis by listwise deletion. Below the means will be the analyses, first the principal analyses with pairwise deletion, then the alternate analyses with listwise deletion. For ANOVA and Kruskal-Wallis,  $p$  values and conclusions will be listed, then, if a follow-up analysis was performed, the results of Tukey's test or the Mann-Whitney test as appropriate.

After all results are discussed individually, they will be presented in a graphical and numerical summary, to better assess the results as a whole.

## 4.2 Statistical Analysis

### 4.2.1 Analysis of Total Error Rate

**Table 4.2.1 Analysis of Total Error Rate**

Means	Principal	No NRs
Intermediate	16.20%	15.24%
Advanced	17.26%	16.73%
Native Speakers	8.54%	8.54%
<b>Analyses</b>		
Kruskal-Wallis:	$p = 0.001$ , adjusted for ties At least two groups significantly different	
Mann-Whitney:	Intermediate and Advanced not significantly different Native Speakers erred significantly less than Intermediate and Advanced	
Alt Kruskal-Wallis:	$p = 0.001$ , first finding supported	
Mann-Whitney:	First finding supported	

To begin, the total mean error rates of the three groups were compared. Initial examination of the data shows that the native speakers' total mean error rate (8.54%) was much lower than that of either of the groups of Brazilians. A rather unexpected result, however, was that the total mean error rate of the Advanced group (17.26%) was slightly higher than that of the Intermediate group (16.20%). Surprisingly, this pattern would be observed in many subsequent comparisons.

The Ryan-Joiner normality test found only the Intermediate and Native Speaker groups to be normal, but the Intermediate group was normal at  $p = 0.052$ . This value is above the alpha level of 0.05, but just barely. Since the Advanced group's results were not found to be normal, the Kruskal-Wallis test was used after a comparison of data plots. It should be noted that the removal from each group of the response with the most extreme error rate affects the normality test significantly, resulting in a  $p$  value much

nearer to or greater than 0.100, the highest value the Ryan-Joiner test reports. For the principal analysis and the retest discussed below, these extreme values were left in place.

The Kruskal-Wallis test revealed that at least two among the Intermediate, Advanced, and Native Speaker groups differ significantly at this broad level of assessment. The test indicated a very high level of confidence in the conclusion ( $p = 0.001$ ). Retesting with non-responders removed confirmed the result at the same level of significance ( $p = 0.001$ ).

To determine which groups differed significantly, the Mann-Whitney test was performed. As might be expected from a glance at the numbers, the Native Speakers' mean error rate was shown to be significantly lower than that of either Brazilian group, while the mean error rates of the Intermediate and Advanced groups were not found to be significantly different. These conclusions were supported by the re-run of the Mann-Whitney test.

### 4.3 Analysis of Total Error Rate per vowel

To examine the effect of preceding vowel context on the results of the various tests, total error rates for each context were compared among the Intermediate, Advanced and Native Speaker groups.

#### 4.3.1 /ɛ/ Error Rate vs. Class

**Table 4.3.1 /ɛ/ Error Rate vs. Class**

Means	Principal	No NRs
	Intermediate	14.48%
Advanced	21.63%	19.79%
Native Speakers	13.19%	13.19%

Analyses	
One-way ANOVA:	$F(2, 46) = 1.92, p = 0.158$ , no significant differences
Alt ANOVA:	$F(2, 32) = 1.27, p = 0.293$ , first findings supported

The vowel /ɛ/ appears before dark /l/ in 16 test tokens in Tests 1, 3 and 5, being 14.3% of the items in Tests 1 and 3, and 10% of the items in Test 5. Mean error rates of the Intermediate group (14.48%) and Native Speakers (13.19%) are very similar, while the Advanced (21.63%) is well higher. But one-way ANOVA results comparing individual /ɛ/ total error rates by group show no significant differences among them ( $p = 0.158$ ).

Retesting without non-responders also produces non-significant results ( $p = 0.293$ ), but, curiously, the Intermediate mean error rate (12.95%) is slightly lower than the Native Speakers mean error rate (13.19%). The Advanced mean error rate (19.79%) remains higher than both.

### 4.3.2 /ɔ/ Error Rate vs. Class

**Table 4.3.2 /ɔ/ Error Rate vs. Class**

Means	Principal	No NRs
	Intermediate	28.49%
Advanced	34.05%	33.93%
Native Speakers	6.35%	6.35%

<b>Analyses</b>	
One-way ANOVA:	$F(2, 46) = 10.25, p = 0.000$ At least two groups are significantly different
Tukey's test:	Intermediate and Advanced not significantly different Native Speakers erred significantly less than Intermediate and Advanced
Alt ANOVA:	$F(2, 32) = 10.48, p = 0.000$ , first finding supported
Alt Tukey's test:	First finding supported.

The vowel /ɔ/ precedes dark /l/ in 14 items in the first five tests, making up 14.3% of the items in Tests 1 and 3 and 10% of the items in Test 5. Mean error rates of the groups are more extremely different between Brazilians and Native Speakers than in any other test: Intermediate, 28.49%; Advanced, 34.05%; and Native Speakers, 6.35%. A one-way ANOVA showed, not surprisingly, that at least one of the groups is significantly different from the others ( $p = 0.000$ ). Tukey's test showed no significant difference between the Brazilian groups, and found that the Native Speakers' error rate was significantly lower.

Removal of non-responders lowered the Intermediate mean error rate to 29.32% and the Advanced to 33.93%. ANOVA re-run with non-responders removed showed a similarly minimal  $p$  value of 0.000, confirming the initial results. The re-run of Tukey's test also supported the original conclusion.

### 4.3.3 /i/ Error Rate vs. Class

**Table 4.3.3 /i/ Error Rate vs. Class**

Means	Principal	No NRs
	Intermediate	10.45%
Advanced	9.79%	7.81%
Native Speakers	4.17%	4.17%

**Analyses**

Kruskal-Wallis:  $p = 0.277$  adjusted for ties, no significant differences

Alt Kruskal-Wallis:  $p = 0.429$  adjusted for ties, first findings supported

For /i/, a normal distribution was rejected by the Ryan-Joiner normality test for both the Intermediate and Advanced groups ( $p < 0.010$ ). Examination of histograms shows more or less similar shapes among the three groups' distributions, so analysis was conducted with the non-parametric Kruskal-Wallis test.

The Kruskal-Wallis test indicates ( $p = 0.277$  adjusted for ties) that the median error rates of the three groups do not differ significantly. When the test is re-run with non-respondents removed, the conclusion is the same ( $p = 0.429$  adjusted for ties).

### 4.3.4 /o/ Error Rate vs. Class

**Table 4.3.4 /o/ Error Rate vs. Class**

Means	Principal	No NRs
	Intermediate	23.18%
Advanced	20.98%	23.44%
Native Speakers	9.39%	9.39%

**Analyses**

One-way ANOVA:  $F(2, 46) = 6.08, p = 0.005$   
At least two groups are significantly different

Tukey's test:  
Intermediate and Advanced not significantly different  
Native Speakers erred significantly less than  
Intermediate and Advanced

Alt ANOVA:  $F(2, 32) = 6.13, p = 0.006$ , first findings supported  
Alt Tukey's test: First findings supported

The vowel /o/ precedes dark /l/ in 32 items in all six tests, making up 14.3% of the items in Tests 1 and 3, 25% of the items in Tests 2 and 4, 10% of the items in Test 5,

and 37.5% of the items in Test 6. Mean error rates of the groups are lower as the “level” of English increases: Intermediate, 23.18%; Advanced, 20.98%; and Native Speakers, 9.39%. A one-way ANOVA showed that at least one of the groups is significantly different from the others ( $p = 0.005$ ). As in the overall results, Tukey’s test found no significant difference between the Brazilian groups, and showed that the Native Speakers’ error rate was significantly lower.

Again we see no meaningful difference without the non-responders. Their removal lowered the Intermediate mean error to 22.77% while increasing the Advanced mean error to 23.44%. ANOVA re-run without non-responders showed a small  $p$  value of 0.006, confirming the initial result of at least one difference among the groups. The statistical conclusions of the second run of Tukey’s test are the same as the first run.

#### 4.3.5 /u/ Error Rate vs. Class

**Table 4.3.5 /u/ Error Rate vs. Class**

Means	Principal	No NRs
	Intermediate	11.31%
Advanced	11.29%	10.00%
Native Speakers	5.93%	5.93%

<b>Analyses</b>	
One-way ANOVA:	$F(2, 46) = 3.68, p = 0.033$ At least two groups are significantly different
Tukey’s test:	Intermediate and Advanced not significantly different Native Speakers erred significantly less than Intermediate and Advanced
Alt ANOVA:	$F(2, 32) = 2.68, p = 0.084$ No significant differences among the groups. The conclusion of the first test is not supported.

The vowel /u/ precedes dark /l/ in 30 of the test items across all six tests. One-way ANOVA test results for this phoneme combination showed that at least two of the groups are different ( $p = 0.033$ ). The Intermediate and Advanced groups’ mean error rates are quite close at 11.31% and 11.29% respectively, and the Native Speakers’ mean

error rate is quite low at 5.93%. Tukey's test confirms that the difference between the Native Speakers and Brazilians is statistically significant.

The mean error rates of the Intermediate and Advanced groups are slightly lower without the non-responders, at 9.79% and 10.00% respectively. Though the mean of the Native Speakers is still quite a bit smaller (5.93%) than that of both Brazilian groups, this drop is enough for the re-run ANOVA to find no significant differences ( $p = 0.084$ ).

#### 4.3.6 /aɪ/ Error Rate vs. Class

**Table 4.3.6 /aɪ/ Error Rate vs. Class**

Means	Principal	No NRs
	Intermediate	3.04%
Advanced	5.60%	4.72%
Native Speakers	2.59%	2.59%

Analyses	
One-way ANOVA:	$F(2, 46) = 2.14, p = 0.129$ , no significant differences
Alt ANOVA:	$F(2, 32) = 1.18, p = 0.320$ , first finding supported

The vowel /aɪ/ appears before dark /ɪ/ in 30 test tokens across all six tests, comprising 14.3% of the items on Tests 1 and 3, 25% of items on Tests 2 and 4, 20% of the items on Test 5, and 12.5% of the items on Test 6.

All three groups were found to be normal by the Ryan-Joiner test, though the confidence level for the Native Speaker group was rather low at  $p = 0.062$ . Analysis was performed with a one-way ANOVA, and the results on these test items shows no significant differences among the groups ( $p = 0.129$ ). Retesting without non-responders confirms that finding ( $p = 0.320$ ).



### 4.3.7 /au/ Error Rate vs. Class

**Table 4.3.7 /au/ Error Rate vs. Class**

Means	Principal	No NRs
	Intermediate	41.61%
Advanced	41.46%	40.63%
Native Speakers	28.47%	28.47%

Analyses	
One-way ANOVA:	$F(2, 46) = 3.22, p = 0.049$ At least two groups are significantly different
Tukey's test:	No significant differences were found
Alt ANOVA:	$F(2, 32) = 3.58, p = 0.040$ , first finding supported
Alt Tukey's test:	Native Speakers erred significantly less than Intermediate

The vowel context /au/ is a special case among the contexts studied in this experiment. Contrasts were examined for /au/ primarily between the English-only *vow* and *vowel*, which appeared in 14 of 16 instances. In the other two instances, *pow*, /paʊ/, was contrasted with *pal*, /pæl/, (according to Merriam-Webster, /pæɪ/ according to the OED). These contrasts are obviously not precisely comparable to each other, which will be discussed in detail later. Note: one respondent's test was entirely removed from this analysis because of a very high non-response rate (75%).

One-way ANOVA performed on /au/ error rates found that at least two groups were different, but not with great certainty ( $p = 0.049$ ). Oddly, Tukey's test did not confirm this. Results of a second ANOVA using listwise deletion matched the first at a fair confidence level of  $p = 0.04$ . Here, Tukey's test found that the Native Speakers erred significantly less than the Intermediate group, but found no other differences.

### 4.3.8 /eɪ/ Error Rate vs. Class

**Table 4.3.8 /eɪ/ Error Rate vs. Class**

Means	Principal	No NRs
	Intermediate	4.16%
Advanced	5.06%	3.57%
Native Speakers	3.97%	3.97%

Analyses	
Kruskal-Wallis:	$p = 0.815$ adjusted for ties, no significant differences
Alt Kruskal-Wallis:	$p = 0.761$ adjusted for ties, first findings supported

The diphthong /eɪ/ appears before dark /l/ in Tests 1, 3, and 5, totaling 14 tokens per respondent. Eight instances occur in Test 1, 4 in Test 3 and 2 in Test 5.

The Ryan-Joiner normality test rejected the null hypothesis that the distribution was normal for the Advanced group ( $p < 0.010$ ), and barely confirmed normality for the Intermediate ( $p = 0.055$ ). Examination of histograms showed more or less similar shapes, so the Kruskal-Wallis one-way analysis of variance was employed to compare the three groups. The results indicate very strongly ( $p = 0.815$  adjusted for ties) that the three groups' error rates do not differ significantly. The retest results are similar ( $p = 0.761$  adjusted for ties) and support the findings of the principal analysis.

Though the Kruskal-Wallis analyzes for equality of medians, not means, a comparison of the mean error rates found using pairwise deletion to those using listwise deletion is very interesting. In the principal analysis, the mean error rates are Intermediate, 4.16%; Advanced, 5.06%; and Native Speakers, 3.97%. The pattern is similar to results for /ɛ/, with Intermediate and Native Speaker mean error rates differing little while the Advanced group errs much more.

Listwise deletion has a surprising effect - the Advanced error rate drops below the Native Speaker rate (3.57% and 3.97% respectively), and the Intermediate rate is cut by almost a third to a level greatly below that of both other groups (2.55%).

#### 4.4 Error Rates Compared by Test

To examine more closely the differences between the groups, each test was analyzed separately. This was done primarily to help answer research questions two and three, which concerned differences between native speakers and Brazilians and between the Intermediate and Advanced students. It is hoped that this analysis will also help indicate the reliability of the tests – if all error rates are similar across the tests, that will give some indication.

##### 4.4.1 Test 1 Error Rate vs. Class

**Table 4.4.1 Kruskal-Wallis Test: Test 1 Error Rate vs. Class**

Means	Principal	No NRs
Intermediate	14.20%	12.00%
Advanced	15.61%	15.03%
Native Speakers	7.74%	7.74%
<b>Analyses</b>		
Kruskal-Wallis:	$p = 0.128$ adjusted for ties, no significant differences	
Alt Kruskal-Wallis:	$p = 0.142$ adjusted for ties, first finding supported	

Test 1 is the most extensive of the six tests, using 8 tokens for each of all vowels in the study except /au/ before dark /l/ in a Categorical Discrimination Test of both English and Portuguese.

A total of four participants' responses were removed from Test 1 due to high non-response rates: 26.8% and 100% for Intermediate, and 42.3% and 60.7% for Advanced. The Ryan Joiner test roundly rejected normality for the Intermediate group ( $p < 0.010$ ), due solely to the presence of an outlier with a very high error rate of 58.18%. After histograms of the three groups were examined and found to have similar shapes, the non-parametric Kruskal-Wallis test was used to check for differences.

KW does not find a difference among groups ( $p = 0.128$  adjusted for ties) when using data from all respondents. Median error rates, for whose equality Kruskal-Wallis tests, were 11.81% for Intermediate, 10.71% for Advanced, and 7.14% for Native Speakers. The mean error rates were all higher and are provided for comparison with what is reported in ANOVAs elsewhere. The mean rates were 14.20% for Intermediate, 15.61% for Advanced, and 7.74% for Native Speakers. In Test 1, the Native Speakers performed much better than the Brazilians, while the Brazilians performed similarly, but the results of the Kruskal-Wallis test do not indicate a sufficient level of statistical significance to generalize beyond this sample.

Retesting without non-responders found no differences among the groups at a similar  $p$  value of 0.142 adjusted for ties. A third retest to remove the outlier mentioned above is discussed briefly below, and at length in Appendix 5.

#### 4.4.2 Test 2 Error Rate vs. Class

**Table 4.4.2 One-way ANOVA: Test 2 Error Rate vs. Class**

Means	Principal	No NRs
Intermediate	17.83%	18.75%
Advanced	19.79%	20.57%
Native Speakers	13.58%	13.58%

Analyses	
One-way ANOVA:	$F(2, 44) = 1.59, p = 0.216$ , no significant differences
Alternate ANOVA:	$F(2, 32) = 1.68, p = 0.202$ , first finding supported

Test 2, like Test 1, was a Categorical Discrimination Test, but here only English words were used. Only four vowel contexts were analyzed - /aɪ/, /aʊ/, /o/ and /u/. Eight tokens were presented of each for a total of 32 items. Two Advanced participants were removed from Test 2 due to high non-response rates of 59.4% and 84.4%.

Mean error rates of the three groups were Intermediate, 17.83%, Advanced 19.79%, and Native Speakers, 13.58%, but the differences were too small for a one-way ANOVA to find a significant difference ( $p = 0.216$ ). An ANOVA re-run using listwise deletion instead of pairwise deletion produced similar results ( $p = 0.202$ ).

#### 4.4.3 Test 3 Error Rate vs. Class

**Table 4.4.3 Kruskal-Wallis Test: Test 3 Error Rate vs. Class**

Means	Principal	No NRs
Intermediate	7.32%	6.63%
Advanced	11.30%	9.82%
Native Speakers	3.57%	3.57%
<b>Analyses</b>		
Kruskal-Wallis:	$p = 0.019$ adjusted for ties at least one significant difference among the groups	
Mann-Whitney:	Native Speakers erred significantly less than Advanced No significant difference between Intermediate and either of the other groups	
Alt Kruskal-Wallis:	$p = 0.030$ adjusted for ties, first finding supported	
Mann-Whitney	First findings supported	

Test 3 was a forced-choice test of seven vowel contexts with both English and Portuguese words. For each vowel context, there were two words per language.

No tests were removed for a high rate of non-responses, but the Ryan-Joiner normality test failed for the Advanced group ( $p < 0.010$ ), so, after histograms were compared and found to be of roughly similar shape, the Kruskal-Wallis test was used.

Kruskal-Wallis found at a significant level ( $p = 0.019$ ) that at least two of the groups differed, so the Mann-Whitney test was run to compare the groups. The median of Native Speaker error rates (3.57%) is significantly lower than that of Advanced students (10.71%), but not significantly lower than the median error rate of Intermediate speakers (7.14%). However, the median rate of Intermediate students, between the medians of the other groups, is not significantly different from either the Advanced *or*

the Native Speakers. Mean error rates were Intermediate, 7.32%, Advanced, 11.30%, and Native Speakers, 3.57%, identical to the median. Results from the groups without non-responses were similar ( $p = 0.030$ ), and support the same conclusion.

#### 4.4.4. Test 4 Error Rate vs. Class

**Table 4.4.4 One-way ANOVA: Test 4 Error Rate vs. Class**

Means	Principal	No NRs
Intermediate	11.88%	12.05%
Advanced	10.02%	7.29%
Native Speakers	6.94%	6.94%

Analyses	
One-way ANOVA:	$F(2, 46) = 1.25, p = 0.295$ , no significant differences
Alt ANOVA:	$F(2, 32) = 2.22, p = 0.125$ , first finding supported

Test 4, an English-only same/different test, was one of two tests with only 16 items. It tested four tokens each of four vowels before dark /l/: /aI/, /aU/, /o/ and /u/. Results from all participants' tests were considered. Mean error rates were 11.88% for Intermediate, 10.02% for Advanced, and 6.94% for Native Speakers. A one-way ANOVA comparing the results showed no significant differences among the groups ( $p = 0.295$ ). Retesting on results without non-responders raised the Intermediate mean slightly and lowered the Advanced mean greatly, thus reducing the  $p$  value of the ANOVA to 0.125.

#### 4.4.5 Test 5 Error Rate vs. Class

**Table 4.4.5 One-way ANOVA: Test 5 Error Rate vs. Class**

Means	Principal	No NRs
Intermediate	20.08%	18.93%
Advanced	25.79%	23.82%
Native Speakers	12.22%	12.22%

<b>Analyses</b>	
One-way ANOVA:	$F(2, 43) = 4.96, p = 0.012$ At least two groups significantly different
Tukey's test:	Native Speakers erred significantly less than Advanced Intermediate not significantly different from Advanced or Native Speakers
Alt ANOVA:	$F(2, 32) = 4.16, p = 0.025$ , first finding supported

Test 5 presented both English and Portuguese words in an identification test. The participant listened to one word at a time and identified whether it was English or Portuguese in a forced choice test. There were ten words from each language, examining dark /l/ perception in the context of all vowels in the study besides /aʊ/. There were two instances of /aʊ/, /eɪ/, /o/, and /u/, and four instances of /aɪ/, /ɛ/ and /i/, for a total of 20 items.

Exhibiting a pattern that by now must be familiar, Advanced performed poorly, Intermediate better, and Native Speakers best. Group mean error rates were Intermediate 20.08%; Advanced, 25.79%; and Native Speakers, 12.22%.

A one-way ANOVA indicates that at least two groups differ significantly ( $p = 0.012$ ). Tukey's test finds the Intermediate mean error rate on Test 5 statistically equal to those of the other groups. The Native Speakers mean error rate, though, is significantly lower than that of the Advanced group.

Re-running ANOVA with only >99% responders supported the first ANOVA's result at a high level of confidence ( $p = 0.025$ ), and a second Tukey's test confirmed the results of the first.

#### 4.4.6 Test 6 Error Rate vs. Class

**Table 4.4.6 One-way ANOVA: Test 6 Error Rate vs. Class**

Means	Principal	No NRs
Intermediate	33.24%	33.18%
Advanced	29.30%	27.60%
Native Speakers	6.94%	6.94%

Analyses	
One-way ANOVA:	$F(2, 45) = 17.76, p = 0.000$ At least two groups are significantly different
Tukey's test:	Intermediate and Advanced not significantly different Native Speakers erred significantly less than either Intermediate or Advanced
Alternate ANOVA:	$F(2, 32) = 17.09, p = 0.000$ , first finding supported
Alt Tukey's test:	First findings supported

Test 6 consisted of 16 English-only words ending in dark /l/ or /u/ in a forced choice identification test. The vowels here were /au/ (4 tokens), /aɪ/ (2), /o/ (6) and /u/ (4). A high non-response rate of 75% led to the removal of one Advanced participant's test; none were removed from Intermediate.

The results of this test showed a dramatically strong contrast between the Brazilians and the Native Speakers. Mean error rate for each group was Intermediate, 33.24%, Advanced, 29.30%; and Native Speakers, 6.94%. One-way ANOVA confirmed this stark contrast at  $p = 0.000$ . Tukey's test showed no significant difference between the Intermediate and Advanced groups, and showed that the Native Speakers' mean error rate was significantly, vastly lower than both groups of Brazilians.

Removing non-responders and retesting reduced the mean error rate of both Brazilian groups slightly, to 33.18% and 27.60%, but the ANOVA again registered a very strong  $p$  value of 0.000. Tukey's test results supported the first findings.



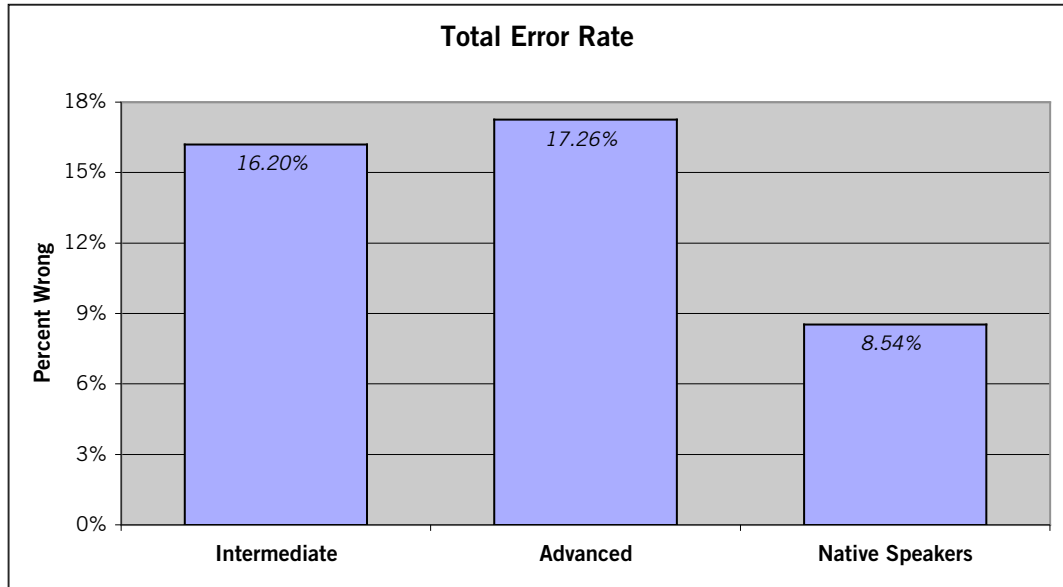
#### **4.5 One unusual case in Test 1**

One participant in the Intermediate group, who shall be identified as IK, stood out from the rest for his unusual results. IK's error rate on Test 1, the first CDT, was more than 20 percentage points higher than anyone else's at 56.36% with only one non-response. His extreme error rate on Test 1 was identified as an outlier on a boxplot of Test 1 error rates in the software Minitab and with Grubb's test. To address IK's odd response here, the Total Error Rate analysis, all vowel context analyses, and the analysis of Test 1 were performed twice - once including his responses in Test 1 and once without them. For the Total Error Rate analysis, for Test 1, and for all of the vowel-by-vowel analyses, all statistical conclusions were the same at similar levels of confidence. These tertiary analyses are discussed at length in Appendix 5.

## 4.6 Conclusions

### 4.6.1 Total Error Rate

Graph 4.6.1 Total Error Rates Compared



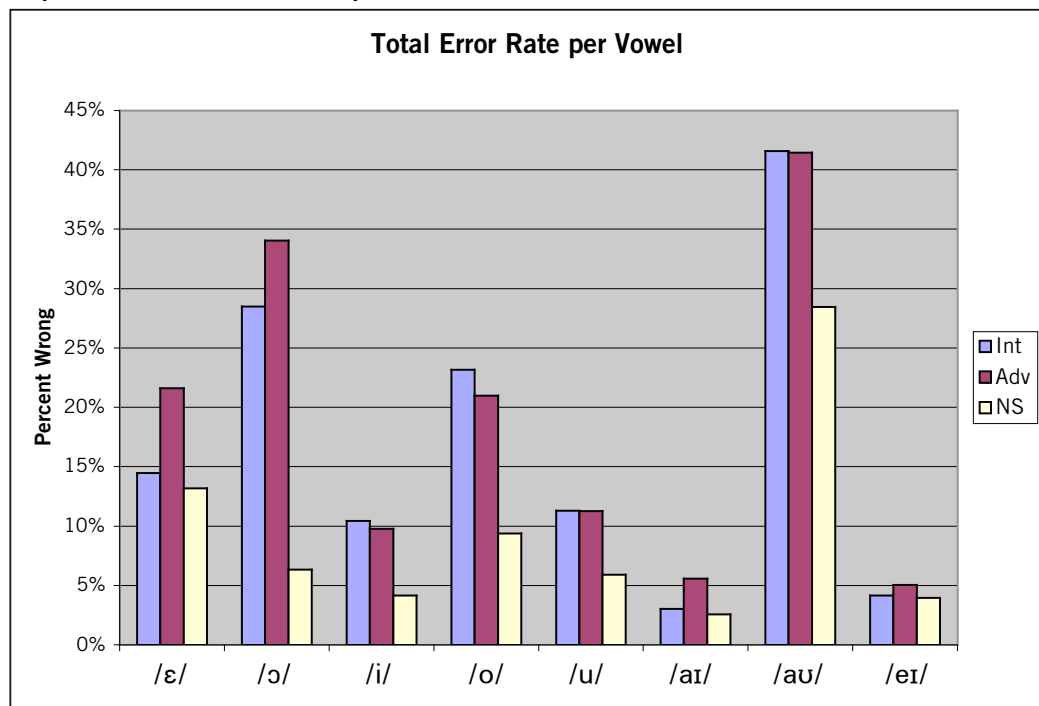
Test	Conclusion
TE vs. class: Kruskal-Wallis	Int and Adv not significantly different, NS < Int and Adv

In the principal analysis, Native Speakers' mean error rate for all tests combined and for every individual comparison by vowel and by test was lower than the mean error rate of either group of Brazilians. This difference was statistically significant for the overall results in both the principal analysis, with all responses, and in the secondary analysis with non-responders removed. Broadly speaking, this suggests that the Brazilians perceive English dark /l/ less often than native speakers. Later, when the results by vowel and by test are examined, it will become clear that a conclusion so plain will not fully accommodate the findings.

#### 4.6.2 Total Error Rate per Vowel

In the graph below, statistical conclusions from the principal and secondary analysis are summarized. Where the two differed, the more conservative result was chosen as representative. The results of the less conservative test appear as footnotes.

Graph 4.6.2. Total Error Rate per Vowel



	/ɛ/	/ɔ/	/i/	/o/	/u/	/aɪ/	/aʊ/	/eɪ/
<b>Intermediate</b>	14.48%	28.49%	10.45%	23.18%	11.31%	3.04%	41.61%	4.16%
<b>Advanced</b>	21.63%	34.05%	9.79%	20.98%	11.29%	5.60%	41.46%	5.06%
<b>Native Speakers</b>	13.19%	<b>6.35%*</b>	4.17%	<b>9.39%*</b>	5.93%	2.59%	28.47%	3.97%

Test	Conclusion
/ɛ/ vs. class: 1-way ANOVA	no significant differences
/ɔ/ vs. class: 1-way ANOVA	Int and Adv not significantly different, NS < Int and Adv
/i/ vs. class: Kruskal-Wallis	no significant differences
/o/ vs. class: 1-way ANOVA	Int and Adv not significantly different, NS < Int and Adv
/u/ vs. class: 1-way ANOVA	no significant differences†
/aɪ/ vs. class: 1-way ANOVA	no significant differences
/aʊ/ vs. class: 1-way ANOVA	no significant differences††
/eɪ/ vs. class: Kruskal-Wallis	no significant differences

\* Significantly lower than Intermediate and Advanced.

† Principal analysis: Int and Adv not significantly different, NS < Int and Adv.

†† Secondary analysis: NS erred significantly less than Intermediate

To investigate research questions one and four, error rates by vowel context must be examined carefully. As can be quickly grasped by a glance at the graph, error rates varied widely depending on the vowel context. Some general consistencies are apparent. The two lowest error rates among all three groups were shared between the two fronting diphthongs /aɪ/ and /eɪ/. Neither error rate climbed above 6% for any of the groups in these contexts, and no significant differences were found among the groups in either the principal or secondary statistical analysis.

At least two possibilities exist to help explain the low error rates overall for these two diphthongs. First, they are both fronting diphthongs whose articulation ends at a high front position. The physical transition to the mid-back or high-back articulation of [w] or [ɥ] is a long one, and provides a large amount of additional acoustic information that participants could use to distinguish between sounds. Only the transition from [i] to [w] or [ɥ] would be longer, and then only by a small amount. But the higher error rates among the Brazilians in the /i/ context suggest that something else is at work.

The second possibility is the different syllabic treatment of the two diphthongs in English and Portuguese. Words like *paio* or *cheio* have two syllables in Portuguese, while the corresponding English *pile* and *shale* have only one syllable. The stress falls on the diphthong, and in the recordings used in these experiments, the stresses are quite clear. Furthermore, according to Azevedo, syllable final /l/ follows only monophthongal vowels in Portuguese (p. 68), potentially offering an extra clue to the Brazilian participants. Additionally, in these recordings, the speaker often exhibited a very slight /ə/ insertion in the transition to final /l/ in English words, a not uncommon occurrence in some dialects (Fujimura & Erickson, p. 100-101).

In addition, remember that Lehiste found a very strong coarticulatory effect for final /l/ after the diphthong /aɪ/ (though not for /eɪ/) and described the second element of the diphthong as appearing to be “particularly affected” (p. 26). The “strongly centralized sound” she found could have further differentiated the English diphthong from the Portuguese one.

Error rates ranked third for the front vowel context /i/ in all three groups. No significant differences were found among the groups in any analysis, although in this context Brazilians’ error rates were roughly twice as high as in the /aɪ/ and /eɪ/ contexts, while Native Speaker rates remained quite low. The words contrasted here were phonologically very similar—English *feel* and *peel* and Portuguese *fio* and *piu*—but differed in their phonetic realization. One cue was provided by the duration of the words in Tests 1 and 3. The length of the contrasted /i/ recordings varies a good deal, with most English instances produced casually and somewhat more slowly than their Portuguese complements, which were generally uttered forcefully. Also in this context, the speaker again produced /ə/ before /t/ in English words.

Also, consider that, as mentioned earlier, the transition from [i] to [w] or [ʃ] is the longest among the vowels under consideration in this study. Acoustically, this is borne out by Lehiste’s findings: she shows that F2 for /i/ followed by /t/ goes from 2105 Hz to 740 Hz (p. 24), a greater difference than for any other vowel she studied.

The fourth lowest error rate for Brazilians and Native Speakers was observed for the context /u/. As /u/ is one of the vowels most frequently compared to dark /ɹ/, it is somewhat surprising that error rates in this context were so low. Despite many articulatory differences described by Azevedo (p. 66), formant frequencies for General American /u/ and Brazilian Portuguese tonic /u/ are quite similar. For GA /u/,

Ladefoged (2001, p. 172) reports F1 and F2 as 310Hz and 870Hz. For BP tonic /u/, two studies by Fails and Clegg (1992, p. 33-36) report F1 at 315–318Hz and F2 between 832Hz–896Hz. Perhaps the amount of lip rounding that accompanies /u/ is quite significant acoustically, and helps make clear the difference between the final segments.

In the primary analysis, even though all groups' error rates were low, Native Speakers mistakenly identified tokens significantly less than Brazilians, whose error rates differed by a trivial two hundredths of one percent. The secondary analysis lowered the Brazilians' mean error rates enough for one-way ANOVA to find no difference among the groups. To remain conservative, the conclusion must be, then, that there are no significant differences.

As with the diphthongs /aɪ/ and /eɪ/, phonetic differences in the realization of /u/ could have contributed to the participants' low error rates. Azevedo (p. 66) and Avery and Ehrlich (1992, p. 33) point out that English /u/ often features a slight diphthongization. This is evident in the experiment's recordings in words like *poo* and *foo*. Also, the words' duration is almost clipped, as are the durations of the Portuguese words *pul* and *ful*, in contrast to the more relaxed pronunciation of English *fool* and *pool* that the speaker uses. Also, here again the final /l/ in English is preceded by a barely noticeable /ə/. These factors increased the contrasts between the tokens, and perhaps made the distinctions easier to perceive for Brazilian participants.

The only other context with across the board similarities in rank was the diphthong /aʊ/, which had the highest error level for all three groups of participants. For Native Speakers it was the worst by far, with almost twice the errors of /ɛ/. The primary analysis found no statistically significant differences among the groups, while the secondary found Native Speakers to have erred significantly less than only the

Advanced group, whose error rate climbed 4 points without non-responders. Considering the nearly insignificant *p* level in the first ANOVA, the conservative conclusion is that there are no differences.

As mentioned earlier, the vowel context /aʊ/ is peculiar among the contexts studied here. Contrasts were examined for /aʊ/ primarily between the English-only *vow* and *vowel*, which appeared in 14 of 16 instances. In the other two instances, *pow*, /paʊ/, was contrasted with *pal*, /pæl/, (according to Merriam-Webster, /pæɪ/ according to the OED). These contrasts are not precisely comparable to each other. The word *vowel* features /l/ after the diphthong, rather than replacing a final [w], [u] or [ʊ] with [ɫ]. There may also be a /ə/ before the final /l/ in some pronunciations, as it is in two of the tokens spoken here. The word *pal* substitutes [ɪ] for the [ʊ] of the diphthong /aʊ/ in *pow*, but the preceding vowel is not necessarily /a/, depending on the dialect. In this experiment's speaker's pronunciation, the vowel in *pal* varies, but is very similar to his vowel in *pow*. These several caveats would seem to suggest the presence of more phonetic variability in the syllable rhyme that could be used to distinguish the tokens from one another, and thus make less likely that any differences noticed were due solely to the presence or absence of /l/. But, in fact, the error rates for /aʊ/ were very high for all groups, suggesting instead that the /l/ was particularly difficult to distinguish in this context. Given the peculiarities of this vowel context, this can tentatively be attributed to the great phonetic similarity between /ʊ/ and dark /l/, especially considering that this diphthong makes its transition to a mid-back articulation before any further transition to dark /l/.

For the mid-front English-Portuguese vowel context /ɛ/, no significant differences were found in any analysis. The middling error rates for Brazilians came as a surprise,

especially considering the excellent error rates for the two fronting diphthongs and /i/, and the changes in articulation from front to back. Even more surprisingly, it was on this vowel context that Native Speakers performed second worst.

The relatively long transition from front to back provides additional phonetic information, but this did not provide any group with an apparent advantage. For the most part, Brazilian and Native Speaker error rates varied together. With few exceptions, if Brazilians performed well on a particular item, native speakers did, too, and vice versa. When error rates were disparate, there was no apparent pattern.

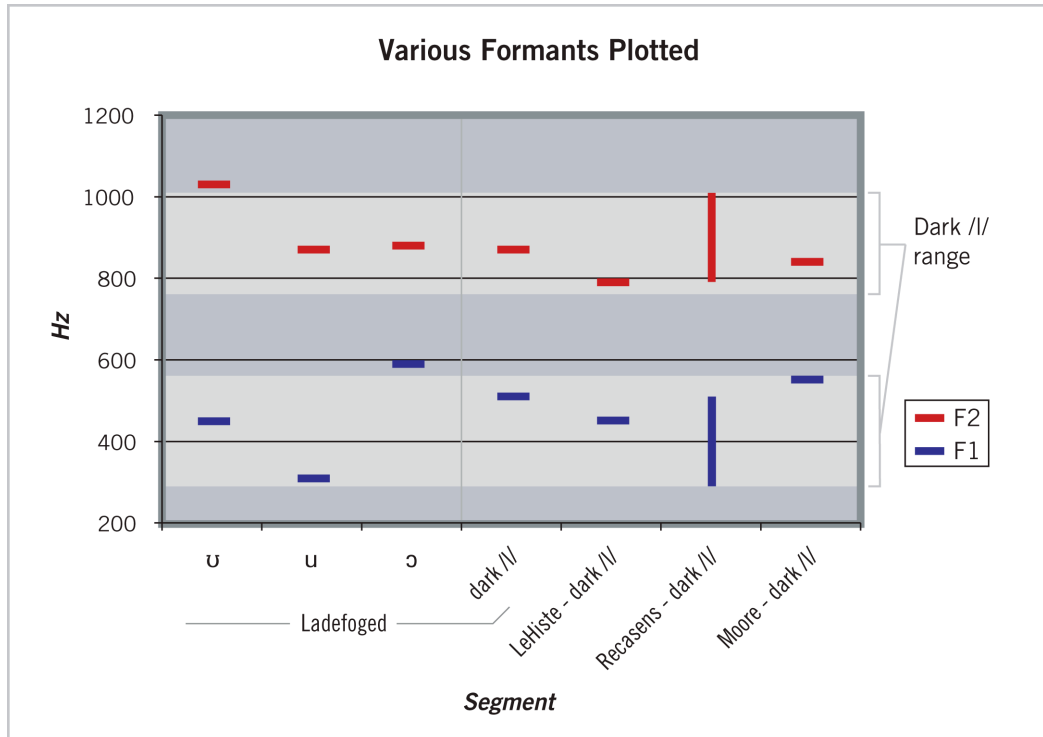
For the monophthong /o/, which was examined in all six tests, Native Speakers were found to have made significantly fewer mistakes than either group of Brazilians in both the primary and secondary analysis. Here, similarity between the mid-back /o/ and final /l/, and thus fewer differences in the transition from one to the other, could have led to higher errors for the Brazilians. On the other hand, the slight diphthongization of English /o/ could have provided an additional clue to distinguish among or between tokens on the tests of English and Portuguese.

Concerning /ɔ/, which appeared in the tests of English-Portuguese contrasts, the differences among the groups are most stark. Native Speakers identified dark /l/ correctly significantly more often than Brazilians, and at a much lower error rate. The monophthong /ɔ/ is a mid-height back vowel, and though it is not cited as a similar sound in any texts consulted, corresponds very closely to dark /l/ acoustically, at least according to some measurements, as illustrated by graph 4.6.2b. Ladefoged (2001) shows American English /ɔ/ to have first and second formants of 590 and 880 Hz (p. 172), while dark /l/ is reported by Recasens (1996), Lehiste (1964), and Moore (2006) to have F1 between 300 and 551 and F2 to be between 770 and 1000. Two other back vowels, /ʊ/ and /u/, are reported by Ladefoged as follows: /ʊ/ - F1, 450 Hz, F2, 1030



Hz; /u/ - F1, 310 Hz, F2, 870 Hz. Only /u/ could be said to be more similar to dark /l/ than /ɔ/ based on the first two formants.

**Graph 4.6.2b. Various Formants Plotted**



So why would Brazilians have erred so much more on /ɔ/ than on /u/? Perhaps the insertion of /ə/ before /l/ in English /u/ words could have provided enough extra information to make identification easier for Brazilians. If not, lip rounding for /u/ provides even more additional phonetic information. No /ə/ insertion after /ɔ/ is apparent and lip rounding is minimal. There is also very little transition between the vowel and the final segment. An additional contributing factor could be that the words used for /ɔ/ might as well have been nonsense words in both languages: *kol* edited from *skol* in Portuguese, and *cawl*, a kind of Welsh soup. Uncommon or nonsense words perhaps reduce the possibility of lexical interference, and permit a more direct experience of phonetic information. The similarity of the vowels could play a part as

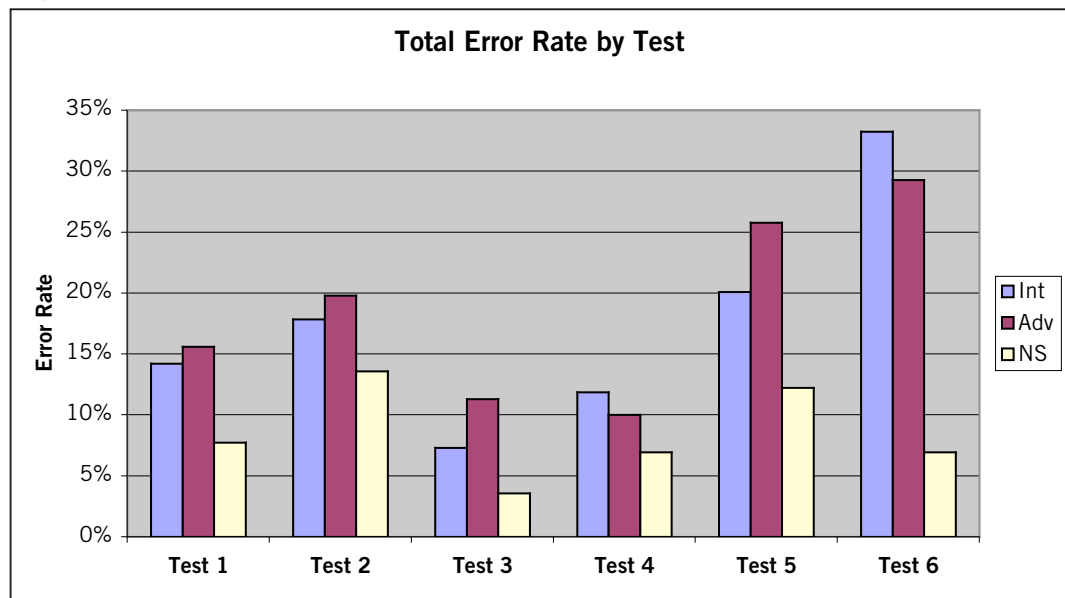
well. Azevedo notes that Portuguese [ɔ] is shorter and the tongue is positioned higher than “is required” for English [ɔ]. He concludes that aside from these details, English [ɔ] is “as good an approximation to Portuguese [ɔ] as any” (p. 64).

With so little to distract from the final segment, unlike with /o/ or /u/, this comparison provides what may be the best evidence that Brazilians perceive English dark /l/ poorly, as it best isolates the distinction in question.

### 4.6.3 Total Error Rate by Test Summary

The graph below summarizes the statistical conclusions from a comparison of the principal and secondary analysis. For all tests, the results of the second analysis supported the conclusions suggested by the first analysis.

Graph 4.6.3 Total Error Rate by Test



	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
<b>Intermediate</b>	14.20%	17.83%	7.32%	11.88%	20.08%	33.24%
<b>Advanced</b>	15.61%	19.79%	11.30%	10.02%	25.79%	29.30%
<b>Native Speakers</b>	7.74%	13.58%	<b>3.57%**</b>	6.94%	<b>12.22%**</b>	<b>6.94%*</b>

Test 1: Kruskal-Wallis	no significant differences
Test 2: 1-way ANOVA	no significant differences
Test 3: Kruskal-Wallis	Int not significantly different from either Adv or NS, NS < Adv
Test 4: 1-way ANOVA	no significant differences
Test 5: 1-way ANOVA	Int not significantly different from either Adv or NS, NS < Adv
Test 6: 1-way ANOVA	Int and Adv not significantly different, NS < Int and Adv

\* Significantly lower than Intermediate and Advanced. \*\* Significantly lower than Advanced

As reported earlier, one-way ANOVAs and Kruskal-Wallis tests were performed to compare all three groups of participants on each of the six tests. On Test 1, a CDT of English and Portuguese contrasts, and on Tests 2 (CDT) and 4 (same/different), of

English-only contrasts, no significant differences in error rate were found among the groups in either the principal or secondary analysis.

On Test 3, a same/different test of English and Portuguese, Native Speakers' error rate was significantly lower than only the Advanced group, while the Intermediate error rate was not found to differ from either of the other groups. The same result was found for Test 5, an identification test which also compared both English and Portuguese.

Only on Test 6, an identification test of English-only words ending in back vowels and dark /l/, were Native Speaker error rates found to be lower than both groups of Brazilians on both analyses. Native Speakers error rates were second lowest on Test 6 and, curiously, Brazilian error rates were highest. This could indicate that Brazilians' perception of the English sounds in isolation is poor. It must be admitted as well that at this point in testing, Brazilians might have grown fatigued, which could have contributed to their higher error rates.

But there is also a lexical and linguistic component to consider for Tests 5 and 6. In Test 5, participants were expected to identify the language (English or Portuguese) they heard. In Test 6, the task was to identify the sound of the final letter. In both cases, participants were applying their knowledge of English and Portuguese vocabulary and orthography to the sounds they heard, not merely distinguishing between two or three alternatives. Thus, unfamiliarity with the words may have played a part as well. On Test 5, the most misidentified words were *ful*, *kol*, *gol*, *fel*, and *fio*, in that order. While *gol* and *fio* are very common words, *ful* and *fel* are certainly not. And *kol*, as noted before, is not a proper Portuguese word, having been edited from *Skol*, a popular brand of beer. The four most missed words on Test 6 were *poo*, *foo*, *vow*, and *pow*. While these words are perhaps not so commonly known to Brazilians, some of the best identified words

were also quite possibly unfamiliar—*foal*, *bile*, and *bayou* had the 6<sup>th</sup>, 5<sup>th</sup> and 1<sup>st</sup> lowest error rates respectively.

In contrast to the results of test 6, results on Test 4, which presented two English words in quick succession, suggest that Brazilians have little trouble distinguishing a contrast between the sounds of English word-final /l/ and word-final back rounded vowels when the sounds are heard close together. Presumably, this would extend to even better identification within the flow of speech, when other lexical and phonetic cues are available.

#### **4.6.4 Discussion by data pattern**

As noted earlier, the two groups of Brazilians did not significantly differ in their responses overall, or on any of the comparisons by vowel context or by test. Nevertheless, despite the lack of statistical significance, it should be pointed out that in half the vowel contexts and on two thirds of the tests, the Intermediate group erred less than the Advanced group. In two cases in the analyses of error rate by test, because of the low error rates of the Intermediate group, the Native Speakers erred significantly less than only the Advanced group. In the cases of /ɛ/, /aɪ/, and /eɪ/, the Intermediate group actually outperformed the Native Speakers in the secondary analysis.

No obvious explanations were found. Despite that no broad correlation was found earlier, the groups were examined to check whether more Intermediate students had spent significant time in English-speaking countries than Advanced. Rather, just the opposite was true—exactly twice the number of students in the Advanced group had lived for three or more months in an English-speaking country, and twice the number had visited for a short time. As touched on earlier, participants were not limited by age

for this study. But because many studies do limit participants by age, and because the Advanced group had a greater number of people over thirty, including two in their sixties, another series of ANOVA and Kruskal-Wallis tests were performed on the vowel responses with only participants aged 18-30 (see Appendix 6). Statistical results all support the same conclusions as the original tests except for the /u/ vowel context and Test 3. Concerning /u/, Native Speakers erred significantly less than both groups of Brazilians aged 18-30. This is the same result as the primary analysis, but not the secondary. On Test 3, reanalysis found no significant differences among the groups where the primary analysis found that Native Speakers erred less than the Advanced group.

If not age, what else could explain this peculiar result? Due to the dual language nature of half the tests, it is possible that linguistic factors besides the final phoneme are the culprit. As discussed with respect to the vowel contexts, there are many additional phonetic clues present in the recordings that could aid in their distinction from each other. It also could be that the Intermediate students were better than Native Speakers at recognizing Portuguese tokens. And, of course, it is possible that the Intermediate group's low error rates (or the Advanced group's elevated error rates) represented nothing more exotic than a chance occurrence.

It is even conceivable that perception could get *worse* with more exposure. U-shaped development—from “good” to “bad” and back again—is common for grammatical structures in both first language acquisition (Ellis, p. 77) and second language acquisition (p. 303). Whether it is common in phonological development is

less clear<sup>10</sup>. Flege, Bohn, and Jang (1997) concluded that more exposure corresponded to better perception in a study of non-native speakers of English from a variety of countries. On the other hand, Leather and James (1996, p. 289) suggest that L2 sounds similar to L1 sounds can actually “regress” to make way for L2 sounds that are less familiar.

With regard to theory, consider the SLM’s second and fifth hypotheses (Flege, 1995, p. 239):

H2: A new phonetic category can be established for an L2 sound that differs phonetically from the closest L1 sound if bilinguals discern at least some of the phonetic differences between the L1 and L2 sounds.

H5 states in part: Category formation for an L2 sound may be blocked by the mechanism of equivalence classification.

Other authors offer similar ideas. Kuhl says “foreign language units that are similar to a native-language category are particularly difficult to perceive as different from the native-language sound” and adds that L2 phones which are too similar to L1 phones will be assimilated into L1 categories (1993, p. 131). In contexts with little phonetic information besides the target contrast, such as /ɔ/, Flege’s and Kuhl’s statements offer plausible support for the findings.

But the results of this experiment lead to the conclusion that in some vowel contexts even native speakers do not perceive a difference between word-final /l/ and word final [u] or [w] well. For this reason, we must consider the likelihood, at least in some contexts, that not only are the phonetic differences insufficient to create a new category, they are also insufficient for Native Speakers to discern.

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<sup>10</sup> Anecdotally, consider the case of Brazilians learning to suppress word final epenthesis. For a word like *cookie*, an intermediate stage pronunciation may involve oversuppression of the final vowel, resulting in a pronunciation more like *cook*. Advanced learners learn to correctly pronounce both words.

## **Chapter 5 – Correlation: Results and Analysis**

### **5.1 Correlation Exploration**

The fifth research question concerns possible correlations between demographic characteristics of the participants and their combined total error rates on the 6 tests. To explore, a variety of statistical procedures were performed, each selected for its appropriateness to the data to be analyzed. The data from the detailed demographic questionnaire was codified to allow for statistical analysis. For the most part, only the Total Error Rates of the Brazilian groups were examined for correlations with demographic data. Where data from Native Speakers was also present, for items such as sex and age, they were included in the correlation test. For one test of Native Speakers only, the respondents were subdivided into British and American groups. Questionnaire results which were examined for correlations appear in Appendices 11, 12 and 13.

After a brief introduction, all results are presented as charts, with the character ♣ in the last column before any results with  $p$  values below or near the alpha level of 0.05. Any interesting correlations will be discussed below the charts.

### **5.2 Correlations with all participants**

Basic information about all respondents was compared with Total Error Rates to examine for correlations using the point-biserial correlation formula or Pearson's product-moment correlation. Because the Total Error Rates of Native Speakers were generally lower than those of the student groups, the results were re-examined without the Native Speakers. For the variables examined – sex and age – no results were remotely close to significant. Further analysis with listwise deletion and with outliers



removed was also performed, but all conclusions were the same. These results can be seen in Appendix 7.

Often experimental groups are homogenized by age. In this study, the decision not to was based on the SLM's first postulate, that "the mechanisms and processes used in learning the L1 system...remain intact over the life span, and can be applied to L2 learning" (Flege, 1995, p.239): As all students were at the same level in a homogenous program, it was not felt necessary to limit the group by age.

**Table 5.2. Correlations: universal data**

<b>Variable</b>	<b>Measurement</b>	<b>Test type</b>	<b>Result</b>
All Groups - Sex	male/female	point-biserial	$r = -0.071, p = 0.628$
All Groups - Age	numerical age	Pearson's r	$r = -0.036, p = 0.808$
Brazilians only - Sex	male/female	point-biserial	$r = -0.066, p = 0.685$
Brazilians only - Age	numerical age	Pearson's r	$r = 0.055, p = 0.734$

### 5.3 Correlations with Brazilians only

The extensive questionnaire given to Brazilian participants allowed a large number of interesting factors to be examined for correlations with Total Error Rate. The bulk of the questions analyzed for correlations concerned geographical factors or travel and language experience.

All tests were performed three times. The principal analysis was performed with Total Error Rates for both groups of 20 Brazilian participants, which were calculated by handling missing data through pairwise deletion. The second analysis, as with the earlier tests, was conducted only on the Total Error Rates of those Brazilian participants who responded to all items on the test, which left just 11 per group. The second analysis was performed for two reasons. First, there is no consensus among statisticians on a best method for dealing with missing data. Second, if a correlation found in the analysis

with pairwise deletion was also found using listwise deletion, a conclusion could be stated with great confidence, especially since the number of people per group drops so steeply in the second analysis.

Finally, a third analysis was conducted on the Total Error Rates of all Brazilian participants *minus* one outlier from each group, since outliers can have a pronounced effect on correlation coefficients. The outliers were identified as mild outliers on the box plots drawn for each group separately in Minitab, but Grubb's test did not agree. Nevertheless, for curiosity's sake, the analysis was performed again. The two participants with Total Error Rates identified as outliers did not respond to all items, so they were excluded from the second analysis by default.

In the charts, some variable names and measurements are self-evident. Notes are below for the remaining variables. Discussion will follow the charts concerning the significant or near significant results marked in the chart's last column with ♣. Only significant or near significant correlations are shown for the second and third analyses.

Charts with all results are in Appendix 8.

*Accent heard when growing up.* "Other" included "Arabic of my father" in one case and "German of relatives" in all others.

*Teacher's evaluation of student.* This item was not on the questionnaire, but rather reflects the researcher's opinion of the student's spoken English relative to his or her class level. The measurements were "below average for level, average for level, above average for level."

*English-speaking country experience.* The measurement "little" corresponds to trips and stays of less than one month. "Extensive" indicates greater than three contiguous months living in an English-speaking country.

*Other foreign country experience?* None reported was in a non-English-speaking country whose language includes dark /l/.

*Speak other languages?* This question was asked both to gauge whether general language knowledge might have an effect on performance and to find whether anyone spoke a language with dark /l/. One student reported Arabic, acquired

naturally from Lebanese father and relatives. This student did not perform particularly well. Even if he had, this would only have been a curiosity that would need further study.

*Other native English-speaking teacher?* If participants responded “yes,” they were asked to tell their other teacher’s country of origin. Responses included US, England, Australia and Scotland.

*Contact with Continental Portuguese?* Responses generally described a very low level of contact. Only one student had had a good deal of exposure, by living with a Portuguese roommate in London. Here again, the student did not perform too well.

*Contact with older Riograndenses?* The questionnaire specified Riograndenses older than 60 years and asked for details if the answer was yes. In all cases but one the exposure came from relatives.

*Contact with NS (Native Speakers) of English.* This question refers to contact outside the classroom. Positive responses indicated either sporadic contact or regular contact.

**Table 5.3a Correlations: primary analysis**

Variable	Measurement	Test type	Result
Place of origin	region (S, SE, CW, NE)	ANOVA	$p = 0.491$
Accent heard when growing up	region (S, SE, other)	ANOVA	$p = 0.954$
Self-reported accent	region (S, SE, indeterminate)	ANOVA	$p = 0.727$
Teacher’s evaluation of student	above avg, avg, below avg	Pearson’s $r$	$r = -0.269, p = 0.094$
English-speaking country exp.	none, little, extensive	Pearson’s $r$	$r = 0.231, p = 0.152$
Other foreign country experience	yes/no	point-biserial	$r = -0.124, p = 0.451$
Native speaker audio in class	none, little, much	Pearson’s $r$	$r = -0.125, p = 0.443$
Speak other languages?	yes/no	point-biserial	$r = -0.094, p = 0.569$
Other native Eng-speaking teacher?	yes/no	point-biserial	◆ $r = 0.298, p = 0.065$
Contact w/ Continental Portuguese?	none, little, much	Pearson’s $r$	$r = 0.004, p = 0.982$
Contact with older Riograndenses?	yes/no	point-biserial	◆ $r = -0.308, p = 0.056$
Contact with NS of English	little outside class, regular	point-biserial	$r = 0.082, p = 0.627$

**Table 5.3b Correlations: no non-responders**

Variable	Measurement	Test type	Result
Speak other languages?	yes/no	point-biserial	◆ $r = -0.372, p = 0.061$
Other native Eng-speaking teacher?	yes/no	point-biserial	$r = 0.308, p = 0.125$
Contact with older Riograndenses?	yes/no	point-biserial	◆ $r = -0.406, p = 0.039$

**Table 5.3c Correlations: no outliers**

Variable	Measurement	Test type	Result
Speak other languages?	yes/no	point-biserial	$r = -0.239, p = 0.154$
Other native Eng-speaking teacher?	yes/no	point-biserial	◆ $r = 0.339, p = 0.040$
Contact with older Riograndenses?	yes/no	point-biserial	◆ $r = -0.447, p = 0.006$

In the principal analysis, no  $p$  values descend below 0.05, but two are close enough to merit discussion. Regarding *Other native-speaking teacher?* vs. *Total Error Rate*, a mild positive correlation of 0.298 with a nearly significant  $p$  value of 0.065 was found. *Yes* was codified as 1, and *no* as 0, thus, a positive correlation here means that those who had *not* studied under another native speaker had lower Total Error Rates. Regarding *Much contact with older Riograndenses?* vs. *Total Error Rate*, a mild correlation of -0.308 with a nearly significant  $p$  value of 0.056 was found. Again, 0 and 1 signified *no* and *yes*. Here, though, the correlation, because it is negative, indicates that those who reported significant exposure to older Riograndenses had lower Total Error Rates. This is intriguing given the assertion in many descriptions of Brazilian phonology that the Riograndense dialect contains or contained dark /l/.

The second analysis finds a very similar correlation coefficient for *Much contact with older Riograndenses?* at a lower  $p$  value ( $r = -0.406$ ,  $p = 0.039$ ), and thus confirms the first findings. Here, though, the *Other native English-speaking teacher?* confidence level weakens to  $p = 0.125$ . In the third analysis, with outliers removed, the correlations for both *Other native English-speaking teacher* and *Contact with older Riograndenses?* are stronger than in the first analysis and are significant at  $r = 0.339$ ,  $p = 0.040$  and  $r = -0.447$ ,  $p = 0.006$  respectively. The second analysis also found a nearly significant weak negative correlation between *speak other languages?* and Total Error Rate, but neither of the other analyses found a significant correlation.

No clear conclusion can come from these analyses, unfortunately, except that further study is needed. Since it is impossible to know (in this study) whether students' previous native speaker teachers from England, the US or Australia spoke a regional dialect that vocalizes final /l/, a future experiment comparing students of only native speakers with known accents would perhaps be more likely to show whether exposure

to English dark /l/ helps students recognize it. Similarly, the possible correlation between *Much contact with older Riograndenses?* and Total Error Rate, while intriguing, is called into question by the lack of detail in the survey question. The survey provides no way to know whether the particular elderly Riograndenses to whom participants were exposed spoke with dark /l/, and does not ask for specific details on the amount of contact. A study, say, comparing a large number of students controlled for consistent exposure to older Riograndenses of a particular dialect to a group from other regions might more accurately find whether a correlation indeed exists.

#### 5.4 Correlations with Native Speakers only

Native Speakers were compared by their country of origin. The results appear below.

**Table 5.4 Correlations: Native Speakers only**

Variable	Measurement	Test type	Result
Place of origin	US/UK	point-biserial	◆ $r = 0.632, p = 0.068$

There was a fairly strong correlation of 0.632 reported by the point-biserial correlation formula. Because *US* was coded as 0 and *UK* as 1 to run the test, this would mean that the US speakers responded more accurately than the UK speakers if the confidence level was at or below the preset alpha level of 0.05. But let us consider what *p* signifies, which is “the probability of obtaining a result by chance alone.” While it cannot be said with great confidence that a correlation exists here, a retest with a larger group of native speakers from both the US and UK would be interesting to carry out.

What would such a correlation mean? It could mean that American dark /l/ is such a subtle sound that it is difficult to detect even by Native Speakers of other English dialects. Or perhaps the widely noted weakening of the dark /l/ to a vocalized back

vowel in a number of Southern English accents is to blame. The experimenter found that all speakers spoke with dark /l/, but perhaps it is a subtler sound than he realizes.

## Chapter 6 – Conclusion

### 6.1 Major Findings

Let us now address the research questions posed in Chapter Three. And let us begin where an unambiguous answer can be offered: with research question three.

Research question three purported to investigate whether Advanced students would perceive dark /l/ more accurately than Intermediate students. Here, the overall results were somewhat unexpected, and the answer is that they categorically do not. For overall error rates, for error rates by vowel, and for error rates by test, no statistically significant differences were ever found between the two groups of Brazilians. In fact, though it was not statistically significant, the Advanced group had a *higher* overall error rate than the Intermediate group in the comparison of total error rates. This pattern was also found in more than half the analyses by vowel, and 2/3 of the analyses by test, but, as in the overall results, it was never statistically significant. While a statistically significant difference between the groups would have been surprising, at least some previous research suggests that where a difference is perceived, a group with more exposure to the target language would perceive more accurately.

Research question one concerned whether native speakers of English and Intermediate and Advanced Brazilian learners of English all have difficulty perceiving a difference between English dark /l/ and various back vowels and diphthongs. It appears that all groups do, at least in some settings, although generally the Native Speakers had less difficulty than the Brazilians. Depending on the vowel context, the error rates for all three groups varied greatly. All groups' best results were on the same four contexts—/aɪ/, /eɪ/, /i/ and /u/—and were so low on the two fronting diphthong contexts that it cannot be said that they had any real difficulty there. Similarly, all groups' worst

context was the same; it can be stated unequivocally that all groups had pronounced difficulty distinguishing between final phones after /au/. In only two contexts, Native Speakers appeared to perceive fairly well when Brazilians had difficulties. In the remaining contexts, error rates for all three groups varied together. If Native Speakers always perceived dark /l/ distinctly, their error rates would have been low regardless of the context.

Research question two sought to learn whether Brazilians perceive differences less frequently than Native Speakers, since dark /l/ does not exist in the great majority of modern Brazilian Portuguese dialects. Overall error rates of Native Speakers were significantly lower than those of both groups of Brazilians, but not so low as might be expected. Flege (ms) suggests that a Native Speaker error rate of 3% is reasonable to expect for change trials on a CDT investigating vowel contrasts. For Native Speakers, error rates here were almost 7% on the CDT of English and Portuguese, and close to 14% on the CDT of English only. (Only on Test 3, the English-Portuguese identification test, did Native Speakers have an error rate near 3%.) Some other investigations of consonant sounds using a CDT have found more native difficulties than Flege predicted as well. Aoyama (2003), Kluge (2004), and Reis (2006) all showed error rates for native speakers higher than Flege's prediction and variously attributed the results to perceptual similarity or to flaws in test design.

While error rates were mostly lower for Native Speakers than for Brazilians, they were conclusively *significantly* lower only on two contexts, with a third context suggested to be lower by only one analysis. Thus, it is possible to say confidently that the Brazilians perceived the final-phone differences less frequently only after the vowels /ɔ/ and /o/. The /ɔ/ context stands out among the other tests for the great



difference between the Brazilian and Native Speaker error rates and perhaps provides the best evidence that dark /l/ is a difficult sound for Brazilians.

The fourth research question aimed to discover whether some phones before dark /l/ and /w/ make these word-final distinctions harder to discern than others. All participants made perception errors that varied greatly depending on the vowel presented, although it is not possible to attribute the difficulty to spectral cues alone. Among Native Speakers, error rates were generally low, but did vary with context, and for the vowels /ɛ/ and /aʊ/ were quite high. The Brazilian groups' variations were more extreme, from lows near Native Speakers' on the diphthongs /aɪ/ and /eɪ/ to error rates above 40% for the diphthong /aʊ/.

That all groups showed greater facility at recognizing differences in many contexts does not necessarily mean that they perceived differences between only the final phones, however. Other cues, such as stress, prosody, partial diphthongization of English vowels, and occasional insertion of /ə/ before /l/ could have made distinctions between tokens clearer.

Research question five aimed to investigate correlations, and though no correlations were found to be statistically significant in the primary analysis (and only one in the secondary), several results were nearly significant and could merit further study. Most intriguingly, lower error rates among Brazilians nearly correlated with contact with elderly Riograndenses in the primary analysis, and did correlate in the second and third analyses. It was also interesting to find that American English speakers possibly perceive dark /l/ more accurately than British speakers.

## 6.2 Pedagogical Implications

The teacher with an awareness of phonological research is better able to sensitively teach pronunciation. With an ear towards common difficulties in perception and production, reasonable performance expectations can be set for students, and they can be taught to create reasonable expectations for themselves. With phonological knowledge, teachers are better able to understand the language they are teaching and are more capable of passing that knowledge to students. And by teaching not only *of* the language but *about* it, new doors to learning can be opened.

Where new sounds in an L2 (or differences between L1 sounds and L2 sounds) cannot be perceived initially, instruction can direct students' attention and perhaps speed the process of acquisition. So if Brazilians do poorly discern the English phone [ɫ] in word final position as suggested by this experiment's results, they could be explicitly instructed in all aspects of its articulation to help them identify it. By showing some vowel contexts which may make Brazilians' (and Native Speakers') discernment of dark /l/ more difficult, teachers could focus attention where it would be most helpful. Especially in the case of /o/, which was shown to be significantly more difficult for Brazilians than for Native Speakers, common word pairs, among them *toe/toll*, *row/roll*, *bow/bowl* and *hoe/hole* differ only in the presence or absence of a final dark /l/. Contexts in which they could be confused can easily be imagined. The results of this study indicate possible additional phonetic clues such as schwa insertion or word duration that could be pointed out to help in the identification of dark /l/.

Of course, not all students are concerned with attaining native-like pronunciation. It must be acknowledged that the potential for embarrassment is not nearly as high as for the /i/ vs /ɪ/ contrast, which affords two potentially very offensive mistakes with the words *beach* and *sheet*. And, we must consider that Native Speakers themselves had

clear difficulty with perception of word final /l/ in this experiment, even though they were explicitly told the subject of the study. Realistically, instruction in the particulars of dark /l/'s production will probably be restricted to those students for whom native-like production is very important. Thus, this study is perhaps more relevant to theory of second language acquisition than to pedagogy.

### **6.3 Limits of the study and suggestions for further research.**

One obvious, and large, limitation was the use of a single speaker to record all utterances heard by the participants. The speaker's idiosyncrasies may have affected the results, especially on the English only section. His pronunciation of *pool*, for instance, reflected a shift in the vowel to /ə/ before the /l/ that perhaps made the distinction between *poo* and *pool* easier to make. More speakers would allow for a broader picture of the character of the final phonemes in English and Portuguese.

A more general problem that would affect many speakers of English is the different temporal characteristics of contrasts like *tow/toll* and *poo/pool*. In both cases, the shorter word is pronounced more quickly, giving listeners an additional clue they can use to distinguish differences between words. Temporal and intonation characteristics also affect the contrasts between Portuguese and English words in the Portuguese/English section in contrasts like *shale/cheio*. This became especially clear when editing the sounds. The speaker's tone of voice was lower in Portuguese, and the speed with which words were spoken was almost always faster. Varying the speaker would possibly have made these differences less noticeable. If this type of variation of the CDT is used in the future, three "true" bilinguals should be used to ensure that participants are not listening to differences in the speaker or recording, but are paying

attention to the sounds of speech at a more abstract level, as long as pronunciations are otherwise similar.

It must also be considered that the CDT might not be an appropriate test for consonant sounds. As noted earlier, the CDT was designed to investigate vowel perception, and its use in consonant studies has produced higher error rates than Flege predicted for vowel studies.

Because of the range of potential problems in using two languages in CDT, same/different and identification tests exposed by this experiment, it seems it might be better to compare the contrast between final /l/ and /w/ by using more English words in a future experiment, especially given the stark performance contrast between native speakers and Brazilians in Test 6. Also, because of the temporal clue in many contrasts, speakers could be instructed to pronounce the same word (in English) in two ways: normally and with a vocalized /l/. Because this is a common speech error made by children and often imitated by adults, consistent production would probably not be difficult to acquire from the speakers. Further, it would be easy to describe to them how to produce the alternate sound. This approach would necessarily be limited to minimal pairs that do not actually exist in English, however, for example /hiw/ contrasted with /hil/. Another way to remove temporal and intonational influence would be to synthesize tokens. Minimizing some potential aural distractors with speech synthesis could only come at the cost of naturalness, however. Much further refinement of this experiment must be done before attempting it again, to eliminate even more irrelevant variation, and to focus solely on the phonemes whose perception is to be investigated.

Despite the perhaps excessive extent to which the results of the current study were analyzed statistically, further investigation of correlations would be interesting. By using word frequency lists or textbook vocabularies to divide test tokens into “common

words” and “uncommon words” an effect of lexical familiarity could perhaps be explored. Would words that students are more likely to know be easier to identify as ending in /l/ based on recalled orthography? Conversely, any lexical familiarity effect could be eliminated by using only nonsense words.

Nonsense words would also make test design easier. The words chosen for this experiment were limited to those that had phonetic analogues in English and Portuguese both, such as the pair *fail/feio*. This led to an unequal number of tokens to analyze for the eight different vowel contexts studied, from 4 tokens for /a/ to 32 tokens for /o/. Because of the desire to use natural phonetic complements in the two languages, there was no attempt to control for phonetic environment before the vowel that preceded the final /l/ or /w/ in the tokens recorded. So, for instance, one pair, *feel/fio*, begins with a labiodental voiceless fricative, while *goal/gol* begins with a voiced velar consonant and thus is articulated on the opposite end of the mouth from /f/. Although most words in this study are monosyllabic, in some difficult cases a two-syllable word was used.

Many other aspects of the results and of the design could be developed further. Additional analysis of English/Portuguese versus English only tests would be valuable to investigate the effect of language on the results. Such investigation should have been planned based on the unusual bilingual nature of this study. A comparison of results based on whether token words were common or not might show the effect of lexical interference. Future experiments could be conducted with synthesized tokens instead of recordings to eliminate extraneous phonetic information where phonetically possible within the constraints of natural pronunciation.

And, finally, the intriguing, though perhaps remote, possibility of a correlation between overall performance and exposure to elderly Riograndenses was a delightful discovery. Only further study can determine whether such a relationship exists.

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## Appendix 1: Questionnaire

The questionnaire as presented here contains all original questions, but in a different format from the original. Plenty of space was allowed for participants to write their responses.

Nome \_\_\_\_\_ Idade \_\_\_\_\_  
Turma \_\_\_\_\_

1. De onde você é? Caso tenha morado em vários lugares durante a infância, quanto tempo passou em cada um?
2. Qual é seu sotaque? (catarinense, rio grandense, paranaense, paulista, carioca, etc.)
3. Qual é o sotaque que você ouviu mais durante a infância (o dos seus pais, seus avós, sua babá, por exemplo “meus pais – Mãe é de uma pequena aldeia de Santa Catarina, Pai é de uma cidadezinha de São Paulo” ou “meus avós – ambos do interior de São Paulo”)?
4. Já esteve num país onde se fala inglês? Por favor, descreva detalhadamente. Onde foi? Quando? Quanto tempo tinha estudado inglês quando foi?
5. Já esteve em qualquer outro país estrangeiro? Por favor, descreva detalhadamente. Qual país? Quando? Quanto tempo estudou inglês antes de ir?
6. Como você aprendeu inglês? Estudou no segundo grau? Em escola de idiomas? Estudo casual? Aulas particulares? Você aprendeu "naturalmente", apenas por estar em um lugar onde todos falavam inglês? Por favor descreva a maneira em que você aprendeu. (i.e. Duas aulas de uma hora e meia cada semana por dois anos na Cultura Inglesa, que é uma escola particular, etc.)
7. Com que frequência em outras aulas de inglês você escutou gravações de falantes nativos de inglês?
8. Você fala outros idiomas além de português e inglês? Como você os aprendeu? (X anos de estudo no colégio, aulas particulares, contato, etc.)
9. Já foi aluno de um falante nativo? Se sim, por quanto tempo? Quando? De onde era o professor?
10. Já estudou outras línguas com falante nativo? Se sim, por quanto tempo? Quando? De onde era o professor e qual foi a língua?
11. Já teve muito contato com português de Portugal? Se sim, por favor, descreva em detalhes.
12. Já teve muito contato com pessoas com 60 anos ou mais do Rio Grande do Sul? Se sim, por favor descreva em detalhes.
13. Já teve contato com falantes nativos de outras línguas? Se sim, por favor descreva em detalhes.

14. Qual é o seu nível de contato com falantes nativos de inglês? Por favor, descreva em detalhes – por quanto tempo, com que frequência, etc. Com que frequência falou com eles em inglês?

15. Você diria que teve muito ou pouco treinamento na pronúncia do inglês? Por favor descreva o treinamento (como foi ensinado a pronunciar-lo, ou como o “L” foi descrito).

16. Qual é seu teor de contato com inglês fora da sala de aula?

*Tipo de conteúdo*                      *Frequência: Todo dia? Muitas vezes por semana? Semanalmente? Algumas vezes por mês?*

filme	_____
TV	_____
música	_____
livros/histórias	_____
revistas	_____
jornais	_____
email	_____
messenger	_____
internet	_____
outro _____	_____

17. Por favor, escreva aqui qualquer outra coisa sobre seu contato com inglês que achar interessante.

## Appendix 2: Instructions

The sheet handed to Brazilian participants contained instructions in both English and Portuguese for clarity.

First of all, thank you very much for participating!

This activity is a test of perception of words that end with the English “L” sound compared with words that don’t end in this sound. Sometimes the other words will be in English, sometimes in Portuguese.

There are 7 parts to the test:

First is a very brief training exercise for parts one and two.

**Parts 1 & 2. Pick the item that is different.**

You will hear 3 words. Choose the word that is different from the others. If all words are the same, choose “same.”

**Parts 3 & 4.** Determine if the words are the same or different.

**Part 5.** Do you hear English or Portuguese?

**Part 6.** Does the word end in English “L” or not?

Thanks again!

Primeiramente, muito obrigado pela sua participação!

Esta atividade é um teste de percepção de palavras que terminam no “L” inglês em comparação a palavras que não terminam neste som. Às vezes, as outras palavras serão em inglês, às vezes em português.

Tem 7 partes no teste:

Primeiro é um treinamento curto para partes 1 e 2.

**Parte 1 & 2. Escolha o item que é diferente.**

Você vai ouvir 3 palavras. Escolha a palavra que é diferente das outras. Se todas as palavras são iguais, escolha “same.”

**Partes 3 & 4.** Determine se as palavras são iguais ou não.

**Parte 5.** Você ouve inglês ou português?

**Parte 6.** A palavra termina em “L” inglês ou não?

Obrigado de novo!

### Appendix 3: Response sheets

Examples

Name: \_\_\_\_\_

	1	2	3	Same
1				
2				
3				
4				

Age: \_\_\_\_\_

Part 1 – Port./English: select the odd word. If all words are the same, select “same.”

	1	2	3	Same
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				

	1	2	3	Same
29				
30				
31				
32				
33				
34				
35				
36				
37				
38				
39				
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				
51				
52				
53				
54				
55				
56				

Second response sheet:

Part 2 - English only: select the odd word. If all words are the same, select "same."

	1	2	3	Same
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

	1	2	3	Same
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				
31				
32				

Part 3 - Same or Different?

	Different	Same
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		

	Different	Same
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		

Part 4 - Same or Different?

	Different	Same
1		
2		
3		
4		
5		
6		
7		
8		

	Different	Same
9		
10		
11		
12		
13		
14		
15		
16		



Third response sheet:

**Part 5 – English/Portuguese: What language do you hear?**

	English	Portuguese
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

	English	Portuguese
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

**Part 6 – English Only: Identify the final sound**

	"L" as in "tool"	Not "L"
1		
2		
3		
4		
5		
6		
7		
8		

	"L" as in "tool"	Not "L"
9		
10		
11		
12		
13		
14		
15		
16		

#### Appendix 4: Possibility Exhauster

This appendix shows words considered when designing the tests. At this stage, all possibilities—from rough matches to idiosyncratic or dialectal pronunciations—were reviewed. Phonemic judgements were loose, so some words appear in multiple places. English words ending in /l/ and /ʊ/ for each vowel are in the first two columns; Portuguese words are in the third.

<b>/aɪl/</b>	<b>/aɪʊ/</b>	<b>Portuguese</b>	<b>/ɛl/</b>	<b>/ɛʊ/</b>	<b>Portuguese</b>
aisle		aio	bell		bel
bile	bayou	baio	kell		
kyle		caio	dell		déu
dial			fell		fel
file			Gell		
guile			hell		
heil	ohio	raio	jell		
kyle			quell		
lyle					Leo
mile		maio	mel		mel
nile			nell		neo
pile		paio	pell		
rile			quell		
sigh'll		saio	sell		céu
shy'll			shell		
tile			tell		téu
vile	vaio		well		
while			yell		

<b>/oɪl/</b>	<b>/oʊl/</b>	<b>Portuguese</b>	<b>/iɪl/</b>	<b>/iʊl/</b>	<b>Portuguese</b>
bowl	bow	acabou	beal		
coal	Coe	secou	deal		dio
dole	dough	dou	eel		io
foal	foe	safou	feel		fio
goal	go	gol/cegou	heel/heal		rio
hole	hoe				io
	joe		congeal		dio
	low	falou	keel		
mole	mow	amou			lio
	know		meal		mio/mil
pole	Poe	empou	neal		
role	row		peel		pio
sole/soul	sew	sou	real		
shoal	show	show	seal		cio
stole		estou	she'll		chio
toll	tow	estou/catou	teal		tio/til
vole		vou/vôo	veal		vil
	whoa		wheel		
	yo		zeal		

<b>/uɪ/</b>	<b>/u/</b>	<b>Portuguese</b>	<b>/eɪl/</b>	<b>/eɪʊ/</b>	<b>Portuguese</b>
cool	boo coo chew	facul	bail kale dale		
dool	do		fail		feio
fool	foo	ful	gail		
ghoul	goo		hail		reio
who'll	hoo		jail		
joule	Jew		kale		
kool	Kew		mail		meio
mule	Lou mew new		nail pail quail		
pool	poo queue	pul	rail sail		seio cheio
rule			shale		
sue'll	sue	sul	tail		
shoe'll	shoe	chuchu	vail/veil		veio
tool	too oo woo		whale yale ail		
yule	you zoo				

<b>/ɔɪ/</b>	<b>/ɔʊ/</b>	<b>Portuguese</b>	<b>/æɪ/</b>	<b>/aʊ/</b>	<b>Portuguese</b>
awl			al	ow	al
bawl		futebol		bow	BAL
cawl		skol	cal	cow	cal
doll				dow	dal
gaul			fal		
haul		rol skol	gal/gall hal	how	gal
knoll		nó	mal		mal
maul		mol	nal	now	nau
paul		pó	pal		pau/PAL
saul		sol	sal	sow	sal
shawl			val		tal val

<b>/aʊl/</b>	<b>/aʊ/</b>	<b>Portuguese</b>	<b>/aʊl/</b>	<b>/aʊ/</b>	<b>Portuguese</b>
owl	ow	al	pow(e)ll	pow	pau qual
	bow	bal			
cowl	cow	cal		row	
	chow	tchau		sow	sal
dowel	dow	dal	shall		
fowl			tow(e)l		tal
	gal	gal	vowel	vow	val
howl	how		yowl	wow	
jowl					
	Mao	mal			
	now				

## Appendix 5: Reanalysis without participant IK

### A5.1 Considering IK's responses

One participant in the Intermediate group, who shall be identified as IK, stood out from the rest for his unusual results. IK's error rate on Test 1, the first CDT, was much higher than his error rate on any of the other tests at 56.36% with only one non-response. This extreme error rate was identified as an outlier on a boxplot of Test 1 error rates in the software Minitab and by Grubb's test. Several possibilities could explain this anomaly - an error in his responses, confusion surrounding the test, or genuine poor performance.

Misrecording responses, the simplest error to discover, was tested for by taking responses after the non-response and shifting them one cell in either direction to see whether the pattern of errors changed dramatically. It barely changed at all. Since all responses were checked twice when entered into the computer, recording error on the part of the researcher was ruled out as well.

Could the results have been due to confusion? IK's error rate on Test 1 was 56.36%, while his error rates were 25.00%, 14.29%, 0.00%, 15.79% and 31.25% on Tests 2 through 6, respectively. There were only two non-responses, on Tests 1 and 5. The second-highest error rate on Test 1, from an Advanced student whose error rates were generally high, AN, was 33.93%, more than 22 percentage points lower. IK's high error rate on Test 1 compared to the other tests would seem to suggest that it confused him. Further suggesting that confusion was at the root of his poor performance, he made no errors on the /aɪ/, /ɛ/, and /eɪ/ vowel contexts anywhere but in the first test.

However, a close examination of his results found that IK performed very well in both Test 1 (25%) and overall (16.67%) in the /u/ context, despite his high *total* number of errors in Test 1. Too, the vowel contexts with his worst error rates on Test 1

remained the two contexts with the worst performance on the other English/Portuguese tests when Test 1 was removed. Most confounding to the notion of confusion as the fault forming factor is that Test 2, on which his error rate was only 25%, was also a CDT, and neither new directions nor review were provided between the tests. Confusion alone seems unlikely as the source of error.

**Table A5.1: IK's error numbers**

<b>Vowel</b>	<b>Error % Test 1 Only</b>	<b>Overall Error% Test 1 included</b>	<b>Overall Error % Test 1 removed</b>
/ɛ/	62.5%	31.3%	0.0%
/ɔ/	87.5%	64.3%	33.3%
/i/	75.0%	50.0%	25.0%
/o/	62.5%	35.5%	26.1%
/u/	25.0%	16.7%	13.6%
/aɪ/	25.0%	6.7%	0.0%
/eɪ/	57.1%	30.8%	0.0%

As you will recall, tests with high non-response rates were considered a mark of confusion for these analyses, and were entirely removed from consideration in the initial analysis on a test-wise basis. But because IK's high error rate could not be attributed conclusively and solely to confusion, his Test 1 could not be considered in the same class as test responses with greater than 20% error rates.

To address IK's odd response here, the Total Error Rate analysis, all vowel context analyses except /aʊ/, and the analysis of Test 1 were performed twice: once including his responses in Test 1 and once without them. The Total Error Rate analysis and each vowel context analysis would be affected by the removal of an entire test from evaluation, so each was analyzed again. But for analysis of the total error rates by test, only Test 1 would need a second analysis.

## A5.2 Total Error Rate analysis

As with earlier analyses, the Kruskal-Wallis test was used to compare Total Error Rates among the groups. Results were very similar numerically and supported the same statistical conclusions with a high degree of statistical certainty (see table below).

## A5.3 Vowel Context analyses

The same type of analysis, one-way ANOVA or Kruskal-Wallis, was used to analyze the results in the various vowel contexts without IK's Test 1. Most results featured very similar  $p$  values to the principal analysis, and all supported the same conclusions as the original tests (see table below). All F values in the ANOVAs below are for F(2,46).

**Table A5.3: Total Error Rate and Vowel analysis with and without IK's Test 1**

Test	With IK	No IK	Conclusion
Kruskal-Wallis: TE vs. class	$p = 0.001$	$p = 0.001$	at least two groups different Int and Adv not significantly different, NS < Int and Adv
One-way ANOVA: /ɛ/ vs. class	$p = 0.158$	$p = 0.093$ F = 2.51	no significant differences
One-way ANOVA: /ɔ/ vs. class	$p = 0.000$	$p = 0.000$ F = 11.44	at least two groups different Int and Adv not significantly different, NS < Int and Adv
Kruskal-Wallis: /i/ vs. class	$p = 0.277$	$p = 0.272$	no significant differences
One-way ANOVA: /o/ vs. class	$p = 0.005$	$p = 0.005$ F = 5.96	at least two groups different Int and Adv not significantly different, NS < Int and Adv
One-way ANOVA: /u/ vs. class	$p = 0.033$	$p = 0.034$ F = 3.65	at least two groups different Int and Adv not significantly different, NS < Int and Adv
One-way ANOVA: /aɪ/ vs. class	$p = 0.129$	$p = 0.093$ F = 2.50	no significant differences
Kruskal-Wallis: /eɪ/ vs. class	$p = 0.815$	$p = 0.533$	no significant differences

Though the results for /u/ without IK's Test 1 were consistent with the first analysis, remember that the second analysis found no differences among the groups.

#### A5.4 Test 1 analysis

**Table A5.4: Test 1 analysis with and without IK's Test 1**

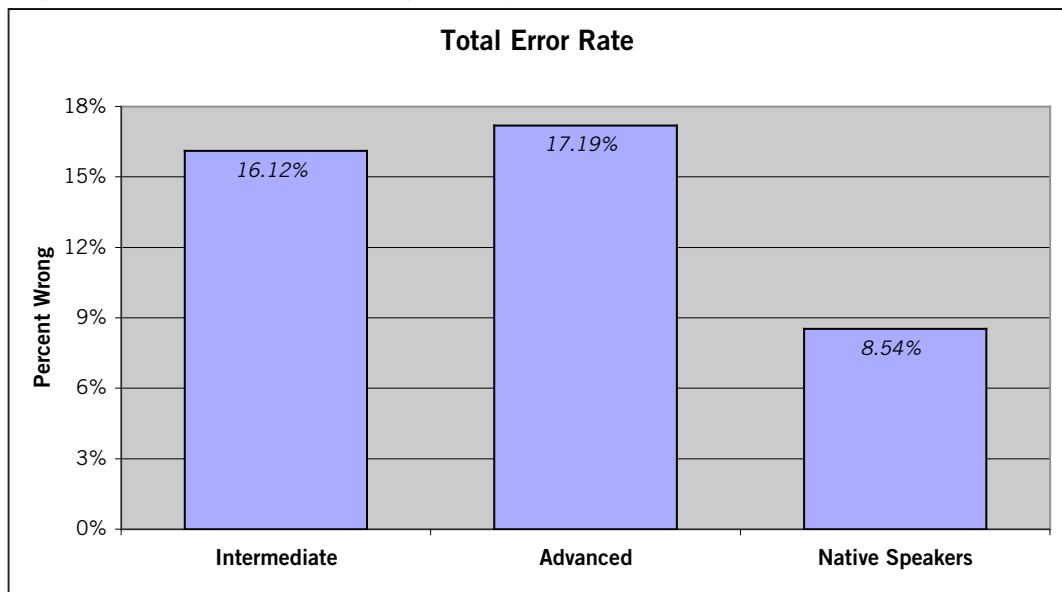
<b>Means</b>	<b>With IK</b>	<b>No IK</b>
Intermediate	14.20%	11.72%
Advanced	15.61%	15.61%
Native Speakers	7.74%	7.74%
<b>Analyses</b>		
<i>With IK</i>		
Kruskal-Wallis:	$p = 0.128$ adjusted for ties, no significant differences	
<i>No IK</i>		
Kruskal-Wallis:	$p = 0.150$ adjusted for ties, first finding supported	

In the case of Test 1 compared by group, IK's inclusion makes no difference. Without IK, Kruskal-Wallis finds that there is no difference ( $p = 0.150$ ) among the groups, confirming the original findings.

## Appendix 6: Reanalysis of Brazilians Ages 18-30 Only

In this appendix, three graphs summarize the results of statistical tests performed using only data from participants between the ages of 18 and 30. Minitab's raw output follows the graphs.

**Graph A6.1: Total Error Rates Compared (Ages 18-30)**




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### Test

TE vs. class: Kruskal-Wallis

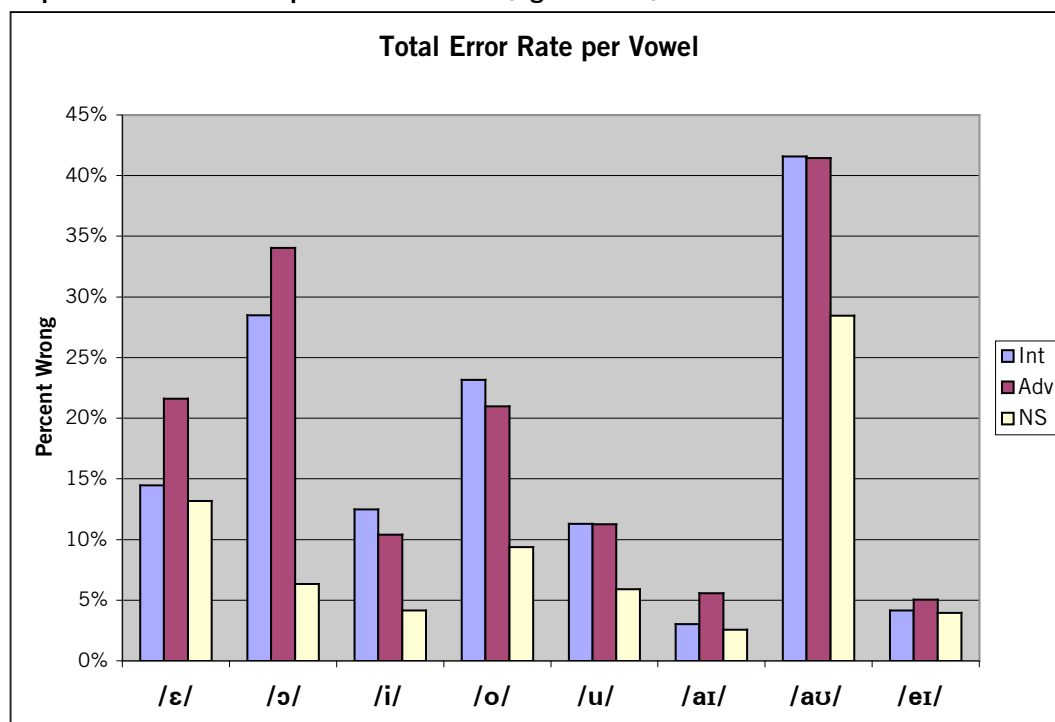
### Conclusion

Int and Adv not significantly different, NS < Int and Adv

---



Graph A6.2: Error Rates per Vowel Context (Ages 18-30)



	/ɛ/	/ɔ/	/i/	/o/	/u/	/aɪ/	/aʊ/	/eɪ/
<b>Intermediate</b>	14.25%	29.44 %	12.50%	21.81%	11.84%	3.80%	38.39%	3.96%
<b>Advanced</b>	21.07%	34.67%	10.42%	20.74%	11.72%	6.81%	38.54%	4.68%
<b>Native Speakers</b>	13.19%	<b>6.35%*</b>	4.17%	<b>9.39%*</b>	<b>5.93%*</b>	2.59%	28.47%	3.97%

**Test**

/ɛ/ vs. class: 1-way ANOVA

/ɔ/ vs. class: 1-way ANOVA

/i/ vs. class: Kruskal-Wallis

/o/ vs. class: 1-way ANOVA

/u/ vs. class: 1-way ANOVA

/aɪ/ vs. class: 1-way ANOVA

/aʊ/ vs. class: 1-way ANOVA

/eɪ/ vs. class: Kruskal-Wallis

**Conclusion**

no significant differences

Int and Adv not significantly different, NS &lt; Int and Adv

no significant differences

Int and Adv not significantly different, NS &lt; Int and Adv

Int and Adv not significantly different, NS &lt; Int and Adv

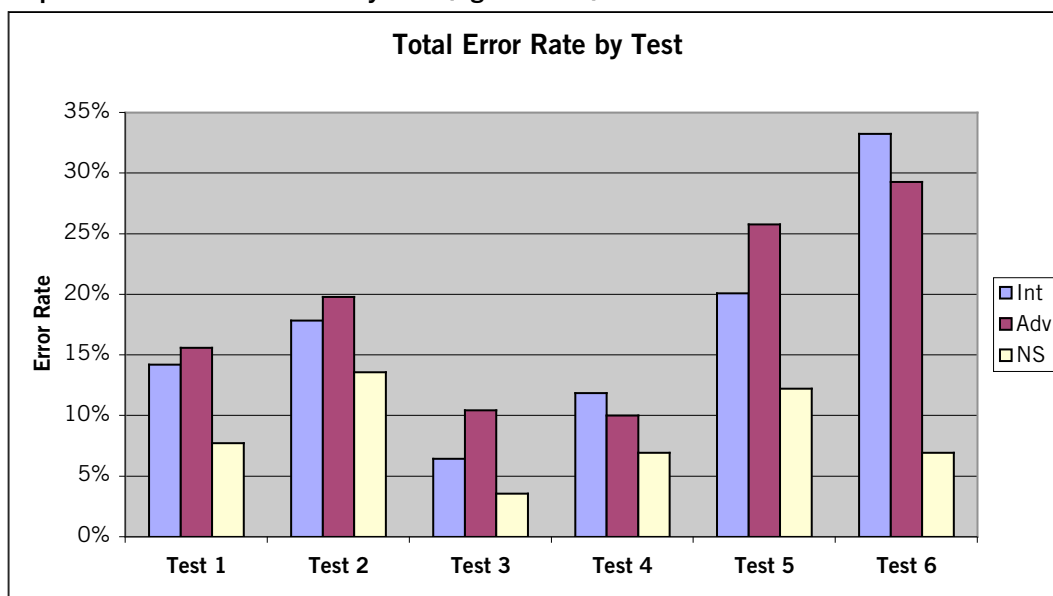
no significant differences

no significant differences

no significant differences

\* Significantly lower than Intermediate and Advanced.

Graph A6.3: Total Error Rates by Test (Ages 18-30)



	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
<b>Intermediate</b>	15.34%	16.47%	6.43%	10.00%	20.44%	33.94%
<b>Advanced</b>	16.49%	19.71%	10.44%	9.82%	23.99%	28.48%
<b>Native Speakers</b>	7.74%	13.58%	3.57%	6.94%	<b>12.22%**</b>	<b>6.94%*</b>

Test 1: Kruskal-Wallis no significant differences

Test 2: 1-way ANOVA no significant differences

Test 3: Kruskal-Wallis no significant differences

Test 4: 1-way ANOVA no significant differences

Test 5: 1-way ANOVA Int not significantly different from Adv and NS, NS < Adv

Test 6: 1-way ANOVA Int and Adv not significantly different, NS < Int and Adv

\* Significantly lower than Intermediate and Advanced. \*\* Significantly lower than Advanced

## Minitab 15.1.1.0 Output for Ages 18-30

Results for: the numbers 18-30

### Kruskal-Wallis Test: TE versus Class

Class	N	Median	Ave Rank	Z
1	15	0.14286	22.5	1.36
2	14	0.16419	23.4	1.65
3	9	0.07738	8.4	-3.43
Overall	38		19.5	

H = 11.83 DF = 2 P = 0.003  
H = 11.85 DF = 2 P = 0.003 (adjusted for ties)

Means and StDev				Individual 95% CIs For Mean Based on Pooled StDev			
Level	N	Mean	StDev	-----+-----+-----+-----			
1	15	0.16119	0.06467	(-----*-----)			
2	14	0.17185	0.07538	(-----*-----)			
3	9	0.08536	0.03417	(-----*-----)			
				-----+-----+-----+-----			
				0.050	0.100	0.150	0.200

Pooled StDev = 0.06365

### Mann-Whitney Test and CI: TE\_1, TE\_2

	N	Median
TE_1	15	0.1429
TE_2	14	0.1642

Point estimate for ETA1-ETA2 is -0.0065  
95.3 Percent CI for ETA1-ETA2 is (-0.0546,0.0357)  
W = 219.5  
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.8273  
The test is significant at 0.8272 (adjusted for ties)

### Mann-Whitney Test and CI: TE\_1, TE\_3

	N	Median
TE_1	15	0.14286
TE_3	9	0.07738

Point estimate for ETA1-ETA2 is 0.06299  
95.1 Percent CI for ETA1-ETA2 is (0.02977,0.10713)  
W = 238.5  
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.0026  
The test is significant at 0.0026 (adjusted for ties)

### Mann-Whitney Test and CI: TE\_2, TE\_3

	N	Median
TE_2	14	0.16419
TE_3	9	0.07738

Point estimate for ETA1-ETA2 is 0.07441  
95.3 Percent CI for ETA1-ETA2 is (0.02974,0.13298)  
W = 217.0  
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.0022  
The test is significant at 0.0022 (adjusted for ties)

**One-way ANOVA: openE versus Class**

Source	DF	SS	MS	F	P
Class	2	0.0467	0.0233	1.40	0.260
Error	35	0.5831	0.0167		
Total	37	0.6297			

S = 0.1291    R-Sq = 7.41%    R-Sq(adj) = 2.12%

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
1	15	0.1425	0.1020	-----+-----+-----+-----+----- (-----*-----)
2	14	0.2107	0.1655	(-----*-----)
3	9	0.1319	0.1010	(-----*-----) -----+-----+-----+-----+-----
				0.060    0.120    0.180    0.240

Pooled StDev = 0.1291

**One-way ANOVA: openO versus Class**

Source	DF	SS	MS	F	P
Class	2	0.4704	0.2352	8.90	0.001
Error	35	0.9252	0.0264		
Total	37	1.3957			

S = 0.1626    R-Sq = 33.71%    R-Sq(adj) = 29.92%

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
1	15	0.2944	0.1582	-----+-----+-----+-----+----- (-----*-----)
2	14	0.3467	0.2019	(-----*-----)
3	9	0.0635	0.0753	(-----*-----) -----+-----+-----+-----+-----
				0.00    0.15    0.30    0.45

Pooled StDev = 0.1626

Tukey 95% Simultaneous Confidence Intervals  
All Pairwise Comparisons among Levels of Class

Individual confidence level = 98.04%

Class = 1 subtracted from:

Class	Lower	Center	Upper	-----+-----+-----+-----+-----
2	-0.0955	0.0523	0.2001	(-----*-----)
3	-0.3986	-0.2309	-0.0632	(-----*-----)
				-----+-----+-----+-----+-----
				-0.25    0.00    0.25    0.50

Class = 2 subtracted from:

Class	Lower	Center	Upper	-----+-----+-----+-----+-----
3	-0.4531	-0.2832	-0.1132	(-----*-----)
				-----+-----+-----+-----+-----
				-0.25    0.00    0.25    0.50

**Kruskal-Wallis Test: i versus Class**

Class	N	Median	Ave Rank	Z
1	15	0.06250	20.8	0.57
2	14	0.06250	21.4	0.82
3	9	0.06250	14.4	-1.58
Overall	38		19.5	

H = 2.52    DF = 2    P = 0.284

H = 2.76    DF = 2    P = 0.252 (adjusted for ties)



Tukey 95% Simultaneous Confidence Intervals  
All Pairwise Comparisons among Levels of Class

Individual confidence level = 98.04%

Class = 1 subtracted from:

Class	Lower	Center	Upper	
2	-0.04825	-0.00121	0.04584	(-----*-----)
3	-0.11250	-0.05912	-0.00575	(-----*-----)

-----+-----+-----+-----+  
-0.060      0.000      0.060      0.120

Class = 2 subtracted from:

Class	Lower	Center	Upper	
3	-0.11200	-0.05792	-0.00383	(-----*-----)

-----+-----+-----+-----+  
-0.060      0.000      0.060      0.120

**One-way ANOVA: ai versus Class**

Source	DF	SS	MS	F	P
Class	2	0.01143	0.00572	2.93	0.067
Error	35	0.06834	0.00195		
Total	37	0.07978			

S = 0.04419    R-Sq = 14.33%    R-Sq(adj) = 9.43%

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
1	15	0.03798	0.04256	(-----*-----)
2	14	0.06811	0.04635	(-----*-----)
3	9	0.02593	0.04339	(-----*-----)

-----+-----+-----+-----+  
0.000      0.025      0.050      0.075

Pooled StDev = 0.04419

**One-way ANOVA: au versus Class**

Source	DF	SS	MS	F	P
Class	2	0.0686	0.0343	1.81	0.178
Error	35	0.6624	0.0189		
Total	37	0.7310			

S = 0.1376    R-Sq = 9.38%    R-Sq(adj) = 4.21%

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
1	15	0.3839	0.1587	(-----*-----)
2	14	0.3854	0.1263	(-----*-----)
3	9	0.2847	0.1132	(-----*-----)

-----+-----+-----+-----+  
0.210      0.280      0.350      0.420

Pooled StDev = 0.1376

**Kruskal-Wallis Test: ei versus Class**

Class	N	Median	Ave Rank	Z
1	15	0.000000000	18.3	-0.54
2	14	0.000000000	19.8	0.14
3	9	0.000000000	21.0	0.46
Overall	38		19.5	

H = 0.35    DF = 2    P = 0.839  
H = 0.50    DF = 2    P = 0.780 (adjusted for ties)

Means and StDev				Individual 95% CIs For Mean Based on Pooled StDev			
Level	N	Mean	StDev	-----+-----+-----+-----+-----			
1	15	0.03956	0.08528	(-----*-----)			
2	14	0.04677	0.09575	(-----*-----)			
3	9	0.03968	0.05189	(-----*-----)			
				-----+-----+-----+-----+-----			
				0.000	0.030	0.060	0.090

Pooled StDev = 0.08324

#### Kruskal-Wallis Test: t1 versus Class

35 cases were used  
3 cases contained missing values

Class	N	Median	Ave Rank	Z
1	13	0.10714	20.3	1.01
2	13	0.17857	19.3	0.58
3	9	0.07143	12.8	-1.76
Overall	35		18.0	

H = 3.14 DF = 2 P = 0.208  
H = 3.17 DF = 2 P = 0.205 (adjusted for ties)

Means and StDev				Individual 95% CIs For Mean Based on Pooled StDev			
Level	N	Mean	StDev	+-----+-----+-----+-----+-----			
1	13	0.1535	0.1342	(-----*-----)			
2	13	0.1649	0.1201	(-----*-----)			
3	9	0.0774	0.0346	(-----*-----)			
				+-----+-----+-----+-----+-----			
				0.000	0.060	0.120	0.180

Pooled StDev = 0.1116

#### One-way ANOVA: t2 versus Class

Source	DF	SS	MS	F	P
Class	2	0.02051	0.01025	1.23	0.306
Error	34	0.28435	0.00836		
Total	36	0.30486			

S = 0.09145 R-Sq = 6.73% R-Sq(adj) = 1.24%

Means and StDev				Individual 95% CIs For Mean Based on Pooled StDev			
Level	N	Mean	StDev	-----+-----+-----+-----+-----			
1	15	0.16465	0.09473	(-----*-----)			
2	13	0.19712	0.10395	(-----*-----)			
3	9	0.13575	0.06026	(-----*-----)			
				-----+-----+-----+-----+-----			
				0.100	0.150	0.200	0.250

Pooled StDev = 0.09145

#### Kruskal-Wallis Test: t3 versus Class

Class	N	Median	Ave Rank	Z
1	15	0.03571	19.6	0.04
2	14	0.07143	23.0	1.50
3	9	0.03571	13.8	-1.75
Overall	38		19.5	

H = 3.76 DF = 2 P = 0.153  
H = 4.06 DF = 2 P = 0.131 (adjusted for ties)

Means and StDev				Individual 95% CIs For Mean Based on Pooled StDev			
Level	N	Mean	StDev	-----+-----+-----+-----+-----			
1	15	0.06429	0.05263	(-----*-----)			
2	14	0.10440	0.11610	(-----*-----)			
3	9	0.03571	0.03571	(-----*-----)			
				0.000	0.050	0.100	0.150

Pooled StDev = 0.08004

**One-way ANOVA: t4 versus Class**

Source	DF	SS	MS	F	P
Class	2	0.00608	0.00304	0.47	0.629
Error	35	0.22624	0.00646		
Total	37	0.23232			

S = 0.08040 R-Sq = 2.62% R-Sq(adj) = 0.00%

Means and StDev				Individual 95% CIs For Mean Based on Pooled StDev			
Level	N	Mean	StDev	-----+-----+-----+-----+-----			
1	15	0.10000	0.07008	(-----*-----)			
2	14	0.09821	0.10318	(-----*-----)			
3	9	0.06944	0.04886	(-----*-----)			
				0.035	0.070	0.105	0.140

Pooled StDev = 0.08040

**One-way ANOVA: TE5% versus class**

Source	DF	SS	MS	F	P
class	2	0.0750	0.0375	3.36	0.047
Error	34	0.3800	0.0112		
Total	36	0.4551			

S = 0.1057 R-Sq = 16.49% R-Sq(adj) = 11.58%

Means and StDev				Individual 95% CIs For Mean Based on Pooled StDev			
Level	N	Mean	StDev	-----+-----+-----+-----+-----			
1	15	0.2044	0.1055	(-----*-----)			
2	13	0.2399	0.0973	(-----*-----)			
3	9	0.1222	0.1176	(-----*-----)			
				0.070	0.140	0.210	0.280

Pooled StDev = 0.1057

Tukey 95% Simultaneous Confidence Intervals  
All Pairwise Comparisons among Levels of class

Individual confidence level = 98.06%

class = 1 subtracted from:

class	Lower	Center	Upper	-----+-----+-----+-----+-----			
2	-0.0628	0.0355	0.1338	(-----*-----)			
3	-0.1915	-0.0822	0.0272	(-----*-----)			
				-0.12	0.00	0.12	0.24

class = 2 subtracted from:

class	Lower	Center	Upper	-----+-----+-----+-----+-----			
3	-0.2301	-0.1177	-0.0052	(-----*-----)			
				-0.12	0.00	0.12	0.24



**One-way ANOVA: TE6% versus class**

Source	DF	SS	MS	F	P
class	2	0.4293	0.2146	14.98	0.000
Error	35	0.5014	0.0143		
Total	37	0.9307			

S = 0.1197    R-Sq = 46.13%    R-Sq(adj) = 43.05%

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
1	15	0.3394	0.1430	(-----*-----)
2	14	0.2848	0.1126	(-----*-----)
3	9	0.0694	0.0793	(-----*-----)

+-----+-----+-----+-----+  
0.00      0.12      0.24      0.36

Pooled StDev = 0.1197

Tukey 95% Simultaneous Confidence Intervals  
All Pairwise Comparisons among Levels of class

Individual confidence level = 98.04%

class = 1 subtracted from:

class	Lower	Center	Upper	-----+-----+-----+-----
2	-0.1634	-0.0546	0.0542	(-----*-----)
3	-0.3935	-0.2700	-0.1465	(-----*-----)

+-----+-----+-----+-----+  
-0.40      -0.20      0.00      0.20

class = 2 subtracted from:

class	Lower	Center	Upper	-----+-----+-----+-----
3	-0.3405	-0.2154	-0.0903	(-----*-----)

+-----+-----+-----+-----+  
-0.40      -0.20      0.00      0.20

## Appendix 7: All Universal correlations

Exhaustive correlation analysis of sex and age was also performed using listwise deletion and with outliers removed. Outliers were removed on the same basis as they were removed from the Brazilian-only correlation tests. One item per group was shown to be a mild outlier on boxplots in Minitab, but this finding was not confirmed by Grubb's test. Again, analysis was performed out of curiosity. The results did not differ extremely from the original analysis with the exception of "Brazilians only, no outliers - Sex." Both outliers were male, and this obviously affected the outcome of the correlation equation for sex and Total Error Rate. Still, no findings were significant.

**Chart A7.1: Universal Correlations – Exhaustive Analysis**

Variable	Measurement	Test type	Result
All Groups - Sex	male/female	point-biserial	$r = -0.071, p = 0.628$
All Groups - Age	numerical age	Pearson's r	$r = -0.036, p = 0.808$
All Groups, no outliers - Sex	male/female	point-biserial	$r = -0.225, p = 0.128$
All Groups, no outliers - Age	numerical age	Pearson's r	$r = -0.011, p = 0.941$
Brazilians only - Sex	male/female	point-biserial	$r = -0.066, p = 0.685$
Brazilians only - Age	numerical age	Pearson's r	$r = 0.055, p = 0.734$
Brazilians only, no NR - Sex	male/female	point-biserial	$r = -0.165, p = 0.422$
Brazilians only, no NR - Age	numerical age	Pearson's r	$r = 0.109, p = 0.595$
Brazilians only, no outliers - Sex	male/female	point-biserial	$r = -0.273, p = 0.098$
Brazilians only, no outliers - Age	numerical age	Pearson's r	$r = 0.096, p = 0.565$

## Appendix 8: All Intermediate and Advanced correlations for Brazilian students

**Table A8.1a Correlations: primary analysis**

Variable	Measurement	Test type	Result
Place of origin	region (S, SE, CW, NE)	ANOVA	$p = 0.491$
Accent heard when growing up	region (S, SE, other)	ANOVA	$p = 0.954$
Self-reported accent	region (S, SE, indeterminate)	ANOVA	$p = 0.727$
Teacher's evaluation of student	above avg, avg, below avg	Pearson's r	$r = -0.269, p = 0.094$
English-speaking country exp.	none, little, extensive	Pearson's r	$r = 0.231, p = 0.152$
Other foreign country experience	yes/no	point-biserial	$r = -0.124, p = 0.451$
Native speaker audio in class	none, little, much	Pearson's r	$r = -0.125, p = 0.443$
Speak other languages?	yes/no	point-biserial	$r = -0.094, p = 0.569$
Other native Eng-speaking teacher?	yes/no	point-biserial	◆ $r = 0.298, p = 0.065$
Contact w/ Continental Portuguese?	none, little, much	Pearson's r	$r = 0.004, p = 0.982$
Contact with older Riograndenses?	yes/no	point-biserial	◆ $r = -0.308, p = 0.056$
Contact with NS of English	little outside class, regular	point-biserial	$r = 0.082, p = 0.627$

**Table A8.1b Correlations: no non-responders**

Variable	Measurement	Test type	Result
Place of origin	region (S, SE, CW)	ANOVA	$p = 0.855$
Accent heard when growing up	region (S, SE, other)	ANOVA	$p = 0.444$
Self-reported accent	region (S, SE, indeterminate)	ANOVA	$p = 0.504$
Teacher's evaluation of student	above avg, avg, below avg	Pearson's r	$r = -0.202, p = 0.322$
English-speaking country exp.	none, little, extensive	Pearson's r	$r = 0.306, p = 0.128$
Other foreign country experience	yes/no	point-biserial	$r = -0.217, p = 0.286$
Native speaker audio in class	none, little, much	Pearson's r	$r = 0.045, p = 0.826$
Speak other languages?	yes/no	point-biserial	◆ $r = -0.372, p = 0.061$
Other native Eng-speaking teacher?	yes/no	point-biserial	$r = 0.308, p = 0.125$
Contact w/ Continental Portuguese?	none, little, much	Pearson's r	$r = -0.145, p = 0.478$
Contact with older Riograndenses?	yes/no	point-biserial	◆ $r = -0.406, p = 0.039$
Contact with NS of English	little outside class, regular	point-biserial	$r = 0.015, p = 0.945$

**Table A8.1c Correlations: no outliers**

Variable	Measurement	Test type	Result
Place of origin	region (S, SE, CW, NE)	ANOVA	$p = 0.811$
Accent heard when growing up	region (S, SE, other)	ANOVA	$p = 0.685$
Self-reported accent	region (S, SE, indeterminate)	ANOVA	$p = 0.579$
Teacher's evaluation of student	above avg, avg, below avg	Pearson's r	$r = -0.178, p = 0.285$
English-speaking country experience	none, little, extensive	Pearson's r	$r = 0.225, p = 0.175$
Other foreign country experience	yes/no	point-biserial	$r = -0.160, p = 0.343$
Native speaker audio in class	none, little, much	Pearson's r	$r = -0.116, p = 0.489$
Speak other languages?	yes/no	point-biserial	$r = -0.239, p = 0.154$
Other native Eng-speaking teacher?	yes/no	point-biserial	◆ $r = 0.339, p = 0.040$
Contact w/ Continental Portuguese?	none, little, much	Pearson's r	$r = -0.110, p = 0.518$
Contact with older Riograndenses?	yes/no	point-biserial	◆ $r = -0.447, p = 0.006$
Contact with NS of English	little outside class, regular	point-biserial	$r = 0.169, p = 0.332$

### Appendix 9: Results summarized by vowel

Participants are listed by code, with the first letter indicating Intermediate, Advanced or Native Speaker. All numbers are error percentages.

Code	/ɛ/	/ɔ/	/i/	/o/	/u/	/aɪ/	/eɪ/	/aʊ/	TE%
IA	0.00	42.86	0.00	21.88	13.33	0.00	0.00	43.75	14.29
IB	25.00	35.71	6.25	18.75	10.00	3.33	7.14	37.50	16.07
IC	0.00	33.33	25.00	16.67	18.18	9.09	0.00	37.50	17.86
ID	6.25	28.57	18.75	21.88	10.00	0.00	0.00	25.00	13.10
IE	12.50	28.57	6.25	6.25	3.33	0.00	0.00	25.00	8.33
IF	0.00	7.14	6.25	25.00	6.67	0.00	0.00	31.25	10.12
IG	12.50	28.57	6.25	25.00	3.33	3.33	0.00	50.00	14.88
IH	25.00	25.00	9.09	26.67	11.54	3.85	16.67	37.50	18.62
II	6.25	21.43	6.25	31.25	10.00	0.00	7.14	50.00	16.07
IJ	7.14	21.43	0.00	12.90	10.00	0.00	0.00	37.50	10.30
IK	31.25	64.29	50.00	35.48	16.67	6.67	30.77	43.75	30.72
IL	31.25	14.29	6.25	31.25	10.34	0.00	0.00	75.00	19.76
IM	18.75	21.43	0.00	15.63	6.67	0.00	0.00	43.75	11.90
IN	25.00	21.43	6.25	9.38	10.00	0.00	7.14	25.00	11.31
IO	25.00	0.00	37.50	25.00	22.73	4.55	0.00	43.75	21.43
IP	20.00	15.38	0.00	28.13	10.00	3.33	0.00	7.14	11.66
IQ	18.75	28.57	6.25	18.75	16.67	10.00	0.00	56.25	18.45
IR	6.25	46.15	0.00	34.38	6.67	0.00	0.00	56.25	17.37
IS	12.50	42.86	18.75	43.75	16.67	13.33	14.29	75.00	28.57
IT	6.25	42.86	0.00	15.63	13.33	3.33	0.00	31.25	13.10
AA	25.00	64.29	0.00	40.63	10.00	6.67	0.00	56.25	23.81
AB	6.25	8.33	6.25	6.25	10.00	6.67	7.14	33.33	9.70
AC	6.25	57.14	0.00	18.75	16.67	3.33	0.00	50.00	17.26
AD	6.25	14.29	6.25	12.50	6.67	10.00	0.00	18.75	9.52
AE	18.75	28.57	12.50	25.00	3.33	0.00	7.14	43.75	15.48
AF	50.00	57.14	6.25	50.00	13.33	3.33	0.00	50.00	27.38
AG	12.50	21.43	12.50	18.75	16.67	10.00	0.00	37.50	16.07
AH	20.00	21.43	0.00	32.26	13.33	0.00	7.14	43.75	16.87
AI	25.00	25.00	8.33	13.33	3.57	11.54	8.33	25.00	13.51
AJ	25.00	35.71	12.50	7.69	7.69	0.00	0.00	54.55	13.91
AK	12.50	14.29	12.50	3.13	10.00	6.67	0.00	25.00	9.52
AL	0.00	50.00	0.00	15.38	16.67	0.00	0.00	37.50	15.52
AM	43.75	57.14	25.50	18.75	13.33	10.00	7.14	25.00	22.02
AN	50.00	61.54	43.75	32.26	23.33	16.67	35.71	50.00	34.94
AO	12.50	35.71	0.00	31.25	6.67	0.00	14.29	43.75	16.67
AP	12.50	33.33	12.50	6.25	7.14	7.14	0.00	37.50	12.50
AQ	0.00	21.43	6.25	21.88	6.67	0.00	0.00	31.25	10.71
AR	56.25	38.46	18.75	25.00	24.14	13.33	0.00	60.00	27.61
AS	25.00	7.14	6.25	25.00	3.33	3.33	14.29	50.00	15.48
AT	25.00	28.57	6.25	15.63	13.33	3.33	0.00	56.25	16.77
NA	12.50	14.29	6.25	9.38	3.33	0.00	0.00	18.75	7.14
NB	0.00	0.00	0.00	6.25	0.00	3.33	0.00	18.75	3.57
NC	31.25	14.29	12.50	12.50	13.33	0.00	0.00	25.00	12.50
ND	18.75	14.29	6.25	15.63	6.67	0.00	0.00	50.00	12.50
NE	6.25	0.00	0.00	15.63	6.67	0.00	7.14	31.25	8.33
NF	18.75	0.00	6.25	9.38	10.00	13.33	7.14	43.75	13.10
NG	18.75	0.00	0.00	0.00	6.67	3.33	0.00	18.75	5.36
NH	0.00	0.00	6.25	12.50	6.67	3.33	7.14	25.00	7.74
NI	12.50	14.29	0.00	3.23	0.00	0.00	14.29	25.00	6.59

### Appendix 10: Results summarized by test

Participants are listed by code, with the first letter indicating Intermediate, Advanced or Native Speaker. As indicated in the text, some tests were entirely removed from consideration. All numbers are error percentages.

Code	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6
IA	10.71	18.75	7.14	12.50	10.00	37.50
IB	8.93	12.50	10.71	12.50	35.00	37.50
IC		21.88	10.71	18.75	15.00	25.00
ID	12.50	12.50	3.57	0.00	25.00	31.25
IE	5.36	12.50	14.29	0.00	10.00	6.25
IF	7.14	15.63	0.00	6.25	15.00	25.00
IG	12.50	18.75	3.57	18.75	20.00	25.00
IH	16.36	21.88	14.29	18.75		28.57
II	8.93	25.00	14.29	18.75	5.00	37.50
IJ	7.41	9.68	3.57	6.25	20.00	25.00
IK	56.36	25.00	14.29	0.00	15.79	31.25
IL	12.50	28.13	7.14	25.00	30.00	33.33
IM	8.93	15.63	3.57	0.00	15.00	37.50
IN	8.93	9.38	3.57	12.50	25.00	18.75
IO		12.50	3.57	12.50	50.00	43.75
IP	7.41	3.23	7.14	12.50	15.79	46.67
IQ	19.64	18.75	0.00	12.50	25.00	43.75
IR	10.91	25.00	10.71	18.75	20.00	31.25
IS	23.21	43.75	14.29	18.75	15.00	68.75
IT	17.86	6.25	0.00	12.50	15.00	31.25
AA	30.36	28.13	10.71	18.75	20.00	25.00
AB	3.70	12.50	0.00	6.25	15.00	40.00
AC	25.00	18.75	10.71	0.00	15.00	18.75
AD	3.57	6.25	3.57	0.00	30.00	31.25
AE	10.71	15.63	14.29	6.25	25.00	31.25
AF	26.79	37.50	10.71	12.50	35.00	43.75
AG	7.14	31.25	14.29	6.25	25.00	18.75
AH	7.14	25.00	3.57	31.25	21.05	40.00
AI	21.43	6.25	3.57	25.00		6.25
AJ	7.14	21.88	7.14	6.67	35.00	
AK	3.57	12.50	3.57	0.00	25.00	25.00
AL			14.81	6.25		26.67
AM	30.36	6.25	17.86	0.00	35.00	37.50
AN	33.93	25.00	46.15	18.75	45.00	43.75
AO	10.71	25.00	14.29	12.50	15.00	31.25
AP			14.29	0.00	15.00	18.75
AQ	3.57	18.75	3.57	12.50	15.00	25.00
AR	27.27	18.75	18.52	18.75	47.37	50.00
AS	10.71	18.75	10.71	12.50	30.00	18.75
AT	17.86	28.13	3.57	6.25	15.79	25.00
NA	10.71	9.38	0.00	0.00	15.00	0.00
NB	1.79	3.13	0.00	6.25	10.00	6.25
NC	12.50	15.63	3.57	6.25	35.00	0.00
ND	10.71	21.88	7.14	12.50	5.00	18.75
NE	7.14	15.63	3.57	0.00	15.00	6.25
NF	7.14	21.88	3.57	12.50	25.00	18.75
NG	3.57	12.50	3.57	12.50	0.00	0.00
NH	8.93	12.50	0.00	6.25	5.00	12.50
NI	7.14	9.68	10.71	6.25	0.00	0.00

## Appendix 11: Intermediate Group Demographics

Participant code	Sex	Age	Place of Origin - Brazilian state	Accent heard most when young	Self-reported accent	Level evaluation	Eng speaking country experience	Other foreign country experience	NS audio in class	Speak other languages	Other NS of English teacher	Lusitanian Portuguese contact	Contact with elderly Programadenses	Current level of contact w/ NS of Eng:
IA	f	22	MS	SC/PR	SC	1	2	y	1		yes	y	y	
IB	f	22	SC	RJ	???	1	2		0	y	Eng.	y	y	
IC	f	23	SC	SC	SC	1	0	y	2					
ID	f	20	SC	SC	SC	2	0		2	y				
IE	m	23	MG	MG	2	0	0	y	2	y				
IF	m	22	SP	SP	2	0	0	y	2	y				
IG	f	21	SC	SC	SC	1	0		0			y		
IH	m	15	SC	SC/SP	SC	1	0		2	y	Aust.	y		nr
II	m	48	SP	SP	???	0	2	y	2	y	US			
IJ	m	15	SC	RS/SC	SC	0	0	y	2			y		
IK	m	20	SC	German	SC	1	0		0	y				
IL	f	45	RJ	RJ/RS	RJ	0	2	y	0	y				
IM	f	21	SC	SC/RS	SC	1	0		2	y	US	y		
IN	f	23	SC	SC	SC	1	0	y	1	y		y		
IO	f	21	SC	SC	SC	1	0		2					
IP	m	26	BA	RS/SE	BA	1	1		0	y			y	
IQ	m	21	SP	SP	SP	1	0		2	y				
IR	m	53	SC	SC	???	1	1		nr	y				nr
IS	m	21	SP	SP	SP	1	0		2		Scot.			
IT	m	20	SC	SC	SC	2	0		0	y				

Brazilian state abbreviations are: BA Bahia, MG Minas Gerais, MS Mato Grosso do Sul, PR Paraná,

SC Santa Catarina, SE Sergipe, SP São Paulo, RJ Rio de Janeiro, RS Rio Grande do Sul

Eng speaking country experience: 0 = none, 1 = less than 3 months, 2 = long term stay

NS audio in class: 0 = little, 1 = some, 2 = significant amount

??? in Self-reported accent column means *indeterminate*

## Appendix 12: Advanced Group Demographics

Participant code	Sex	Age	Place of Origin	Accent heard most when young	Self-reported accent	Level evaluation	Eng Speaking Country Experience	Other foreign country experience	NS audio in class	Speak other languages	Other NS of English teacher	Contact with elderly Portuguese contact	Current level of contact w/ NS of Eng.
AA	f	21	SC	SC	1	0	0	0	0				
AB	m	20	PR	PR	1	0	0	nir					
AC	m	25	PR	PR	1	0	0	1		US			
AD	m	20	SC	MG, Lebanese RS/SC	2	0	0	2	y	US		y	
AE	f	41	RS	RS	1	0	0	0	y			y	
AF	f	22	SC	SC	2	2	2	2	y	Eng.		y	
AG	m	24	SC	SC	1	0	0	2	y	Eng.			
AH	m	23	SC	SP	1	2	2	2	y	Eng.			
AI	f	23	SC	SC, German	1	2	2	0					regularly
AJ	f	60	SC	SC, German	0	2	2	1	y	US			
AK	m	21	SC	SC	1	1	1	1	y	Aust.		y	
AL	f	65	SC	SC	1	1	1	0	y	Eng.		y	
AM	f	22	SC	PR/RJ	2	2	2	0		Eng.			
AN	m	30	SC	Florianópolis	0	2	2	2	y	US			
AO	f	37	SC	Florianópolis	1	2	2	0					
AP	m	22	SC	SC	1	0	0	2	y			y	
AQ	f	18	SC	SP	2	0	0	2	y				
AR	f	35	SC	SC	0	1	1	1	y	US			regularly
AS	f	48	RS	German	0	2	2	0	y	Scot.		y	regularly
AT	f	20	SC	SC	1	1	1	2	y	Eng., NZ			regularly

Brazilian state abbreviations are: BA Bahia, MG Minas Gerais, MS Mato Grosso do Sul, PR Paraná,

SC Santa Catarina, SE Sergipe, SP São Paulo, RJ Rio de Janeiro, RS Rio Grande do Sul

Eng speaking country experience: 0 = none, 1 = less than 3 months, 2 = long term stay

NS audio in class: 0 = little, 1 = some, 2 = significant amount

??? in Self-reported accent column means *indeterminate*

### Appendix 13: Native Speaker Group Demographics

Participant code	Sex	Age	Years in Brazil	Place of Origin
NA	f	20	1	US - Connecticut
NB	f	60	32	US - California
NC	m	40	8	UK - Manchester
ND	m	44	12	UK - London
NE	m	30	3	UK - Newcastle
NF	m	32	7	UK - London
NG	m	23	2	UK - London
NH	m	23	1	US - North Carolina
NI	f	23	2	US - Hawaii







### Appendix 14: Intermediate Responses – Tests 3 and 4

			IA	IB	IC	ID	IE	IF	IG	IH	II	IJ	IK	IL	IM	IN	IO	IP	IQ	IR	IS	IT	
<b>Test 3</b>	1	ɔ	cawl, cawl		X			X		X		X	X			X							
	2	o	goal goal						X		X			X			X						
	3	ɛ	cell ceu																				
	4	er	shale shale																				
	5	ar	bayou bayou																				
	6	ɔ	kol kol		X											X							
	7	i	feel feel			X		X		X	X			X									X
	8	ɛ	cell cell					X		X	X				X								
	9	u	fool fool																				
	10	o	goal goal					X						X									
	11	ɔ	cawl kol	X		X																	
	12	ɛ	ceu ceu																				
	13	ar	bile bile																				
	14	ar	bile bayou																				
	15	ɔ	kol cawl								X											X	X
	16	o	goal goal	X	X					X				X					X		X	X	X
	17	u	fool ful																				
	18	ɛ	ceu cell				X												X				X
	19	er	cheio shale																				
	20	ar	baio bile																				
	21	i	fio feel																				
	22	i	feel fio																				
	23	er	shale cheio																				
	24	u	fool fool			X																	
	25	u	ful ful																				
	26	o	goal gol																				
	27	i	fio fio																				
	28	er	cheio cheio																				
			IA	IB	IC	ID	IE	IF	IG	IH	II	IJ	IK	IL	IM	IN	IO	IP	IQ	IR	IS	IT	
<b>Test 4</b>	1	au	vowel vowel							X						X						X	
	2	u	fool foo																				
	3	au	vow vow							X				X									
	4	ar	bile bayou																				
	5	ar	bile bile			X																	
	6	u	foo foo							X	X			X									X
	7	au	vow vowel	X							X			X				X		X	X	X	X
	8	au	vowel vow	X		X				X		X	X		X			X	X	X	X	X	X
	9	o	toll tow														X						
	10	ar	bayou bayou		X					X													
	11	u	foo fool																				
	12	o	tow tow			X			X														
	13	u	fool fool						X														
	14	o	toll toll		X					X													
	15	ar	bayou bile																				
	16	o	tow toll																X		X		

## Appendix 14: Intermediate Responses – Tests 5 and 6

			IA	IB	IC	ID	IE	IF	IG	IH	II	IJ	IK	IL	IM	IN	IO	IP	IQ	IR	IS	IT	
<b>Test 5</b>	1	ε	Cell		X			X		nr				X		X							
	2	eɪ	Shale		X					nr	X												
	3	i	Fio		X		X			nr				X			X						
	4	ε	Ceu							nr							X						
	5	ɔ	Cawl					X		nr													
	6	ε	Fel		X				X	nr		X			X	X	X	X	X	X	X		
	7	o	Gol		X		X		X	nr		X	nr	X			X	X	X	X			X
	8	i	Piu				X		X	nr			X				X	nr					
	9	i	Feel							nr							X						
	10	ε	Fell							nr				X									
	11	aɪ	Pile							nr													
	12	u	Ful	X	X	X	X		X	X	nr		X	X	X	X	X	X	X	X	X	X	X
	13	o	Goal							nr								X					
	14	aɪ	Paio							nr								X					
	15	ɔ	Kol	X	X	X	X		X	nr		X	X	X	X	X	X	X	X	X	X	X	X
	16	aɪ	Baio							nr										X			
	17	u	Fool							nr								X					
	18	i	Peel			X				nr							X						
	19	aɪ	Bile							nr													X
	20	eɪ	Cheio							nr													
			IA	IB	IC	ID	IE	IF	IG	IH	II	IJ	IK	IL	IM	IN	IO	IP	IQ	IR	IS	IT	
<b>Test 6</b>	1	aʊ	Pow			X		X	X	X	X	X			X					X		X	
	2	aʊ	Pal	X	X		X	X						X	X			nr	X		X		
	3	u	Poo	X	X	X	X	X			X		X	nr	X	X	X	X	X	X	X	X	
	4	o	Foe							nr	X		X				X	X		X	X		
	5	u	Pool	X						nr							X					X	
	6	aʊ	Vow				X		X		X	X		X	X		X			X	X		
	7	u	Fool							nr							X					X	
	8	aɪ	Bile															X	X			X	X
	9	u	Foo	X	X	X	X			X		X	X	X		X	X	X	X			X	X
	10	aɪ	Bayou																				
	11	o	Foal							X	X												X
	12	o	Toll						X					X		X					X		
	13	aʊ	Vowel		X				X					X						X		X	X
	14	o	Goal	X	X		X								X		X	X	X	X		X	X
	15	o	Tow	X	X	X	X		X		X	X		X	X		X	X	X	X			
	16	o	Go							X									X			X	

## Appendix 15: Advanced Responses – Test 1

Item	Vowel	Words	Participants																							
			AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT				
Test 1	1	u	fool ful											X			nr	X			nr		X		X	
	2	o	goal gol	X		X	X	X	X	X							nr		X	X	nr	X	X	X	X	
	3	ɔ	cawl kol	X	nr	X				X	X			X			nr		X	X	nr		X		X	
	4	ar	bile baio												X		nr				nr					
	5	ɛ	cell ceu									X					nr				nr					
	6	i	feel fio										X				nr				nr					
	7	u	fool ful				X										nr				nr					
	8	ɔ	cawl kol														nr				nr					
	9	ar	bile baio														nr				nr					
	10	er	shale cheio		X												nr			X	nr				X	
	11	ar	bile baio	X													nr				nr					
	12	ɛ	cell ceu	X					X								nr	X	X		nr					X
	13	er	shale cheio														nr				nr					
	14	o	goal gol	X													nr				nr					
	15	ar	bile baio														nr				nr				X	
	16	o	goal gol	X		X				X							nr		X		nr				X	
	17	ɔ	cawl kol	X		X				X							nr	X	X		nr			nr		
	18	o	goal gol														nr				nr					
	19	i	feel fio														nr				nr					
	20	ɛ	cell ceu							X	X						nr	X	X		nr			X		
	21	ɔ	cawl kol	X	nr	X			X	X		X					nr	X	X		nr			X		
	22	ɛ	cell ceu							X							nr		X		nr			X		
	23	er	shale cheio														nr				nr					
	24	o	goal gol										X				nr				nr					
	25	o	goal gol														nr				nr					
	26	er	shale cheio											X			nr				nr				X	
	27	er	shale cheio						X								nr				nr					
	28	ɔ	cawl kol	X		X			X	X			X				nr	X	X		nr	X				X
	29	ɛ	cell ceu							X		X	X				nr	X	X	X	nr			X		X
	30	o	goal gol	X		X			X	X			X				nr	X			nr			X	X	X
	31	ɛ	cell ceu	X						X			X		X		nr		X		nr			X		X
	32	i	feel fio														nr				nr					
	33	er	shale cheio														nr		X		nr					
	34	ɔ	cawl kol											X			nr				nr					
	35	i	feel fio														nr		X		nr					
	36	u	fool ful	X		X											nr		X		nr					
	37	i	feel fio		X												nr	X	X		nr					
	38	ɔ	cawl kol	X		X				X				X			nr	X	X		nr					X
	39	i	feel fio														nr				nr					
	40	ar	bile baio														nr				nr					
	41	u	fool ful				X										nr				nr			X		
	42	u	fool ful														nr				nr					
	43	ɔ	cawl kol	X		X				X			X				nr	X	X	X	nr			X		
	44	ɛ	cell ceu	X		X				X			X				nr	X			nr			X		X
	45	i	feel fio					X					X				nr	X			nr					
	46	ar	bile baio	X													nr				nr					
	47	u	fool ful											X			nr				nr					
	48	er	shale cheio														nr		X		nr					
	49	u	fool ful														nr				nr					
	50	er	shale cheio														nr				nr					
	51	ar	bile baio														nr				nr					
	52	o	goal gol	X		X				X			X				nr	X		X	nr				X	
	53	i	feel fio														nr	X	X		nr					
	54	u	fool ful														nr				nr					
	55	ar	bile baio														nr	X			nr			X		
	56	ɛ	cell ceu									X					nr				nr				X	

## Appendix 15: Advanced Responses – Test 2

			AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN	AO	AP	AQ	AR	AS	AT	
Test 2	1	u	foo foo						X					nr				nr				X	
	2	o	tow toll					X	X	X				nr		X	X	nr					
	3	o	toll toll	X				X	X	X				nr				nr					
	4	u	fool foo						X					nr				nr		X			
	5	o	tow tow											nr				nr					
	6	u	fool foo											nr				nr					
	7	au	vow vowel	X	X	X		X	X				X	X	nr	X	X	nr				X	X
	8	au	vow vowel	X		X		X	X		X		X		nr	X	X	nr			X	X	X
	9	u	fool fool												nr			nr					
	10	ar	bile bile												nr			nr					
	11	au	vowel vow	X		X	X		X		X		X		nr	X		nr	X	X	X	X	
	12	ar	bile bayou												nr			nr					
	13	o	tow tow												nr			nr					
	14	ar	bile bile												nr			nr					
	15	ar	bayou bayou												nr			nr					
	16	u	foo fool												nr			nr					
	17	o	toll toll	X							X				nr			X	nr	X			
	18	ar	bile bayou											X	nr			nr					
	19	u	foo fool						X						nr		X	nr					
	20	o	tow toll	X					X	X					nr	X		nr	X			X	
	21	ar	bayou bayou							X					nr			nr					
	22	au	vow vow					X		X	X				nr			nr	X				
	23	o	toll tow				X		X	X					nr			X	nr				
	24	au	vowel vowel	X	X	X		X	X	X	X	X	X		nr	X		nr			X	X	X
	25	au	vowel vowel	X		X		X					X	X	nr	X		X	nr		X		X
	26	ar	bayou bile												nr			nr					
	27	ar	bayou bile												nr			nr					
	28	au	vow vow	X	X	X		X	X		X	X	X		nr	X		nr	X	X	X	X	
	29	au	vowel vowel		X			X		X					nr			X	nr	X			
	30	u	fool fool												nr			nr					
	31	u	foo foo												nr			nr					
	32	o	toll tow					X		X		X			nr	X	X	nr				X	













## Appendix 16: Native Speaker Responses – Tests 5 and 6

			NA	NB	NC	ND	NE	NF	NG	NH	NI
<b>Test 5</b>	1	ε	Cell	X							
	2	er	Shale								
	3	i	Fio			X					
	4	ε	Ceu			X		X			
	5	ɔ	Cawl								
	6	ε	Fel			X		X	X		
	7	o	Gol	X	X	X	X	X			
	8	i	Piu			X					
	9	i	Feel								
	10	ε	Fell								
	11	ar	Pile								
	12	u	Ful			X		X	X		
	13	o	Goal						X		X
	14	ar	Paio						X		
	15	ɔ	Kol	X		X					
	16	ar	Baio		X						
	17	u	Fool								
	18	i	Peel								
	19	ar	Bile								
	20	er	Cheio								

			NA	NB	NC	ND	NE	NF	NG	NH	NI
<b>Test 6</b>	1	au	Pow			X	X				
	2	au	Pal								
	3	u	Poo							X	
	4	o	Foe					X		X	
	5	u	Pool								
	6	au	Vow		X		X				
	7	u	Fool								
	8	ar	Bile					X			
	9	u	Foo					X			
	10	ar	Bayou								
	11	o	Foal								
	12	o	Toll								
	13	au	Vowel								
	14	o	Goal								
	15	o	Tow								
	16	o	Go				X				