UNIVERSIDADE FEDERAL DE SANTA CATARINA
PÓS-GRADUAÇÃO EM LETRAS/INGLÊS E LITERATURA CORRESPONDENTE

THE PERCEPTION AND PRODUCTION OF ENGLISH INTERDENTAL

FRICATIVES BY BRAZILIAN EFL LEARNERS

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ABSTRACT

THE PERCEPTION AND PRODUCTION OF ENGLISH INTERDENTAL

FRICATIVES BY BRAZILIAN EFL LEARNERS

MARA SILVIA REIS

UNIVERSIDADE FEDERAL DE SANTA CATARINA
2006

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The present study investigates the perception and production of the English interdental fricative phonemes, /θ/ and /ð/, by Brazilian learners of English as a foreign language (EFL) in different levels of proficieny. The main questions of the study are (a) whether there is a pattern of replacement of the target phonemes; (b) whether the participants can perceive replacement of the target phonemes; (c) to what extent learners in different levels are influenced by foreign language experience (d) whether there is a correlation between perception and production of the interdental fricatives, and (e) whether one of the target phonemes is more difficult than the other. The participants of the study are two groups attending the extracurricular language project of the Universidade Federal de Santa Catarina, 12 learners from the pre-intermediate level and 12 students from the advanced level. The learners performed the three production tests and the three perception tests that constituted the data gathering instruments, while five native speakers of English participated as a control group in the perception tests. The production tests consisted of (a) reading a text, (b) reporting the story of the text, and (c) reading a list of sentences. The perception tests were (a) listening to a recorded speech

and identifying any inaccurate pronunciation of word-initial consonants, (b) a discrimination test, and (c) an identification test. The Speech Learning Model (Flege, 1995) was the main theoretical framework used to account for the findings. Briefly, the model hypothesizes that learners, eventually, are able to achieve a native-like pronunciation. The results suggest that (a) there is a pattern of replacement of the target phonemes; (b) the perception of the replacements varies according to the type of perception test; (c) language experience seems not to significantly influence production and perception; (d) there is not a correlation between perception and production, and (e) /θ/ is less difficult to produce and perceive than /ð/.

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RESUMO

A PERCEPÇÃO E A PRODUÇÃO DOS FONEMAS FRICATIVOS INTERDENTAIS

INGLESES POR APRENDIZES DE INGLÊS COMO LÍNGUA ESTRANGEIRA (EFL)

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2006

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Esta pesquisa investiga a percepção e a produção dos fonemas fricativos interdentais, $/\theta/$ and $/\eth/$, por brasileiros estudantes de inglês como lingua estrangeira (EFL), oriundos de diferentes níveis de aprendizado. Os principais objetivos desta investigação são verificar (a) a possibilidade de haver um padrão de substituição dos fonemas em questão; (b) se os participantes percebem substituições das fricativas interdentais; (c) se há influência da experência de estudo de inglês na performance dos estudantes; (d) se há correlação entre a percepção e a produção dos fonemas em questão, e (e) se um dos fonemas em questão é mais difícil do que o outro. Os participantes deste estudo são dois grupos de alunos do Projeto Extracurricular de Ensino de Línguas da Universidade Federal de Santa Catarina, 12 estudantes do nível pré-intermediário e 12 do nível avançado. Os estudantes de EFL fizeram três testes de produção e três de percepção e cinco falantes nativos de inglês participaram como grupo controle nos testes de percepção. Os testes de produção consistem em (a) leitura de texto, (b) reportar a estória do texto, e (c) leitura de uma lista de frases. Os testes de percepção são (a) ouvir a uma estória gravada e identificar qualquer erro de pronúncia em consoantes em início de

palavras, (b) um teste de discriminação, e (c) um teste de identificação. A principal proposição teórica para o estudo foi o Modelo de Aprendizagem da Fala (Speech Learning Model, Flege, 1995), o qual propõe a possibilidade de que os aprendizes de língua estrangeira atinjam uma pronúncia tal qual a nativa. Os resultados sugerem que (a) existe um padrão de substituição dos fonemas em questão; (b) a percepção das substituições varia de acordo com o tipo de teste; (c) a experiência com a língua estrangeira pouco influencia a produção e a percepção dos fonemas; (d) não existe correlação entre a percepção e a produção, e (e) /θ/ é menos difícil de perceber e produzir do que /ð/.

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ABBREVIATIONS

AFC - Alternative Forced Choice Identification Test

AOL - Age of learning

BP - Brazilian Portuguese

CDT - Categorial Discrimination Test

CPH - Critical Period Hypothesis

EFL - English as foreign language

ESL - English as a second language

GA - Group of advanced learners

GI - Group of pre-intermediate learners

GPE - General Pronunciation Error Perception Test

H - Hypothesis

IL - Interlanguage

L1 - First language

L2 – Second/Foreign language

MDH - Markedness Differential Hypothesis

NL - Native language

NS - Native speaker

PAM - Perceptual Assimilation Model

Pro- Production Test

RQ – Research question

SCH - Structural Conformity Hypothesis

SLA - Second language acquisition

SLM - Speech Learning Model

UFSC – Universidade Federal de Santa Catarina.

Chapter 1 — Introduction

I was about 17 years old when I had my first contact with English in a private instructional setting. Although in Brazil English surrounds us anytime we turn on the radio or go to the movies, in the public educational system Brazilian students are officially first exposed to the foreign language at approximately 11 years. One could say that after seven years of learning, students are nothing more than reasonable "to be-logists". Thus, it was at 17 that I was really confronted by the challenge of learning a new language in general, and a new phonological system in particular.

Concerning phonological differences between Brazilian Portuguese (BP) and English, the sound of the *th*-words immediately drew my attention, although there are many more dissimilarities between the two sound systems. Something intriguing happened every time the teacher produced words like *theater* or *they.* The way the articulators moved in order to produce those sounds were unfamiliar to any Portuguese articulatory movement. First I thought it had something to do with sigmatism, a type of dyslalia frequently called a lisp. But the spelling of the words invalidated this hypothesis. Finally, I asked the teacher whether the *th*-words had a proper manner in which to be produced, and she confirmed the guess.

My personal experience with the English interdental fricative phonemes exemplifies some of the issues that will be discussed in this study: (a) the role of perception for second language (L2) accurate production, (b) the influence of the native language (NL) experience on the learning of the L2, (c) the importance of noticing a difference, and (d) the implication of L2 experience in pronunciation improvement, among other matters.

The role of pronunciation has passed through extreme viewpoints in the last decades of foreign language education, from having practically no function in the Grammar-Translation approach to being the major focus in the Audio-Lingual method. During the

late 1960's and the 1970's the effectiveness of teaching pronunciation in the English as a Second/ Foreign Language (ESL/EFL) curriculum was strongly questioned. Pronunciation programs were "viewed as meaningless noncommunicative drill-and-exercise gambits" (Morley, 1991, p.485).

However, Pennington (1989) claims that there is "no firm basis for asserting categorically that pronunciation is not teachable or that it is not worth spending time on..."(p.20). Celce-Murcia (1987) claims that there is a threshold for intelligibility, and that communication may be harmed if the learners' output falls below this level, regardless of how good their command of grammar and vocabulary may be. Seidlhofer (2001, cited in Rauber[1], 2002. p.1) states that people relate to a community and manifest their identity through the way they speak, and that "pronunciation is responsible for intelligibility".

Gass and Selinker (2001) assert that phonology is a significant field of research for Linguistics studies in general and second language acquisition (SLA) research in particular. According to these authors, the two areas share the same concern with the phonological processes involved in language acquisition, especially with the intricate mechanisms of acquiring/learning[2] the phonological system of an L2. These researchers also remark on the complexity of phonological acquisition and affirm that the "understanding of how learners learn a new phonological system must take into account linguistic differences between the native language and the target language systems as well as universal facts of phonology "(p.163).

Regarding phonetics and phonology, SLA research has generally focused on the L2 pronunciation problems that seem to be related to differences in the inventories of the first language (L1) and the L2. Within this framework, research has shown that there are

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[1] Cited work will be referred in Secondary References
[2] The terms *language learning* and *language acquisition* will be used interchangeably in this thesis, although several scholars (e.g., Krashen, 1981; Paradis, 1985) make a distinction between them.

several factors that influence the learning of a new phonological system, such as individual characteristics: sex, personality, motivation (Major, 1987, 1994); social ambience (Leather & James, 1996); age (Major, 1994; Flege, 1993 and elsewhere); transfer from L1 (Flege, 1987; Major, 1987, 1994); developmental factors (Major, 1987; Hecht & Mulford, 1987); markedness (Eckman, 1977; Carlisle, 1994); style shifting (Major, 1994; Carlisle, 1994; Van Patten, 1994); length of study (Ellis, 1994); and perception of the L2 sound system (Flege, 1993 and elsewhere; Wode, 1995; Best, 1995; Rochet, 1995; Kuhl & Iverson, 1995; Brannen, 1999, 2002).

Native language transfer has been cited as a variable that may cause L2 pronunciation mistakes. The idea of learners having difficulty to produce what does not exist in the L1 inventory underlies the conceptualization of the contrastive analysis hypothesis (CAH, Lado, 1957), and was the assumption almost exclusively used in early research in L2 phonetics and phonology. However, empirical findings have indicated that the CAH is neither a reliable source of prediction of errors nor a good theory for elucidating different kinds of errors that are not directly caused by the L1 (Major, 1987; Hecht & Mulford, 1987; Leather & James, 1996).

Therefore, other theories should be taken into consideration when dealing with L1 and L2 contact that could explain pronunciation difficulties. Eckman proposed the markedness differential hypothesis (MDH, 1977) and claimed that the more frequent a form is in the world's languages, the less marked it is and vice-versa. The MDH, based on universals and on the relationship between L1 and L2, states that the L2 learner will have more difficulty to acquire a more marked form that is not present in his/her L1. Nevertheless, empirical studies (Broselow, 1983, 1984; Ioup 1984,) have not entirely supported the hypothesis. Thus, Eckman (1991) reformulated the MDH, naming it the structural conformity hypothesis (SCH). He argued that predictions could only be made in

terms of universals; that is, that "the universal generalizations that hold for the primary languages also hold for interlanguages[3]" (p.24).

Speech perception is another variable that seems to play a significant role in the process of learning an L2. The L1 would mediate the acquisition of the new phonological system (Flege, 1981 and elsewhere; Best, 1995) and this mediation could lead to misperception of foreign phones. As Kuhl and Iverson (1995) point out, "language experience alters the mechanisms underlying speech perception, and thus, the mind of the listener." (p. 121). Flege (1981) states that the foreign sound may be identified through L1 categories, which would result in a distinct perception from the native speakers of the L2. Major (1986) states that an accurate perception of the L2 sound would result in a native or native-like mental representation. Sancier and Fowler (1997) claim that "perception of speech may foster imitation" (p. 422). Flege (1995) argues that accurate perception of the L2 sound would, ultimately, lead to its accurate production.

The BP sound system does not have as many fricatives as the English inventory. The phonemes /f, v, s, z, ʃ, ʒ/ are present in both systems, whereas the interdental /θ/ and /ð/ are present only in English. In spite of the fact that Brazilian EFL learners frequently present problems with the production of the interdental fricatives (Reis, 2004a), to my knowledge no research has been carried out so far in order to investigate whether perception is involved with these difficulties. The principal aim of this study is, therefore, to examine how Brazilian EFL learners at different stages of interlanguage development perceive and produce the English phonemes /θ/ and /ð/ in word-initial position.

The same study (Reis, 2004a), found that /θ/ is often replaced with /t/, /f/ and /s/, while /ð/ is often substituted for /d/, whereas /z/ and /v/ rarely occurs. Concerning the

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[3] Interlanguage (Selinker, 1972), henceforth IL, is an intermediary language system between the native language and the second language.

feature specifications of the target phonemes and their most frequent replacements Table 1 displays in which features they coincide and differ.

Table 1. Feature specifications of /θ/ and /ð/ and their frequent replacements.

Feature	/θ/	/t/	/f/	/s/	/ð/	/d/	/v/	/z/
[Consonantal]	+	+	+	+	+	+	+	+
[Anterior]	+	+	+	+	+	+	+	+
Place of articulation	inter dental	alveolar	labio dental	alveolar	inter dental	alveolar	labio dental	alveolar
Manner of articulation: Fricative	+	-	+	+	-	-	+	+
Manner of articulation: Stop	-	+	-	-	-	+	-	-
[Continuant]	+	-	+	+	+	-	+	+
[Coronal]	+	+	-	+	+	+	-	+
[Voice]	-	-	-	-	+	+	+	+

There were five major objectives of investigation in this study: (a) whether there is a pattern of replacement of the target phonemes in production; (b) whether the participants can perceive replacement of the target phonemes; (c) to what extent learners at different levels of learning are influenced by amount of language experience; (d) whether there is a correlation between perception and production of the interdental fricatives, and (e) whether one of the target phonemes is more difficult than the other.

The Speech Learning Model (SLM, Flege, 1995) is the main postulation that provides a theoretical basis for the investigation of the perception and production of the English interdental fricatives by Brazilian EFL learners. The SLM proposes that the mechanisms to learn a sound system "remain intact over the life span, and can be applied to L2 learning" (p. 239). Flege also argues that perception is the major reason for errors in segmental production, and that perception may be involved in the differential replacement of /θ/ and /ð/ by learners of distinct L1 background learning English. Thus, differences in perception may explain why /θ/ and /ð/ are replaced with /t/ and /d/, respectively, by speakers of Canadian French (Brannen, 2002), Russian (Weinberger, 1996), and Brazilian

Portuguese[4] (Reis, 2004a), and by /s/ and /z/ by speakers of European French (Brannen, 2002), Japanese, and German (Weinberger, 1996).

In order to present the results obtained in this investigation, the thesis is organized into five chapters: Chapter 2 reviews the most relevant literature regarding the mechanism of speech perception, the main framework which supports the study, as well as some studies concerning perception, production, and their relationship. Chapter 3 describes the research questions and hypotheses elaborated for the study, and the method used to collect data as well as some information about the participants. Chapter 4 presents the analysis and discussion of the results found, and Chapter 5 concludes the study, discussing some pedagogical implications, limitations and offering suggestions for further research.

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[4] Reis (2004a) also found other substitutes for the voiceless interdental fricative, such as /f/ and /s/. However, /t/ was the most used pattern of replacement of /θ/.

Chapter 2 — Review of the literature

Several hypotheses and models have been proposed in an attempt to explain the complexity of the relationship between L2 speech perception and production (e.g., Flege, 1995; Best, 1995; Kuhl & Iverson, 1995), although a definite explanation has not been presented yet. Related to the perception and production relationship is the question of *what* is perceived in the spoken utterance and *how* it is perceived. This chapter reviews the theoretical proposals which attempt to explain these issues.

A basic definition of speech perception could be the act by which listeners map continuous and variable acoustic signals onto linguistic targets. Massaro defines speech perception "as the process of imposing a meaningful perceptual experience on an otherwise meaningless speech input" (2001, p. 14870). Similarly, Wright, Frisch and Pisoni point out that "the study of speech perception is concerned with the process by which the human listener, as a participant in a communicative act, derives meaning from spoken utterances" (1996-1997, p. 2).

Research on monolingual speech perception started in the late 1940s, being devoted mainly to the investigation of issues such as the variability in the physical signals, the search for acoustic invariants, and the capacity that human beings have to perceive and categorize these variations (Strange, 1995; Wright, et al., 1996-1997)

Two decades later, cross-language speech perception studies initiated pursuing basically the same interests, while more recently several researchers (e.g., Major, 1994; Flege, 1993 and elsewhere; Wode, 1995; Rochet, 1995; Best, 1995; Kuhl & Iverson, 1995) have contributed to the development of the field proposing an influence of speech perception on the production of L2 sounds.

This chapter presents an overview of some theoretical and empirical issues related to such a relationship—how L2 segmental production can be affected by speech

perception. The SLM (Flege, 1995), is concerned with this relationship and is the main framework that structures both the chapter and the study. The chapter addresses issues regarding theories and studies on *how* a speech sound is perceived, as well as *what* is perceived. It also discusses the matter of perception and production concerning IL phonology, with particular attention to aspects that may cause foreign accent, such as the age-related limitations to L2 pronunciation improvement, the interference of language experience, (both L1 and L2) in the perception and production of the foreign language, and also further considerations on the issue of L2 perception and production.

2.1 Main theories and models of speech perception

The theoretical study of speech perception encompasses several divergent perspectives. An overview of theories and models that try to elucidate how perceivers deal with the main problem in spoken utterances, the lack of invariance, will be briefly discussed.

There is some debate on whether speech perception is as ordinary as any type of human perception, or whether it occurs through a specialized mode of perception (Sternberg, 2003). Theories about the modularity of the mind, which assert that human perception occurs through specific modules (Fodor, 1983), had an impact on theories about speech perception. The main argument that favors speech perception as a specialized mode of perception in general is the inherent human ability to discriminate speech sounds in a categorical fashion. That is, humans distinguish speech sounds only when they are between phonetic categories but not within categories (Strange, 1995; Jusczyk, Hohne & Mandel, 1995; Kuhl & Iverson, 1995). In other words, humans distinguish speech sounds that are prototypical in their category, such as the voiced stops

in /bɑ/, /dɑ/ or /gɑ/, but not when computer-synthesized sounds present acoustic patterns in between these categories (Jusczyk et al., 1995).

As Koerich (2002) relevantly observes, the mechanism whereby the stimuli are categorized remains an unanswered question. That is, it is still "discussed whether the metric employed in speech sound categorization is based on criteria in the articulatory domain, in the acoustic domain, or in the combination of both" (p. 85)

The establishment of a phonetic category is problematized by the intrinsic characteristic of the human speech: its lack of invariance, or lack of constancy. As observed by Strange (1995), "there is no one-to-one correspondence between phonemes as perceived and acoustic patterns generated by speech gestures that constitute the stimuli for speech perception" (p. 5). He cites three complementary theories that intend to explain how perceivers overcome the lack of constancy in order to categorize a speech sound: (a) the associative learning theory, in which categorization occurs through the association of the ambiguous stimulus with previous unambiguous experiences; (b) the nativist theory, which proposes a human innate mental capacity to categorize ambiguous stimuli, and (c) the direct realist theory, which suggests that categorization occurs through detection of constant patterns that the stimulus offers, without mental association or innate knowledge. As Strange (1995) remarks, the theories were originally postulated to explain visual perception, and were later applied to the understanding of speech perception.

In cognitive terms, perception is broadly seen from two perspectives, a bottom-up approach and a top-down view (Sternberg, 2003). The bottom-up, or passive, theories are built on the hypothesis that there is a direct relationship between the acoustic signal and the perceived phoneme. That is, perception is an experience in which the physical stimulus would reach the sensory receptors and, without any higher cognitive processing, recognition, organization and conceptualization of the stimulus would occur. As Mannell (1994) points out, "perceptual constancy is in some way matched to a real acoustic

constancy" and "these theories tend to concentrate on discovering the identity of such constant perceptual cues and on the ways the auditory system might extract them from the acoustic signal" (p. 34).

On the other hand, the top-down, or active, theories propose that perception is driven by higher-level cognitive processes. In other words, these theories suggest that there is no direct relationship between the acoustic signal and the perceived phoneme. On the contrary, they postulate that pre-existing knowledge, intelligence, already formed schemata, thoughts and expectancies about the stimulus are involved in the process of perception. As Sternberg (2003) pertinently remarks, no single theory can explain such a complex phenomenon and "a complete theory of perception will need to encompass both bottom-up and top-down approaches" (p. 127).

Serniclaes (2004) reviewed some theories and models of speech perception and didactically summarized them as below. The asterisk indicates two models not included in the original figure.

	innate	*acquired*
auditory	*psychoacoustic* Quantal (Stevens, 1989) Natural boundaries (Kuhl & Padden,1983) Locus (Sussman & Abbs, 1998)	*gestaltist* Auditory scenes (Bregman,1990) Perceptual Magnet (Kuhl, 1991) * Fuzzy Logical (Massaro, 1987)
speech specific	*phonetic* Motor (Liberman & Mattingly, 1985)	*phonological* Direct Realism (Fowler, 1986) *articulatory* * Perceptual Assimilation (Best, 1995)

Figure 1. Main theories and models of speech perception

Note. Called a figure in the original publication. From Serniclaes, W. (2004). *Speech perception: psychoacoustic, productive and linguistic factors*. Unpublished conference report. Germany: German-French Summerschool, 19th -24th September 2004.

An important bottom-up model of speech perception, the Motor Theory (Liberman, & Mattingly, 1985, cited in Hayward, 2000, p. 124) basis its postulations on the articulatory domain in order to explain how perceivers compensate for the lack of

invariance, as well as on the modularity hypothesis (Fodor, 1983). This specific module for speech perception 'translate' acoustic information into intended gestures directly, or in Best's words (1995), "the perceptual primitives are the *intended* gestures represented in the mind/brain" (p. 176).

Another relevant bottom-up model, Direct Realism (Fowler, 1986, cited in Hayward, 2000, p. 125), also relies on the articulatory domain to explain how perceivers overcome the problem of lack of constancy. As Hayward (2000) points out, "Lack of invariance is not a problem for the Direct Realism approach because it arises naturally from the gestural pattern" (p. 126). However, in contrast to the Motor Theory, Direct Realism advocates that speech perception is as ordinary as any kind of human perception and that the perceptual "primitives are the actual gestures produced by the speaker's vocal tract" (Best, 1995, p. 176).

The Fuzzy Logical Model (Massaro, 1987, cited in Hayward, 2000, p. 126) is an example of a top-down model of speech perception which postulates that the perceiver "is equipped with a set of prototypes, stored in memory, corresponding to the various V, CV and VC syllables of his or her language". Because the model allows for a large number of prototypes in the perceivers' mind, lack of constancy is not a problem.

The Quantal Model (Stevens, 1989, cited in Hayward, 2000. p. 127) relates the articulatory, the acoustic and the auditory systems in order to elucidate the phenomenon of speech perception. It postulates that "the listener identifies individual segments by extracting abstract phonological features from an auditory representation". The lack of invariance is not problematic for the model since it considers that the acoustic and auditory systems relate directly to the phonological features.

The main models of general speech perception (i.e., not specific to L1 or L2) were briefly discussed in this section. L2 models of speech perception will be discussed in 2.3, but first it is important to consider a question that many researchers have been seeking to

answer: the issue of *what* is perceived in the spoken utterance, and whether there is a universal unit of speech perception.

2.2 The unit of speech perception

A much debated subject in the field of speech perception concerns the identification of the smallest unit of perception. Empirical findings so far do not support the existence of a universal phonological mental representation (Jenkins & Yeni-Komshian, 1995). Instead, these studies suggest that the mental representation may depend on factors such as the nature of the L1 that is being investigated, and, in cross-language research, on the listener's experience with the L2, that is, on "the property of the spoken inputs and the specificities of the perceptual 'occasions'" (Koerich 2002, p. 99).

For some languages such as Portuguese (Rodrigues, 1994), Spanish (Bradley, Sánchez-Casa, & Garcia-Albea, 1993), and French (Cutler, Mehler, Norris, & Segui, 1986), the speech chain segmentation appears to be done through a syllabic pattern. That is, the L1 speakers of these languages tend to perceive the input in syllables. On the other hand, languages such as English (Cutler et al., 1986) and German (Kipp, Wesenick, & Schiel, 1996) are likely to be perceived by L1 speakers on a phonemic level.

While phonemic recognition seems to be faster, since the phoneme would provide the smallest unit for perception, it also requires a context to be recognized (Koerich, 2002). The syllabic level, on the other hand, provides the necessary context and, thus, seems to facilitate perception (Cutler et al., 1986). Jenkins and Yeni-Komshian (1995) suggest that there may be still other levels of speech perception, such as the allophonic and the phonetic, possibly more appropriate for experiments on perceptual training.

As can be seen, although research has pointed out some tendencies, the issue of the unit of speech perception is far from clear. According to Jenkins and Yeni-Komshiam, "in

the absence of definitive data, we think a pluralistic approach should be encouraged" (1995, p. 472) for elucidating the mechanism of speech perception. Since the present study deals with segmental speech sound recognition and follows the reasoning of the SLM (Flege, 1995), and of Flege and colleagues (Flege, 1990; Flege & Munro, 1994), it is assumed here that the perception of the segments occurs on the phonetic level. The first hypothesis of the SLM (Flege, 1995, p. 239) proposes that "sounds in the L1 and L2 are related to one another at a position-sensitive allophonic level, rather than at a more abstract phonemic level". In addition, Flege (1991) claims that

> When processed at a phonemic level, sounds that may be distinct auditorily are treated as realizations of a single category. … according to the SLM, listeners remain able to access a phonetic level of representation, which enables them to learn to distinguish a novel phonetic contrast" (p. 407).

2.3 Perception and Production Interlanguage Phonology

2.3.1. Foreign accent

Empirical findings have suggested that speech processing is altered by language experience in the course of life (Kuhl & Iverson, 1995). Human beings seem to be able to recognize speech sounds since the prenatal period, a stage in which babies process prosodic features better than segmental ones (Jusczyk, Hohne, & Mandel, 1995). At birth babies demonstrate the capacity to discriminate phonetic contrasts that belong to any language; young infants show a broader speech sound recognition compared to older children and adults (Jusczyk et al., 1995; Kuhl & Iverson, 1995). Kuhl (1993, cited in Koerich, 2002, p 77) state that by the age of one year, the phase when children begin to be aware of word meanings, speech perception starts to become more sensitive to the contrasts of the L1. In addition, studies reported by Jusczyk et al. (1995) indicate that between the age of 4 ½ and 5 years language-general phonetic perception has already changed into a language-specific pattern. Thus, by this age children demonstrate

practically the same adult pattern of difficulty to distinguish foreign contrasts (Werker & Polka, 1993), usually perceiving the L2 sound "through the grid" of the L1 phonological system (Wode, 1978, cited in Flege, 1995).

Strange (1995) proposed the term *perceptual foreign accent* for the phenomenon of perceiving a foreign contrast based on the L1 phonetic parameters. Inaccurate perception of non-native contrasts has been pointed out as one of the causes of foreign accent (Major, 1994; Flege, 1993 and elsewhere; Wode, 1995; Rochet, 1995; Best, 1995). As Koerich affirms, the term *perceptual foreign accent* is "a perceptual correspondent to the concept of foreign accent" (2002, p. 78).

The influence of the L1 phonological system on L2 speech perception has been extensively studied since the 1940's (Bohn, 1995). Although the initial simplistic idea of L1 transfer is not supported any longer, Trubetzkoy's classic statement that the L1 phonological system works as "a sieve through which everything that is said passes" (1969, cited in Weinberger, 1996, p. 261) seems to still be current. Trubetzkoy believed that the differences between the mother tongue and the L2 phonological systems would lead to an incorrect evaluation of a L2 sound, and, thus, to a perceptual foreign accent. According to Flege (1995), this incorrect evaluation is the inaccurate perception that L2 learners, especially in the beginning of learning, demonstrate. For instance, differences in perception may underlie the findings that /θ/ and /ð/ are replaced by /t/ and /d/, respectively, in Canadian French, Russian and Brazilian Portuguese, and for /s/ and /z/ in European French, Japanese and German (Weinberger, 1996; Brannen, 2002; Reis, 2004a).

In addition to the differences between the L1 and L2 phonological systems, Jenkins and Yeni-Komshian (1995) report some other factors that might interfere in L2 speech perception, particularly in experimental situations, such as the listener's age, his or her degree of experience with the L2, the acoustic saliency of the contrast, how prototypical

the token is, whether the L2 sound is embedded in real or nonsense words, and the syllabic position and phonological context that the token is inserted in.

Age is certainly a factor that must be taken into consideration when discussing L2 pronunciation acquisition. The critical period hypothesis (CPH, Lenneberg), is the traditional biological proposal that attempts to explain the constraints in language learning. After puberty the cognitive functions of the brain are specialized in the left and right brain hemispheres and in areas within them, a process called cerebral lateralization (Baron-Cohen, Tager-Flusberg, & Cohen, 2000). The CPH postulates that when cerebral lateralization takes place, the neurological plasticity of the brain reduces to a point that native-like acquisition of the L2 is impeded. Thus, the critical period for language acquisition would be between the two years and puberty. In addition, Scovel (1969, cited in Leather & James, 1991, p. 306) claims that the cortical lateralization "inhibits subsequent attempts at mastery of the sound patterns of a new language".

However, there has been some counter-evidence to the proposal. Koerich (2002) cites some neurophysiological research (e.g., Perani, Paulesu, Galles, Dupoux, Dehaene, Bettinardi, Cappa, Fazio, & Mehler, 1998; Wang, Sereno, Jongman, & Hirsch, 2000) showing that adults maintain the capacity to change cortical representations through constant experience. In addition, linguistic studies have shown that motivated adults are able to attain a good pronunciation (Bongaerts, Planken, & Schils, 1995, cited in Flege, 1997), whereas strong accented pronunciation has been found among learners whose first contact with the L2 had occurred before the age of four years (Flege, Munro, & Mackay, 1995).

Therefore, age should not be considered an absolute constraint for native-like L2 pronunciation. Issues such as L2 experience, motivation toward the L2, aptitude, inadequate phonetic input, and motoric difficulties must influence the degree of success in

L2 speech perception and production (Flege, Munro & MacKay, 1995, 1996a). In a study investigating the production of word-initial /p, t, θ, ð/ by 240 native Italians living in Canada for over 30 years, and whose first contact with English occurred between the age of 3 and 21 years, Flege et al. (1996a) found that only 51% of the variance in /θ, ð/ production could be accounted for. From this total, 43% of the variance was due to age of learning, 5% to language use factors, while 4% was due to the learners' motivation to pronounce the L2 accurately. Similarly, Koerich (2002, p. 82) cites numerous studies (e.g., Best & Strange, 1992; Bohn & Flege, 1996; Flege, Frieda, & Nowaza, 1997; Guion, Flege, & Loftin, 2000) suggesting that activation of the L1 and the amount of exposure to the L2 may be important factors that affect adults' L2 perception and production Although Flege et al. (1996a) demonstrated that factors other than age do affect learning, they also found empirical support for the belief that for a good L2 pronunciation, the earlier the better—the researchers found that segmental inaccuracy increased linearly with the increase in age of learning (AOL). In other words, the less experience with the L1 previous to L2 learning, the more native-like L2 pronunciation tend to be.

However, studies on training in non-native speech contrasts have given counter-evidence to the claim that adults are unable to achieve native-like pronunciation. Although adults tend to base target language perception on the L1 phonetic parameters, whereas children are able to modify it during the learning process (Werker & Polka, 1993), training seems to enhance discrimination of foreign contrasts. Hardison (1997) demonstrated that, after training, both Japanese and Korean adults are able to perceive /r/ and /l/ as different phonemes, and that perceptual training alone can result in improvement in production. Collins and Mees (1999, cited in Heeren, 2004) claim that native Dutch speakers usually replace /θ/ with /s/ and suggest that the inaccuracy may have a perceptual basis. Heeren (2004) carried out a study with Dutch speakers and

concluded that the discrimination of the /θ-s/ contrast improved significantly after a training period. Similarly, Jamieson and Moroson (1986) demonstrated that training affected positively the discrimination of the English /θ-ð/ contrast by Canadian francophones. Reis (2004c) found that training in production of /θ/ and /ð/ improved considerably the production of /θ/ by adult BP speakers.

The latter study, however, also showed that training did not cause a significant improvement in the production of the more marked phoneme /ð/. Besides supporting the suggestion that instruction may be more effective for less than for more marked structures (Ellis, 1994; Hu, 2002; Butler, 2002), this finding seems also to corroborate Jusczyk's (1985 and 1992, cited in Flege, 1995, p. 265) argument in favor of the stabilization of the L1 parameters as the main constraint on L2 phonetic acquisition, since all the participants of Reis' study (2004c) were literate adult BP speakers. Jusczyk claims that the systematization of the L1 phonological inventory occurs when children begin learning to read, around the age of 5 or 6 years. Before this systematization they "rely on purely sensory information, and thus are more prone to detect auditory-acoustic details" of an utterance (Koerich, 2002, p. 83). Adults, on the other hand, seem to associate L2 allophonic variations to an L1 prototype (Rochet, 1995; Kuhl & Iverson, 1995; Best, 1995). As a rationale for the age-related factors that influence L2 pronunciation development, Flege (1995) proposed the SLM. One of its premises is that the stabilization of the L1, due to the onset of reading, is the main constraint for L2 pronunciation improvement.

2.3.2 The Speech Learning Model

The finding that as AOL increases, L2 segmental accuracy production decreases (Flege et al., 1996a) upholds an SLM hypothesis that L2 segmental perception and production improvement interact with the stage of development of the native language (Flege, 1995). Wode (1995) claims that this interaction is due to the co-existence of the native and the foreign language sound systems in the same phonological space. Jusczyk (1985 and 1992, cited in Flege, 1995, p. 265) states that the systematization of the L1 parameters, resulting from the onset of reading, seems to be the main constraint for L2 phonetic acquisition. The SLM (Flege, 1995, p. 239), through its four postulates and seven hypotheses, proposes that that the longer the L1 experience, the greater the interference is, and the stronger the foreign accent.

In spite of the fact that age is considered a relevant constraint for native-like L2 pronunciation achievement, it is important to bear in mind that the SLM is proposed to account for ultimate attainment of highly experienced L2 speakers. Cross-language studies have been conducted in order to test the hypotheses of the SLM and the age-related constraints to L2 phonetic acquisition (e.g., Flege, & Munro, 1995; Flege et al., 1996a; Flege, Schmidt, & Wharton, 1996). The studies have supported the claim that as AOL increases, foreign accent also increases. However, these studies were not able to conclude whether there is an AOL threshold for native-like pronunciation and whether the hypothesized sensitive period for pronunciation acquisition affects all individuals.

The SLM is permeated by the inter-related concepts of categorical perception, category formation, and equivalence classification. The model, as put forward especially in Postulate 1, proposes that the capacity to form new phonetic categories is not lost with age, which means, in other words, that even adults are able to establish an L2 phonetic category. However, the model also proposes that the successful establishment of a foreign

sound depends, among other factors, (a) on the learner's length of experience with the L1 and the L2, (b) on the interaction of the two phonological systems, and (c), on the perceptual distance between the L2 phone and the closest L1 counterpart, an issue related to equivalence classification.

Concerning learner's length of L1 and L2 experience, the SLM hypothesizes that as AOL increases, an aspect related to L1 experience, foreign accent also increases (H4), but that experienced L2 learners may eventually attain native-like pronunciation (H7). As regards the interaction of the L1 and L2 phonological systems, the SLM postulates that the two systems "are related perceptually to one another at a position-sensitive allophonic level, rather than at a more abstract phonemic level" (H1). The SLM suggests that the perceptual distance is related to the phonetic similarity between sounds from the L1 and the L2; that is a "new phonetic category can be established for an L2 sound that differs phonetically from the closest L1 sound" (H2), and "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" (H3, all hypotheses on p.239).

As discussed previously, humans perceive speech sounds in a categorical manner; that is, irrespective of the lack of constancy in the natural input or whether it is presented in a computer-synthesized continuum, humans discriminate speech sounds in distinct phonetic categories (Miller & Jusczyk, 1989; Jusczyk et al., 1995). Koerich (2002) remarks on the complexity of the operation of the categorical perception system, claiming that it occurs "at levels of processing ranging from unconscious processing of 'unperceived' physical differences in the continuum to their identification with one specific target or another" (p. 87).

The mechanism whereby the stimuli are categorized remains an unanswered issue, as pointed out by Koerich (2002, p. 88). However, it seems that subsequent to a period of

experiences with the stimuli the establishment of the category is accomplished or, as Flege (1995) states, "during the L1 acquisition, speech perception becomes attuned to the contrastive phonic elements of the L1" (p. 238). The formation of categories in the L2, however, is closely related to the mechanism of equivalence classification.

The SLM proposes that the mechanism of equivalence classification may block the establishment of a new L2 phonetic category if the new sound has a close counterpart in the L1 phonological system (H5). For L1 acquisition, equivalence classification enables learners to identify speech sounds in different phonetic contexts, or produced by different talkers, and classifies them under the same category (Flege, 1987). For L2 learning, however, Flege (1987) suggests that equivalence classification "may lead to foreign accent in older children and adults by preventing them from making effective use of auditorily accessible acoustic differences between phones in L1 and L2" (p. 50).

The SLM, through the concept of equivalence classification, brings up the discussion of what is meant by an *identical*, a *similar* and a *new* L2 phone in relation to the L1 sound system. Wode (1995, p.323) defines the terms as follows: (a) *identical* L1 and L2 phones occupy the same perceptual space and the L2 sounds are "handled via the pre-existing categories". (b) *Similar* phones overlap the perceptual space in a way that the L2 sounds "feed into pre-existing categories". As a result, L1 phonological interference tends to occur. (c) *New* phones are those which occupy a vacant perceptual space; thus, category formation is likely to be accomplished, "although it may take some time".

Wode also claims that the speech perceptual space is not completely used by any language. According to him, if the L2 sound is located in an area not occupied by any L1 sound, the L2 phone may be perceived as new. Rochet (1995), on the other hand, believes that there is not an uncommitted perceptual space in the L1 inventory and "that the notion

of 'new' L2 phone—where 'new' means 'not perceived as belonging to the same category as any of the existing L1 sounds'—is not a not a meaningful one" (p. 392).

Major (1994) claims that there are three possibilities in the perception of an L2 speech sound: the same as the L1, the same as the L2, or an intermediate perception. According to him, however, perception of the L2 speech sounds as identical or similar to that of the native language does not necessarily lead to accurate production.

As Koerich (2002) remarks, three basic criteria have been discussed in the literature in order to evaluate similarity: the phonetic symbol, the acoustic similarity, and the perceiver's judgment of the phones. According to her, however, the perceptual criterion seems to be the most reasonable "for the process of equivalence classification, since the question at stake is the question of how L2 learners relate L1-L2 sounds, and not how linguistic theory describes the languages as phonetic/phonological systems" (p. 91).

Although the mechanism whereby equivalence classification occurs has not yet been precisely determined, Rochet (1995) remarks that it "is not restricted to the auditory mode and … [it] can result from orthographic representations, occurrence in cognate words, visual information, and so forth" (p. 392). Thus, he concludes that a truly new L2 phonetic category is rare.

Earlier studies by Flege and colleagues frequently employed the terms *new, similar* and *identical* for comparing L1 and L2 phonetic systems. However, due to the controversy and the lack of an agreement on the use of the terms, the authors have been avoiding them. Instead, by saying that "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" (H3 of the SLM, Flege, 1995, p. 239), Flege and colleagues appear to have acknowledged that (a) the judgment whether an L2 sound is new or not takes place in the learner's mind and seems not to be predictable by a

theoretical account, and (b) that the distinction is not a dichotomy but a continuum. As Rochet (1995) appropriately claims, the terms *new, similar* and *identical* are "labels for describing the way in which L2 phones are perceived by the L2 learners" (p. 390) and may not be the actual process that occurs in their mind.

In addition, Flege et al. (1996a) state that "L2 sounds which are perceived as being distinct phonetically …. will ultimately be produced more accurately than will sounds which differ acoustically from a phonetic counterpart in the L1 but which are *not* perceived as phonetically distinct" (p.51). That is, the authors claim that once the learner perceives the L2 sound as a distinct one, and establishes a phonetic category for it, eventually he or she may be able to produce the sound in a native-like fashion. The present study aimed, among other objectives, to investigate whether Brazilian EFL learners perceive the interdental fricative phonemes as distinct sounds, and in doing so, whether they could produce them accurately. As Flege claims, "without accurate perceptual 'targets' to guide the sensorimotor learning of L2 sounds, production of the L2 sounds will be inaccurate" (1995, p. 238). The following sub-section discusses the perception of the target phonemes under the perspective of the SLM.

2.3.3 The SLM and the perception and production of the interdental fricatives

As mentioned in section 2.3.1, Flege et al. (1996a) conducted an experiment with 240 native Italians producing the phones /p, t, θ, ð/ in word-initial position. All participants had been living for over 30 years in Canada but they differed in their first contact with English, ranging from 3 to 21 years. In Italian the phones /p/ and /t/ are realized with shorter voice onset values than in English, while the interdental fricatives do not exist in the Italian inventory. The authors mention (p. 51) that from the perspective of the SLM, /θ/ and /ð/ were expected to be more accurately produced than /p/ and /t/, at

least by those who began learning the L2 as adults. They found a clear effect of AOL, as predicted by the model, but differently from the SLM's expectation, more participants produced /p/and /t/ in a native-like fashion than did with /θ/ and /ð/.

The same study revealed that the groups who began leaning English between the age of 3 and 7 years produced the target phonemes as accurately as the native speakers. Those who began learning after the age of 11 produced the phonemes less accurately than the native group, usually realizing them as the stops /t/ and /d/, respectively. The researchers concluded that, besides AOL, other factors influenced the pronunciation of /θ/ and /ð/, such as the use of the L1 at home, work and social settings, the motivation to integrate in the foreign community, and eagerness to pronounce accurately.

Since the interdental fricatives do not exist in the BP sound system, from the SLM point of view, and similarly to Flege et al.'s (1996a) study with the Italian learners of English, it could be expected that the participants of the present study would perceive the sounds as distinct phonetically, which could lead to the establishment of the L2 phonetic category. H2 of the SLM proposes that "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" (p. 239). In addition, H7 suggests that "the production of a sound eventually corresponds to the properties represented in its phonetic category representation" (p. 239). Thus, at least for the advanced participants of the present study, it is interesting to investigate whether they discern the interdental fricatives as distinct or as phonetically close to L1 counterpart. Equally interesting, if it is possible to conclude that the participants established a new L2 category for the target phonemes, is to examine whether their production correspond to the category representation.

H6 of the SLM proposes that the "category established for L2 sounds by a bilingual may differ from a monolingual" because "the bilingual's representation is based on different features, or feature weights, than a monolingual's" (p. 239). Similarly, Weinberger (1996) and Brannen (2002) claim that the differential substitution found for the interdental fricatives in different L1s is due to a 'non-obvious transfer', in which the features of the L2 phone are weighted differently by different L1 speakers. Flege and colleagues also cite other researchers (e.g., Ritchie, 1968; Hancin-Bhatt, 1993, in Flege et al., 1996a, p. 58) who support the standpoint that different feature weights may have an effect on L2 category formation.

In fact, H6 is of particular interest to the present study: on the one hand, if the perception tests demonstrate that the participants of the experiment are able to discriminate the target phonemes from the most common substitutes, the finding could lead to the conclusion that the new L2 categories may have been established. On the other hand, if the production tests, especially of the advanced learners, reach low accuracy scores, H6 would be supported. Flege (1995) acknowledges that "even when categories are established for an L2 sound, *the L2 sound might not be produced exactly as it is produced by native speakers"* (p. 243), and that "noninventory sounds may in some instances be produced inaccurately even by highly experiences learners" (p.265). He suggests that the SLM is now congruent with Grosjean's (1989, cited in Flege, 1995, p. 243) viewpoint of bilingualism, in which the L1 and L2 are inevitably mixed because the two systems are always engaged, which may cause the "mixing" of the L1 and L2.

Motoric difficulties are mentioned as one of the constraints on L1 segmental acquisition (Flege et al., 1996a). The authors claim that there are some sounds that "are more complex articulatorily than others and are acquired late by most children" (p.48). Concerning L2 learning, the researchers assert that "beyond a certain age, L2 learners

may have difficulty at a motoric level in modifying pre-established patterns of articulation or in learning new patterns of speech articulation" (p. 48), especially if the sound is learned late by children learning the sound as L1. Indeed, Menyuk (1968) claims that the interdental fricatives are the last sounds mastered by native learners of English. In addition, Moskowitz (1970) claims that difficulties in producing the interdental fricatives due to the lack of motor control by children—an "an inability to maintain the articulators in as finely adjusted position as is required" (p. 367). Furthermore, Flege (1999) argues that there might be an age limit for learning new forms of articulation: "It may be the case, especially for articulatory complex sounds commonly found in human languages, that true age-related limits exist for articulatory learning" (p. 1275).

In addition to the SLM, there are some other propositions of L2 speech perception and production which are important to consider in the analysis of the present study. Besides, some general SLA theories may shed some light on the comprehension of the issue. Thus, the next two sub-sections describe other theories that might be helpful for this understanding.

2.3.4 L2 speech perception and production: Further perspectives

The learner's capacity to perceive phonetic differences that are not distinctive in his/her L1 is an essential factor involved in the acquisition of a different phonological system. The relationship between perception and production has been extensively discussed in the L2 phonetics and phonology literature. Although there is no agreement about whether one aspect of learning precedes the other, there is significant evidence that an interdependence between perception and production does exist (Major, 1994; Flege, 1993 and elsewhere; Wode, 1995; Rochet, 1995; Best, 1995; Kuhl & Iverson, 1995; Baker & Trofimovich, 2001; Koerich, 2002)

Baker and Trofimovich (2001) state that there are three main hypotheses concerning the issue of speech perception and production, citing the researchers who hold up each viewpoint. The first, supported by Flege (1993 and elsewhere) among other scholars, affirms that accurate perception is necessary for correct production and that the former precedes the latter. The second assumption (held by MacDonald & McGurk, 1978; Best, 1995; Fowler, 1986) states that perception and production develop simultaneously. Finally, some researchers (e.g., Sheldon & Strange, 1982; Labov, Karan, & Miller, 1981) argue that accurate production precedes perception and that both aspects of learning can develop independently.

Likewise, Koerich (2002), reviewing studies which investigate the relationship between perception and production, reveals that there are three distinct findings: (a) studies which suggest that perception outperforms production (e.g., Flege & Hammond, 1982; Flege, 1984; Flege & Hillebrand, 1984; Archibald, 1992; Broselow & Park, 1995). (b) Studies which indicate a correlation between perception and production (e.g., Flege, 1993; Flege & Schmidt, 1995; Best, 1995; Flege, 1999; Flege et al., 1999). (c) Studies which suggest that production might outperform perception (e.g., Sheldon & Strange, 1982; Flege & Eefting, 1987; Flege et al., 1997).

Regardless of the divergence on the issue, Baker and Trofimovich (2001) claim that "understanding such a relationship is important for both theoretical and pedagogical reasons" (p.273). Under a theoretical perspective, the understanding of the relationship may shed some light on the complex process of L2 learning. For pedagogical reasons, L2 teaching might take advantage of such an understanding, which would in turn contribute for reducing foreign accent.

As previously discussed, the SLM relates L2 perception to production, proposing that ultimately production may resemble the category established for the L2 sound. Although the following scholars do not necessarily correlate perception to eventual

pronunciation attainment, they put forward relevant hypotheses concerning the issue of L2 speech perception and production.

Best (1995), who works with speech perception from an articulatory point of view, defines non-native segments as "those whose gestural elements or intergestural phasing do not match precisely any native constellations" (p.193). She proposes the perceptual assimilation model (PAM) for cross-language speech perception, a model which suggests that the non-native segments "tend to be perceived according to their similarities to, and discrepancies from, the native segmental constellations that are in closest proximity to them in the native phonological space" (p. 193). To sum up, the researcher argues that non-native gestures which resemble the native constellation will be perceived through the native system in six different types of assimilation.

Equally important, concerning cross-language speech perception, is the effect of L1 experience on L2 perception. Kuhl and Iverson (1995) point out that language experience affects L2 perception and named this phenomenon the "perceptual magnet effect". According to these authors, the continuous contact with the L1 phones tunes the sound system to the native language inventory, which "produces a change in perceived distances in the acoustic space underlying phonetic distinctions, and this subsequently alters both the perception of spoken language and its production" (p.122). They claim that this attunement to the L1 sound system causes a considerable impact for children learning an L1 and adults attempting to learn an L2: the L1 sound prototypes would function as perceptual magnets and guide, or misguide, L2 speech perception.

As mentioned in section 2.3.2, Rochet (1995) states that there is not an uncommitted space in L2 learners' phonological mental representation. On the contrary, he hypothesizes that the native phonological space would be entirely occupied by L1 phones and when L2 learners encounter a non-contrastive foreign sound, they inevitably relate this sound to an L1 prototype. Thus, according to Rochet's perspective, Brazilian EFL

learners would always relate the English interdental fricatives to a Portuguese prototype, which may prevent them from identifying the foreign phones as distinct.

In addition to these accounts of L2 speech perception, some SLA standpoints on the issue of L2 learning might be useful to interpret the findings of the present study. Therefore, next topic presents several further SLA theories, such as the "Noticing Hypothesis" (Schmidt, 1990 and elsewhere), and the "Input Frequency Hypothesis" (Ellis, 2002a, 2002b).

2.3.5 Some SLA theories and the present study

Another aspect concerning perception is Schmidt's (1990, 1994, 1995) perspective of the term. He claims that for a learner to acquire language, consciousness as awareness is essential in the course of learning. He makes the distinction between perceiving and noticing, arguing that perception may be conscious or not, whereas for noticing an item of a language a conscious process is necessary. Furthermore, he operationalizes noticing as "availability for verbal report" (Schmidt, 1990, p. 132), claiming that noticing is the required condition for learning and that what is noticed in the input becomes intake. He also argues that there is "more learning with more noticing and less learning with less noticing" (Schmidt 1995, p. 22).

Although Schmidt mentions nothing specifically about the relationship between noticing and the production of L2 phones, he maintains that the learners who are able to verbalize the rules of the grammar are those who demonstrate better performance (1995). Moreover, Schmidt claims that "noticing is a necessary condition for storage" (1990, p.141), and that noticing is a pre-requisite for understanding to take place. He also affirms that understanding is the ultimate level of consciousness and that "[input] understanding led to correct production and misunderstanding was reflected in deviant performance" (Schmidt, 1990 p.147). In other words, it seems that when the learner notices an item and

is able to reflect on it, the item starts to appear in the output. Accordingly, it could be hypothesized that if the participants of the present study demonstrate capacity to produce the target phonemes accurately, it could be assumed that these learners have already passed through the process of noticing the target phonemes as distinct L2 phones and reached the understanding level.

Similarly, in terms of perception, it could be hypothesized that if the participants of the study are capable to demonstrate the presence a mental representation of the target phonemes at the time of the experiment, most likely the learners have already noticed the peculiarity of the interdental fricatives. On the other hand, if the participants do not demonstrate this awareness at the time of the experiment, it could be assumed that they have not reached noticing during the learning process yet.

Input frequency is, according to Ellis (2002a. 2002b), another aspect that must be taken into consideration in the discussion of L2 acquisition. Ellis affirms that "learners have to *figure* language out" (2002a, p.144) and, this process would be facilitated by input frequency. Through a top-down process, the frequent input would activate schemata, associated with previous knowledge and then classified in categories. Many of the *th*-words involved in the present study are highly frequent in both spoken and written English (Leech, Rayson, & Wilson, 2001), especially the function words. Drawing on Ellis' perspective on the importance of input frequency in L2 learning, and disregarding any other theoretical approach which attempts to explain L2 acquisition, such as L2 speech perception, markedness factors, or L1 interference, it would be expected that the high frequent words were produced accurately before the less frequent words.

In conclusion, this chapter presented an overview of some theoretical proposals and empirical findings related to the relationship between L2 segmental perception and production. Various theories and models which attempt to elucidate the mechanism of

speech perception as well as the existence of a unit of speech perception were discussed in the chapter.

Some models of speech perception, such as Motor Theory (Liberman Liberman, & Mattingly, 1985) and Direct Realism (Fowler, 1986) hypothesize that there is a direct relationship between the acoustic signal and the perceived phoneme; that is, speech perception would occur in a bottom-up fashion. Models such as the Fuzzy Logical (Massaro, 1987) and the Quantal (Stevens, 1989) on the other hand, advocate that top-down cognitive processes influence speech perception. As regards the unit of speech perception, research (Jenkins & Yeni-Komshian, 1995; Rodrigues, 1994; Bradley et al., 1993; Cutler et al., 1986; Kipp et al., 1996; Flege, 1991) suggests that the phenomenon might occur through a syllabic, a phonemic, an allophonic or a phonetic level, depending on the language, on the L1-L2 contrast, or on the experimental situation.

The Speech Learning Model (Flege, 1995), which attempts to account for L2 speech perception and production, provided the main framework that structures the study; nevertheless further reflections on the issue were also considered. The SLM and hypothesizes that for the learner to produce the L2 sound accurately, the establishment of the L2 perceptual target is essential.

Concerning the perception and production of the interdental fricatives, a few studies conducted so far (Schmidt, 1987; Flege et al., 1996a) suggest that L2 misperception may be involved in the misproduction of the sounds; that AOL influences the production of target phonemes; that the non-existence of the phonemes in the L1 inventory does not guarantee that they are necessarily perceived as distinct; and that different /θ/ and /ð/ replacements are found for different L1 backgrounds (Weinberger, 1996; Brannen, 2002; Reis, 2004b).

Chapter 3 — Method

This chapter describes the experiments conducted in order to investigate the perception and production of the English interdental fricative phonemes in word-initial position. Three groups participated in the study: a group of native speakers (NS) of English, and two groups of Brazilian EFL learners, one of pre-intermediate students and the other of advanced learners. The results of the NS, which took only the perception tests, provided the minimal ground for comparison with the EFL groups' performance in this skill. Two different learning levels were chosen mainly in order to verify whether English language experience, henceforth language experience, may influence both perception and production of the target phonemes. The more experienced group had been learning English for an average of 5 years, whereas the less experienced for an average of 1½ years. It was expected that learners at different levels would have developed different strategies of production and perception of the interdental fricatives.

The data collection was conducted in April 2005 through six instruments: three production tests and three perception tests, besides a questionnaire for selecting participants and evaluating their profile. The data gathering took place in the language laboratory of the Centro de Comunicação e Expressão, at the Universidade Federal de Santa Catarina (UFSC). This chapter describes the research questions (RQs) and the hypotheses (Hs) of the study, the participants involved, the data gathering instruments, the procedures, and the statistical analyses employed in the study.

3.1 Research Questions and Hypotheses

In order to investigate the perception and the production of the interdental fricative phonemes, the following research questions and hypotheses were proposed:

RQ1.: Is there a pattern of replacement of the target phonemes among Brazilian EFL learners?

    H1.: Brazilian learners will use more than one substitute, especially for /θ/.

    H2.: The most common sounds used to replace the target phonemes will be /t/ for /θ/ and /d/ for /ð/.

    H1 and H2 are based on Reis (2004a) who investigated the production of the *th* phonemes by Brazilian EFL learners, as well as Lombardi (2003), who argues that all learners from the same L1 background tend to follow the same pattern of replacement.

RQ2.: Does English language experience influence production of the target phonemes?

    H3.: The more experienced learners are expected to produce the target phonemes better than less experienced learners.

    H3 is based on the SLM, which proposes that experienced EFL learners may eventually be able to attain native-like pronunciation.

RQ3.: Does English language experience influence perception of the target phonemes?

    H4.: The more experienced learners are expected to perceive the target phonemes better than the less experienced learners.

RQ4.: Do Brazilian EFL learners perceive when the two target phonemes are replaced by their most common variants ([t], [s] and [f] for /θ/, and [d], [z] and [v] for /ð/)?

    H5.: The more experienced learners will perceive replacements more frequently than the less experienced learners.

    Again, H4 and H5 are based on the SLM, which proposes that experienced EFL learners may eventually be able to establish a category if the L2 phone is new in the L1 inventory.

RQ5.: Is one target phoneme more problematic than the other?

    H6.: /ð/ will be more difficult to perceive than /θ/.

H7.: /ð/ will be more difficult to produce than /θ/.

H7 is in accordance with Eckman's MDH (1977), which asserts that both phonemes are marked in the world's languages, and that voiced phonemes are more marked than voiceless phonemes.

RQ6.: Is there a relationship between perception and production of the target phonemes?

H8.: There will be a relationship between perception and production; that is, learners who perceive the phonemes more frequently will produce them more frequently.

H9.: The relationship will be more consistent among experienced learners than among less experienced learners.

H8 and H9 follow the predictions of the SLM. The model postulates that there is a relationship between perception and production and that more experienced learners may eventually be able to establish a new phonetic category.

RQ7.: Will error rate for the production of the target phonemes change according to the different test styles represented by the three production tests in the present study?

H10.: Learners will produce more accurately in more formal tests.

This hypothesis is in accordance with the standpoint that learners of foreign language demonstrate more accuracy in more formal situations (Major, 1994; Tarone, 1979; Beebe, 1987; Schmidt, 1987)

3.2 Participants

Twenty-four Brazilian EFL learners participated in the study, seven women and seventeen men, aged from 15 to 23. The participants were regularly attending the EFL classes of the Extracurricular Language Project of the Universidade Federal de Santa Catarina (UFSC). This project encompasses ten levels of language proficiency and each level takes one semester to be completed. The material adopted from levels 1 to 6 was the series *New Interchange* (Richards, Hull, & Proctor, 1998), whereas from levels 7 to 10

the *Passages* series (Richards & Sandy, 2000) was used. The participants were divided into two groups—12 pre-intermediate learners from the third semester, named here group I (GI), and 12 advanced learners from the tenth semester, named group A (GA). Regarding language experience, as mentioned before, GI had been learning English for an average of 1 ½ year, while GA for an average of 5 years.

All the participants began studying English after the age of seven, the commonly held threshold for the hypothesized Critical Period Hypothesis (Scovel, 1988, cited in Flege, 1995), and no participant recalled having received formal specific instruction in English phonetics and phonology, in particular about the perception and production of the interdental fricative phonemes.

They all self-reported normal hearing and speaking capacities. Five subjects claimed to be fluent in another foreign language, two claimed that Spanish and Italian were spoken at home and three subjects from GA had already had a short experience in an English speaking country. Although this experience may perhaps have influenced their perception and production of the target phonemes, I decided to maintain them in the analysis since they were abroad for only a short period of time, from 2 to 5 months, and they reported having had more contact with their Brazilian family and friends. Moreover, Bjork and Bjork (1992, cited in Sancier & Fowler, 1997) believe that very recent past experience in a language setting affects speech perception more strongly than more distant past experience. These participants were back to Brazil in 2000, 2001 and 2002; thus, their most recent language setting was BP rather than English.

Five male native English speakers constituted the group of native speakers (NS), their ages ranging from 19 to 42. Three of them were from different parts of the United States and two from Australia. At the time of data collection they had been living in Brazil for a minimum of 6 months and maximum of 2 years. All reported that in their

dialects the interdental fricative phonemes are phonologically distinctive (see Appendix L for more detailed information about the participants).

3.3 Instruments and procedures

Six different data-gathering instruments were utilized in order to verify the perception and production of the English interdental fricative phonemes in word-initial position: three production and three perception tests. In addition, two questionnaires were applied, one, in Portuguese, for the two EFL groups and another, in English, for the NSs (Appendix A). The instruments will be described in the following sub-sections according to the sequence they were presented to the participants.

All the participants agreed formally to participate in the research project (Appendix M), although the main objective of the experiment was not formally revealed to any of them. The tests were conducted in the language laboratory of the Universidade Federal de Santa Catarina, which provided suitable conditions for listening and recording. Each participant was given headphones, a microphone and a set of answer sheets on which the responses should be indicated.

The three groups were tested separately, in a single session only. The three production tests were given before the three perception tests in order to keep learners from figuring out what was being tested. The two EFL groups received instructions in Portuguese and were told to perform the production tasks at their own pace and not to leave any item blank in the perception assessment. The NSs, on the other hand, took only the perception tests and the instructions were given in English.

The data collection of the two EFL groups took approximately 85 minutes each, and was conducted as follows: (1) Pro1—10 minutes; (2) break—3 minutes; (3) Pro2—20 minutes; (4) break—3 minutes; (5) Pro3—5 minutes; (6) break—5 minutes; (7) GPE—10

minutes; (8) break—3 minutes; (9) CDT—15 minutes; (10) break—3 minutes; (11) AFC—5 minutes. The NSs took around 35 minutes to conclude the tasks since they participated only in the perception tests—steps from 7 to 11.

3.3.1. Production tests

Three production instruments were employed in order to test participants' pronunciation of /θ/ and /ð/: reading a text, retelling the story of the text, and reading a list of sentences. The NS did not perform the production tests.

3.3.1.1 Production Test 1: Reading a text

In the first production test (Pro1) 1 the participants tape-recorded a text containing 21 occurrences of each phoneme in word-initial position (Appendix B). They were asked not to read or rehearse the text before recording it, but to read it calmly, self-paced, and without repetition of words they might have mispronounced. When the participants repeated a word with the target phonemes, only the first occurrence of the word was considered for the purpose of the analysis.

In order to give different opportunities for the participants to produce the interdental fricatives accurately, it would have been preferable to avoid repetition of words with the target phonemes in the text. Unfortunately, however, it was not possible to avoid some repetitions, especially of the function words, in particular the definite article. A previous study which investigated the production of interdental fricative phonemes by Brazilian learners of English (Reis, 2004a) showed that *the* is almost never produced accurately. However, since the definite article is the most frequent word in English (Butler, 2002; Leech, Rayson, & Wilson, 2001), it appeared seven times in the text. Table 2 displays the number of repetitions of each target phoneme in Pro1.

Table 2. Number of repetitions of words with /θ/ and /ð/ in Production Test 1.

Number of repetitions	1	2	3	4	7
/θ/	theory thieves thirteen thin thermometer thanks	theft theater thought thing thirty therapy	think		
/ð/	though than there	this them	that	they	the

This greater repetition of /ð/is due to the high frequency of function words in both the spoken and the written language (Leech, et al., 2001). Since initial voiced *th* occurs in current English only in function words, it was not possible either to avoid some occurrences or to vary the use of words without changing the meaning of the text.

Frequency of occurrence was a criterion taken into account for the choice of the words with the voiceless interdental fricative. As a result, familiar words would probably offer less difficulty for the participants to read the text.

Equally important to mention is that the previous phonological environment was not controlled in the design of the text. Although the researcher acknowledges that the previous sound may interfere in the production of the interdental fricatives, especially if this sound is one of the frequent substitutes for the target phonemes, to provide an intelligible story containing the target phonemes was the main purpose of this instrument. Thus, it was preferable to plan this text in a meaningful manner in order to try to prevent participants from figuring out the objectives of the study.

3.3.1.2. Production Test 2: Reporting the story of Production Test 1

In the second production test (Pro2) the participants were asked to retell the story of Pro1, in the third person and with as much detail as possible. Since on first contact with the text the participants were allowed to read it only once, now they were told to reread

the text twice before recording it from memory, without the aid of the text. The subjects were free to spend as much time as necessary to retell the story (Appendix C).

3.3.1.3. Production Test 3: Reading a list of sentences

In the third production test (Pro3) the participants tape-recorded a list of 45 randomized sentences in which 30 contained one target phoneme each (Table 3), while 15 were distracter sentences (Appendix D). Each participant was given a list with the sentences in a different order, so as to minimize ordering effects. Again the subjects were asked not to read the sentences before recording them.

Table 3. Words with /θ/ and /ð/ in Production Test 3.

/θ/	thoughts, thought, thickens, Thanksgiving, thick, theme, thirteen, thought, things, theater, thinks, thought, theatrical, theology, thesis
/ð/	that, they, their, they, that, those, them, these, they, these, there, that, those, this, that.

As Pro1, Pro3 was designed to provide a meaningful context for the words with the target phonemes. However, in order to avoid any possible previous phonological influence over the production of the target phonemes, this time the environment was controlled. Assuming that words ending in consonants could complicate the production of the following *th*, such as in *state things* or *beside this*, examples not present in this study, now the interdental fricatives are preceded by words ending in tense vowels or diphthongs. The choice for tense vowels or diphthongs is justified by the fact that these types of vowels are usually fully produced and not reduced. Vowel reduction, in last instance, could lead to an emphasis of the consonant sound that precedes the vowel. However, due to the lack of time during the test design, it was not possible to construct all the sentences with these types of vowels. In two sentences with the voiceless *th*, *Take a theology course* and *This is only a thesis,* the target phoneme is preceded by a lax vowel. As in Pro1, here again the definite article could not be avoided. It occurred four times in

the 45 sentences, but in this instrument it just constituted part of the context, providing meaning to the sentences, and was not considered in the statistical analysis regarding the production of /ð/.

Both the first and the third production tests were kept small because of the number of tests involved in the entire study—6 production and perception tests, in addition to the questionnaire—which were administered in one single session only.

3.3.2 Perception tests

In order to evaluate participants' perception of the target phonemes in word-initial position, three different types of data-gathering instruments were used: a general pronunciation error perception test, a Categorial Discrimination Test, and an Alternative Forced Choice Identification Test. The first two tests were piloted some months before the actual data collection, with different participants. In the present study, the participants were given a set of answer sheets, on which they were asked to mark their responses. For this part all three groups (GI, GA and NS) participated in the study.

3.3.2.1. Perception Test 1: the general pronunciation error perception test

The first perception test was designed specially for this study and was named the general pronunciation error perception test (GPE). The purpose of this test was to verify whether the subjects were able to notice inaccurate *th* pronunciation when the interdental fricatives were inserted in a context of communication. The same text from Pro1 was recorded by a Brazilian EFL speaker, who did not participate in the study, with problematic pronunciation both on the segmental and the supra segmental levels. The reading was recorded on a Sony Minidisk, digitized and normalized by the Sound Forge 7.0 program.

The written and listening tests that accompany the *New Interchange* series (Richards et al., 1998) were given to the speaker in order to evaluate his level of English proficiency. The results showed that he would be placed in the third semester of the UFSC Extracurricular Language Project. A native English speaker examined the speech according to a holistic and personal experience, evaluating the sample as heavily accented, with all *th*-sounds inaccurately produced.

Together with the speaker's own production errors, I also manipulated the speech by asking the speaker to pronounce the target phonemes differently (Appendix E). The choice of the substitutions was based on a previous study that investigated the production of the target phonemes by Brazilian EFL learners (Reis, 2004a), which found that /θ/ was frequently replaced with /t/, /f/, and rarely with /s/. Hence, words that were repeated in the test were substituted differently. The word *think*, for example, appeared first as [fɪnk], secondly as [sɪnk] and finally as [tɪnk]. Likewise, the words *thought* and *thing* were produced, respectively, as [tɔt] and [fɔt], and as [fɪŋ] and [sɪŋ]. All the voiced interdental fricatives were replaced with [d], since this was the most frequent pattern of substitution found in the same study.

The participants heard the text twice and were asked to point out any pronunciation mistakes they could notice in word-initial position. Since the diversity and the number of pronunciation inaccuracies might overload their attention and distract them from the purpose of the study, I decided to guide their task by specifying position, because the GPE pilot study (Reis, 2004b) indicated that word-initial errors were not as readily perceived as word-final errors.

3.3.2.2. Perception Test 2: the Categorial Discrimination Test

In order to evaluate participants' discrimination of the interdental fricative phonemes in word-initial position from their most common replacements, the second perception instrument was the Categorial Discrimination Test (CDT, Flege et al., 1994). Originally designed to evaluate vowel perception, the CDT was utilized in this specific consonant perception assessment with some adaptations, which will be explained in this sub-section.

Flege and colleagues (1994) recommend comparing the target sound with its most frequent form of replacement in two ways: through catch trials and through change trials. In the CDT each trial has three samples being contrasted, each sample recorded by a different talker. In the catch trial all three phonemes are identical in all three positions. The phoneme can be either the target one, such as the vowel sound of *cat* (æ/ æ/ æ), or one of its substitutions used by English learners (ɛ/ ɛ/ ɛ). The change trial, on the other hand, contains an odd item in one of the three positions; that is, one of the phonemes is different from the other two. Similarly, the odd item may be either the target sound (e.g., æ/ ɛ/ ɛ) or one of its substitutions (e.g., æ/ æ/ ɛ). According to this design, the comparison of each contrast would require eight trials: two catch trials, one with the target phoneme and the other with the replacement, and 6 change trials, three varying the position of the target phoneme and three varying the position of the substitute.

In a CDT, participants hear a sequence of trials and are asked to indicate whether there is an odd item in each trial and, if so, in what position it is located. If all three items are identical, they are instructed to mark the label '0'. On the other hand, if the odd item out is the first word heard, participants are asked to mark '1'; if it is the second word, the correspondent label is '2', and, finally, if the third word heard is the odd item, they should indicate the label '3'.

Based on the results of the two CDT pilot studies (Appendices F and G)**,** which aimed to investigate the discrimination of the target phonemes in word-initial position by Brazilian EFL learners (Reis, 2004a, 2004b) but appeared to be rather long and mentally demanding, the following modifications were made: (a) only one catch trial for each target phoneme was included, even though each one was paired with three different substitutions; (b) the test words were de-contextualized; (c) all words were produced by talkers of the same sex—female because of availability in the region; (d) nonsense words and distracters were excluded, leaving the objectives of the test apparent to the participants; (e) the within-trial and between-trial intervals were increased, and (f) the target phonemes and their possible substitutions were tested separately, first the voiceless set and then the voiced**.**

As a result, the final version of the CDT (Appendix H) was an oddity format test consisting of 44 randomized trials (6 contrasts x 6 change trials = 36 + 8 catch trials)**.** The two minimal sets *thigh-fie-tie-sigh* and *thee-vee-dee-zee* were recorded on a Sony Minidisk by three women native speakers of English, then digitized and normalized for peak intensity at 6dB using the Sound Forge 7.0 program. They were then organized into the 22 trials for each target phoneme, which were randomized separately (within each set of 22) in Praat 4.2, in order to reduce the ordering effect. Intervals were set at 2.0 seconds between each word within a trial and of 2.7 seconds between trials. The test was recorded on a CD to be played in the laboratory.

The participants were provided with a 6-set practice session, with feedback, before the task itself began (Appendix I). In the test they heard the trials only once and were asked to mark the discrimination according to the design of the CDT, described above. In order to focus participants' attention even more, they were instructed to concentrate on the initial sound of each word.

3.3.2.3. Perception Test 3: the Alternative Forced Choice Identification Test

In order to verify whether the subjects were able to identify differences between the interdental fricative phonemes and their most frequent replacements, the third data gathering instrument consisted of an Alternative Forced Choice Identification Test (AFC, Beddor & Gottfried, 1995).

The participants heard the same set of words from the CDT—*thigh-fie-tie-sigh* and *thee-vee-dee-zee—*for the voiceless and voiced target phonemes, respectively, recorded by the same female native speakers of English. Each word appeared 5 times at random, totaling 40 trials: 20 for each phoneme (Appendix J). The words were presented in isolation with an interval of 2.7 seconds among the trials, an interval that followed the pattern of the CDT. The two interdental fricatives were tested independently, that is, first the 20 words with the voiceless *th*, and then the 20 words with its voiced counterpart.

The two target phonemes were tested separately in order to limit the number of labels provided to the participants. If the identification of the two target phonemes and their replacements were done at the same time, the subjects would have eight labels to select from. Having eight labels rather than four could make the subjects' task more time consuming, confusing and could result in inappropriate performance due to the design of the test. Moreover, the labeling of the difference between the voiceless and the voiced *th* would bring up an issue that is not under analysis in this experiment: whether the subjects are able to identify the voicing difference between /θ/ and /ð/. Besides, it would be necessary to use different symbols for the two phonemes, probably the actual phonetic symbols. Again, the possibility of a low achievement due to an unfamiliar aspect of the design of test should be avoided. I could have used words which the initial sound was the same of each phoneme being tested. However, the participants would still have had 8 choices to make, a quantity that might mislead their performance. Thus, the two AFC

tests were conducted separately, with four labels for each: 'f/ s/ t/ th' for /θ/ and 'v/ z/ d/ th' for /ð/.

The participants heard each trial only once and were instructed to pay attention to the word-initial sound of the word they would hear, labeling the sound according to the four possibilities given. Again participants were provided a 6-set practice session with feedback before the experiment itself began (Appendix K).

3.3.3. Questionnaire

A questionnaire was employed in order to obtain participants' personal information and information about their learning experience (Appendix A). Among other issues, it was possible to discover when their first contact with English occurred, how long they had been studying the language without interruption, whether they listened to songs frequently, or whether they dedicated more time to study the language by themselves. Furthermore, they could express their opinion on the importance of pronunciation in communication, and give their opinions on the difficulty of production of the target phonemes (Appendix L for the results).

3.4 Data Analysis

With the purpose of investigating the perception and production of the English interdental fricative phonemes in word-initial position by Brazilian EFL learners at two different levels of proficiency, the analysis was based on the results obtained in the data collected through the six instruments. The two EFL groups, with a total of twenty-four participants, produced the following results in the production tests: (a) Pro1—1008 responses—504 for each phoneme; (b) Pro2—119 samples of the voiceless *th* and 255 samples of the voiced counterpart, totaling 374 occurrences; (c) Pro3—a total of 720

samples, 360 for each target phoneme. The 15 distracters of Pro3 were not analyzed, since they did not contain the target phonemes.

Regarding the transcriptions of the production tests, only the relevant components of the speech were transcribed in the study (Appendices N1, N2 and N3 for the results); that is, the part of the talking that included the two target phonemes. The recordings were transcribed by the researcher twice, with an interval of three weeks between each transcription. The data were analyzed as accurate concerning only the production of initial interdental fricative phonemes. Spectrogram analysis was not used since the image would not help much to discriminate the target phonemes from their most confusing replacements. The /θ/-/f/ and /ð/-/v/ contrasts, for example, are acoustically very similar (Ladefoged, 2001). The words with the target phonemes were not avoided by any participant, possibly due to the high frequency of *th*-words in English. Despite the expected inaccuracies, all interdental fricative phonemes, or their forms of replacement, were produced audibly by the subjects.

The 2102 tokens of the three production tests were heard and transcribed by a second listener with experience in phonetic transcription, who is also a native speaker of English. In case of disagreement on the pattern of substitution employed by the participants, a third listening by the researcher and a second listening by the second listener together was enough for them to agree upon the outcome. Hence, all 2102 occurrences of the target phonemes were statistically analyzed.

The analysis of the perception tests was based on the following responses: (a) GPE—1008 occurrences, 504 of each target phoneme; (b) CDT—528 samples of each fricative phoneme, totaling 1056; and (c) AFC—960 responses, 480 for each target phoneme. The NSs performed the perception tests as well, resulting in 210 responses in the first test (GPE), 105 for each *th*; 220 answers in the second test (CDT), 110 for each

target phoneme, and 200 responses in the third test (AFC), 100 for the voiceless *th* and 100 for the voiced counterpart. Since the participants were asked not to leave any trial without an answer, all 3654 trials of the three perception tests were completed. These answers were organized according to group and test by the researcher alone and all responses were considered in the statistical analysis.

In order to verify whether the results of this study are statistically significant regarding the perception and production of the two English interdental fricatives by Brazilian EFL learners, a parametric test and several non-parametric tests were used.

Since parts of the data were not normally distributed, non-parametric tests were more suitable to assess significance in terms of percentages, proportions, and frequencies. Non-parametric tests such as the Kruskal-Wallis, the Mann-Whitney, and the Wilcoxon tests analyze samples consisting of ordinal data rather than direct measurements; that is, the tests deal not with raw values but with ranked data. Both Mann-Whitney and Wilcoxon are non-parametric tests that correspond to the *t*-test. The Mann-Whitney is equivalent to an independent sample *t*-test in which the results of two groups who took one test are compared. The Wilcoxon, on the other hand, is equivalent to a paired-sample *t*-test, in which the results of a single group who took two tests are compared (for the present study, the voiced and voiceless *th* tests).

Finally, the Spearman rho rank correlation test was run for examining the significance of the relation between the perception and production of the target phonemes. This test was chosen because the dataset did not satisfy the normal distribution assumption. For all the statistical tests, which were run considering the mean results, the level was set at .05.

Chapter 4 — Results and Discussion

This chapter reports and discusses the results of the two Brazilian EFL groups on the production tests as well as the results on the perception tests by the native and the non-native groups. The report and discussion are approached in two main sections: first the production results, and second, the perception results.

4.1 Results of the production tests

In order to investigate Brazilian EFL learners' production of the English interdental fricative phonemes, three production tests were used: reading a text, retelling the story of the text, and reading a list of sentences. The results are divided in three main subsections, which discuss the results of each production test relating them to the research questions and hypotheses of the study.

For the purpose of analysis, the production of the target phonemes was considered accurate only when the voiceless interdental fricative was realized as [θ], and the voiced counterpart [ð]. The production of the remaining part of the word carrying the target sounds was not considered, regardless of whether it was produced correctly or not.

4.1.1. Production Test 1: Reading a text

In the first production test the twenty-four EFL participants read a text containing 21 occurrences of each target phoneme (Appendix B). The results (Appendix N1) indicate the same outcome pattern for both groups, that is, greater difficulty in the production of the voiced *th* than its voiceless counterpart. Table 4 displays the overall rates of accurate production by each group in Pro1.

Table 4. Accurate production scores of /θ/ and /ð/ by the pre-intermediate (GI) and the advanced (GA) groups in Production Test 1.

| | /θ/ | | | | /ð/ | | | | Total | |
Group	N	Acc. (%)	M	SD	N	Acc. (%)	M	SD	N	Acc. (%)
GI	252	33 (13)	2.75	3.41	252	0 (0)	0	0	504	33 (6)
GA	252	97 (38)	8	6.66	252	6 (2)	.5	.8	504	102 (20)

Note: N= Total number of occurrences. Acc= Accurate production. (%)= percentage of accuracy. M= Mean. SD= Standard deviation

A Mann Whitney test yielded a non-significant result for voicing effect. The GA did not significantly outperform the GI with the voiceless *th* (Z=-1.84, p=.07). Similarly, the production of the voiced phoneme showed a non-significant difference between the two groups (Z=-2.13, p=.17). Comparing the results of the target phonemes within each group, using Wilcoxon signed rank test, the GA produced the voiceless *th* significantly more accurate than its voiced counterpart (Z=-2.52, p=.01). The same tendency was observed with the GI, the voiceless *th* was produced more accurately than the voiced *th* (Z=-3.37, p=.11), which was not produced accurately even once.

The general results of this production test seem to support H7 of RQ5, which proposes, according to Eckman's MDH (1977), that because the voiced *th* is more marked than its voiceless counterpart, it is more difficult to produce. H3 of RQ2, however, seems not to be supported; that is, the results of Pro1 suggest that language experience does not affect the production of the target phonemes significantly. However, it is important to keep in mind that some unexpected significance or non-significance in the results can be due to the small number of participants in each group and the high variation found in their performance, as can be seen from the means and the standard deviation in the tables.

The overall pattern of replacement for the voiceless *th* found in this study corroborates previous findings for Brazilian EFL learners (Reis, 2004a) and supports H1 and H2 of RQ1. Table 5 shows that the participants of the present study used more than one pattern of replacement (H1), and, most frequently, both groups used [t] to replace /θ/ (H2).

Table 5: Realization of /θ/ by the pre-intermediate (GI) and the advanced (GA) learners in Production Test 1.

		[θ]	[t]	[f]	[d]	[tʰ]	[s]	[tʃ]	[tθ]	Total
Group	N	Ac. (%)	Re. (%)	Re. (%)	Re. (%)	Re. (%)	Re. (%)	Re. (%)	Re. (%)	Re. (%)
GI	252	33 (13)	132 (52)	34 (13)	16 (6)	29 (11)	5 (2)	2 (0.8)	1 (0.4)	219 (87)
GA	252	97 (38)	102 (40)	26 (10)	0 (0)	22 (8)	2 (0.8)	1 (0.4)	2 (0.8)	155 (61)

Note: N= total number of occurrences. Ac. Accurate. Re= replacement. (%)= percentage of substitution.

Concerning voiceless replacement, the [t] substitution was followed in quantity of occurrences by [f] and [tʰ], whereas [s] appeared occasionally, as well as some uncommon forms of replacement, such as [d], [tʃ] and [tθ]. The use of different variants for the voiceless *th* may have distinct reasons. As Flege et al. (1995, 1996a) point out, aspects such as misperception, motoric difficulties, inadequate phonetic input, motivation, early and incorrect habit formation[5] might be involved in the inaccurate production of an adult EFL learner. In addition to these reasons, the realization of the voiceless *th* as [t] can be interpreted as resulting from the influence of L1 transfer, since cognate words are pronounced as [t] in Portuguese, such as *teatro* (*theater*)*, terapia* (*therapy*)*,* and *termômetro (thermometer)*, all of them spelled with '*t*' in BP. In fact, the word *theater*, within the loan word *home theater*, is produced with [t] or [tʃ] in BP.

Indeed, /θ/ cognate words (Tables N1 and N2—Appendix N1) were in general realized as [t]: 92% by the GI and 71% by the GA, in both cases quite a bit more than the average found for the non-cognates. Besides, both the spelling with *t* in BP and the lower frequency of these words in English, in relation to function words, should be taken into account. Perhaps, due to the fewer opportunities learners may have had to be exposed to

[5] *Habit formation* was a term used by Flege and colleagues in earlier publications (Flege, Munro, & MacKay, 1995; Flege et al, 1996a). However, in their most recent publications (Flege, 1997, 1999; Flege et al., 1996b) the term has not been mentioned any longer. The term *habit* is often related with behaviorist theories of language learning, in vogue in the 1950s and 1960s in teaching methods such as the Audio-lingual (Celce-Murcia, Brinton & Goodwin, 1996). Behaviorist theories posit that language learning is a matter of habit formation, resulted from environmental conditioning; that is, positive and negative feedback causes reinforcement and memorization of habits. Currently, most applied linguistics prefers the term *automatization*, related to cognitive theories of learning (Baptista, 1995; McLaughlin, 1987). See discussion about automatization process in section 4.1.4. I will favor the term automatization even when interpreting the results from Flege's perspective.

these words, they may have simply carried the Portuguese pattern over into the English one.

However, the use of the other less frequent replacements for the voiceless *th*, such as tθ], as well as the more frequent [f] and [tʰ], may perhaps be interpreted as an attempt to produce the target phoneme. When the learners produce /θ/ as [f], [tʰ], or [tθ], they might have already noticed that the voiceless *th* has a distinct pronunciation from any BP phone. Thus, they may be trying to accomplish the target phoneme by using one of these variants, which may sound to them perceptually comparable to /θ/.

Concerning pattern of replacement of the voiced *th* in Pro1, [d] was found in 95% of occurrences (Table 6). This result supports previous findings among Brazilian EFL learners (Reis, 2004a) and corroborates H2 of RQ1—BP speakers almost exclusively substitute /d/ for /ð/. A setback in the design of Pro1 was the use of the definite article as a source of investigation of /ð/.

Table 6: Realization of /ð/ by the pre-intermediate (GI) and the advanced (GA) learners in Production Test 1.

Group	N	[ð] Acc. (%)	[d] Re. (%)	[θ] Re. (%)	[t] Re. (%)	[tʰ] Re. (%)	[f] Re. (%)	Total Re. (%)
GI	252	0 (0)	239 (95)	0 (0)	9 (3.5)	3 (1.1)	1 (0.3)	252 (100)
GA	252	6 (2.3)	240 (95)	3 (1.1)	3 (1.1)	0 (0)	0 (0)	246 (97)

Note: N= Total number of occurrences. Acc. Accurate. Re= replacement. (%)= percentage of substitution.

A previous study concerning production of the interdental fricatives by Brazilian EFL learners from different levels of proficiency (Reis, 2004a) demonstrated that the definite article is hardly ever accurately produced. However, it would not be feasible to avoid its use and, moreover, if more and different words with the voiced *th* were used in this instrument, the numbers of occurrences of the two target phonemes would be unbalanced, which was avoided for statistical reasons.

When /ð/ was accurately produced, only by the GA, it occurred 4 times with the word *them* and 2 with *there*. The words *them* and *there* are the 59th and 46th most frequent words in spoken and written English (Leech, et al., 2001), respectively. On the other hand, other function words like *the, that* and *this* are even more frequent (the 1st, the 13th and the 24th, respectively) but were never accurately produced in this study. Although function words are very frequent, this aspect does not seem to favor their accurate production, as Ellis (2002a, 2002b) claims in the role of input frequency for L2 learning.

The early encounter of these words in the L2 learning, a period when the learners may not be perceptually aware of the distinct pronunciation of this marked phoneme, may result in automatization and early fossilization of the inaccurate pronunciation. According to Flege et al. (1996a), automatization is one of the reasons for inadequate production among adult EFL learners. Following this viewpoint, the more frequent a marked phoneme is, the greater the possibility of automatization of the wrong form if the learner is required to produce it early on in the IL development process.

The word *though* seemed to have caused some confusion among the participants. Within the GI /ð/ was realized 9 out of 12 times as [t], 2 as [tʰ] and 1 as [f̪]. Similarly, 7 participants from the GA seem to have had difficulties producing the word accurately: 4 realized /ð/ as [θ] and 3 as [t]. Maybe the use of a less frequent word and the fact that in this kind of reading task, in which the participants were asked not to rehearse or repeat the words, they may have confused *though* with *tough* or *thought*, since the spelling of these words is similar. On the other hand, the use of *though* allowed the observation that these learners are aware that there are two distinct realizations for words that start with the same *th* spelling.

To conclude, the results of the Pro1 corroborate H1 and H2 of RQ1: Brazilian learners tended to use more than one replacement, especially for the voiceless *th*; the most

common substitutes of the target phonemes were /t/ for /θ/ and /d/ for /ð/. Similarly, H7 of RQ5 seems to be partially supported: among the GA learners /ð/ was more difficult to produce than /θ/, apparently indicating an effect of markedness, but also possibly influenced by the fact that the function words in /ð/ are automatized early. However, H3 of RQ2 seems not to be corroborated: language experience appears not to significantly influence production of interdental fricatives.

4.1.2. Production Test 2: Reporting the story of Production Test 1

In the second production test the participants were asked to retell the story they had just recorded in the Pro1. The purpose of this test was to investigate participants' production on a task that they would not be visibly focused on form. According to some researchers (Tarone, 1979; Beebe, 1987; Major, 1994) L2 learners tend to modify their speech to a different degree in different sociolinguistic situations; that is, more formal contexts would lead to less NL transfer. After the analysis of the three production tests, a comparison of the participants' achievement in each test will be discussed in order to consider whether different types of tests affected their performance.

The results (Table 7) of Pro2 suggest, again, that language experience does not seem to play a significant role in the production of the target phonemes. Concerning /θ/ production, while the GI achieved 12% of accuracy, the GA reached 40%.

Table 7. Accurate production scores of /θ/ and /ð/ by the pre-intermediate (GI) and the advanced (GA) groups, in Production Test 2.

Group	/θ/				/ð/				Total	
	N	Acc. (%)	M	SD	N	Acc. (%)	M	SD	N	Acc. (%)
GI	57	7 (12)	.58	1.16	62	0 (0)	0	0	119	7 (6)
GA	67	27 (40)	2.17	2.17	178	4 (2)	3	.33	245	31 (12)

Note: N= Total number of occurrences. Acc=: accurate production. (%)= percentage of accuracy.
M= Mean. SD= Standard deviation

A Mann Whitney test reveals that the difference is non-significant, (Z = -1.91, p =.08), which does not confirm that the more experienced learners tend to produce /θ/ better than the less experienced learners (H3 of RQ2).

Regarding /ð/ production, 100% of the GI's productions were realized as [d], while the GA realized it as [d] 98% of the time. A two-tailed independent Mann-Whitney test revealed that the results of the two groups yielded a non-significant difference (Z = -1.44, p = .51), which suggests that language experience does not influence positively the production of this phoneme, disconfirming H3 of RQ2.

A Wilcoxon test showed that within the GA the voiceless *th* was significantly more accurately produced than its voiced counterpart (Z = -2.45, p = .01). However, the same test revealed a non-significant difference between the production of the voiceless and the voiced *th* by the GI (Z = -1.63, p = .10). Thus, H7 of RQ5 seems to be supported again: /ð/ is more difficult to produce than /θ/, but this difference in difficulty only shows up after a certain degree of proficiency is reached.

In relation to /θ/ production (Table N5 and N6—Appendix N2), the number of words each group produced did not differ significantly: 57 words appeared in the speech of the GI, and 67 words in that of the GA. Likewise, both groups followed a similar pattern of substitution of the target phoneme, although the GI tended to present more variation in the use of replacements than GA (Table 8).

Table 8. Realization of /θ/ by the pre-intermediate (GI) and the advanced (GA) groups in Production Test 2.

Group	N	[θ] Ac.(%)	[t] Re. (%)	[f] Re.(%)	[d] Re.(%)	[tʰ] Re.(%)	[s] Re.(%)	[tʃ] Re. (%)	[tθ] Re.(%)	[ð] Re. (%)	Total Re.(%)
GI	57	7 (12)	35 (61)	5 (8)	5 8)	2 (3)	2 (3)	1 (1.7)	0 (0)	0 (0)	50 (87)
GA	67	27 (40)	28 (41)	2 (3)	0 (0)	7 (10)	0 (0)	0 (0)	2 (3)	1 (1.5)	40 (59)

Note: N= Total number of occurrences. Ac. Accurate Re= Replacement. (%)= percentage of substitution.

This tendency within the GI to use more varieties may be due to the early stage of IL development in relation to the advanced learners. Furthermore, the [t] was again the most frequently used substitute for /θ/ within both groups, a finding that supports previous results on voiceless *th* production among Brazilian EFL learners (Reis, 2004a), as well as H2 of RQ1.

There was variation in the replacement of /θ/ for the same word repeated in the speech, by both groups. The words most repeated by all participants were *theater* and *thieves*, and in both words the target phoneme were replaced by [t], [f], [s], and [t^h] by the same subject. This finding corroborates H1 of RQ1, which proposes that Brazilian EFL learners use more that one substitute for /θ/ production. The results also show that the GI produced more variation than the GA. The smaller variation in the GA may be interpreted as a step toward automatization of the target sound.

Concerning the results of /ð/ production (Table N7 and N8—Appendix N2), the two EFL groups differed considerably in the number of words produced in this test: while the GI produced 62 words containing the target phoneme, the GA produced 178 words (Table 9). Overall, both groups followed the word frequency displayed by Leech et al. (2001): the article *the* was the most frequent word (63% by GI, and 40% by GA), followed by the pronoun *that* (21% by GI, and 22% by GA).

Table 9. Realization of /ð/ by the pre-intermediate (GI) and the advanced (GA) groups in Production Test 2.

		[ð]	[d]	Total
Group	N	Acc. (%)	Re. (%)	Re. (%)
GI	62	0 (0)	62 (100)	62 (100)
GA	178	4 (2)	174 (98)	174 (97)

Note: N= Total number of occurrences. Acc. Accurate. Re= Replacement. (%)= percentage of substitution.

An average of 98% of all words were realized as [d] by both groups. Yet again, this finding supports H2 of RQ1 and previous results found among Brazilian EFL learners producing word-initial /ð/ (Reis, 2004a).

The only four occasions that /ð/ was produced accurately were by GA and with the words *there* (twice), *then* (once) and *this* (once). The reasons why these but not other words were produced accurately are not clear. Possibly, as Leather and James (1996) and Major (1987, 1994) point out, the motive is probably more related to individual differences than to intrinsic difficulties of a word in relation to another. These four accurate productions were realized only by two subjects: participant A1 produced 3 instances of [ð], while participant A3 produced one exemplar of the target phoneme. Indeed, participant A1 was the same who performed better in the Pro1 with both interdental fricatives.

Therefore, the Pro2 seems to confirm H1 and H2 of RQ1: Brazilian learners used more than one replacement, especially for /θ/, and the most common substitutes for the target phonemes were /t/ for /θ/ and /d/ for /ð/. H7 of RQ5 was again supported: /ð/ was more difficult to produce than /θ/. Lastly, H3 of RQ2 was again disconfirmed: L2 experience appears not to influence much the production of the target phonemes.

4.1.3 Production Test 3: Reading a list of sentences

The third production test consisted of participants reading a list of 45 sentences: 15 distracters and 30 containing 15 tokens of each target phoneme. The results (Table 10) demonstrated the same pattern of performance for both groups—more accuracy in producing the voiceless *th* than in producing the voiced *th*.

Table 10. Accurate production scores of /θ/ and /ð/ by the pre-intermediate (GI) and the advanced (GA) groups, in Production Test 3.

Group	/θ/				/ð/				Total	
	N (%)	Acc. (%)	M	SD	N	Acc. (%)	M	SD	N	Acc. (%)
GI	180	41 (22)	3.33	3.65	180	3 (1)	.25	.62	360	44 (12)
GA	180	82 (45)	6.83	6.06	180	36 (20)	3	5.46	360	118 (32)

Note: N= Total number of occurrences. Acc= Accurate production. (%)= percentage of accuracy. M= Mean. SD= Standard deviation

However, a Mann Whitney test does not confirm significance of the difference between the groups regarding the voiceless *th* ($Z = -1.32$, $p = .19$) or the voiced *th* ($Z = -1.82$, $p = .12$). Thus, H3 of RQ2 is again not supported by the results: language experience does not seem to significantly influence the production of *th*-sounds.

As regards the production within groups, the GA scored 45% for /θ/ and 20% for /ð/, a result that indicates a voicing effect. This difference was confirmed significant by a Mann-Whitey test ($Z = -2.36$, $p = .01$). Similarly, the GI scored better in /θ/ production— 22%—than in /ð/ production—1.6%, also found to be a significant difference by the Mann-Whitney ($Z = -2.52$, $p = .01$). Thus, H7 of RQ5 was supported a third time: /ð/ was more difficult to produce that /θ/.

Concerning the patterns of substitution of the 180 tokens of the voiceless *th* production for each group (Tables N9 and N10—Appendix N3), GI replaced 51% of the occurrences of /θ/ with [t], while GA produced the target phoneme as [t] in 40% of the occurrences (Table 11).

Table 11. Realization of /θ/ by the pre-intermediate (GI) and the advanced (GA) groups, in Production Test 3.

Group		[θ]	[t]	[f]	[d]	[tʰ]	[s]	[tʃ]	Total
	N	Ac. (%)	Re. (%)	Re.(%)	Re. (%)	Re. (%)	Re. (%)	Re. (%)	Re. (%)
GI	180	41 (22)	93 (51)	12 (6)	11 (6)	18 (10)	1 (0.5)	4 (2)	139 (77)
GA	180	82 (45)	72 (40)	13 (7)	3 (1.6)	9 (5)	0 (0)	1 (0.5)	98 (54)

Note: N= Total number of occurrences. Ac. Accurate. Re= Replacement. (%)= Percentage of accuracy.

Accurate realization of the voiceless *th* appeared in 22% of occurrences in the GI and 45% in the GA. The results, again, indicate that H1 and H2 of RQ 1 are confirmed. That is, there is more than one form of substitution for the voiceless *th*, whereas [t] and [d] are the most frequent replacements for /θ/ and /ð/, respectively.

The results also show that the GA learners are more stable in their choice of variants: for example, from the 48 tokens of the word *thought* (4 tokens X 12 participants), the advanced learners produced 21 [θ]s and 21 [t]s. On the other hand, the pre-intermediate learners produced only 9 [θ]s, 29 [t]s, and 10 other variants, such as [f], [d], [tʃ] and [tʰ]. Again, it may be an indication of the earlier stage of IL development of these latter participants, a period in which they are experimenting more, and thus, producing more varied inaccuracies.

Regarding voiced *th* production (Table 12), the results indicate again that the GA was more consistent in the choice of replacement. Two patterns were found in the GA: the [d] substitute was used in 80% of all occurrences, while [ð] appeared in 20%.

Table 12. Realization of /ð/ by the pre-intermediate (GI) and the advanced (GA) groups, in Production Test 3.

Group	N	[ð] Ac. (%)	[d] Re. (%)	[tʰ] Re. (%)	[dʰ] Re. (%)	[dʒ] Re. (%)	[tʃ] Re. (%)	[θ] Re. (%)	[t] Re. (%)	Total Re. (%)
GI	180	3 (1.6)	164 (91)	5 (2.7)	2 (1.1)	1 (0.5)	3 (1.6)	1 (0.5)	1 (0.5)	177 (98)
GA	180	36 (20)	144 (80)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	144 (80)

Note: N= Total number of occurrences. Ac. Accurate. Re= Replacement. (%)= percentage of substitution.

On the other hand, the GI showed more variation in production. Although the [d] substitute appeared in 91% of all occurrences, three other replacements also occurred— [tʰ], [dʰ], and [tʃ]. Again, this finding may be interpreted as a suggestion of the early stage of IL development of GI.

In short, Pro3 also supported H1 and H2 of RQ1: these Brazilian EFL learners used more than one replacement, especially for the voiceless *th;* the most common substitutes of the target phonemes being /t/ for /θ/ and /d/ for /ð/. The results of this test indicate that H3 of RQ2 is not supported: L2 experience appears not to influence positively the production of /θ/, but not as consistent the production of /ð/. Besides, H7 of RQ5 was supported a third time: /ð/ was more difficult to produce than /θ/.

4.1.4 Summary and discussion of production test results

As we have seen, the results from the three production tests appear to support the claims of Eckman's MDH (1977) for the target phonemes and corroborate H7 of RQ5 of this study: the more marked sound, /ð/, tends to be more difficult to produce than the less marked one, /θ/. As a matter of fact, in phonological acquisition, some sounds are acquired later than others and this seems to be the case of the interdental fricatives (Smit, Freilinger, Bernthal, Hand, & Bird, 1990). These authors claim that the *th*-sounds are the last ones to be accurately produced by children learning English as L1, and that the voiced *th* is acquired later than the voiceless counterpart.

Concerning the role of language experience on the production of the target phonemes, the results demonstrated that language experience does not seem to significantly influence the production of the interdental fricatives. The results seem to indicate that there is only a tendency for improvement in the production of the less marked phoneme over time, whereas its voiced counterpart seems not to be significantly influenced by L2 experience. Thus, H3 of RQ2 is not entirely supported. Maybe, due to the markedness aspect of the voiced *th,* more language experience would be necessary than that of the advanced group of this study to show any positive effect.

In addition, the results of the present study support previous findings (Reis, 2004a) concerning the pattern of replacement of the target phonemes among Brazilian EFL learners and, thus, help to answer RQ1. In fact, the participants of the present experiment replaced the target phonemes by using more than one substitute, as predicted by H1. Although the same speaker may vary the type of substitution, the phones [t] and [d] were the sounds most commonly used to replace /θ/ and /ð/, respectively, as predicted by H2. If we sum up (Table 13) all productions of /θ/ in the three tests, the [t] replacement was used in 53% of occurrences by GI, and 40% by GA, whereas for the production of /ð/, GI substituted [d] for the target phoneme in 96% of all occurrences, and GA in 92%.

Table 13. Overall percentage of replacement of /θ/ as [t] and of /ð/ as [d] by the pre-intermediate (GI) and the advanced (GA) learners, in the three Production Tests.

| | /θ/ as [t] | | | | | | /ð/ as [d] | | | | | |
| | GI | | GA | | Total | | GI | | GA | | Total | |
Pro. Test	N	[t] (%)	N	[t] (%)	N	[t] (%)	N	[d] (%)	N	[d] (%)	N	[d] (%)
Pro 1	252	132 (53)	252	103 (41)	504	235 (46)	252	252 (100)	252	246 (97)	504	498 (99)
Pro 2	57	35 (61)	67	28 (41)	124	63 (51)	62	62 (100)	178	174 (97)	240	236 (98)
Pro 3	180	93 (51)	180	72 (40)	360	165 (46)	180	164 (91)	180	144 (80)	360	308 (85)
Total	489	260 (53)	499	203 (40)	988	463 (47)	494	478 (96)	610	564 (92)	1104	1042 (94)

Note: N= Total number of occurrences. [t] and [d]= Type of replacement. (%)= percentage of substitution

Furthermore, the results of the three production tests seem to indicate that the variant /d/ for /ð/ may be automatized early, maybe due to the high frequency of function words. Baptista (1995) and McLaughlin (1987) suggest that the learning of an L2 demands a skill whose processing capacity is limited. Due to this limitation, Shiffrin and Dumais, (1981, cited in Baptista, 1995) propose that learners deal with general learning in either a controlled or in an automatic fashion. According to these authors, the controlled processing is effortful, conscious, requires attention, is mostly serial, utilizes the general cognitive processing capacity, and, because of this, does not permit two controlled

parallel operations. Automatic processing, on the other hand, does not require conscious attention, is fast, is not limited by memory capacity, usually is not under voluntary control, is difficult to modify, is fast and efficient, and can process parallel operations.

Baptista (1995) points out that automatization of some components of the language is essential for the liberation of the controlled processing to deal with other information being learned. Drawing on this standpoint, when faced from the beginning of learning with the task of producing sounds that are cross-linguistically marked (Eckman, 1977), but frequent in a language, such as the interdental fricatives in English, and without any input enhancement[6] (Sharwood-Smith, 1983) or instruction on them, learners tend to automatize the inaccurate pronunciation in order to liberate processing capacity for dealing with novel information.

Concerning automatization, Flege et al. (1996a) claim that because L2 learners are compelled early to arrange new words meaningfully, the L1 sound may be substituted for an L2 phone, especially if the substitution does not impede speech comprehension. Ellis (2002a) emphasizes the role of focus on form or any kind of consciousness-raising (Sharwood-Smith, 1993) that might facilitate the noticing of marked items, particularly at the beginning of learning: "the effects of practice are greatest at early stages of learning, but they eventually reach asymptote[7]" (p. 152). At this initial level, according to Ellis, learners spend more time processing each item, until through practice the processing time is reduced and it becomes automatized. It might be the case that after processing /θ/ and /ð/ as /t/ and /d/, respectively, in the very beginning of learning and without any consciousness raising, learners simply do not spend more time processing the input any

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[6] Input enhancement (Sharwood-Smith, 1993): focus learners' attention to a specific aspect of the language input, which in turn may lead to further cognitive processing and, thus, language acquisition.
[7] Asymptote: The point on a graph where a line reaches a plateau; in the growth of a population it is the point at which numerical stability is reached.

longer, especially for meaning. Thus, they would tend to fossilize the inaccurate realization.

Due to the differences in style between the three tests, it was expected that the participants would present divergent results. Several researchers (e.g., Major, 1994; Tarone, 1979; Beebe, 1987) assert that IL is less susceptible to errors in more formal situations than in more informal contexts. Major (1994) claims that "all other things being equal, the more formal the style, the more target-like the production and further, the less transfer is likely to occur." (p.190). In the present study the degree of formality decreases from Pro3 (reading a list of sentences) and Pro1 (reading a text) to the least formal Pro2 (reporting the story of Pro1). As a result, it was expected that accuracy would somehow follow the same pattern: more focus on form in the more formal tests (Pro3 and Pro1), and thus greater accuracy, and more focus on meaning in the less formal test (Pro2), and thus less accuracy. It is important to keep in mind that other factors might influence the pronunciation of *th*-sounds in different task types: (a) L1 transfer in the pronunciation of cognate words, (b) the association of the *th*-sounds with the *th*-spelling in reading tests, and (c) the pattern of speech rate in different task types—the production in reading tasks tend to be less reduced and more emphasized.

Despite the expectancies, the results in Table 14 demonstrate only a slight tendency among the GA for greater accuracy in more formal tests—20% in Pro1, 12% in Pro2, and 32% in Pro3— and even less evidence for the GI—6% correct responses in Pro1 and Pro2, and 12% in Pro3.

Table 14. Overall achievement by the pre-intermediate (GI), and the advanced (GA) groups, in the three Production Tests (Pro).

Pro. Tests	GI		GA		Total	
	N.	Acc. (%)	N.	Acc. (%)	N.	Acc. (%)
Pro1	504	33 (6)	504	103 (20)	1008	136 (13)
Pro2	119	7 (6)	245	31 (12)	364	38 (10)
Pro3	360	44 12)	360	118 (32)	720	162 (22)
Total	983	84 (8)	1109	252 (22)	2092	336 (16)

Note: N= Number of occurrences. Acc= Number of accurate production. (%)= Percentage of accuracy.

However, Kruskal-Wallis tests revealed that the difference was non-significant for the GI (H = 2.98, p = .22) as well as for the GA (H = 2.108, p = .34). Although statistically the results are non-significant, they demonstrate a slight tendency for the advanced participants to modify their production according to the task type. Thus, the results provide only a weak support for H10 of RQ7, which proposes that learners would produce the target sounds more accurately in more formal tests.

Moreover, in terms of Schmidt's (1990 and elsewhere) perspective on consciousness of the target phonemes, the results of the production tests might be interpreted differently for the two EFL groups. According to the researcher, "noticing is a necessary condition for storage" (1990, p.141), and noticing is a pre-requisite for understanding to take place. He also argues that "[input] understanding led to correct production and misunderstanding was reflected in deviant performance" (Schmidt, 1990 p.147). In other words, when the learner has already noticed the item, and is able to reflect on it, this item starts to emerge in the output. Since a considerable number of advanced learners seem to be able to produce one of the target phonemes, the voiceless *th*, it could be assumed that these learners have already passed through the process of noticing this *th* as a distinct sound and reached the understanding level. On the other hand, given that the pre-intermediate learners varied their production considerably, their results could be interpreted to mean that at the pre-intermediate stage, fewer learners have undergone the process of noticing the voiceless *th* as a novel sound.

Flege and colleagues' standpoint on the role of speech perception is another concept that is important to bear in mind when considering L2 production. Flege et al. point out that "given that adults are language-specific perceivers of speech, we suspect that a larger proportion of production errors in second language may have a perceptual basis (1996a, p.66)". Flege (1995) argues that experienced L2 learners may eventually be able to establish a new phonetic category that is only present in the L2 inventory. Through this

new L2 perceptual 'target' the learners can ultimately produce the segment accurately. Drawing on McLaughlin (1987) and Flege (1995), once having acquired the L2 perceptual 'target', learners must put in practice the new sensorimotor acquisition in order to automatize the component. According to McLaughlin, practice provides the opportunity for the learners to restructure the mental representations which, ultimately, afford automaticity. Similarly, Ellis affirms that "learners analyze the language input that they are exposed to; practice makes perfect (2002a, p.178)."

Flege et al. (1996a) state that there are other factors besides misperception that might influence speech production, such as inadequate phonetic input, incorrect habit formation—or automatization, motivation, psychosocial factors, and motoric difficulties. It is interesting to note that when the participants were asked to rank the importance of pronunciation in a communicative setting, 12 out of 24 declared it to be essential, 11 said it was important and only 1 that pronunciation was unimportant. Thus, it seems that most of the participants feel motivated to acquire accurate pronunciation.

Regarding psychosocial factors, several scholars (Ellis, 1994; Tarone, 1987; Flege et al., 1996) argue that L2 learners may choose to maintain a foreign accent as a way to preserve their ethnic identification. It is worth mentioning that the majority of the studies just cited above were carried out in an ESL setting, where speaking the L1 or the L2 with a foreign accent is a way to maintain a bond with a community. However, in an EFL setting, as in the case of this study, the learners are in their own environment, and thus, may not feel so threatened by a different culture, maybe not deeply compelled to keep their L1 accent. On the contrary, they might be eager to attain the most native-like pronunciation possible, which can be assumed from the importance these participants gave to the role of pronunciation in communicating in an L2.

When questioned about the possible factors that could impede the accurate pronunciation of *th*, 18 out of 24 participants affirmed that the major problem was

difficult articulation of the phonemes, while five said that the phonemes are irrelevant. Other reasons cited by the participants are more related to perception and will be approached in the analysis of this skill.

Concerning motoric difficulties, Flege and colleagues state that, in L1 acquisition, there are some sounds that "are more complex articulatorily than others and are acquired late by most children" (1996a, p.48). Moreover, Menyuk (1968, cited in Schmidt, 1987) claims that the interdental fricatives are the last sounds mastered by native learners of English and that the features distinguishing fricative and stop (+- continuant), and fricative and strident (+- strident) are the last features acquired by children learning English as an L1. Furthermore, Moskowitz (1970, cited in Schmidt, 1987) argues that problems with production of fricatives, interdentals in particular, are due to the lack of motor control—"an inability to maintain the articulators in as finely adjusted position as is required" (p. 367).

As reviewed in section 2.3.3, Flege et al. (1996a) also argue that there may be an age limit for learning new forms of articulation. He affirms that "it may be the case, especially for articulatory complex sounds commonly found in human languages, that true age-related limits exists for articulatory learning" (Flege 1999, p. 1275). Since all the participants of this study had their first contact with the English sound system after the age of 7, at an average of 10 years old, it can be assumed that they had already established the pattern of articulation of the BP inventory. This motoric language specificity could complicate the modification of the NL pattern, ultimately resulting in an ultimate inaccurate production for the majority of EFL learners.

Regarding automatization, this could be a reasonable motive for the inaccurate interdental fricative production, as discussed in the automatization issue. As Flege et al. (1996a) point out, adult L2 learners are frequently required to promptly use the foreign language, which may cause replacement of the L2 sound not found in the L1 inventory,

and "once a 'shortcut' articulatory pattern has been adopted, it might become habitual (p. 48)". In addition, if the interdental fricatives are replaced, the meaning of the word can usually be recovered from the context (Abrahamsson, 2003), which permits the learners to keep using the substitutes without comprehensibility being reduced.

Inadequate phonetic input has certainly to be considered a possible reason for inaccurate *th* production. In a pilot study carried out to investigate the perception and production of the interdental fricatives by 13 highly proficient Brazilian speakers of English, most of them English teachers, Reis (2004b) found that 52% and 95% of the occurrences of /θ/ and /ð/, respectively, were produced inaccurately. Hence, it could be assumed that at least the students of those English teachers are not receiving adequate *th* input in order to build a proper L2 perceptual target for guiding their L2 perception.

Given that Flege and colleagues (1996a) mention several possible causes for inaccurate production, it was decided to listen to the opinion of ten Brazilian EFL teachers who did not participate in the present study or the pilot studies, on the reasons why they may mispronounce the *th*-sounds. They were given a questionnaire and asked to rank possible reasons for their inaccurate production of the target phonemes, the levels of importance ranging from 1, the most important reason, to 7, the least important reason.

From the seven possibilities given, motoric difficulties obtained the lowest score, indicating the highest level of importance. Lack of perception was the next most important reason, followed by automatization of the inaccurate form. The fourth reason, as far as I know, has not been mentioned in any of the literature, but is usually cited by my Brazilian EFL learners: a sense of silliness preventing them from trying to produce the phonemes accurately in front of other Brazilian learners. Next, their lack of concern with the accurate production of the *th*-words, as well as the irrelevance of the interdental phonemes for communication purposes received equal score. Lastly, they said that they

had not received accurate input of the sounds when they were learning English. It is

interesting to note that 6 out of the 10 teachers substitute /t/ and /d/ for /θ/ and /ð/,

respectively, an indication that even proficient foreign speakers of English have

difficulties to produce interdental fricatives accurately (Table 15).

Table 15. Opinion of 10 Brazilian EFL teachers on possible reasons for mispronouncing
the interdental fricative phonemes.

Reasons	Score
1. The articulation of the sounds is complicated.	17
2. I did not perceive that the *th* had different sounds from any Portuguese sound.	28
3. I think that when I finally perceived that the *th* had different sounds, I was already accustomed to replace them with another sound.	37
4. I felt a little silly producing the sounds accurately.	44
5. I am not concerned with the accurate production of these sounds. The production of the sounds is irrelevant for communicating in English.	49
6. During my EFL learning I think I did not hear the sounds being produced accurately.	53

Finally, the results of the present study confirm that accurate production may be also

related to individual differences, as discussed by Ellis (1994) and Martens and Lambacher

(1999). Two EFL learners from GA, subjects A1 and A3, obtained much better results

than the other participants in all three tests: participant A1 attained an overall average of

91% in voiceless production and 37% in voiced production, while the participant A3

achieved 75% and 34% in voiceless and voiced interdental fricative production,

respectively.

4.2 Results of the perception tests

With the purpose of investigating Brazilian EFL learners' perception of the target

phonemes, three perception tests were used: the General Pronunciation Error Perception

Test (GPE), the Categorial Discrimination Test (CDT), and the Alternative Forced Choice

Identification Test (AFC). Three groups took the tests: the pre-intermediate and advanced

EFL learners, and a group of five native speakers (NS) of English. Again, the results are

divided in three subsections, each one being discussed and related to the research questions and hypotheses of the study.

4.2.1 Perception Test 1: the general pronunciation error perception test

The first perception test (GPE) consisted of participants listening to the same text used in the Pro1, recorded by a Brazilian EFL learner. The speech contained problematic pronunciation in segmental and supra-segmental levels, all *th*-words being produced inaccurately (Appendix O1). The participants were asked to mark all the pronunciation errors they could detect in word-initial position.

To the best of my knowledge, this kind of design has not been used in perception tests, thus a threshold for native-like attainment has not yet been established. A GPE pilot study investigating the perception of the target phonemes by Brazilian EFL learners and NSs (Reis, 2004b), with different participants from the present study, found /θ/ inaccuracies to be detected 67% of the time by the seven advanced learners, and 37% by the 6 pre-intermediates, while the five NSs of English obtained an average of 41%. For the perception of /ð/, the NSs and the advanced learners detected 2% of the inaccuracies, while the pre-intermediate group did not notice any error. It is important to bear in mind that the advanced learners had received formal instruction in perception and production of the target phonemes, which might explain why their score was better than the NSs.

Concerning the results of the voiceless *th* perception in the present study (Tables O1, O2, O3—Appendix O1), of the 21 inaccurate tokens present in the text played to the participants 24% were detected by the NSs, 17% by the GA and 9% by the GI (Table 16). A Kruskal-Wallis test reveals a significant difference between the results of the three groups for the voiceless *th* (H = 6.52, p = .03). A Mann-Whitney test confirms

significance between the NSs and the GI, (Z = -2.04, p = .04) and between the GA and the

GI (Z = -2.17, p = .03). However, the test yields a non-significant difference between the

NSs and the GA, (Z = -.48, p = .64).

Table 16. Accurate perception of /θ/ and /ð/ errors by the pre-intermediate (GI), the
advanced (GA), and the native speakers (NS) groups in the Perception Test 1—GPE.

Group	[θ] identification					[ð] identification					Total		
	N	Ac.	%	M	SD	N	Ac.	%	M	SD	N	Ac.	%
GI	252	22	9	1.75	1.96	252	3	1.19	.25	.62	504	25	5
GA	252	42	17	8.5	6.66	252	2	0.79	.17	.39	504	44	8
NS	105	25	24	5	3.74	105	2	1.90	.40	.55	210	27	13

Note: N= Number of occurrences. Ac.= Number of accurate answer. (%)= Percentage of accuracy.
M= Mean. SD= Standard deviation

Overall, the results of the GPE concerning voiceless perception seem to support H4
of RQ3, which states that the GA would demonstrate better perception than the GI. A first
attempt to interpret these results suggests that language experience seems to play a role in
perception of the target phoneme, which in turn, suggests that there may be a relationship
between perception and production of this target phoneme. However, other factors might
be involved in the dissimilar achievement by the EFL groups, such as the type of test,
since the results of the other two perception tests did not reveal a significant difference
between the two groups, as will be discussed in sub-sections 4.2.2 and 4.2.3.

Still with reference to voiceless *th* perception, there were four words which yielded
particularly low rates of perception for both EFL groups: *think, theater, thin,* and *therapy*,
pronounced respectively as [fink], [fiater], [fiŋ], and [tɛrapi]. Each of these words were
identified as inaccurate only once out of 29 times. Indeed, the lack of detection of the [f]
is not surprising given the high phonetic similarity between [θ] and [f] (Ladefoged, 2001).
The lack of detection of the [t] in [tɛrapi] is also consistent with the production findings,
which showed that out of all the occurrences of the word *therapy* in the production tests,
84% were produced as [tɛrapi]. Thus, the participants may have not perceived the

inaccuracy because this may be the manner they hear the word—with the same initial

sound as in the Portuguese cognate. Similarly, the NSs also demonstrated a low rate of

perception for these words. This may be due to the acoustic similarity between [θ] and [f],

or due to their lack of concern with the pronunciation of the sound in a communicative

situation, as they reported in the questionnaire.

Out of all the occurrences of the 3 different realizations of /θ/, [s] was the most

frequently indicated as inaccurate by all the subjects (Table 17). Indeed, [s] was the one

least used /θ/ production replacement by the participants of the present study (an average

of 1%), as well as among the subjects in my earlier study investigating how Brazilian

EFL learners would replace the target phoneme (Reis, 2004a).

Table 17. Accurate perception of /θ/ realized as [s], [t], and [f] by the pre-intermediate (GI), the advanced (GA), and the native speakers (NS) groups, in Perception Test 1—GPE.

	[s]		[t]		[f]		Total	
Groups	N.	Acc. (%)	N.	Acc. (%)	N.	Acc. (%)	N.	Acc. (%)
GI	24	4 (16)	132	10 (7)	96	8 (8)	252	22 (8)
GA	24	5 (20)	132	23 (17)	96	14 (14)	252	42 (16)
NS	10	4 (40)	55	13 (23)	40	8 (20)	105	25 (24)

Note: N= Number of occurrences. Acc. = Number of accurate answer. (%)= Percentage of accuracy.

Finally, a surprising finding regarding the perception of /θ/ inaccuracies occurred

with the words that were repeated in the test: *think* appeared with [f], [t], and [s]; *thing*

with [f] and [s]; and *theater*, *thirty, thought, theft*, and *therapy* with [f] and [t]. In the

words *think* and *thing*, the realizations with [s] were the ones most frequently indicated as

inaccurate, a result somehow expected, since of all the variants [s] is the one with a

largest number of phonemic features different from /θ/ (Giegerich, 1992). However, the

words *thought* and *theft* realized with [f] were the most regularly detected as inaccurate. It

is worth mentioning that the recognition of the [f] replacement occurred more often with

GA than with GI. This result might suggest that the advanced learners may be more aware

that /θ/ has a sound different from any Portuguese phone, contrary to the pre-intermediates, and also aware of the '[f] strategy' to acoustically approximate the realization of the target phoneme.

Regarding the results of the voiced *th* perception (Tables O4, O5, O6—Appendix O1), they suggest that this phoneme is nearly completely ignored by all groups: the NS group indicated the target phoneme as inaccurate in only 1.90%, whereas the GA and the GI indicated it in 0.79% and 1.19% of the time, respectively (Table 16). Due to the extremely low percentages of accurate discrimination of the voiced target phoneme, no statistical test was used to check any differences across the three groups. Therefore, the results of the voiced *th* perception in GPE do not support H5 of RQ4, which assumes that the more experienced L2 learners would perceive replacements of the target phonemes better than the less experienced learners.

In summary, the results of the GPE indicate a voicing effect in the perception of pronunciation errors of the *th*-sounds. Comparing the results of the perception of the voiceless and the voiced *th* within each group, using Wilcoxon signed rank tests, the NSs perceived the voiceless *th* more accurately than its voiced counterpart (Z=-2.02, p=.04). The same tendency was observed with the GI, (Z=-2.38, p=.001), and with GA (Z=-3.07, p=.001). Thus, the results of the GPE seem to support H6 of RQ5—the voiced *th* is more difficult to perceive than is voiceless counterpart. H5 of RQ4 is partially supported by the GPE: language experience seemed to affect the discrimination of /θ/ but not significantly that of /ð/.

In conclusion, the results of the GPE seem to support Schmidt's assertion that "learners are not free to notice whatever they want" (1990, p. 144). Both EFL groups might be constrained by some of the factors that interfere in noticeability: task demands, learner's skill level, learner's attitude, and input saliency, among others (Schmidt, 1990).

In addition, the test may have indicated that the participants lack a well-established category for the target phonemes. They might have wanted to pay attention and notice the *th* mispronunciations. However, since they seem to lack prototypes for the sounds, they failed to notice the mistakes.

The GPE seems not to sufficiently draw the participants' attention to a particular aspect of speech sound perception. Since attention is not always under voluntary control (Schmidt, 1994, p. 17) a test like the GPE seems to allow the subjects to become more attentive to the communicative aspect of the speech than to segmental inaccuracies. This fact is consistent with Van Patten's (1994) claim that attention is a very limited conscious resource for language processing. Besides, he hypothesizes that:

> H1. Learners process input for meaning before they process it for form.
>
> H1a. Learners process content words in the input before anything else.
>
> H2b. Learners prefer processing lexical items to grammatical items (e.g., morphological markings) for semantic information.
>
> H1c. Learners prefer processing "more meaningful" morphology before "less or non-meaningful morphology."
>
> H2. In order for learners to process form that is not meaningful, they must be able to process informational or communicative content at no or little cost to attention. (p. 32)

Therefore, maybe few mistakes were identified because the participants were more attentive to the meaning of the speech, thus to content words, rather than to segmental inaccuracies. Similarly, argues that control over IL is related to real-time selective attention to the mental representation of the input. In addition, she states that "when listening to spoken language, our attention is drawn more singularly to the meanings" (p. 160). Still, Jenkins and Yeni-Komshian (1995) argue that when the token under analysis is embedded in real-time speech, accurate perception diminishes and the NL system seems to prevail over attention and classification abilities. In addition, Morgan and Demuth (1996, cited in Polka, Colantino & Sundara, 2001, p. 2198) remark that function

words are less salient than content words in natural discourse. What has to be borne in mind is that all word-initial voiced *th* are function words, which in turn, are embedded in real-time speech with the marked phoneme /ð/. Likewise, McLaughlin (1987) asserts that "because human learners are limited in their information-processing abilities, only so much attention can be given at one time to the various components of complex tasks" (p.136).

Concerning the relation between learners' skill level and attention, maybe experienced learners are also capable of comprehending the meaning more automatically, in such a way that "attention can be devoted to the other components of the task and a previously difficult or impossible task becomes possible" (McLaughlin, 1987, p.136). Thus, perhaps they have left over processing capacity for focusing on form, especially for the less marked phoneme /θ/ in relation to /ð/, and to content words in relation to function words.

4.2.2 Perception Test 2: the Categorial Discrimination Test

The second perception test was a Categorial Discrimination Test (CDT, Flege, Munro, & Fox, 1994), in which the sets of words *thigh-fie-sigh-tie*, and *thee-vee-zee-dee* were used to compare the target phonemes with their respective variants. After hearing a trial of three words produced by three different native English speakers, the participants were asked to indicate in which of the three positions the odd item was heard (the change trials), or whether the three words were identical (the catch trials).

According to Flege, Mackay, and Meador (1999), the catch trials evaluate whether the participants can discriminate the stimuli irrespective of variations; that is, the participants have to "respond to relevant phonetic differences while ignoring auditory accessible differences (e.g., voice quality) that [are] not phonetically relevant" (p. 6).

Moreover, Flege and MacKay (2004) claim that the catch trials are used to test "the participants' ability to ignore audible but phonetically irrelevant within-category variation" (p. 9). The change trials, on the other hand, are used to test "the participants' ability to distinguish [sounds] drawn from two different categories" (Flege & MacKay, 2004, p. 9). The analysis of the present study focuses on the results of the change trials first, while the results of the catch trials will be discussed further.

The overall results of each target phoneme (Table 18) seem to demonstrate that there is a tendency for better discrimination of the voiceless *th* than of its voiced counterpart: for /θ/ discrimination the GI obtained 60% of accuracy, the GA 72%, and the NSs 81%, while for /ð/ discrimination the GI attained 59%, the GA 88%, and the NSs 77%. However, comparing the results of the target phonemes within each group, using Wilcoxon signed rank tests, no significant effect for voicing was found for either of the 3 groups: the NSs (Z=-.44, p=.65), the GI (Z=-.41, p=.68), and the GA (Z=-1.39, p=.16).

Table 18. Accurate discrimination of change trials by the pre-intermediate (GI), the advanced (GA), and the native speaker (NS) groups, in Perception Test 2—CDT.

	[θ] identification				[ð] identification				Total		
Group	N	Ac.	%	M	SD	N	Ac.	%	M	SD	N	Ac.	%
GI	216	131	60	10.92	2,84	216	128	59	10.67	2.53	432	259	60
GA	216	157	72	13.08	2.81	216	143	66	11.92	1.88	432	300	69
NS	90	73	81	14.60	2.51	90	70	77	14.00	2.35	180	143	79

Note: N= Number of occurrences. Ac= Number of accurate answer. (%)= Percentage of accuracy. M= Mean. SD= Standard deviation

Concerning the results of the voiceless test (Tables O7, O8, O9—Appendix O2), there seems to have been a tendency for increasing discrimination from the GI to the GA to the NSs. However, a Kruskal-Wallis test reveals no significant difference among the results of the three groups for the voiceless *th* (H = 4.93, p = .08). In addition, a Mann Whitney test confirms the lack of significant difference between the NSs and the GI, (Z =-1.77, p = .08), the NSs and the GA (Z=-.82, p=.44), and the GA and the GI (Z=-1.79, p = .07). Thus, neither H4 of RQ3, which proposes that language experience affects

positively the perception of the target phonemes, nor H5 of RQ4, which suggests that more experienced learners would perceive replacements of /θ/ and /ð/ better than the less experienced learners, are supported.

Within the discrimination of the voiceless contrasts the pair /θ/-/f/ was shown to be the most difficult to perceive: the GI obtained only 40% of accurate perception, the GA 57%, and the NSs 47% (Table 19). It is unexpected and difficult to explain why the NSs scored lower than the GA. The low achievement in the /θ/-/f/ contrast is, again, explained by the acoustic similarity between these two phonemes (Ladefoged, 2001). The /θ/-/s/ and /θ/-/f/ contrasts seemed to have been influenced by language experience, whereas the contrast /θ/-/t/ does not show the same effect.

Table 19. Accurate perception of the voiceless change trial contrasts by the pre-intermediate (GI), the advanced (GA), and the native speaker (NS) groups, in Perception Test 2—CDT.

Group	/θ/ - /s/		/θ/ - /t/		/θ/ - /f/		Total	
	N	Acc. (%)	N	Acc. (%)	N	Acc. (%)	N	Acc. (%)
GI	72	44 (61)	72	54 (75)	72	29 (40)	216	127 (58)
GA	72	57 (79)	72	50 (69)	72	41 (57)	216	148 (68)
NS	30	28 (93)	30	28 (93)	30	14 (47)	90	70 (77)

Note: N= Number of occurrences. Acc.= Number of accurate answer. (%)= Percentage of accuracy.

As regards discrimination of the voiced set (Tables O10, O11, O12—Appendix O2), the NSs outperformed the GA, which in turn outperformed the GI: each group obtained 77%, 66% and 59%, respectively. A Kruskal-Wallis test reveals a significant difference among the results of the three groups for the voiced *th* (H=5.99, p=.05). Similarly, a Mann Whitney test confirms a significant difference between the NSs and the GI, (Z =-2.29, p=.02). However, no significant difference was found between the NSs and the GA (Z=-1.55, p=.12), or the GA and the GI (Z=-1.29, p=.29). Therefore, H4 of RQ3, which proposes that more experienced learners perceive the target phonemes better than the less experienced learners, and H5 of RQ4, which suggests that more experienced

learners perceive replacements of the target phonemes better than less experienced learners, are not supported

Regarding the different pairs of phonemes, the voiced change trials obtained results parallel to those of the voiceless trials (Table 20): the /ð/-/v/ contrast was the most problematic for all three groups. This result was somehow expected, due to the acoustic likeness between the contrast /ð/-/v/ (Ladefoged, 2001), but the higher score in the /ð/-/d/ pair compared to the /ð/-/z/ contrast for GA and NS was intriguing, due to the acoustic saliency of /z/ compared to that of /ð/ and /d/.

Table 20. Accurate perception of the voiced change trial contrasts by the pre-intermediate (GI), the advanced (GA), and the native speaker (NS) groups, in Perception Test 2—CDT.

Group	/ð/ -/z/		/ð/ - /d/		/ð/ - /v/		Total	
	N	Acc. (%)	N	Acc. (%)	N	Acc. (%)	N	Acc. (%)
GI	72	61 (85)	72	55 (76)	72	17 (24)	216	133 (61)
GA	72	54 (75)	72	59 (82)	72	21 (29)	216	134 (62)
NS	30	25 (83)	30	28 (93)	30	12 (40)	90	65 (72)

Note: N= Number of occurrences. Acc= Number of accurate answer. (%)= Percentage of accuracy.

There are at least three reasons for expecting a superior performance in the discrimination of /ð/-/z/ than of /ð/-/d/: (a) since [d] is the most frequent substitute for [ð], the cause of its replacement could be related to perception—Brazilian EFL learners would replace the voiced *th* with a voiced alveolar stop because they hear the target phoneme as a stop. (b) The /ð/-/z/ pair was expected to achieve higher score than the /ð/-/d/ pair because /z/ involves a greater number of different phonetic features from the target phoneme. (c) /z/ is a more salient sound than /d/ (Ladefoged, 2001), which in theory would make the discrimination between /ð/-/z/ easier than between /ð/-/d/.

Yet again language experience does not seem to influence clearly these kinds of discrimination. While there is a pattern of improvement in the /ð/-/v/ and /ð/-/d/ contrasts

from GI to GA to NSs, the /ð/-/z/ pair yielded a peculiar result: GI obtained a higher

score—85%—than GA—75%—or even than the NSs—83%.

In summary, the change trials of the CDT demonstrated that there is only a

tendency for better discrimination of voiceless *th* than of its voiced counterpart, a result

that does not support H6 of RQ5—/ð/ was not significantly more difficult to perceive

than /θ/. Similarly H4 of RQ3, which suggests that more experienced learners would

discriminate the target phonemes better than the less experienced learners, is not

supported.

Table 21 illustrates the comparison of general participants' attainment in the two

kinds of trials, considering the results of the two phonemes together. Overall, the results

show that the participants performed better with catch trials (when all words where

identical), than with change trials (when there was an odd item).

Table 21. Accurate discrimination of /θ/ and /ð/, in catch and change trials, by the pre-intermediate (GI), the advanced (GA), and native speaker (NS) groups, in Perception Test 2—CDT.

Group	/θ/ and /ð/ change trials			/θ/ and /ð/ catch trials		
	N.	Acc.	%	N.	Acc.	%
GI	432	259	60	96	72	75
GA	432	300	69	96	70	73
NS	180	143	79	40	36	90

Note: N= Number of occurrences. Acc= Number of accurate answer. (%)= Percentage of accuracy.

The discrimination of the change trials was as follows: 60% by the GI, 69% by the

GA, and 79% by the NSs. On the other hand, the discrimination of the catch trials was:

75% by the GI, 73% by the GA, and 90% by the NSs. Indeed, it was more difficult for the

participants, both the EFL learners and the NSs, to accurately discriminate the target

phonemes from their variants than to perceive that there was not a contrast within the

trial. According to Flege et al. (1994), results such as these may be due to the design of

the test, which might entail an intense load on working memory, because in the CDT the

participants have to not only perceive a difference but also to remember the position of the odd item. In addition, in the present study each item of the trial consisted of a word, which would impose even more load on working memory than if the item was composed only of phones. The results show that, although the task was demanding (in terms of overloading participants' memory), the participants seemed to be reasonably concentrated, since the EFL participants managed to identify over 70% of the catch trials.

This aspect of the test, the use of words, may also explain the low achievement of the NSs. Their attainment was much inferior to what Flege and colleagues consider being an appropriate native achievement, an average of 97% for change trials, and 99% for catch trials (Flege et al., 1994). Sozinho (2004), investigating perception and production of compound noun stress patterns in English, found in his CDT that perception among native speakers was below Flege's estimation, about 86%. Similarly, examining the perception and production of English word-final nasals, Kluge (2004) verified that the NSs were able to discriminate an average of 78%. As these researchers affirm, the results of the CDT in both studies seem to question the validity of the test for examining stress pattern and consonant discrimination. Besides, Kluge points out that "the original Categorial Discrimination Test was designed to assess the perception of vowels; thus, the estimated success rate suggested by Flege may not be a realistic expectation for the perception of consonants" (2004, p. 45). Although the investigation of this caveat in the method is beyond the scope of this study, it is important to keep in mind that Flege and colleagues have been working with vowel perception and significantly smaller units in the trials. As he acknowledges (Flege, 1990, 1995) vowel and consonant perception may occur through different processes.

In conclusion, the CDT revealed that these Brazilian EFL learners tend slightly to discriminate the voiceless target phoneme and its variants better than the voiced set, a suggestion made by H6 of RQ5. In addition, the results of the test suggest that there is an

interaction between language experience and markedness. In other words, it seems that the discrimination of /θ/ may eventually be influenced by language experience, while the discrimination of /ð/ does not seem to be positively influenced by language experience. Thus, H4 of RQ3 is partially and weakly supported: the more experienced learners tend to perceive only the voiceless *th* better than the less experienced learners.

4.2.3 Perception Test 3: the Alternative Forced Choice Identification Test

The third perception test consisted of an identification test (AFC) in which the participants heard the set of words *thigh-fie-sigh-tie*, and *thee-vee-zee-dee* produced by three different native speakers of English. They heard each word five times, randomly, and were asked to label the first consonant sound of each word accordingly to four possibilities given on an answer sheet. Each target phoneme and its possible substitutions were tested separately.

The results of the AFC test demonstrate that, in general, these Brazilian EFL learners are able to identify the target phonemes and their most common substitutes (Table 22). The AFC was the test in which the participants obtained the highest scores out of all three perception tests: overall, the GI identified 87% of all occurrences, the GA obtained 91%, and the NSs 95%.

Table 22. Accurate identification of voiceless—[-vd]—and voiced—[+vd]—consonants sets by the pre-intermediate (GI), the advanced (GA), and the native speaker (NS) groups, in Perception Test 3—AFC.

Group	[-vd] identification					[+vd] identification					Total		
	N	Ac.	%	M	SD	N	Ac.	%	M	SD	N	Ac.	%
GI	240	207	86	17.25	1.96	240	212	88	17.67	1.83	480	419	87
GA	240	223	93	18.58	1.31	240	213	89	17.83	2.17	480	436	91
NS	100	95	95	19	1.73	100	96	96	19.20	1.30	200	191	95

Note: N= Number of occurrences. Ac= Number of accurate answer. (%)= Percentage of accuracy.
M= Mean. SD= Standard deviation

However, to the best of my knowledge, a threshold for native attainment has not been established for this kind of identification test. Comparing the results of the target phonemes within each group, using Wilcoxon signed rank tests, no significant effect for voicing was found for either of the 3 groups: the NSs (Z=-.18, p=.85), the GI (Z=-.30, p=.76), and the GA (Z=-1.36, p=.17).

Concerning the results of the identification of the voiceless consonants (Tables O13, O14, O15—Appendix O3), the NSs obtained 95% of accuracy, the GA achieved 93%, and the GI 86% (Table 21). A Mann-Whitney test reveals that there was no statistically significant difference between the NSs and the GI (Z = -1.77, p = .08), between NS and GA (Z=-.82, p=.40), or between the two EFL groups (Z = -1.79, p = .07). Although the statistical tests do not confirm a significant difference, the difference between the NSs and the GI, and that of the learners came close to significance, which may demonstrate a tendency for language experience effect. However, these results do not entirely support H4 of RQ3, which proposes that language experience influences positively the perception of the target voiceless phoneme. In fact, it appears to be possible for EFL learners to achieve NS ability in this skill.

Still concerning the voiceless consonants, the phonemes /f/ and /θ/ were the most difficult to label, a result somehow predicted by their acoustic similarity (Ladefoged, 2001). For the /f/ identification, the groups scored as follows: the GI obtained 83%, the GA 82%, and the NSs 84%. The /θ/ results were: 67% for the GI, 92% for the GA, and 96% for the NSs. Interestingly, the three groups did not differ considerably in the identification of /s/, /t/ and /f/. In the identification of /θ/, however, the GA obtained a native-like performance. Thus, the /θ/ was apparently solely responsible for the tendency for language experience effect found below (Table 23).

Table 23. Accurate identification of voiceless consonants by the pre-intermediate (GI), the advanced (GA), and the native speaker (NS) groups, in Perception Test 3—AFC.

	/θ/		/s/		/t/		/f/		Total	
Group	N	Ac. (%)	N	Ac. (%)	N	Ac. (%)	N	Ac. (%)	N	Ac. (%)
GI	60	40 (67)	60	58 (97)	60	59 (98)	60	50 (83)	240	207 (86)
GA	60	55 (92)	60	59 (98)	60	60 (100)	60	49 (82)	240	223 (93)
NS	25	24 (96)	25	25 (100)	25	25 (100)	25	21 (84)	100	95 (95)

Note: N= Number of occurrences. Ac= Number of accurate answer. (%)= Percentage of accuracy.

Regarding the results of the set of voiced identification (Tables O16, O17, O18—Appendix O3), the NSs attained 96% accuracy, the GA 89%, and the GI 88% (Table 22). A Mann-Whitney test reveals no significant difference between the results of the NSs and the GA ($Z = -1.36$, $p = .19$), the NS and the GI ($Z = -1.67$, $p = .10$), or the two EFL groups ($Z = -44$, $p = .61$). Thus, language experience seems not to have influenced the identification of the voiced phonemes, contrary to H4 of RQ3, which predicted that the more experienced learners would perceive better than the less experienced ones.

Within the voiced set, the target phoneme /ð/ was the most difficult for the learners to identify accurately, whereas their scores for /z/, /d/, and /v/ were close to or even better than the NSs' scores (Table 24). While for the voiceless set it was found that the interdental was responsible for the tendency for a language experience effect, for the voiced set it was the interdental which was responsible for the significant difference between the two learner groups and the NSs.

Table 24. Accurate identification of voiced consonants by the pre-intermediate (GI), the advanced (GA), and the native speaker (NS) groups, in Perception Test 3—AFC.

	/ð/		/z/		/d/		/v/		Total	
Group	N	Ac. (%)	N	Ac. (%)	N	Ac. (%)	N	Ac. (%)	N	Ac. (%)
GI	60	41 (68)	60	60 (100)	60	57 (95)	60	55 (91)	240	213 (88)
GA	60	38 (63)	60	60 (100)	60	59 (98)	60	57 (95)	240	214 (89)
NS	25	25 (100)	25	24 (96)	25	25 (100)	25	22 (88)	100	96 (96)

Note: N= Number of occurrences. Ac= Number of accurate answer. (%)= Percentage of accuracy.

However, the other voiced consonants prevented the statistical tests from showing significance in general results. When /ð/ and /v/ were not identified correctly, whether by

the learners or the NSs, they were most often confused with each other. That is, when participants misidentified /ð/, they marked it as /v/ 35 out of 41 times, while when misidentifying /v/, they marked it as *th* 11 out of 12 times. Again, this result was somehow expected, since several researchers (e.g., Miller & Nicely, 1955; Lambacher et al., 1997; Ladefoged, 2001) had found that the pair /v/ and /ð/ is acoustically very much alike.

In summary, as with the discrimination results, the identification of the voiceless interdental fricative seems to show a tendency for a language experience effect, which is not found for its voiced counterpart. Thus, the results of the AFC partially confirm H4 of RQ3, which predicted that the more experienced learners would perceive the target phonemes better than the less experienced, and H5 of RQ4, which suggested that the more experienced learners would perceive replacements of /θ/and /ð/ better than the less experienced. Contrary to what was found for the other perception tests, which seem to support H6 of RQ5, the results of the AFC do not support the prediction that the more marked phoneme /ð/ would be more difficult to perceive that the less marked /θ/.

However, even when the learners do perceive the voiceless and voiced *th* as distinct phonemes, accurate production does not seem necessarily to be a consequence, especially of the voiced consonant. Maybe due to the early necessity to produce the marked phonemes, since *th*-words are the most frequent in English (Butler, 2002), Brazilian learners seem to disregard its distinction in both perception and production. Besides the influence of the markedness aspect (Eckman, 1991), some other factors may be involved with the difficulty of perception and production of these sounds, such as automatization.

4.2.4 Summary and discussion of perception test results

All in all, the results of the three perception tests suggest that language experience does not significantly affect the perception of the target phonemes. It seems that there is only a tendency for improvement in the perception of the less marked phoneme over time, whereas its voiced counterpart appears not to be significantly influenced by L2 experience. Thus, H4 of RQ3 and H5 of RQ4 are partially supported. Concerning H6 of RQ5, which inquires whether one target phoneme is more difficult to perceive than the other, the results are inconclusive: while GPE supports that /ð/ is more difficult that /θ/, the CDT shows only this tendency, and the AFC does not support the prediction.

In addition, the results of the three perception tests, particularly of those of the GPE, appear to support two related viewpoints: (a) Van Patten's (1994) hypotheses about conscious attention as a limited resource, and (b) Schmidt's assertion that "learners are not free to notice whatever they want" (1990, p.144). Both EFL groups might have been constrained by some of the factors that may interfere in noticeability, such as task demands, learner's skill level, and saliency (Schmidt, 1990).

In terms of saliency, the interdental fricatives are often perceptually confused with stops by children acquiring English as L1 (Eilers & Minifie, 1975). Acoustically, spectrograms demonstrate that /θ/ and /f/ are so similar that it is common for them to be confused by listeners (Ladefoged, 2001; Lambacher et al., 1997). Furthermore, the pairs /θ/-/f/ and /ð/-/d/ are mentioned as being among the most difficult contrasts to be distinguished (Eilers & Minifie, 1975; Polka, Colantino & Sundara, 2001). Miller and Nicely (1955) found that under noisy conditions adults usually confuse the low intensity fricatives /θ/ and /f/.

When questioned, in the questionnaire, on the possible reasons that could hinder accurate pronunciation of the *th*, the participants of the study emphasized mainly the

importance of motoric difficulties. Nevertheless, some of the answers given under "other" could be considered as more related to perception, such as the similarity of the phonemes with other sounds, how confusing and demanding of attention these sounds are, and simply because they could not perceive any difference between the target phonemes and their variants.

Another aspect that should be taken into consideration is that both phonemes are introduced early in the process of learning EFL, particularly the voiced *th*, a phoneme found in word-initial position only in function words. As Morgan and Demuth (1996) point out, "function words are less salient forms in natural discourse given that they are short, contain unstressed vowels are typically not produced in isolation, and are not highlighted by intonation" (cited in Polka, Colantino & Sundara, 2000, p. 2198). Even when this class of words is inaccurately produced, in contrast to content words, their meaning can frequently be recovered from the context (Abrahamsson, 2003).

Still another aspect that must be taken into account is whether these EFL learners received accurate phonetic input (Flege et al., 1996a). As discussed in the results of the production tests, a pilot study conducted to examine the perception and production of the target phonemes by proficient Brazilian speakers of English (Reis, 2004b), the majority of them English teachers, found production inaccuracies in 52% of occurrences of /θ/, and 95% of /ð/. This finding might suggest that many Brazilian EFL learners are not receiving adequate *th* input in order to build a proper L2 perceptual target for guiding their L2 perception (Flege et al., 1996).

As Strange (1995) points out, there may be an age limit for learning new perceptual segments without much difficulty. The participants of the present study had had their first contact with the English sound system at an average age of 10 years, and Strange argues that "first language patterns of perception are well in place by 5 years of age" (1995,

p.35). Flege (1995) argues that after the stabilization of the L1, L2 learning may become more constrained than before the systematization.

Concerning learners' proficiency level, the results of the perception tests suggest that, in general, L2 experience does not seem to significantly influence the perception of the target phonemes. While perception of /θ/ appears to be slightly affected by language experience, perception of /ð/ seems not to receive the same influence. The aspects discussed above, such as the low acoustic intensity of the interdental fricatives, their acoustic similarity with other phones, their markedness characteristic, their early introduction into speech production, probable inadequate phonetic input, and the fact that the voiced *th* is only present in word-initial position in function words, might be some causes of the lack of influence of L2 experience on the perception of the target phonemes.

Just as the production tests were of two types (Pro3 and Pro1 - more focus on form, and Pro2 - more focus on meaning), the perception tests can also be classified in this manner: the GPE could be considered more meaning-focused, whereas the CDT and AFC are more form-focused. Van Patten (1994) argues that L2 learners process input for meaning rather than for form. In a test such as the GPE, even when the participants are processing with guided attention, since they were asked to pay attention to the sounds in word initial position, they seem to ignore pronunciation mistakes that do not lead to misunderstandings, and tend to detect more errors in content words than in function words. The CDT and the AFC, on the other hand, are tests in which there is no content to be understood; thus the listeners may allocate their attention more acutely to what they are told to.

Following this reasoning, the tests present different levels of task demands, which can ultimately interfere in the participants' performance. Thus, the CDT and the AFC could be considered actual perception tests, in terms of how often the L2 learners are able

to detect whether a non-contrastive phoneme in their L1 can be perceived or not as a distinct sound. On the other hand, the GPE could be described as a test that verifies the allocation of attention the participants give to a certain item.

In terms of Schmidt's Noticing Hypothesis (1990, 1995), the CDT and the AFC appear to demonstrate that some EFL learners have already noticed the peculiarity of the interdental fricatives. Schmidt emphasizes the importance of consciousness for L2 learning. However, it seems reasonable to assume that if a learner is able to demonstrate the presence of a mental representation of a target phoneme at the time of testing, probably he or she has already noticed its peculiarity. Accordingly, if the learner does not demonstrate this awareness at the time of testing, possibly he or she has not reached the point of noticing during the learning process.

In fact, the results of these tests corroborate this assumption. The more form-focused tests (the CDT and the AFC) seem to support H4 of RQ3, which proposes that experienced learners are able to perceive the most common replacements of the target phonemes. That is, when required to demonstrate awareness of the replacement of the target phonemes, participants were capable of discriminating and identifying the differences, maybe demonstrating that noticing had taken place and a mental representation has already been established.

However, the results of the more meaning-focused test, the GPE, suggest that the *th* sounds are irrelevant for understanding the content of the speech, including among native English speakers. Thus, the GPE seems to disconfirm H4 of RQ3, which proposes that the more advanced learners would be able to perceive replacement better than the less experienced learners: in 93% of the occurrences the participants simply ignored the different substitutions of the target phonemes. Indeed, five participants of this study declared in the questionnaire that the *th* sound is unimportant for them.

As a matter of fact, in some English dialects the target phonemes are replaced (Ladefoged, 2001). In London Cockney dialect, for instance, /θ/ and /f/ are not phonologically distinct; thus, words like *fin* and *thin* have the same pronunciation- [fɪn] (Ladefoged, 2001). Besides, Miller and Nicely (1955) argue that the acoustic discrimination between /f/ and /θ/ and between /v/ and /ð/ is extremely difficult, depending more on the verbal context and visual observation than on acoustic cues.

On the one hand, the results of the CDT and AFC appear to challenge Rochet's standpoint on the phonological space being occupied entirely by L1 mental representation. According to him, any L2 sound would be filtered by an L1 prototype and its perception would be associated to this L1 phone. The two form-focused perception tests seem to demonstrate that learners may form a mental representation for a sound non-contrastive in the L1. However, this capacity to discriminate and identify phonemes that are non-distinctive in the L1 does not seem necessarily to lead to accurate production. On the other hand, the low accuracy scores in these two perception tests, especially in the CDT, may suggest that the L2 sound is perceived through, and associated with, the L1 prototype, which would confirm Rochet's (1995) proposition.

For those who obtained low scores, the Magnet Effect theory (Kuhl & Iverson, 1995) seems to explain the findings. These researchers propose that L1 experience results in the construction of L1 prototypes, which function as perceptual magnets, guiding, or misguiding, L2 speech perception. The results of the perception tests suggest that /θ/ and /ð/ are attracted to the Portuguese prototypes /t/ and /d/, respectively. Likewise, the voiceless and the voiced interdental fricative contrast, according to Best's (1995) Perceptual Assimilation Model, seem to be assimilated into BP inventory as a two-

category assimilation, the categories /t/ for /θ/ and the /d/ for /ð/. The results also confirm

her claim that differentiation between the contrast /θ/ and /ð/ is excellent.

In terms of phonemic features, substitutions for both production and perception are

not random. On the contrary, the choices are made following a rigid pattern of

similarities: the more features shared, the greater the possibility for another phoneme to

replace the sound that does not exist in the L1 (Rosen, 1991; Eckman, Elreyes & Iverson,

2003). Gatbonton affirms that "If the language lacks a segment with the same features as

the target segment, they [learners] will use the segment containing features closest to the

target features" (1978, p.345).

Finally, in the developmental process, /f/ is often used as a substitute for /θ/ by

children acquiring English as L1, and 97% of children substitute /d for /ð/ in the process

of acquiring the language (Edwards, 1979, cited in Hecht & Mulford, 1987). Although

replacements are related to production, since replacement only occurs among phonemes

that share as many features as possible, this commonality of features may not only lead

speakers to mispronunciation, but also listeners to misperception.

4.3 Relationship between the perception and production of /θ/ and /ð/

As discussed above, the perception of the interdental fricatives, especially the

perception of /ð/, does not appear to be much influenced by language proficiency. Table

25 displays a summary of the scores obtained by each group in each perception test.

Table 25. Summary of accurate perception of the interdental fricatives by the pre-intermediate (GI) and the advanced (GA), in the three Perception Tests—GPE, CDT and AFC.

Group	GPE			CDT			AFC			Total		
	N	Ac.	(%)	N	Ac.	(%)	N	Ac.	(%)	N	Ac.	(%)
GI	504	25	5	432	259	60	480	419	87	1512	776	51
GA	504	44	8	432	300	66	480	436	91	1512	832	55

Note: N= Number of occurrences. Ac= Number of accurate answer. (%)= Percentage of accuracy.

Considering only the results the EFL groups, the differences between their performances in individual tests is not significant, as previously discussed. Similarly, a summary of the results of the three production tests (Table 26) demonstrated that language experience does not play a significant role in the production of the target phonemes. Moreover, the difference in achievement by the two EFL groups in the perception and the production tests seems to suggest that accurate perception may not necessarily lead to accurate production of the target phonemes.

Table 26. Summary of accurate production of the interdental fricatives by the pre-intermediate (GI) and the advanced (GA) groups, in the three Production Tests—Pro1, Pro2, and Pro3.

Group	Pro1			Pro2			Pro3			Total		
	N	Ac.	(%)	N	Ac.	(%)	N	Ac.	(%)	N	Ac.	(%)
GI	504	33	(6)	119	7	(6)	360	44	(12)	983	84	(8)
GA	504	102	(20)	245	31	(12)	360	118	(32)	1109	251	(22)

Note: N= Number of occurrences. Ac= Number of accurate answer. (%)= Percentage of accuracy.

In order to investigate further the relationship between perception and production, Spearman's rho correlations were run, grouping the scores for the voiced and voiceless consonants for each of the three perception tests, and for each of the three production tests. The results yielded no significant correlations between any of the perception and production tests, both for GI or GA (Tables P1 and P2—Appendix P).

The individual results refute the two hypotheses of the RQ6: H8, which proposed that there would be a correlation between perception and production, and the H9, which suggested that the correlation between production and perception would be more consistent among the experienced learners.

However, it is important to bear in mind that the general results of the three perception tests and the three production tests were lower due to two aspects: (a) the results of the more meaning-focused tests—the GPE for the perception tests, and the Pro2 (retelling the story) for production tests; and (b), the results of the production of the

voiced *th* has shown that this phoneme is usually disregarded by most participants, especially in more meaning-focused tests. In addition, the results of the perception tests also demonstrated a tendency of more difficulty to perceive /ð/ than /θ/. Because the participants had a more consistent performance with the voiceless phoneme than with the voiced one, the test results for the former were used to search for possible correlations between perception and production, especially for the more form-focused tests (the CDT and AFC for the perception tests, and the Pro3—list reading, for the production tests). Once again, the results show no significant relationship.

All in all, the lack of correlation between perception and production does not seem to be totally in accord with the prediction of Flege's Speech Learning Model (1995). Although he acknowledges that not all production problems are due to misperception, he also argues that there is a relationship between perception and production, and that the better a learner perceives, the better his/her production will be. Flege te al. (1996b) remark that the revised version of the SLM no longer considers the AOL and the perceived cross-language phonetic distances as dichotomous variables. That is, the revised model hypothesizes that "the likelihood of category formation varies inversely with age of L2 learning, but directly as a function of perceived cross-language phonetic distance (p. 159). According to the scholars, some of the late learners, those who perceive the phonetic distance between the L1 and L2 sound, are able to establish an L2 phonetic category.

It seems that, concerning the perception and production of the English interdental fricatives, the perspective supported by Labov (1972) and Sheldon and Strange (1982, both cited in Koerich, 2002) that production and perception can develop independently is more appropriate to explain the results of this study. However, it is important to bear in

mind that the SLM is proposed to account for findings of highly experienced learners, a condition not found even in the GA group.

Similarly, Jenkins and Yeni-Komshian (1995) posit that although production and perception are sometimes found to be positively correlated, this correlation does not always take place. The authors report that, since the correlation is never perfect, it is comprehensible that accurate production may occur independently of accurate perception. They state that it is less clear, however, "whether perceptual skill can be attained without bringing production along" (p.473).

To conclude, as several authors suggest (e.g., Ellis, 1994; Martens & Lambacher, 1999), individual differences should be taken into account for explaining different results. Participants A1 and A3 achieved the best performances for both the production and the perception tests: A1 attained 64% in production, and 76% in the perception tests; similarly, Participant A3 obtained 54% in production, and 72% in the perception tests. Even though both A1 and A3 consciously disregard accurate pronunciation of the interdental fricatives, as shown in the questionnaire, they may constitute examples that suggest a possible relationship between perception and production.

Chapter 5 — Conclusion

5.1 Summary of overall results

Flege et al. (1996a) stress that for an L2 perception test to be appropriate for evaluating whether non-native perception underlies the inaccuracies in production, "it must be tailored to the kinds of errors actually observed in speech production" (p. 66). The present study was designed with this view in mind, in an attempt to ascertain whether the patterns of misproduction of the interdental fricatives produced by Brazilian EFL learners are associated with misperception.

In order to investigate the perception and production of the interdental fricatives by Brazilian EFL learners, seven research questions and ten hypotheses were proposed. Overall, the RQs and Hs aimed to verify the typical replacement patterns of the phonemes, whether language experience would influence the participants' performance in perception and production, whether there is one particular interdental fricative phoneme which is more difficult than the other, and whether there is a correlation between perception and production. The following paragraphs present the major findings related to the RQs and Hs.

Regarding production, the RQ1 was supported by the results of the tests; that is, the target phonemes were replaced by more than one variant, especially the voiceless *th* (H1), while the most common phones used to replace the phonemes are [t] for /θ/ and [d] for /ð/ (H2). On the other hand, H3 of RQ2 was only partially supported by the production tests: the results indicate that language experience tends to influence the production of /θ/, but not that of /ð/. Finally, the production tests support H7 of RQ5: /ð/ is more difficult to produce than /θ/.

Concerning perception, the results do not support H4 of RQ3: while language experience seems to slightly enhance the perception of replacements of /θ/, the same effect is not as apparent in the perception of replacements of /ð/. H5 of RQ4 does not seem to be supported either: the more experienced learners did not significantly outperform the less experienced learners in the perception of the target phonemes. H6 of RQ5 seems to be supported; that is, the results suggest that the voiced *th* is more difficult to perceive and to produce that its voiceless counterpart.

As regards the correlation between perception and production (RQ6), the results seem to reject the hypotheses: the findings did not show such a correlation (H8), nor was the correlation more consistent among the experienced learners (H9). Finally, the results support H10 of RQ7, which proposed that learners' accuracy vary according different types of tasks, fewer errors being produced in more formal tests and more in less formal tasks.

5.2 Theoretical implications

The SLM (Flege, 1995) postulates that an L2 learner is able to form an L2 phonetic category if the sound is perceived as new; that is, different from any L1 phone. It also proposes that the more the learners have used their L1, the more difficult it will be for them to attain native-like pronunciation. This difficulty would be due to L1 stabilization, which takes place when children begin to read. The 24 EFL participants of the present study ranged in age from 15 to 23, were all literate, had been studying English for an average of 1 ½ years (GI), and 5 years (GA), and were first exposed to English after the age of 7 years.

In spite of differences in purpose and design, relevant comparisons can be made between the present study and Flege et al. (1996a), in which the production of the phones

/p, t, θ, ð/ in word-initial position by native Italians speakers living in Canada for over 30 years was evaluated for degree of nativeness. Maybe the greatest difference between the studies is the fact that the participants of the 1996 experiment had almost surely reached their ultimate level of pronunciation already, as Flege et al. acknowledge (p.65). In contrast, the participants of the present study, even the so-called advanced students, were objects of a cross-sectional research in which data were collected after a maximum of 5 years of EFL study. Regardless of the differences, both studies share the concern of investigating the production of the interdental fricatives by speakers of English whose NLs lack the target phonemes. In addition, the present study aimed to verify whether misperception is involved in the inaccurate production, as Flege and colleagues suggest (1996a).

According to Flege et al. (1996a), because the interdental fricatives do not exist in Italian, they would end up be perceived as new, which could lead to the establishment of the L2 categories and, eventually, to native-like production. On the other hand, the phonemes /p, t/, present in the Italian inventory, would be perceived as similar, which could hinder the production of the phonemes with the English VOT values. The results indicated that the threshold age of learning for native-like production of /θ, ð/ was about 11 years, while for the production of /p, t/ with longer VOT values the threshold was 15 years.

These results suggest at least two conclusions that might serve as perspectives for the present study. First, the perception of the interdental fricatives may occur "through the grid of the L1" (Wode, 1995) and, contrary to the claims of Flege et al. (1996a) these phones may be perceived as similar L1 sounds. This suggestion is consistent with the Magnet Effect theory of L2 perception (Kuhl & Iverson, 1995), with Rochet's (1995) assertion that all L2 sounds are heard through an L1 prototype, and with the Perceptual

Assimilation Model (Best, 1995), which proposes that non-native gestures which resemble the native constellation will be perceived through the native system.

Second, the results may indicate that in addition to perceptual difficulties other aspects might be involved in the production of the interdental fricatives. As Flege acknowledges, "noninventory sounds may in some instances be produced inaccurately, even by highly experienced L2 learners" (1995, p. 265). If the absence of a phone in the L1 is the main cause for perceiving it as new, maybe the age limit for Italian EFL learners to perceive /θ, ð/ would not be 11 years, but something older than this and even older than the 15 years found for a similar L2 sound, such as the /p, t/ phonemes. Flege et al. (1996a) argue that while it is difficult to account for the variations found in the study, a possible explanation "is that certain individuals lose their ability to learn to produce L2 sounds that are 'new'… Another possibility is that some people lose the ability to perceptually distinguish sounds found in the L2 from sounds in the L1 inventory" (p. 60).

Perhaps the loss of the ability to produce L2 sounds is related to the degree of difficulty of the articulation of the sound. As discussed previously, the interdental fricatives are the last phonemes acquired by children learning English as L1, due to their articulatory complexity (Menyuk, 1968; Moskowitz, 1970, cited in Schmidt, 1987; Smit et al., 1990). Flege et al. (1996) state that "beyond a certain age, L2 learners may have difficulty at a motoric level in modifying pre-established patterns of articulation or in learning new patterns of speech articulation" (p. 49), especially if the L2 phone imposes difficulties for children even learning it as an L1 sound, the case of the interdental fricatives.

The results of the present study seem to be in agreement with the latter interpretations, despite the differences in the studies. It is not reasonable to affirm that the participants reached their eventual pronunciation, but the results seem to suggest that, at

the moment of the data collection, (a) as Flege and colleagues (1993 and elsewhere) propose, perception may have been involved in the replacement of the target phonemes; (b) as Wode (1995) and Rochet (1995) claim, the target phonemes may have been perceived through the L1 sieve; (c) as Kuhl and Iverson (1995) advocate, /θ/ seems to have been attracted to the prototype /t/, and /ð/ to the prototype /d/; (d) as Best (1995) suggests, the interdental fricatives seem to resemble the native constellation of /t/ and /d/; (e) from this view, the SLM's prediction that /θ/ and /ð/ would be perceived as new phones because they do not exist in the BP inventory is not supported; (f) motoric difficulties may cause problems in the accomplishment of the new articulatory pattern; finally, (g) the spelling of *th*-words might influence their pronunciation, especially the voiceless *th* production.

The present study seems to be in conformity with the claims of the Markedness Differential Hypothesis (Eckman, 1977), which proposes that the markedness relationship between the phonemes - /ð/ being more marked than /θ/ - affects their degree of difficulty. To conclude, the study appears to be in accordance with the Noticing Hypothesis (Schmidt, 1990 and elsewhere), which proposes that for L2 learning to take place, the conscious process of noticing an item is necessary for the item to occur accurately in the output. Two individual results, those of A1 and A3, appear to exhibit a higher level of understanding, which seems to be reflected in more occurrences of accurate perception and production.

5.3 Pedagogical implications

Cross-language research involving BP and English is rather new, especially concerning the area of interlanguage phonetics and phonology. Some researchers (e.g., Koerich, 2002; Silveira, 2004, Sozinho, 2004; Kluge, 2004) have been examining the role

of L2 perception on production under the perspective of the SLM. These studies offer relevant conclusions both for the theoretical development of the field, and for the improvement of pronunciation teaching and the development of pronunciation materials. However, to the best of my knowledge, no previous study has been carried out to examine the perception and production of the English interdental fricatives by Brazilian EFL learners.

The pronunciation instruction of the interdental fricatives seems to be controversial. On the one hand, Seidlhofer (2004) argues that phones that are "particularly English", such as the target phonemes, are not the core of the language and that the "mastery of these sounds proved not to be crucial for mutual intelligibility" (p. 217). Abrahamsson (2003) acknowledges that the replacement of the target phonemes does not seem to represent any harm for message conveyance. On the other hand, Baptista (personal communication, July, 2005) states that in English-speaking countries there is a social stigma against the replacement of the target fricatives for stops, usually associated with lower social status.

The present study may be useful for indicating to teachers some of the difficulties Brazilians EFL learners tend to have concerning the perception and production of /θ/ and /ð/. Since it is the teacher's responsibility to recognize students' limitations and provide means to overcome them, teachers may make use of the present study to improve the learning of the target phonemes.

In agreement with Jenkins and Yeni-Komshian's (1995) recommendation, teachers should provide instruction and input enhancement (Sharwood-Smith, 1993) of marked items, such as the target phonemes, from the very beginning of learning, as well as give feedback when necessary. Given that the voiced *th*-words are the most frequent in spoken and written English (Leech et al., 2001), due to the voiced *th* function words, the teacher

could offer practice in both perception and production of the phonemes in order to avoid automatization of the inaccurate form, which in turn could result in fossilization.

Input enhancement, among other strategies, could make students aware that the pronunciation of the *th*-words requires a place of articulation which is not used in BP. Sancier and Fowler (1997) suggest that "listeners/speakers are disposed to imitate what they perceive" and that this disposition is "more readily understandable from the perspective of the direct-realistic theory or the motor theory than from a theory in which the acoustic signals are mapped onto abstract phonological categories" (p. 431). From this viewpoint, instruction on the place of articulation of the target phonemes could be considered a way of enhancement of both perception and production.

Moreover, because the results suggest that misperception may be involved in the misproduction of the target phonemes, teachers could enhance awareness of the target phonemes by providing practice in perception. According to Jenkins and Yeni-Komshian (1995), this practice could use natural input utterances, spoken by different speakers, and orthography should be delayed in order for the students to rely on acoustic features before they relate the sounds to a specific spelling.

Indeed, input enhancement seems to have a positive effect on the pronunciation of the target phonemes. Reis (2004c) carried out a pronunciation instruction experiment, with emphasis on production, with six pre-intermediate Brazilian EFL learners, three participants in the control groups (without practice), and three in the experimental group (with practice). Despite the limitations of the study, the results showed considerable improvement in the production of the target phonemes, especially of the voiceless *th,* an improvement still present after two weeks of instruction.

The results of the present study indicate that /θ/, more than /ð/, seems to be positively influenced by language experience. Similarly, the experiment with instruction

of the target phonemes (Reis, 2004c) demonstrated that /θ/ appears to be more influenced by training than /ð/. Perhaps, due to the markedness aspect between the phonemes, it would be more appropriate to focus instruction on the less marked phoneme first, since it appears to be somehow easier to perceive and produce. Maybe practice with /θ/ could be a form of input enhancement for the perception and production of /ð/. As several scholars (e.g. Ellis, 1994; Hu, 2002; Butler, 2002) argue, instruction seems to be more effective for less marked items than for the more marked ones.

5.4 Limitations of the study and suggestions for further research

The main limitation of the present study is the fact that it used a model to account for the role of L2 perception on production, the SLM, designed to explain the outcomes of highly experienced L2 learners, that is, a model that attempts to elucidate *ultimate* pronunciation learning achievement. Contrary to the model, the participants of this study had almost certainly not reached their ultimate pronunciation attainment yet. Thus, some of the hypotheses of the model may have been inappropriate for the interpretation of the results of the present study. Thereafter, future research could investigate highly experienced EFL speakers, such as teachers of English. It is also worth mentioning that most of the studies conducted by Flege and colleagues have been carried out in ESL settings, where learners acquire the L2 in a natural environment, unlike from the participants of the present study, who learn the L2 in an instructional setting.

A second limitation of the study was the impracticality of using acoustic analysis in the investigation of the replacements of the target phonemes. Due to the acoustic similarity between the interdental fricatives and some of their substitutes (Ladefoged, 2001), the use of the spectrogram would not have helped much.

Another limitation pertains to the choice of perception test, as discussed in section 4.2.1: the GPE test appeared to have been an overwhelming task, maybe not appropriate for the purposes of the present study. Besides, since the participants were aware that the recording had been made by a non-native speaker of English, they could be biased in the detection of errors. Thus, further studies could be carried out with an adaptation of this perception test: speech samples produced by both native and non-native speakers could be edited in order to select only words with the target phonemes.

In the matter of technology, a suggestion for future research is Flege's (1991, cited in Koerich, 2002) proposal for the use of refined laboratory tests that measure the speed of processing of a sound. Flege argues that new L2 sounds may require longer processing time than similar L1-L2 phones do, which in turn may require longer processing time than L1-L2 identical sounds.

Another limitation of the study was the use of more formal types of tests rather than of more informal ones. Some scholars (e.g., Major, 1994; Tarone, 1979; Beebe, 1987) believe that the interlanguage is less susceptible to error in more formal situations (reading and list-reading) than in more informal contexts (spontaneous speech). Although the present study showed only a tendency for more accurate production in more formal situations, future research could make more use of spontaneous speech than of list-reading.

To conclude, further research could extend the time of the investigation; that is, instead of a cross-sectional experiment, a longitudinal study might shed more light on the issue of perception and production of the interdental fricatives. In addition, the appropriateness of instruction and practice of the target phonemes could also be further investigated.

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Appendix A

A.1 Questionnaire used with the EFL participants.

The following questionnaire aims to obtain information that could help interpreting and analyzing the present research. Your answers will not be revealed in any circumstance, only the researcher and her adviser will have access to the information.

Name: _____ e-mail_____

Date_____/_____/2005

1. Age _____   2. Gender: (   ) male   (   ) female

3. Have you ever lived in an English speaking country?

( ) no   ( ) yes, Which one?_____

3.1. How long have you lived there?

_____

3.2. How old were you?

_____

3.3. What was the purpose of your trip?

(   ) tourism;

(   ) study;

(   ) work;

(   ) other: _____

3.4. In this country you used to spend more time with:

(   ) native English speakers;

(   ) foreign from different languages;

(   ) Brazilian;

(   ) in a community different from the Brazilian one _____

4. How old were you when you had your first contact with English language?

(   ) less than 7;

(   ) between 7 and 10;

(   ) between 10 and 15;

(   ) between 15 and 20;

(   ) other _____

4.1. Did you continue your English studies since that period?

(   ) no

(   ) yes

4.2. How long have you been studying English regularly, approximately, that is, without interruption?

(   ) less than 6 months;

(   ) between 6 months and 1 year;

(   ) between 1 year and 1 ½ years;

(   ) between 1 ½ year and 2 years;

(   ) between 2 and 3 years;

(   ) between 3 and 4 years;

(   ) between 4 and 5 years;

(   ) between 5 and 6 years;

(   ) other_____

4.3. Apart from the classes at UFSC, how much time do you, approximately, spend studying by yourself at home weekly?

(   ) I don't study;

(   ) less than 1 hour;

(   ) between 1 and 2 hours;

(   ) between 2 and 3 hours;

(   ) other_____

5. Have you done any English proficiency test?
( ) no ( ) yes
      ( )Cambridge
      ( )Trinity
      ( ) TOEFL
      ( ) IELTS
      ( ) Other_____
      What was your score?_____
6. Do you have the habit of listening to English songs?
( ) no ( ) yes
6.1. Do you try to sing with the singer?
( ) no ( ) yes
6.2. How much time do you spend in this kind of activity, daily?
( ) less than 1 hour;
( ) more than 1 hour;
( ) more than _____ hours;
( ) other _____
7. Are you fluent in another language rather than Portuguese and English?
( ) no ( ) yes; Which one? _____
8. Do you speak another foreign language at home with your family?
( ) no ( ) yes; Which one? _____
9. Where are you from?
( ) Florianópolis ( ) other
city/state_____
10. How long have you been living in this city?
_____

11. In your opinion, what is the level of importance you give for the following aspects of communication in a foreign language (you can repeat your evaluation if necessary):

1- Fundamental   2- important   3- indifferent   4- irrelevant

grammar	pronunciation	vocabulary

12. That you know, do you have any auditory problem or difficulty?
( ) no;
( ) yes.
Describe _____
13. That you know, do you have any speaking problem or difficulty?
( ) no;
( ) yes.
Describe _____
14. Please be extremely honest in this answer. I'm trying to find out whether there is a correlation between perception and production of the 'th' sound, as in the words *"think"* and *"though"*. When did you notice the purpose of the experiment? (Look at the tests to check your answer)
( ) I did not notice;
( ) in test 1;
( ) in test 2;
( ) in test 3;
( ) in test 4;
( ) in test 5;
( ) in test 6;

15. If you are not able to produce the "th" sound, what would be the reason? (your answers can overlap)

( ) due to difficult articulation;
( ) it's a sound that sounds ridiculous and childlike;
( ) I don't mind producing it
( ) it's irrelevant;
( ) another reason

_____

16. Did you receive formal instruction about the English *th*-sounds?
( ) yes   ( ) no

A.2 Questionnaire used with the native English speaker participants

The following questionnaire aims obtaining information that can help interpreting and analyzing the current research. Your answers will not be revealed in any circumstance, only the researcher and her adviser will have access to the information.

Name: _____ e-mail_____

Date_____/_____/2005

1. Age _____   2.Gender: (   ) male   (   ) female

3. Where are you from? City/ state/ country?

_____

3.1. How long have you been living in Brazil?

_____

3.2. And in this city?

_____

4. What are you doing here?

(   ) tourism

(   ) studying

(   ) working   (   ) as an English teacher

                  (   ) another job _____

5. In your opinion, what is the level of importance you give for the following aspects of communication in a foreign language (you can repeat your evaluation if necessary):

                1- Fundamental   2- important   3- indifferent   4- irrelevant

grammar	pronunciation	vocabulary

6. That you know, do you have any auditory problem or difficulty?

(   ) no; (   ) yes.

Describe

_____

7. In your English dialect is the *th* sound significant, as in the words *"think"* and *"though"*? In other words, can you say *den* for *then*, or *tin* and *fin* for *thin* without changing the meanings of the words?

(   ) no;   (   ) yes.

8. When communicating with foreigners speaking English, how important do you think the accurate pronunciation of *th*-words is?

(   ) Fundamental   (   ) important   (   ) indifferent   (   ) irrelevant

Appendix B

Production Test 1: Reading a text

Name: _____ e-mail_____

TEST 1

- Record the following text.
- Do not read or rehearse it before recording.
- Please speak clearly and audibly.
- Do not repeat words or sentences that you believe having made mistakes.
- Try to follow your own pace, without interruption and repetition.

     I think I'm still recovering from a theft I experienced last year. Though I knew Aspen Theater is in a dangerous area, I really wanted to see that play and, of course, knowing something in theory is very different from knowing it in practice. So I decided to risk going to the theater. When I got there I saw them. First I thought they were waiting for some other people, but when they started to walk toward me I realized they were thieves. I had no time to do anything, they were bigger than me, the parking lot was empty and I was alone. The thing is that I didn't have much to be robbed, only thirteen dollars in my wallet. And I think this was what annoyed them. I was beaten hard and my car was stolen. I was taken to the hospital in shock and for almost a month I wasn't able to speak. I was thin, weak and had a constant fever. My doctor couldn't explain why the thermometer was always showing thirty-eight or thirty-nine degrees. After one month of intensive therapy I thought I could go back home. This was the best thing that happened to me after the theft. I'm still doing therapy but now I think I can walk around without panicking anymore, thanks to my family and doctors.

Appendix C

Production Test 2: Reporting the story of Production Test 1

TEST 2

- Tell the story you have just recorded in test 1. Use your own words.
- Reread the text twice.
- Try to tell the story with as much detail as possible.
- Speak in the third person, that is, as if the story had happened to someone you know, man or woman.

      I think I'm still recovering from a theft I experienced last year. Though I knew Aspen Theater is in a dangerous area, I really wanted to see that play and, of course, knowing something in theory is very different from knowing it in practice. So I decided to risk going to the theater. When I got there I saw them. First I thought they were waiting for some other people, but when they started to walk toward me I realized they were thieves. I had no time to do anything, they were bigger than me, the parking lot was empty and I was alone. The thing is that I didn't have much to be robbed, only thirteen dollars in my wallet. And I think this was what annoyed them. I was beaten hard and my car was stolen. I was taken to the hospital in shock and for almost a month I wasn't able to speak. I was thin, weak and had a constant fever. My doctor couldn't explain why the thermometer was always showing thirty-eight or thirty-nine degrees. After one month of intensive therapy I thought I could go back home. This was the best thing that happened to me after the theft. I'm still doing therapy but now I think I can walk around without panicking anymore, thanks to my family and doctors.

Appendix D

Production Test 3: Reading a list of sentences

D.1 The sentences for Production Test 3.

/θ/ production	/ð/ production (do not consider the definite article)	distracter sentences
1. I have free **thoughts**.	1. I agree **that** you're right.	1. I see him.
2. He **thought** he could go.	2. *The* coffee **they** serve here is hot.	2. He loves her.
3. His pedigree **thickens** his value.	3. I can see **their** effort.	3. Wash my dress.
4. It's a true **Thanksgiving** Day.	4. Where's *the* glue **they** bought?	4. Say goodbye.
5. Don't issue **thick** envelopes.	5. Is it true **that** you're rich?	5. Such a good dog!
6. It's a taboo **theme**.	6. I'm going to sue **those** plumbers.	6. It's a wonderful sunset!
7. I can't delay **thirteen** trips.	7. Don't disobey **them**.	7. Hold on, please.
8. I had a grey **thought.**	8. Can you play **these** instruments?	8. Such beautiful baby.
9. Everyday **things** happen.	9. *The* subway **they** catch is here.	9. It's a good idea.
10. It's a casino-**theater**.	10. One year ago **these** experiments were forbidden.	10. I love hot dogs.
11. *The* hero **think**s it's normal.	11. Go **there**.	11. Do you know her?
12. It's a bravado **thought**.	12. It's *the* logo **that** is appropriate.	12. I'm hungry.
13. Don't be **theatrical**.	13. Redo **those** exercises.	13. She's lying.
14. Take a **theology** course.	14. Don't say **this**.	14. It's so cold today.
15. It's only a **thesis**.	15. See **that** door?	15. You look terrific.

D.2 Instructions and a sample of a list.

TEST 3

- Read and record the following sentences, including the number that corresponds to the sentence.
- Do not read or rehearse them before recording.
- Please speak clearly and audibly.
- Do not repeat words or sentences that you believe having made mistakes.
- Try to follow your own pace, without interruption and repetition.

1. She's lying.
2. I agree that you're right.
3. Is it true that you're rich?
4. It's a wonderful sunset!
5. Take a theology course.
6. I see him.
7. It's the logo that is appropriate.
8. Go there.
9. It's a good idea.
10. It's only a thesis.
11. I'm hungry.
12. It's a taboo theme.
13. Don't be theatrical.
14. The subway they catch is here.
15. I can see their effort.
16. Do you know her?
17. I can't delay thirteen trips.
18. The coffee they serve here is hot.
19. The hero thinks it's normal.
20. Everyday things happen.
21. Such a beautiful baby.
22. Redo those exercises.
23. I'm going to sue those plumbers.
24. Such a good dog!
25. Don't say this.
26. See that door?
27. It's a true Thanksgiving Day.
28. Wash my dress.
29. He thought he could go.
30. I had a grey thought.
31. Say goodbye.
32. Don't disobey them.

33. It's a bravado thought.
34. It's so cold today.
35. His pedigree thickens his value.
36. He loves her.
37. Don't issue thick envelopes.
38. It's is a casino-theater.
39. I have free thoughts.
40. You look terrific.
41. Where's the glue they bought?
42. One year ago these experiments were forbidden.
43. Hold on, please.
44. Can you play these instruments?
45. I love hot dogs.

Appendix E

Perception Test 1: the general pronunciation error perception test

TEST 4

- Listen to the following speech.
- Pay attention to the pronunciation of the words that begin in consonants letters.
- Circle any syllable that you believe is pronounced incorrectly.
- You are going to hear the speech twice.

I **think** [fink] I'm still recovering from a **theft** [tɛft] I experienced last year. **Though** [dou] I knew Aspen **Theater** [tiater] is in a dangerous area, I really wanted to see **that** [dɛt] play and, of course, knowing something in **theory** [teori] is very different from knowing it in practice. So I decided to risk going to **the** [de] **theater** [fiater]. When I got **there** [dɛr] I saw **them** [den]. First I **thought** [tɔt] **they** [dei] were waiting for some other people, but when **they** [dei] started to walk toward me I realized **they** [dei] were **thieves** [tiːvs]. I had no time to do anything, **they** [dei] were bigger **than** [dɛn] me, **the** [de] parking lot was empty and I was alone. **The** [de] **thing** [fin] is **that** [dɛt] I didn't have much to be robbed, only **thirteen** [tʌrtin] dollars in my wallet. And I **think** [sink] **this** [dis] was what annoyed **them** [dem]. I was beaten hard and my car was stolen. I was taken to **the** [de] hospital in shock and for almost a month I wasn't able to speak. I was **thin** [fin], weak and had a constant fever. My doctor couldn't explain why **the** [de] **thermometer** [ermometer] was always showing **thirty**-eight [tʌrti] or **thirty**-nine [fʌrti] degrees. After one month of intensive **therapy** [tɛrapi] I **thought** [fɔt] I could go back home. **This** [dis] was **the** [de] best **thing** [siŋ] **that** [dɛt] happened to me after **the** [de] **theft** [fɛft]. I'm still doing **therapy** [fɛrapi] but now I **think** [tink] I can walk around without panicking anymore, **thanks** [tɛnks] to my family and doctors.

Appendix F

First CDT pilot study

Instructions, training and test.

Training

- Next you are going to take a perception test.
- You are going to listen to some native English speakers producing some sequences of short phrases.
- Each sequence has 3 phrases that can be identical or not.
- In this answer sheet you have to check:

  (1) If the first phrase is different from the other two
  (2) If the second phrase is different from the other two
  (3) If the third phrase is different from the other two
  (0) If all 3 phrases are identical

Example:

Listen to the following 4 sequences, they are already answered for you.

Then you can see as the test is going to be.

1.	**1**	2	3	0
2.	1	2	**3**	0
3.	1	**2**	3	0
4.	1	2	3	**0**

Now you check the best answer for the following sequences.
If you still have doubts after this training, ask please.

1.	1	2	3	0
2.	1	2	3	0
3.	1	2	3	0
4.	1	2	3	0
5.	1	2	3	0
6	1	2	3	0

CDT – Test (first pilot study)

- Now you are going to listen to 48 sequences.
- According to the training, check the best answer.
- DO NOT leave any sequence without answer.
- The sequences are divided in blocks, each block has 10 sequences.

1.	1	2	3	0
2.	1	2	3	0
3.	1	2	3	0
4.	1	2	3	0
5.	1	2	3	0
6.	1	2	3	0
7.	1	2	3	0
8.	1	2	3	0
9.	1	2	3	0
10.	1	2	3	0

- Sequences heard by the participants, not randomized here.

/t/ - /θ/ contrast

1. Will tanks   Will thanks   Will tanks
2. Will thanks   Will tanks   Will tanks
3. Will tanks   Will tanks   Will thanks
4. Will thanks   Will tanks   Will thanks
5. Will tanks   Will thanks   Will thanks
6. Will thanks   Will thanks   Will tanks
7. Will tanks   Will tanks   Will tanks
8. Will thanks   Will thanks   Will thanks

/s/ - /θ/ contrast

9. Will sanks   Will thanks   Will sanks
10. Will thanks   Will sanks   Will sanks
11. Will sanks   Will sanks   Will thanks
12. Will thanks   Will sanks   Will thanks
13. Will sanks   Will thanks   Will thanks
14. Will thanks   Will thanks   Will sanks
15. Will sanks   Will sanks   Will sanks
16. Will thanks   Will thanks   Will thanks

/f/ - /θ/contrast

17. Will fanks   Will thanks   Will fanks
18. Will thanks   Will fanks   Will fanks
19. Will fanks   Will fanks   Will thanks
20. Will thanks   Will fanks   Will thanks
21. Will fanks   Will thanks   Will thanks
22. Will thanks   Will thanks   Will fanks
23. Will fanks   Will fanks   Will fanks
24. Will thanks   Will thanks   Will thanks

/d/ - /ð/ contrast

25. will dat   will that   will dat
26. will that   will dat   will dat
27. will dat   will dat   will that
28. will that   will dat   will that
29. will dat   will that   will that
30. will that   will that   will dat
31. will dat   will dat   will dat
32. will that   will that   will that

/z/ - /ð/ contrast

33. will zat   will that   will zat
34. will that   will zat   will zat
35. will zat   will zat   will that
36. will that   will zat   will that
37. will zat   will that   will that
38. will that   will that   will zat
39. will zat   will zat   will zat
40. will that   will that   will that

/v/ - /ð/ contrast

41. will vat   will that   will vat
42. will that   will vat   will vat
43. will vat   will vat   will that
44. will that   will vat   will that
45. will vat   will that   will that
46. will that   will that   will vat
47. will vat   will vat   will vat
48. will that   will that   will that

Appendix G

Second CDT pilot study

Instructions, training and test

Training

- Next you are going to take a perception test.
- You are going to listen to some native English speakers producing some sequences of words.
- Each sequence has 3 words that can be identical or not.
- In this answer sheet you have to check:

    (1) If the first word is different from the other two
    (2) If the second word is different from the other two
    (3) If the third word is different from the other two
    (0) If all 3 words are identical

Exemple:

Listen to the following 4 sequences, they are already answered for you. Then you can see as the test is going to be.

1.	**1**	2	3	0
2.	1	2	**3**	0
3.	1	**2**	3	0
4.	1	2	3	**0**

Now you check the best answer for the following sequences.
If you still have doubts after this training, ask please.

1.	1	2	3	0
2.	1	2	3	0
3.	1	2	3	0
4.	1	2	3	0
5.	1	2	3	0
6	1	2	3	0

CDT – Test (second pilot study)

- Now you are going to listen to 58 sequences.
- According to the training, check the best answer.
- DO NOT leave any sequence without answer.
- The sequences are divided in blocks, each block has 10 sequences.

1.	1	2	3	0
2.	1	2	3	0
3.	1	2	3	0
4.	1	2	3	0
5.	1	2	3	0
6.	1	2	3	0
7.	1	2	3	0
8.	1	2	3	0
9.	1	2	3	0
10.	1	2	3	0

- Sequences heard by the participants, not randomized here.

/θ/ - /t/ contrast	/ð/ - /d/ contrast
1. θæb tæb tæb	1. ðæb dæb dæb
2. tæb θæb tæb	2. dæb ðæb dæb
3. tæb tæb θæb	3. dæb dæb ðæb
4. tæb θæb θæb	4. dæb ðæb ðæb
5. θæb tæb θæb	5. ðæb dæb ðæb
6. θæb θæb tæb	6. ðæb ðæb dæb
7. tæb tæb tæb	7. dæb dæb dæb
8. θæb θæb θæb	8. ðæb ðæb ðæb

/θ/ - /s/ contrast	/ð/ - /z/ contrast
1. θæb sæb sæb	1. ðæb zæb zæb
2. sæb θæb sæb	2. zæb ðæb zæb
3. sæb sæb θæb	3. zæb zæb ðæb
4. sæb θæb θæb	4. zæb ðæb ðæb
5. θæb sæb θæb	5. ðæb zæb ðæb
6. θæb θæb sæb	6. ðæb ðæb zæb
7. sæb sæb sæb	7. zæb zæb zæb
8. θæb θæb θæb	8. ðæb ðæb ðæb

/θ/ - /f/ contrast	/ð/ - /v/ contrast
1. θæb fæb fæb	1. ðæb væb væb
2. fæb θæb fæb	2. væb ðæb væb
3. fæb fæb θæb	3. væb væb ðæb
4. fæb θæb θæb	4. væb ðæb ðæb
5. θæb fæb θæb	5. ðæb væb ðæb
6. θæb θæb fæb	6. ðæb ðæb væb
7. fæb fæb fæb	7. væb væb væb
8. θæb θæb θæb	8. ðæb ðæb ðæb

Distracters:
1. θɑt θæt θæt
2. tɑd tɑg tɑg
3. tɛp tɛt tɛt
4. fɪp fɛp fɛp
5. fæk fɑk fɑk
6. ðɛg ðɑg ðɑg
7. dæk dʊk dʊk
8. dɛg dʊg dʊg
9. sɔb sɔd sɔd
10. sɑg sɪg sɪg

Appendix H

Perception Test 2: the Categorial Discrimination Test

H.1 Instructions and the test for the voiceless *th* discrimination test

TEST 5.1

- Now you are going to listen to 22 sequences.
- According to the training, check the best answer.
- The words you are going to hear are: *sigh, thigh, fie* and *tie.*
- DO NOT leave any sequence without answer.
- The sequences are divided in blocks, each block has 10 sequences.
- In this answer sheet you have to check:

    (1) If the first word is different from the other two
    (2) If the second word is different from the other two
    (3) If the third word is different from the other two
    (0) If all 3 words are identical

1.	1	2	3	0
2.	1	2	3	0
3.	1	2	3	0
4.	1	2	3	0
5.	1	2	3	0
6.	1	2	3	0
7.	1	2	3	0
8.	1	2	3	0
9.	1	2	3	0
10.	1	2	3	0

1.	1	2	3	0
2.	1	2	3	0
3.	1	2	3	0
4.	1	2	3	0
5.	1	2	3	0
6.	1	2	3	0
7.	1	2	3	0
8.	1	2	3	0
9.	1	2	3	0
10.	1	2	3	0

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

- Sequences heard by the participants (voiceless *th*), not randomized here.

/θ/ - /t/ contrast	/θ/ - /s/ contrast	/θ/ - /f/ contrast
1. thigh tie tie	9. thigh sigh sigh	16. thigh fie fie
2. tie thigh tie	10. sigh thigh sigh	17. fie thigh fie
3. tie tie thigh	11. sigh sigh thigh	18. fie fie thigh
4. tie thigh thigh	12. sigh thigh thigh	19. fie thigh thigh
5. thigh tie thigh	13. thigh sigh thigh	20. thigh fie thigh
6. thigh thigh tie	14. thigh thigh sigh	21. thigh thigh fie
7. tie tie tie	15. sigh sigh sigh	22. fie fie fie
8. thigh thigh thigh		

- Sequences heard by the participants, randomized:

trial	answer
1. sigh thigh thigh	1
2. thigh thigh tie	3
3. thigh fie thigh	2
4. thigh thigh thigh	0
5. thigh sigh thigh	2
6. tie thigh thigh	1
7. thigh thigh sigh	3
8. thigh fie fie	1
9. thigh tie thigh	2
10. sigh thigh sigh	2
11. thigh tie tie	1
12. fie thigh thigh	1
13. tie tie thigh	3
14. tie tie tie	0
15. sigh sigh sigh	0
16. tie thigh tie	2
17. fie fie thigh	3
18. thigh sigh sigh	1
19. sigh sigh thigh	3
20. fie thigh fie	2
21. thigh thigh fie	3
22. fie fie fie	0

Perception Test 2: the Categorial Discrimination Test

H.2 Instructions and the test for the voiced *th* discrimination test

TEST 5.2

- Now you are going to listen to other22 sequences.
- According to the training, check the best answer.
- The words you are going to hear are: *zee, thee, fee* and *dee.*
- DO NOT leave any sequence without answer.
- The sequences are divided in blocks, each block has 10 sequences.
- In this answer sheet you have to check:

  (1) if the first word is different from the other two
  (2) if the second word is different from the other two
  (3) if the third word is different from the other two
  (0) if all 3 words are identical

1.	1	2	3	0
2.	1	2	3	0
3.	1	2	3	0
4.	1	2	3	0
5.	1	2	3	0
6.	1	2	3	0
7.	1	2	3	0
8.	1	2	3	0
9.	1	2	3	0
10.	1	2	3	0

1.	1	2	3	0
2.	1	2	3	0
3.	1	2	3	0
4.	1	2	3	0
5.	1	2	3	0
6.	1	2	3	0
7.	1	2	3	0
8.	1	2	3	0
9.	1	2	3	0
10.	1	2	3	0

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

- Sequences heard by the participants (voiced *th*), not randomized here.

/ð/ - /d/ contrast	/ð/ - /z/ contrast	/ð/ - /v/ contrast
1. thee dee dee	9. thee zee zee	16. thee vee vee
2. dee thee dee	10. zee thee zee	17. vee thee vee
3. dee dee thee	11. zee zee thee	18. vee vee thee
4. dee thee thee	12. zee thee thee	19. vee thee thee
5. thee dee thee	13. thee zee thee	20. thee vee thee
6. thee thee dee	14. thee thee zee	21. thee thee vee
7. dee dee dee	15. zee zee zee	22. vee vee vee
8. thee thee thee		

- Sequences heard by the participants, randomized:

trial	answer
1. zee thee thee	1
2. Dee Dee Dee	0
3. thee thee thee	0
4. vee thee thee	1
5. zee zee thee	3
6. thee thee Dee	3
7. thee thee zee	3
8. vee thee vee	2
9. zee thee zee	2
10. thee Dee Dee	1
11. Dee Dee thee	3
12. vee vee thee	3
13. thee Dee thee	2
14. vee vee vee	0
15. zee zee zee	0
16. Dee thee Dee	2
17. thee vee thee	2
18. thee thee vee	3
19. thee zee zee	1
20. thee zee thee	2
21. Dee thee thee	1
22. thee vee vee	1

Appendix I

Perception Test 2: The Categorial Discrimination Test

I.1 Training for the voiceless *th* discrimination test

Training 5.1

- Next you are going to take a perception test.
- You are going to listen to some native English speakers producing some sequences of words.
- Each sequence has 3 words that can be identical or not.
- Pay attention to the initial sound of each word and compare if all words start with the same sound.
- The words you are going to hear are: *sigh, thigh, fie* and *tie*.
- In this answer sheet you have to check:

  (1) If the first word is different from the other two
  (2) If the second word is different from the other two
  (3) If the third word is different from the other two
  (0) If all 3 words are identical

Example: Listen to the following 4 sequences, they are already answered for you.

Then you can see as the test is going to be.

1.	**1**	2	3	0
2.	1	2	**3**	0
3.	1	**2**	3	0
4.	1	2	3	**0**

Now you check the best answer for the following sequences.
If you still have doubts after this training, ask please.

1.	1	2	3	0
2.	1	2	3	0
3.	1	2	3	0
4.	1	2	3	0
5.	1	2	3	0
6	1	2	3	0

- Sequences heard by the participants (the answers were given immediately after the training):

trial	answer
1. sigh thigh thigh	1
2. thigh thigh tie	3
3. thigh fie thigh	2
4. thigh thigh thigh	0
5. thigh sigh thigh	2
6. tie thigh thigh	1

Perception Test 2: The Categorial Discrimination Test

I.2 Training for the voiced *th* discrimination test

Training 5.2

- Next you are going to take a perception test.
- You are going to listen to some native English speakers producing some sequences of words.
- Each sequence has 3 words that can be identical or not.
- Pay attention to the initial sound of each word and compare if all words start with the same sound.
- The words you are going to hear are: *zee, thee, vee* and *Dee*.
- In this answer sheet you have to check:

    (1) If the first word is different from the other two
    (2) If the second word is different from the other two
    (3) If the third word is different from the other two
    (0) If all 3 words are identical

Example: Listen to the following 4 sequences, they are already answered for you. Then you can see as the test is going to be.

1.	**1**	2	3	0
2.	1	2	**3**	0
3.	1	**2**	3	0
4.	1	2	3	**0**

Now you check the best answer for the following sequences. If you still have doubts after this training, ask please.

1.	1	2	3	0
2.	1	2	3	0
3.	1	2	3	0
4.	1	2	3	0
5.	1	2	3	0
6	1	2	3	0

- Sequences heard by the participants (the answers were given immediately after the training):

trial	answer
1. zee thee thee	1
2. Dee Dee Dee	0
3. thee thee thee	0
4. vee thee thee	1
5. zee zee thee	3
6. thee thee Dee	3

Appendix J

Perception Test 3: The Alternative Forced Choice Identification Test

J.1 Instructions and the test of the voiceless *th* identification test

TEST 6.1

- Now you are going to hear 20 sequences of isolated words.
- The words you are going to listen to are: *fie, thigh, sigh* and *tie.*
- The 20 words are split in 2 blocks of 10 words each.
- Pay attention to the initial sound of each word.
- After each word check which sound you heard, according to these four possibilities:
  - Sound of "f", as in *fie*
  - Sound of "th", as in *thigh*
  - Sound of "s", as in *sigh*
  - Sound of "t", as in *tie*

1. f th s t	1. f th s t
2. f th s t	2. f th s t
3. f th s t	3. f th s t
4. f th s t	4. f th s t
5. f th s t	5. f th s t
6. f th s t	6. f th s t
7. f th s t	7. f th s t
8. f th s t	8. f th s t
9. f th s t	9. f th s t
10. f th s t	10. f th s t

- Sequences heard by the participants, randomized:

trial	answer	trial	answer
1. thigh	th	11. thigh	th
2. fie	f	12. fie	f
3. tie	t	13. sigh	s
4. sigh	s	14. thigh	th
5. fie	f	15. tie	t
6. tie	t	16. fie	f
7. thigh	th	17. sigh	s
8. fie	f	18. thigh	th
9. tie	t	19. tie	t
10. sigh	s	20. sigh	s

Perception Test 3: the Alternative Forced Choice Identification Test

J.2 Instructions and the test of the voiced *th* identification test

TEST 6.2

- Now you are going to hear 20 sequences of isolated words.
- The words you are going to listen to are: *vee, thee, zee* and *dee*.
- The 20 words are split in 2 blocks of 10 words each.
- Pay attention to the initial sound of each word.
- DO NOT leave any sequence without answer.
- After each word check which sound you heard, according to these four possibilities:
  Sound of "v", as in *vee*
  Sound of "th", as in *thee*
  Sound of "z", as in *zee*
  Sound of "d", as in *Dee*

1. v th z d	1. v th z d
2. v th z d	2. v th z d
3. v th z d	3. v th z d
4. v th z d	4. v th z d
5. v th z d	5. v th z d
6. v th z d	6. v th z d
7. v th z d	7. v th z d
8. v th z d	8. v th z d
9. v th z d	9. v th z d
10. v th z d	10. v th z d

- Sequences heard by the participants:

trial	answer	trial	answer
1. zee	z	11. zee	z
2. dee	d	12. dee	d
3. zee	z	13. thee	th
4. vee	v	14. dee	d
5. thee	th	15. zee	z
6. dee	d	16. vee	v
7. vee	v	17. thee	th
8. zee	z	18. dee	d
9. thee	th	19. vee	v
10. vee	v	20. thee	th

Appendix K

Perception Test 3: The Alternative Forced Choice Identification Test

K.1 Training for the voiceless *th* identification test

Training 6.1

- Now you are going to take a sound identification test.
- You are going to hear to isolated words.
- The words are: *fie, thigh, sigh* and *tie*.
- Pay attention to the initial sound of each Word.
- After each word, check the check which sound you heard, according to these four possibilities

Sound of "f", as in *fie*
Sound of "th", as in *thigh*
Sound of "s", as in *sigh*
Sound of "t", as in *tie*

- You are going to hear 6 sequences already done for you, then you can realize the way the test is going to be conducted.

1. **f** th s t	4. f th **s** t
2. f th **s** t	5. f **th** s t
3. f **th** s t	6. f th s **t**

- Now you are going to hear 6 more sequences, now you check the best option, according to those 4 possibilities. If you still were in doubt at the end of this training, please ask.

1. f th s t	4. f th s t
2. f th s t	5. f th s t
3. f th s t	6. f th s t

- Sequences heard by the participants (the answers were given immediately after the training):

trial	answer
1. thigh	th
2. fie	f
3. tie	t
4. sigh	s
5. fie	f
6. tie	t

Perception Test 3: The Alternative Forced Choice Identification Test

K.2 Training for the voiced *th* identification test

Training 6.2

- Now you are going to take a sound identification test.
- You are going to hear to isolated words.
- The words are: *vee, thee, zee* e *dee*.
- Pay attention to the initial sound of each word.
- After each word, check the check which sound you heard, according to these four possibilities

Sound of "v", as in *vee*
Sound of "th", as in *thee*
Sound of "z", as in *zee*
Sound of "d", as in *dee*

- You are going to hear 6 sequences already done for you, then you can realize the way the test is going to be conducted.

1. **v** th z d	4. v th **z** d
2. v **th** z d	5. v **th** z d
3. v th z **d**	6. **v** th z d

- Now you are going to hear 6 more sequences, now you check the best option, according to those 4 possibilities.
- If you still were in doubt at the end of this training, please ask.

1. v th z d	4. v th z d
2. v th z d	5. v th z d
3. v th z d	6. v th z d

- Sequences heard by the participants (the answers were given immediately after the training):

	trial	answer
1.	zee	z
2.	dee	d
3.	zee	z
4.	vee	v
5.	thee	th
6.	dee	d

Appendix L

Results of the questionnaires

L.1 Results of the questionnaire used with the EFL groups

Questions from 1 to 3.4
1. Age
2. Gender: F (female); M (male)
3. Have you ever lived in an English speaking country? When?
3.1. How long have you lived there (months)?
3.2. How old were you?
3.3. What was the purpose of your trip?
3.4. In this country you used to spend more time with... (Language setting)

Table L1. Pre-Intermediate EFL group: personal information and experience abroad

Participant	Q. 1	Q. 2	Q. 3	Q. 3.1	Q. 3.2	Q. 3.3	Q. 3.4
I1	20	F	X	X	X	X	X
I2	23	F	X	X	X	X	X
I3	23	F	X	X	X	X	X
I4	15	F	X	X	X	X	X
I5	23	F	X	X	X	X	X
I6	19	M	X	X	X	X	X
I7	20	M	X	X	X	X	X
I8	21	M	X	X	X	X	X
I9	20	M	X	X	X	X	X
I10	21	M	X	X	X	X	X
I11	23	M	X	X	X	X	X
I12	22	M	X	X	X	X	X

Note: Q= question

Table L2. Advanced EFL group: personal information and experience abroad

Participant	Q. 1	Q. 2	Q. 3	Q. 3.1	Q. 3.2	Q. 3.3	Q. 3.4
A1	19	F	USA 2001	3	15	tourism	Brazilian family
A2	23	F	X	X	X	X	X
A3	19	M	X	X	X	X	X
A4	21	M	X	X	X	X	X
A5	21	M	X	X	X	X	X
A6	19	M	New Zealand 2002	4	17	tourism/ study	Brazilian and foreign community
A7	19	M	USA 2000	5	18	tourism/ study	foreign community
A8	19	M	X	X	X	X	X
A9	23	M	X	X	X	X	X
A10	19	M	X	X	X	X	X
A11	22	M	X	X	X	X	X
A12	19	M	X	X	X	X	X

Note: Q= question

Questions from 4 to 8

4. How old were you when you had your first contact with English language?

4.1. Did you continue your English studies since that period?

4.2. How long have you been studying English regularly, approximately, that is, without interruption?

4.3. Apart from the classes at UFSC, how much time do you, approximately, spend studying by yourself at home weekly?

5. Have you done any English proficiency test?

6. Do you have the habit of listening to English songs?

6.1. Do you try to sing with the singer?

6.2. How much time do you spend in this kind of activity, daily? (hours/day)

7. Are you fluent in another language rather than Portuguese and English?

8. Do you speak another foreign language at home with your family?

Table L3. Pre-Intermediate EFL group: English learning experience

Participant	Q.4	Q.4.1	Q.4.2	Q.4.3	Q.5	Q.6	Q.6.1	Q.6.2	Q.7	Q.8
I1	10-15	no	1 -1 ½ years	- 1 hour	X	yes	yes	- 1 hour	no	no
I2	10-15	no	1 -1 ½ years	- 1 hour	X	yes	yes	- 1 hour	no	no
I3	10-15	no	6 months-1 year	- 1 hour	X	yes	no	-1 hour	no	no
I4	7-10	no	6 months-1 year	-1 hour	X	yes	yes	+ 2 hours	French	no
I5	10-15	no	1 -1 ½ years	1-2 hours	X	yes	yes	- 1 hour	no	no
I6	10-15		less 6 months	2-3 hours	X	yes	no	- 1 hour	no	no
I7	7-10	no	6 months-1 year	1-2 hours	X	yes	yes	- 1 hour	no	Spanish
I8	10-15	no	- 6 months	1-2 hours	X	yes	no	no	Italian	no
I9	10-15	no	- 6 months	- 1 hours	X	yes	yes	- 1 hour	no	no
I10	7-10	no	-6 months	-1 hour	X	no	no	no	no	no
I11	7-10	no	1-1/2 year	no	X	no	no	no	no	no
I12	7-10	no	6 months-1 year	1-2 hours	X	yes	yes	- 1 hour	no	no

Note: Q= question

Table L4. Advanced EFL group: English learning experience

Participant	Q.4	Q.4.1	Q.4.2	Q.4.3	Q.5	Q.6	Q.6.1	Q.6.2	Q.7	Q.8
A1	10-15	no	- 1	no	X	yes	yes	- 1	no	no
A2	10-15	no	3-4	no	X	yes	yes	-1	French	Italian
A3	7-10	no	4-5	- 1	X	yes	yes	- 1		
A4	7-10	no	1 ½ - 2	no	X	yes	yes	- 1	no	no
A5	7-10	no	- 1	1-2	X	yes	yes	- 1	no	no
A6	10-15		2-3	no	X	yes	no	-1	Spanish	no
A7	10-15	no	4-5	no	X	yes	yes	-1	no	no
A8	10-15	no	5-6	1-2	X	yes	yes	+1	no	no
A9	7-10	no	- 1	- 1	X	yes	yes	+ 1	German	no
A10	7-10	no	10	no	X	yes	yes	-1	no	no
A11	10-15	no	1 ½	-1	X	yes	yes	+2	no	no
A12	7-10	no	1 ½	no	X	yes	yes	+1	no	no

Note: Q= question

Questions from 9 to 15
9. Where are you from?
10. How long have you been living in this city? (years)
11. In your opinion, what is the level of importance you give for the following aspects of communication in a foreign language (you can repeat your evaluation if necessary):

1- Fundamental   2- important   3- indifferent   4- irrelevant

grammar	pronunciation	vocabulary

12. That you know, do you have any auditory problem or difficulty?
13. That you know, do you have any speaking problem or difficulty?
14. Please be extremely honest in this answer. I'm trying to find out whether there is a correlation between perception and production of the 'th' sound, as in the words *"think"* and *"though".* When did you notice the purpose of the experiment? (Look at the tests to check your answer)
15. If you are not able to produce the "th" sound, what would be the reason? (your answers can overlap)
16. Did you receive formal instruction about the English *th*-words?

Table L5. Pre-Intermediate EFL group: origin, importance given to pronunciation and realization of the purpose of the research.

Participant	Q. 9	Q.10	Q.11	Q.12	Q.13	Q.14	Q.15	Q.16
I1	Fpolis- SC	X	essential	X	X	test 5	Difficult articulation. Similar to other ones	X
I2	Imaruí – SC	2	essential	X	X	test 4	I always try, this sound is fundamental	X
I3	Arroio Trinta SC	5	essential	X	X	test 5	Difficult articulation	X
I4	Rio – RJ	12	essential	X	X	test 1	I don't mind producing, it's confusing	X
I5	Tubarão – SC	2	essential	X	X	test 6	difficult articulation, I don1t see any difference between T and TH	X
I6	Penápolis SP	18	essential	X	X	test 1	difficult articulation	X
I7	Ijuí RS	1	important	X	X	no	difficult articulation	X
I8	Capivari SP	14	essential	X	X	test 3	difficult articulation	X
I9	Fpolis- SC	X	indifferent	X	X	test 1	Difficult articulation. The sound doesn't matter, it's irrelevant	X
I10	Piracicaba SP	1,3	essential	X	X	test 5	Difficult articulation.	X
I11	Fraiburgo SC	5	important	X	X	no	Difficult articulation.	X
I12	Fpolis- SC	X	important	X	X	test 4	difficult articulation	X

Note: Q= question

Table L6. Advanced EFL group: origin, importance given to pronunciation and realization of the purpose of the research

Participant	Q. 9	Q.10	Q.11	Q.12	Q.13	Q.14	Q.15	Q.16
A1	Fpolis	X	important	X	X	no	the sound doesn't matter, it's irrelevant	X
A2	Turvo SC	5	important	X	X	test 5	difficult articulation	X
A3	Fpolis-SC	X	essential	X	X	test 1	the sound doesn't matter	X
A4	Goiânia-GO	3,5	important	X	X	test 1	difficult articulation	X
A5	Fpolis-SC	X	essential	X	X	test 6	Difficult articulation. Similar to other ones	X
A6	Goiânia-GO	1	important	X	X	test 5	difficult articulation	X
A7	Ampére PR	18	important	X	X	test 1	difficult articulation	X
A8	Gaspar SC	11	important	X	X	test 1	difficult articulation	X
A9	Curitiba PR	13	essential	X	X	test 5	lack of attention	X
A10	Criciúma SC	8	important	X	X	test 1	I don't mind producing it, irrelevant	X
A11	Goiânia GO	1	important	X	X	test 6	difficult articulation	X
A12	Rio- RJ	3	essential	X	X	test 5	difficult articulation	X

Note: Q= question

L.2 Results of the questionnaire used with the native speakers

Questions from 1 to 7

1. Age
2. Gender: (M) male   (F) female
3. Where are you from?
3.1. How long have you been living in Brazil? (in months)
3.2. And in this city? (in months)
4. What are you doing here?
5. In your opinion, what is the level of importance you give for the following aspects of communication in a foreign language (you can repeat your evaluation if necessary):

1- Fundamental   2- important   3- indifferent   4- irrelevant

grammar	pronunciation	vocabulary

6. As far as you know, do you have any auditory problem or difficulty?
7. In your English dialect is the *th* sound significant, as in the words *"think"* and *"though"*? In other words, can you say *den* for *then*, or *tin* and *fin* for *thin* without changing the meanings of the words?
8. When communicating with foreigners speaking English, how important do you think the accurate pronunciation of *th*-words is?

( ) Fundamental   ( ) important   ( ) indifferent   ( ) irrelevant

Table L7. Native speakers of English: participants' information.

Participant	Q. 1	Q. 2	Q. 3	Q. 3.1	Q. 3.2	Q. 4	Q. 5	Q. 6	Q. 7	Q. 8
NS1	40	M	USA	15	14	English teacher	irrelevant	X	relevant	irrelevant
NS2	35	M	USA	25	25	English teacher	indifferent	X	relevant	indifferent
NS3	18	M	USA	6	6	tourism study	indifferent	X	relevant	irrelevant
NS4	36	M	USA	18	16	English teacher/ study	important	X	relevant	irrelevant
NS5	18	M	Australia	6	6	tourism study	important	X	relevant	irrelevant

Note: Q= question

Appendix M

Authorization for the research

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Departamento de Língua e Literatura Estrangeiras
Programa de Pós-Graduação em Letras/Inglês e Literatura Correspondente

PERMISSION FORM

Dear participant,

My name is Mara Reis and I am a master's degree student at Pós-Graduação de Letras – Língua Inglesa e Literatura Correspondente – UFSC. I would like to invite you to participate in my research data gathering. Unfortunately, I cannot reveal the research objectives since it could interfere in your performance and, thus, in the results of the study. The conclusion of this study will be the basis of my thesis, to be defended in March, 2006.

Procedures:

If you take part in this study, you will be asked to answer a questionnaire and to perform some production and perception tests at the language laboratory (room 245). *You do not need to identify yourself if you do not want to.*

Risks and benefits of the study:

There is no risk in participating in this research. Before answering the questionnaire, you will have time to read it and clarify any doubt. In the end of the research, the results will become public. *Your identity, however, will be preserved as well as any clue that can identify you.* Only my adviser and I will have access to your information.

Volunteer nature of the study:

You decision in taking part or not in the study will not affect you or you relation with the university. If you do not accept it, you don not have to justify your decision.

Name:_____

Signature: _____

Florianópolis, 2005, April, _____

Appendix N

Transcriptions for the Production Tests results

N.1 Production Test 1: Reading a text

Results of the voiceless *th* production – Pro1

I **think** I'm still recovering from a **theft** I experienced last year. Though I knew Aspen **Theater** is in a dangerous area, I really wanted to see that play and, of course, knowing something in **theory** is very different from knowing it in practice. So I decided to risk going to the **theater**. When I got there I saw them. First I **thought** they were waiting for some other people, but when they started to walk toward me I realized they were **thieves**. I had no time to do anything, they were bigger than me, the parking lot was empty and I was alone. The **thing** is that I didn't have much to be robbed, only **thirteen** dollars in my wallet. And I **think** this was what annoyed them. I was beaten hard and my car was stolen. I was taken to the hospital in shock and for almost a month I wasn't able to speak. I was **thin**, weak and had a constant fever. My doctor couldn't explain why the **thermometer** was always showing **thirty**-eight or **thirty**-nine degrees. After one month of intensive **therapy** I **thought** I could go back home. This was the best **thing** that happened to me after the **theft**. I'm still doing **therapy** but now I **think** I can walk around without panicking anymore, **thanks** to my family and doctors.

Table N1.Realization of the voiceless *th*: Pre-intermediate EFL learners (I)

	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12
think	t^h	f	f	f	S	t	f	θ	f	f	f	t
theft	t	t^h	t	d	T	t^h	d	d	f	t	d	d
theater	t^h	t	t	t	T	t	t	t	t^h	t	t	t
theory	t	t	t	t	T	t	t	t	f	t	t	t
theater	t	t	t	d	T	t	t	t	θ	t	t	t
thought	t^h	θ	t	t	T	t	t	f	θ	f	s	t
thieves	t^h	t^h	θ	d	t^h	t	t	t	tθ	t	t	t^h
thing	t	f	θ	θ	θ	t^h	f	θ	θ	t	t	t
thirteen	t^h	f	t	f	t^h	t^h	t	θ	t^h	t	t	t
think	t	f	f	f	θ	t^h	f	θ	θ	s	f	t
thin	t^h	f	f	θ	T	t^h	f	θ	f	s	d	t
thermometer	t	t	t	t	T	t	t	t	t^h	t	t	t
thirty	t	t	θ	f	T	t^h	t	t	tʃ	t	d	t
thirty	t	t	θ	f	T	t^h	t	t	tʃ	t	d	t
therapy	t	t	t	t	T	t	t	t	t	t	t	t
thought	t	t	θ	f	T	t	t	θ	θ	s	t	t
thing	t	f	θ	θ	t^h	t^h	t	θ	θ	θ	f	t
theft	t	t^h	θ	d	T	t^h	d	d	d	t	d	d
therapy	t	t	t	θ	T	t	t^h	t	t	t	t	t
think	t	f	θ	f	t^h	t	f	θ	f	s	f	t^h
thanks	t	θ	θ	t	T	t^h	t	t	θ	t	t	t

Table N2. Realization of the voiceless *th*: Advanced EFL learners (A)

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
think	θ	θ	θ	f	tʰ	t	f	θ	s	f	f	θ
theft	t	t	tʰ	t	tʰ	t	t	θ	t	t	t	θ
theater	θ	θ	tʰ	t	θ	t	t	θ	tθ	t	θ	θ
theory	θ	θ	tʰ	f	t	t	t	t	t	t	t	t
theater	θ	θ	θ	f	θ	t	t	t	t	t	θ	θ
thought	θ	t	tʰ	t	θ	t	f	θ	θ	t	θ	t
thieves	θ	θ	θ	tʰ	θ	tʰ	tʰ	θ	tʃ	t	t	θ
thing	θ	θ	tʰ	f	θ	t	f	θ	θ	f	θ	θ
thirteen	tʰ	θ	θ	t	tʰ	t	tʰ	θ	θ	t	θ	t
think	θ	θ	θ	f	θ	t	f	θ	θ	f	f	θ
thin	θ	s	t	f	θ	t	tʰ	θ	θ	f	t	θ
thermometer	θ	t	θ	t	tθ	t	tʰ	t	t	t	t	t
thirty	θ	t	θ	t	θ	t	t	θ	t	t	θ	t
thirty	θ	t	θ	t	t	t	t	θ	t	t	θ	t
therapy	θ	θ	t	tʰ	tʰ	t	t	θ	t	t	t	t
thought	θ	θ	θ	t	f	t	f	θ	t	t	θ	θ
thing	θ	θ	θ	f	f	t	f	θ	θ	f	θ	θ
theft	θ	t	t	t	tʰ	t	tʰ	t	t	t	θ	t
therapy	θ	t	θ	t	tʰ	t	t	t	t	t	t	t
think	θ	θ	tʰ	f	f	t	f	θ	θ	f	f	θ
thanks	θ	θ	t	t	t	t	tʰ	θ	θ	t	t	t

Results of the voiced *th* production – Pro1

I think I'm still recovering from a theft I experienced last year. **Though** I knew Aspen Theater is in a dangerous area, I really wanted to see **that** play and, of course, knowing something in theory is very different from knowing it in practice. So I decided to risk going to **the** theater. When I got **there** I saw **them**. First I thought **they** were waiting for some other people, but when **they** started to walk toward me I realized **they** were thieves. I had no time to do anything, **they** were bigger **than** me, **the** parking lot was empty and I was alone. **The** thing is **that** I didn't have much to be robbed, only thirteen dollars in my wallet. And I think **this** was what annoyed **them**. I was beaten hard and my car was stolen. I was taken to **the** hospital in shock and for almost a month I wasn't able to speak. I was thin, weak and had a constant fever. My doctor couldn't explain why **the** thermometer was always showing thirty-eight or thirty-nine degrees. After one month of intensive therapy I thought I could go back home. **This** was **the** best thing **that** happened to me after **the** theft. I'm still doing therapy but now I think I can walk around without panicking anymore, thanks to my family and doctors.

Table N3. Realization of the voiced *th:* Pre-intermediate EFL learners (I)

	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12
though	t^h	t	t	t	T	t	t	t	t^h	t	f	t
that	d	d	d	d	D	d	d	d	d	d	d	d
the	d	d	d	d	d	d	d	d	d	d	d	d
there	d	d	d	d	d	d	d	d	d	d	d	d
them	d	d	d	d	d	d	d	d	d	d	d	d
they	d	d	d	d	d	d	d	d	d	d	d	d
they	d	d	d	d	d	d	d	d	d	d	d	d
they	d	d	d	d	d	d	d	d	d	d	d	d
they	d	d	d	d	d	d	d	d	d	d	d	d
the	d	d	d	d	d	d	d	d	d	d	d	d
than	d	d	d	d	d	d	d	d	d	d	d	d
the	d	d	d	d	d	d	d	d	d	d	d	d
the	d	d	d	d	d	d	d	d	d	d	d	d
that	d	d	d	d	d	d	d	d	d	d	d	d
this	d	d	d	d	d	d	d	d	d	d	d	d
them	d	d	d	d	d	d	d	d	d	d	d	d
the	d	d	d	d	d	d	d	d	d	d	d	d
the	d	d	d	d	d	d	d	d	d	d	d	d
this	d	d	d	d	d	t^h	d	d	d	d	d	d
the	d	d	d	d	d	d	d	d	d	d	d	d
that	d	d	d	d	d	d	d	d	d	d	d	d

Table N4. Realization of the voiced *th:* Advanced EFL learners (A)

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
though	θ	d	d	t	t	t	d	θ	d	d	θ	θ
that	d	d	d	d	d	d	d	d	d	d	d	d
the	d	d	d	d	d	d	d	d	d	d	d	d
there	ð	d	ð	d	d	d	d	d	d	d	d	d
them	ð	d	ð	d	d	d	d	d	d	d	d	d
they	d	d	d	d	d	d	d	d	d	d	d	d
they	d	d	d	d	d	d	d	d	d	d	d	d
they	d	d	d	d	d	d	d	d	d	d	d	d
they	d	d	d	d	d	d	d	d	d	d	d	d
the	d	d	d	d	d	d	d	d	d	d	d	d
than	d	d	d	d	d	d	d	d	d	d	d	d
the	d	d	d	d	d	d	d	d	d	d	d	d
the	d	d	d	d	d	d	d	d	d	d	d	d
that	d	d	d	d	d	d	d	d	d	d	d	d
this	d	d	d	d	d	d	d	d	d	d	d	d
them	d	ð	d	d	d	d	d	ð	d	d	d	d
the	d	d	d	d	d	d	d	d	d	d	d	d
the	d	d	d	d	d	d	d	d	d	d	d	d
this	d	d	d	d	d	d	d	d	d	d	d	d
the	d	d	d	d	d	d	d	d	d	d	d	d
that	d	d	d	d	d	d	d	d	d	d	d	d

N.2 Production Test 2: Retelling the story of Pro1

Results of the voiceless *th* production – Pro2

Table N5. Realization of the voiceless *th*: Pre-intermediate EFL learners (I)

I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12
teacher [t]	theater [tʰ]	theater [θ]	theater [t]	think [s]	theater [t]	theater [t]	theater [t]	think [θ]	theater [t]	theater [f]	theater [t]
thirteen [t]	thirteen [t]	thieves [t]	thieves [d]	thin [d]	thieves [tʃ]	theater [t]	theater [d]	theater [θ]	therapy [t]	thirteen [t]	thirteen [t]
therapy [t]	therapy [t]	thirty [θ]	thing [θ]	think [s]	thirteen [t]	theater [t]	theater [t]	theater [θ]	thanks [t]	thirty [t]	thirty [t]
	thanks [f]	thirty [θ]	thirty [f]	therapy [t]	thin [tʰ]	theater [t]	thieves [t]			thirty [t]	thirty [t]
		therapy [t]	therapy [t]		therapy [t]		thirty [t]				
			thought [t]				therapy [t]				
			thing [f]				therapy [t]				
			theft [d]				theft [d]				
			therapy [t]								
			think [f]								

Table N6. Realization of the voiceless *th*: Advanced EFL learners (A)

A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
theater [θ]	theater [θ]	theater [θ]	theater [f]	theater [θ]	thieves [tʰ]	theater [tʰ]	theater [θ]	theater [t]	theater [t]	theater [t]	theater [θ]
theater [θ]	thieves [θ]	theater [θ]	thieves [tʰ]	theater [tʰ]	thieves [t]	therapy [t]	thieves [θ]	thought [tʰ]	thought [t]	theater [t]	thieves [θ]
thought [θ]	therapy [θ]	thieves [θ]	therapy [t]	thought [t]	theft [t]		theory [t]	thieves [t]	thieves [t]	thinking [θ]	thought [θ]
thieves [θ]	thinks [θ]			thieves [tʰ]	therapy [t]		thieves [θ]	thirteen [t]	therapy [t]	theater [t]	thirty [t]
thin [ð]				thieves [tθ]	things [t]		thought [θ]	thirty [t]	things [f]	theater [t]	
therapy [θ]				thieves [tθ]	things [tʰ]		theft [θ]	thirty [t]		thing [θ]	
therapy [t]				thieves [θ]			thirteen [t]	therapies [t]		therapy [t]	
thanks [θ]				thieves [θ]			thieves [t]	thanks [t]			
							thin [t]				

Results of the voiced *th* production – Pro2

Table N7. Realization of the voiced *th*: Pre-intermediate EFL learners (I)

I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12
the [d]	the [d]	the [d]	the [d]	the [d]	that [d]	the [d]	the [d]	that [d]	the [d]	the [d]	the [d]
the [d]	they [d]	the [d]	the [d]	the [d]	the [d]	the [d]	the [d]	there [d]	the [d]	the [d]	
the [d]	the [d]	that [d]	that [d]	the [d]	they [d]	then [d]	the [d]	the [d]	the [d]	then [d]	
	there [d]	the [d]	this [d]	the [d]	than [d]		that [d]	that [d]		the [d]	
	that [d]		the [d]	they [d]	they [d]		the [d]			the [d]	
			that [d]	they [d]	that [d]		that [d]				
			the [d]	that [d]	the [d]		the [d]				
					the [d]		that [d]				
							the [d]				
							the [d]				
							the [d]				
							that [d]				

Table N8. Realization of the voiced *th*: Advanced EFL learners (A)

A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
there [d]	the [d]	the [d]	the [d]	this [d]	the [d]	there [d]	there [d]	that [d]	that [d]	the [d]	the [d]
this [d]	the [d]	that [d]	that [d]	that [d]	the [d]	that [d]	that [d]	that [d]	there [d]	that [d]	that [d]
the [d]	the [d]	the [d]	that [d]	the [d]	that [d]	there [d]	the [d]	that [d]	that [d]	that [d]	there [d]
that [d]		that [d]	the [d]	that [d]	the [d]	the [d]	that [d]	this [d]	the [d]	that [d]	that [d]
the [d]		the [d]	the [d]	the [d]	they [d]	there [d]	there [d]	this [d]	the [d]	the [d]	then [d]
there [d]		that [d]	that [d]	the [d]	that [d]	there [d]	the [d]	there [d]	they [d]	that [d]	they [d]
the [d]		that [d]	the [d]	that [d]	the [d]	those [d]	they [d]	the [d]	they [d]	the [d]	the [d]
the [d]		the [d]	the [d]	there [d]	there [d]	those [d]	than [d]	there [d]	the [d]	the [d]	they [d]
they [d]		that [d]	the [d]	the [d]	there [d]	they [d]	that [d]	there [d]	there [d]	this [d]	that [d]
they [d]		that [d]		the [d]	they [d]	the [d]	they [d]	they [d]	the [d]	the [d]	
they [d]		they [d]		that [d]	the [d]	this [d]	that [d]	they [d]		the [d]	
they [d]		they [d]		there [d]	this [d]		they [d]	that [d]		the [d]	
the [d]		this [ð]		that [d]			that [d]	they [d]		the [d]	
there [ð]		the [d]		the [d]			the [d]	this [d]		the [d]	
there [ð]				there [d]			the [d]	them [d]		the [d]	
				they [d]			the [d]	then [d]		they [d]	
				the [d]			they [d]	they [d]		they [d]	
				the [d]			the [d]	that [d]		the [d]	
				that [d]			the [d]	the [d]		the [d]	
				they [d]			the [d]	there [d]			
				them [d]			the [d]	this [d]			
				they [d]			the [d]	the [d]			
				the [d]				this [d]			
				the [d]				this [d]			
				the [d]				the [d]			
				there [d]							
				the [d]							
				the [d]							
				that [d]							

N3 Production Test 3: Reading a list of sentence

Results of the voiceless *th* production – Pro3

Table N9. Realization of the voiceless *th*: Pre-intermediate EFL learners (I)

	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12
thoughts	t	θ	θ	t	t	t	t	θ	f	f	t	d
thought	t	T	θ	t	t	t	t	t	t	f	t	t
thickens	tʰ	θ	θ	tʰ	tʰ	tʰ	tʰ	tʰ	θ	t	θ	tʃ
Thanksgiving	t	θ	θ	t	t	t	tʰ	t	θ	t	t	t
thick	t	F	θ	θ	t	tʰ	tʰ	θ	θ	tʃ	θ	t
theme	t	T	d	d	t	t	t	t	tʰ	t	t	t
thirteen	t	T	θ	θ	t	tʃ	tʰ	t	θ	t	d	t
thought	t	F	θ	t	t	t	t	θ	f	f	t	t
things	tʰ	F	θ	θ	θ	tʰ	t	θ	θ	s	θ	t
theater	t	T	θ	d	t	t	t	t	θ	θ	f	t
thinks	tʰ	F	θ	f	θ	tʰ	tʰ	θ	θ	θ	θ	t
thought	tʰ	F	θ	t	t	t	tʃ	θ	θ	t	t	t
theatrical	t	T	θ	t	t	t	t	t	t	t	θ	d
theology	t	T	t	t	t	t	t	t	t	t	t	t
thesis	t	tʰ	d	d	t	t	d	d	tʰ	t	t	d

Table N10. Realization of the voiceless *th*: Advanced EFL learners (A)

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
thoughts	θ	T	θ	t	t	t	f	θ	θ	t	θ	θ
thought	θ	T	θ	t	t	t	f	θ	t	t	θ	θ
thickens	θ	tʃ	θ	t	θ	tʰ	tʰ	θ	θ	tʰ	t	θ
Thanksgiving	θ	T	θ	tʰ	t	t	tʰ	θ	t	t	θ	t
thick	θ	T	θ	f	θ	t	f	θ	θ	t	θ	θ
theme	θ	T	θ	t	t	t	d	θ	t	t	t	t
thirteen	θ	θ	θ	tʰ	t	t	t	θ	t	t	θ	t
thought	θ	T	θ	t	t	t	d	θ	t	t	θ	θ
things	θ	θ	θ	f	f	t	f	θ	θ	t	θ	θ
theater	θ	θ	θ	f	θ	t	tʰ	θ	θ	t	θ	t
thinks	θ	θ	θ	f	f	t	f	θ	θ	f	θ	θ
thought	θ	T	θ	f	tʰ	t	d	θ	t	t	θ	θ
theatrical	θ	θ	θ	t	θ	t	t	θ	θ	t	θ	t
theology	θ	T	θ	t	t	t	t	t	t	t	t	t
thesis	θ	θ	θ	t	tʰ	t	t	θ	θ	t	t	θ

Results of the voiced *th* production – Pro3

Table N11. Realization of the voiced *th*: Pre-intermediate EFL learners (I)

	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12
that	d	d	d	d	d	d	d	d	d	d	d	d
they	d	d	d	d	d	d	d	d	d	d	d	d
their	d	d	d	t	d	d	d	d	d	d	d	d
they	d	d	d	d	d	d	d	d	d	d	d	d
that	d	d	d	d	d	d	d	d	d	d	d	d
those	d	dʰ	θ	d	tʃ	tʰ	d	d	tʰ	tʃ	d	d
them	d	dʰ	d	d	d	d	d	ð	d	d	d	d
these	d	d	d	d	d	d	d	d	d	d	d	d
they	d	d	d	d	d	d	d	d	d	d	d	d
these	d	d	d	d	d	tʰ	d	d	ð	dʒ	d	d
there	d	d	d	d	d	d	d	d	d	d	d	d
that	d	d	d	d	d	d	d	d	d	d	d	d
those	d	d	d	d	tʃ	tʰ	d	d	tʰ	d	d	d
this	d	dʰ	d	d	d	d	d	ð	d	d	d	d
that	d	d	d	d	d	d	d	d	d	d	d	d

Table N12.Realization of the voiced *th*: Advanced EFL learners (A)

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
that	ð	d	ð	d	d	d	d	d	d	d	d	d
they	ð	d	ð	d	d	d	d	d	d	d	d	d
their	ð	d	ð	d	d	d	d	ð	d	d	d	d
they	ð	ð	ð	d	d	d	d	d	d	d	d	d
that	ð	d	ð	d	d	d	d	d	d	d	d	d
those	ð	d	ð	d	d	d	d	d	d	d	d	d
them	ð	d	ð	d	d	d	d	ð	d	d	d	d
these	ð	d	ð	d	d	d	d	d	d	d	d	d
they	ð	ð	ð	d	d	d	d	d	d	d	d	d
these	ð	d	ð	d	d	d	d	d	d	d	d	d
there	ð	d	ð	d	d	d	d	d	ð	d	d	d
that	ð	d	ð	d	d	d	d	d	d	d	d	d
those	ð	d	ð	d	d	d	d	d	d	d	d	d
this	ð	ð	ð	d	d	d	d	d	d	d	ð	d
that	ð	d	d	d	d	d	d	d	d	d	d	d

Appendix O

Transcriptions for the Perception Tests results

O.1 Perception Test 1: the general pronunciation error perception test

I **think** [fink] I'm still recovering from a **theft** [tɛft] I experienced last year. Though [dou] I knew Aspen **Theater** [tiater] is in a dangerous area, I really wanted to see that [dɛt] play and, of course, knowing something in **theory** [teori] is very different from knowing it in practice. So I decided to risk going to the [de] **theater** [fiater]. When I got there [dɛr] I saw them [den]. First I **thought** [tɔt] they [dei] were waiting for some other people, but when they [dei] started to walk toward me I realized they [dei] were **thieves** [ti:vs]. I had no time to do anything, they [dei] were bigger than [dɛn] me, the [de] parking lot was empty and I was alone. The [de] **thing** [fiŋ] is that [dɛt] I didn't have much to be robbed, only **thirteen** [tʌrtin] dollars in my wallet. And I **think** [sink] this [dis] was what annoyed them [dem]. I was beaten hard and my car was stolen. I was taken to the [de] hospital in shock and for almost a month I wasn't able to speak. I was **thin** [fin], weak and had a constant fever. My doctor couldn't explain why the [de] **thermometer** [n hermometer] was always showing **thirty**-eight [tʌrti] or **thirty**-nine [fʌrti] degrees. After one month of intensive **therapy** [tɛrapi] I **thought** [fɔt] I could go back home. This [dis] was the [de] best **thing** [siŋ] that [dɛt] happened to me after the [de] **theft** [fɛft]. I'm still doing **therapy** [fɛrapi] but now I **think** [tink] I can walk around without panicking anymore, **thanks** [tɛnks̩] to my family and doctors.

Results of the voiceless *th* – GPE

Table O1. Voiceless *th* recognition: Pre-intermediate EFL learners (I).

	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12
[fink]		√										
[tɛft]					√							
[tiater]					√							
[teori]												
[fiater]					√							
[tɔt]	√	√			√							
[ti¹vs]					√					√	√	
[fiŋ]												
[tʌrtin]												
[sink]		√		√			√		√			
[fin]											√	
[termometer]												
[tʌrti]												
[fʌrti]												
[tɛrapi]												
[fɔt]	√				√							
[siŋ]												
[fɛft]	√				√							√
[fɛrapi]												
[tink]		√					√					
[tɛnks]												

Note: Accurate perception – (√)

Table O2. Voiceless *th* recognition: Advanced EFL learners (A).

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
[fink]												
[tɛft]			√		√						√	
[tiater]												
[teori]			√	√					√	√	√	
[fiater]												
[tɔt]	√											
[ti¹vs]	√		√	√	√	√						
[fiŋ]												
[tʌrtin]												
[sink]			√	√		√			√			
[fin]	√		√					√				
[termometer]	√		√			√		√				
[tʌrti]												
[fʌrti]												
[tɛrapi]			√									
[fɔt]	√				√	√		√				√
[siŋ]	√											
[fɛft]		√	√	√	√	√	√					
[fɛrapi]												
[tink]			√	√			√	√				
[tɛnks]												

Table O3. Voiceless *th* recognition: Native English speakers (NS).

	NS1	NS2	NS3	NS4	NS5
[fɪnk]					
[tɛft]	√	√	√	√	
[tiater]		√			
[teori]					√
[fiater]					
[tɔt]		√		√	
[tiᶦvs]		√		√	√
[fɪŋ]					√
[tʌrtin]					
[sɪnk]				√	
[fɪn]		√		√	
[termometer]					
[tʌrti]					
[fʌrti]					
[tɛrapi]					
[fɔt]		√		√	
[sɪŋ]		√	√	√	
[fɛft]		√			
[fɛrapi]		√		√	
[tɪnk]			√	√	
[tɛnks]					

Note: Accurate perception – (√)

Results of the voiced *th* – GPE

I think [fink] I'm still recovering from a theft [tɛft] I experienced last year. **Though** [dou] I knew Aspen Theater [tiater] is in a dangerous area, I really wanted to see **that** [dɛt] play and, of course, knowing something in theory [teori] is very different from knowing it in practice. So I decided to risk going to **the** [de] theater [fiater]. When I got **there** [dɛr] I saw **them** [den]. First I thought [tɔt] **they** [dei] were waiting for some other people, but when **they** [dei] started to walk toward me I realized **they** [dei] were thieves [tiːvs]. I had no time to do anything, **they** [dei] were bigger **than** [dɛn] me, **the** [de] parking lot was empty and I was alone. **The** [de] thing [fin] is **that** [dɛt] I didn't have much to be robbed, only thirteen [tʌrtin] dollars in my wallet. And I think [sink] **this** [dis] was what annoyed **them** [dem]. I was beaten hard and my car was stolen. I was taken to **the** [de] hospital in shock and for almost a month I wasn't able to speak. I was thin [fin], weak and had a constant fever. My doctor couldn't explain why **the** [de] thermometer [termometer] was always showing thirty-eight [tʌrti] or thirty-nine [fʌrti] degrees. After one month of intensive therapy [tɛrapi] I thought [fɔt] I could go back home. **This** [dis] was **the** [de] best thing [siŋ] **that** [dɛt] happened to me after **the** [de] theft [fɛft]. I'm still doing therapy [fɛrapi] but now I think [tink] I can walk around without panicking anymore**, thanks** [tɛnks] to my family and doctors.

Table O4. Voiced *th* recognition: Pre-intermediate EFL learners (I).

	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12
[dou]											√	
[dɛt]												
[de]												
[dɛr]												
[den]												
[dei]												
[dei]												
[dei]												
[dei]												
[dɛn]												
[de]												
[de]												
[dɛt]												
[dis]												
[dem]												
[de]									√		√	
[de]												
[dis]												
[de]												
[dɛt]												
[de]												

Note: Accurate perception – (√)

Table O5. Voiced *th* recognition: Advanced EFL learners (A). Accurate perception – (√)

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
[dou]					√							
[dɛt]												
[de]												
[dɛr]												
[den]												
[dei]												
[dei]												
[dei]												
[dei]												
[dɛn]												
[de]												
[de]												
[dɛt]												
[dis]												
[dem]												
[de]	√											
[de]												
[dis]												
[de]												
[dɛt]												
[de]												

Note: Accurate perception – (√)

Table O6. Voiced *th* recognition: Native English speakers (NS).

	NS1	NS2	NS3	NS4	NS5
[dou]					
[dɛt]			√		
[de]					
[dɛr]					
[den]				√	
[dei]					
[dei]					
[dei]					
[dei]					
[dɛn]					
[de]					
[de]					
[dɛt]					
[dis]					
[dem]					
[de]					
[de]					
[dis]					
[de]					
[dɛt]					
[de]					

Note: Accurate perception – (√)

O.2 Perception Test 2: The Categorial Discrimination Test

Results of the voiceless *th* – CDT

Table O7. Voiceless *th* discrimination: Pre-intermediate EFL learners (I).

trial	correct answer	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12
1.	1	2	√	√	2	0	√	3	√	√	2	√	2
2.	3	√	√	√	√	√	√	2	√	√	√	√	2
3.	2	√	√	0	0	0	0	√	0	√	0	1	√
4.	0	√	3	√	√	√	1	1	√	1	1	√	3
5.	2	√	√	√	√	0	√	√	√	√	1	1	√
6.	1	0	√	√	√	2	0	3	√	√	3	√	3
7.	3	√	2	√	√	2	√	√	√	√	2	√	2
8.	1	√	0	0	0	0	0	√	0	0	0	0	3
9.	2	√	√	√	√	√	0	0	√	√	1	√	1
10.	2	√	√	√	√	1	3	√	3	√	0	√	1
1.	1	√	√	√	√	√	0	0	√	√	0	0	0
2.	1	3	3	0	0	√	√	√	0	2	0	√	3
3.	3	√	√	√	√	√	√	√	√	√	√	√	√
4.	0	√	√	√	√	√	√	√	√	√	√	√	√
5.	0	√	√	√	√	√	√	√	√	√	√	1	1
6.	2	√	√	√	√	√	0	√	√	√	√	√	√
7.	3	√	√	0	0	√	√	√	0	√	0	1	√
8.	1	√	2	√	√	0	√	√	√	√	√	2	2
9.	3	2	√	√	2	√	√	√	√	√	1	√	2
10.	2	1	0	0	√	3	√	√		0		√	1
1.	3	2	2	0	√	√	√	√	0	2	2	2	√
2.	0	√	3	√	2	√	√	√	√	√	3	2	√

Note: Accurate perception – (√)

Table O8. Voiceless *th* discrimination: Advanced EFL learners (A).

trial	correct answer	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
1.	1	√	2	√	√	√	√	√	√	2	√	2	√
2.	3	√	0	√	√	1	√	√	√	√	0	0	√
3.	2	√	√	0	0	√	√	0	√	0	1	√	√
4.	0	√	2	1	√	√	1	3	√	√	1	1	√
5.	2	√	√	1	√	√	√	√	√	3	3	√	√
6.	1	√	0	√	√	0	3	0	√	√	√	3	√
7.	3	√	√	√	√	√	√	√	√	√	√	2	√
8.	1	0	0	0	√	√	√	2	√	0	√	√	√
9.	2	√	√	√	0	√	√	0	√	√	0	√	√
10.	2	√	√	√	√	√	√	1	√	√	√	√	√
1.	1	√	0	√	3	0	0	0	√	√	√	√	√
2.	1	√	0	√	√	0	√	√	√	√	√	√	0
3.	3	√	√	√	√	√	√	√	√	√	√	√	√
4.	0	√	√	√	2	√	√	√	√	√	√	√	√
5.	0	√	√	√	1	√	1	√	√	√	√	√	√
6.	2	√	1	√	√	1	√	0	√	√	1	0	√
7.	3	2	√	0	0	0	√	√	√	√	√	√	√
8.	1	√	√	√	√	√	√	√	√	√	√	√	√
9.	3	√	√	√	√	√	√	√	√	√	√	√	√
10.	2	√	1	√	3	0	0	0	√	3	√	0	√
1.	3	√	√	0	√	2	2	2	√	2	√	√	√
2.	0	√	√	1	√	√	√	√	√	√	√	√	√

Note: Accurate perception – (√)

Table O9. Voiceless *th* discrimination**:** Native English speakers (NS).

trial	correct answer	NS1	NS2	NS3	NS4	NS5
1.	1	√	√	√	√	√
2.	3	√	√	√	√	√
3.	2	3	0	√	3	√
4.	0	√	3	3	√	√
5.	2	3	√	√	√	√
6.	1	√	√	3	√	√
7.	3	√	√	√	√	√
8.	1	√	0	3	√	√
9.	2	√	√	0	√	√
10.	2	√	√	√	√	1
1.	1	√	√	√	√	√
2.	1	0	3	3	√	√
3.	3	√	√	√	√	√
4.	0	√	√	√	√	√
5.	0	√	√	√	√	√
6.	2	√	√	√	√	√
7.	3	√	2	2	√	√
8.	1	√	√	√	√	√
9.	3	√	√	√	√	√
10.	2	√	0	√	√	√
1.	3	√	2	2	√	√
2.	0	√	√	√	√	√

Note: Accurate perception – (√)

Results of the voiced *th* – CDT

Table O10. Voiced *th* discrimination**:** Pre-intermediate EFL learners (I).

trial	correct answer	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12
1.	1	√	2	√	√	√	2	√	2	2	√	2	3
2.	0	√	√	√	2	√	√	√	√	√	√	√	√
3.	0	2	√	2	√	√	3	3	√	2	3	3	√
4.	1	√	0	0	0	0	√	0	0	0	2	0	3
5.	3	√	√	√	√	√	√	√	√	√	√	√	√
6.	3	1	√	√	√	√	1	√	√	√	√	1	0
7.	3	2	√	√	√	√	√	2	√	√	√	√	√
8.	2	√	0	0	0	0	√	0	0	√	1	0	√
9.	2	√	√	√	√	√	√	√	√	√	√	√	√
10.	1	√	2	√	√	√	√	√	√	√	√	√	0
		√	√										
1.	3	√	√	0	√	√	0	0	√	√	√	0	0
2.	3	√	0	0	√	0	2	0	0	0	0	√	0
3.	2	√	√	0	√	3	0	√	√	√	√	0	√
4.	0	√	√	√	√	√	2	√	√	√	√	2	√
5.	0	√	√	√	√	√	√	√	√	√	√	2	√
6.	2	√	√	√	√	√	√	3	√	√	√	√	0
7.	3	0	2	0	0	0	0	√	1	√	√	√	0
8.	2	√	0	√	0	0	√	√	0	√	0	1	√
9.	1	√	√	√	√	√	√	√	√	√	√	2	√
10.	2	√	√	√	√	3	√	√	√	√	√	3	√
1.	1	√	√	√	√	√	√	√	√	√	0	√	√
2.	1	0	0	0	0	0	3	0	0	0	√	3	0

Note: Accurate perception – (√)

Table O11. Voiced *th* discrimination**:** Advanced EFL learners (A).

trial	correct answer	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
1.	1	√	3	0	√	3	2	√	√	√	2	√	√
2.	0	√	3	√	√	√	√	√	√	√	√	1	√
3.	0	3	3	3	3	√	2	2	1	3	1	√	√
4.	1	2	0	√	0	0	√	0	0	0	2	2	√
5.	3	√	2	√	√	√	0	√	√	√	√	√	√
6.	3	√	1	√	√	√	√	1	√	1	1	√	√
7.	3	√	0	√	√	√	1	2	√	√	√	√	√
8.	2	√	0	√	1	0	3	1	0	√	0	0	0
9.	2	√	0	√	√	√	√	√	√	1	√	0	√
10.	1	√	0	√	√	√	√	√	√	√	√	√	√
1.	3	√	√	√	√	√	0	1	√	√	0	√	√
2.	3	0	√	0	0	0	√	√	0	0	√	2	0
3.	2	√	√	√	√	√	√	√	3	√	3	√	3
4.	0	√	√	2	√	√	2	2	2	√	√	2	√
5.	0	√	√	√	√	√	√	√	√	√	√	√	√
6.	2	√	√	√	√	√	√	√	√	√	√	√	√
7.	3	0	0	√	0	0	√	0	0	√	√	0	0
8.	2	√	√	1	√	0	1	√	1	√	√	√	√
9.	1	√	√	√	√	√	√	√	√	√	√	√	√
10.	2	√	√	√	3	√	√	√	3	3	3	√	√
1.	1	√	√	√	√	√	√	√	√	√	√	√	√
2.	1	√	0	3	√	0	√	2	0	√	√	0	0

Note: Accurate perception – (√)

Table O12. Voiced *th* discrimination**:** Native English speakers (NS).

trial	correct answer	NS1	NS2	NS3	NS4	NS5
1.	1	√	√	√	√	√
2.	0	√	√	√	√	√
3.	0	√	√	√	√	1
4.	1	√	0	0	√	2
5.	3	√	√	√	√	√
6.	3	√	√	√	√	√
7.	3	√	√	√	√	1
8.	2	√	0	0	√	√
9.	2	√	√	3	√	√
10.	1	√	√	√	√	√
1.	3	√	√	√	√	√
2.	3	√	0	√	0	√
3.	2	√	√	√	√	√
4.	0	3	√	√	√	3
5.	0	√	√	√	√	√
6.	2	√	√	√	√	√
7.	3	0	0	0	√	0
8.	2	√	0	√	√	√
9.	1	√	√	√	√	√
10.	2	√	√	√	√	√
1.	1	√	√	2	√	2
2.	1	3	0	0	√	0

Note: Accurate perception – (√)

O.3 Perception Test 3: The Alternative Forced Choice Test

Results of the voiceless *th* – AFC

Table O13. Voiceless *th* identification**:** Pre-intermediate EFL learners (I).

trial	correct answer	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12
1.	TH	√	F	F	√	√	S	√	√	T	√	S	S
2.	F	√	√	√	√	S	S	√	√	√	√	√	√
3.	T	√	√	√	S	√	√	√	√	√	√	√	√
4.	S	√	√	√	T	√	√	√	√	√	√	√	TH
5.	F	√	√	TH	TH	√	√	√	√	√	√	√	√
6.	T	√	√	√	√	√	√	√	√	√	√	√	√
7.	TH	F	F	F	F	F	√	√	√	√	√	√	√
8.	F	√	√	√	√	TH	√	TH	√	√	√	√	√
9.	T	√	√	√	√	√	√	√	√	√	√	√	√
10.	S	√	√	√	√	√	√	√	√	√	√	√	√
1.	TH	F	F	√	√	S	√	√	√	√	√	S	√
2.	F	√	√	√	√	√	√	√	TH	√	√	√	√
3.	S	√	√	√	√	√	√	√	√	√	√	√	√
4.	TH	√	√	√	F	S	S	√	√	√	F	√	√
5.	T	√	√	√	√	√	√	√	√	√	√	√	√
6.	F	√	√	TH	TH	√	√	√	√	√	√	TH	TH
7.	S	√	√	√	√	√	√	√	√	√	√	√	√
8.	TH	√	√	√	F	√	√	√	√	√	√	√	√
9.	T	√	√	√	√	√	√	√	√	√	√	√	√
10.	S	√	√	√	√	√	√	√	√	√	√	√	√

Note: Accurate perception – (√)

Table O14. Voiceless *th* identification**:** Advanced EFL learners (A).

trial	correct answer	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
1.	TH	√	√	√	F	F	√	√	√	√	√	S	√
2.	F	√	√	√	TH	TH	TH	√	√	√	√	√	√
3.	T	√	√	√	√	√	√	√	√	√	√	√	√
4.	S	√	√	√	√	√	TH	√	√	√	√	√	√
5.	F	√	√	TH	TH	√	√	√	√	√	√	√	√
6.	T	√	√	√	√	√	√	√	√	√	√	√	√
7.	TH	√	√	√	√	√	√	√	√	√	√	√	√
8.	F	√	√	√	TH	√	√	√	√	√	√	TH	√
9.	T	√	√	√	√	√	√	√	√	√	√	√	√
10.	S	√	√	√	√	√	√	√	√	√	√	√	√
1.	TH	√	T	√	√	√	√	√	√	√	√	√	√
2.	F	√	√	√	√	√	√	√	√	√	√	√	√
3.	S	√	√	√	√	√	√	√	√	√	√	√	√
4.	TH	√	√	√	√	√	√	F	√	√	√	√	√
5.	T	√	√	√	√	√	√	√	√	√	√	√	√
6.	F	√	TH	TH	√	√	TH	√	TH	√	√	√	√
7.	S	√	√	√	√	√	√	√	√	√	√	√	√
8.	TH	√	√	√	√	√	√	√	√	√	√	√	√
9.	T	√	√	√	√	√	√	√	√	√	√	√	√
10.	S	√	√	√	√	√	√	√	√	√	√	√	√

Note: Accurate perception – (√)

Table O15. Voiceless *th* identification**:** Native English speakers (NS).

trial	correct answer	NS1	NS2	NS3	NS4	NS5
1.	TH	√	√	√	√	√
2.	F	√	TH	TH	√	√
3.	T	√	√	√	√	√
4.	S	√	√	√	√	√
5.	F	√	√	√	√	√
6.	T	√	√	√	√	√
7.	TH	√	√	√	√	√
8.	F	√	√	TH	√	√
9.	T	√	√	√	√	√
10.	S	√	√	√	√	√
1.	TH	√	√	T	√	√
2.	F	√	√	TH	√	√
3.	S	√	√	√	√	√
4.	TH	√	√	√	√	√
5.	T	√	√	√	√	√
6.	F	√	√	√	√	√
7.	S	√	√	√	√	√
8.	TH	√	√	√	√	√
9.	T	√	√	√	√	√
10.	S	√	√	√	√	√

Note: Accurate perception – (√)

Results of the voiced *th* –AFC

Table O16. Voiced *th* identification**:** Pre-intermediate EFL learners (I).

trial	correct answer	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12
1.	Z	√	√	√	√	√	√	√	√	√	√	√	√
2.	D	√	√	√	√	√	√	√	√	√	√	√	TH
3.	Z	√	√	√	√	√	√	√	√	√	√	√	√
4.	V	√	√	√	√	√	√	√	√	√	√	√	√
5.	TH	√	V	√	√	V	V	V	√	√	√	V	√
6.	D	√	√	√	√	√	√	√	√	√	√	√	TH
7.	V	√	√	√	√	TH	√	√	√	√	√	√	√
8.	Z	√	√	√	√	√	√	√	√	√	√	√	√
9.	TH	√	V	√	√	V	√	√	√	√	√	√	√
10.	V	√	√	√	TH	√	√	√	TH	√	√	√	√
1.	Z	√	√	√	√	√	√	√	√	√	√	√	√
2.	D	√	√	√	√	√	√	√	√	√	√	√	TH
3.	TH	√	V	V	√	V	√	√	√	√	√	√	√
4.	D	√	√	√	√	√	√	√	√	√	√	√	√
5.	Z	√	√	√	√	√	√	√	√	√	√	√	√
6.	V	√	√	√	√	√	√	√	TH	√	√	√	√
7.	TH	√	V	V	√	V	Z	√	V	√	V	√	√
8.	D	√	√	√	√	√	√	√	√	√	√	√	√
9.	V	√	√	√	√	TH	√	√	√	√	√	Z	√
10.	TH	√	V	√	√	√	√	V	√	√	√	Z	√

Note: Accurate perception – (√)

Table O17. Voiced *th* identification**:** Advanced EFL learners (A).

trial	correct answer	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
1.	Z	√	√	√	√	√	√	√	√	√	√	√	√
2.	D	√	√	√	√	√	√	√	√	√	√	√	√
3.	Z	√	√	√	√	√	√	√	√	√	√	√	√
4.	V	√	√	√	TH	√	√	√	√	√	√	√	√
5.	TH	√	V	√	V	V	V	√	√	V	√	V	V
6.	D	√	√	√	√	√	√	√	√	√	√	√	√
7.	V	√	√	√	TH	√	√	√	√	√	√	√	√
8.	Z	√	√	√	√	√	√	√	√	√	√	√	√
9.	TH	√	V	√	V	√	√	√	√	V	√	V	√
10.	V	√	√	√	√	√	√	√	√	√	√	Z	√
1.	Z	√	√	√	√	√	√	√	√	√	√	√	√
2.	D	√	√	√	√	√	√	TH	√	√	√	√	√
3.	TH	√	V	√	√	√	√	√	V	√	√	V	√
4.	D	√	√	√	√	√	√	√	√	√	√	√	√
5.	Z	√	√	√	√	√	√	√	√	√	√	√	√
6.	V	√	√	√	√	√	√	√	√	√	√	√	√
7.	TH	√	V	√	√	√	Z	√	√	V	√	Z	√
8.	D	√	√	√	√	√	√	√	√	√	√	√	√
9.	V	√	√	√	TH	√	√	√	√	√	√	√	√
10.	TH	√	V	√	V	√	Z	√	√	√	√	Z	√

Note: Accurate perception – (√)

Table O18. Voiced *th* identification**:** Native English speakers (NS).

trial	correct answer	NS1	NS2	NS3	NS4	NS5
1.	Z	√	√	√	√	√
2.	D	√	√	√	√	√
3.	Z	√	√	√	√	V
4.	V	TH	√	√	√	√
5.	TH	√	√	√	√	√
6.	D	√	√	√	√	√
7.	V	√	√	√	√	√
8.	Z	√	√	√	√	√
9.	TH	√	√	√	√	√
10.	V	√	√	√	√	√
1.	Z	√	√	√	√	√
2.	D	√	√	√	√	√
3.	TH	√	√	√	√	√
4.	D	√	√	√	√	√
5.	Z	√	√	√	√	√
6.	V	√	√	√	√	TH
7.	TH	√	√	√	√	√
8.	D	√	√	√	√	√
9.	V	√	√	√	√	TH
10.	TH	√	√	√	√	√

Note: Accurate perception – (√)

Appendix P

Spearman rho rank statistical correlation test

Table P1. Spearman rho correlations for the pre-intermediate group

	GPE	CDT	AFC
Pro1	-.33	.20	-.14
	(.29)	(.52)	(.66)
Pro2	-.28	.15	.056
	(.37)	(.63)	(.86)
Pro3	-.16	.21	-.10
	(.061)	(.51)	(.75)

Note: Probability indicated in parentheses.

Table P2. Spearman rho correlations for the advanced group

	GPE	CDT	AFC
Pro1	.03	.43	.26
	(.90)	(.15)	(.40)
Pro2	.25	.48	.36
	(.42)	(.11)	(.24)
Pro3	.19	.51	.25
	(.54)	(.08)	(.42)

Note: Probability indicated in parentheses.