Segmental representations in interlanguage grammars: the case of francophones and English /h/

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Abstract

The concept that knowledge is transferred from a speaker's first language grammar into the interlanguage grammar being constructed for his second language makes testable predictions for how learners should behave given certain combinations of first and second language. This thesis examines the perceptual and productive abilities of francophones in order to gain insight into why francophones encounter such persistent difficulty in their acquisition of English /h/. We will see that although the target representation of English /h/ is not a structure that can be acquired by francophones, there are a number of representational options for the phonetic segment [h] that will yield the same acoustic result, and (at least) one of these is predicted to be acquirable. The observation that francophones do not seem to have access to any representation for this segment in the grammar these is therefore puzzling.

The experimental work reported in this thesis begins by refuting the possibility that the acoustic properties of [h] are such that francophones cannot reliably detect this segment in the speech stream. We then go on to show that the problem is indeed a matter of linguistic representation in the grammar: francophones are unable to construct phonological representations containing /h/ in lexical entries. Finally, evidence from a production task is examined, showing that francophones' behaviour in supplying aspiration on voiceless stops matches the pattern that has been observed for suppliance of /h/, supporting the proposal of a common representational problem. Further, the acoustic properties of francophone productions of /h/ are examined and argued to shed light on the

question of why alternate representations for /h/ are unavailable to the interlanguage grammar: it is argued that [h] is not being analyzed as a consonant, but as a partially devoiced vowel.

Résumé

Le concept du transfert de connaissances de la langue maternelle vers la grammaire construite lors de l'apprentissage d'une deuxième langue nous permet de prédire d'une manière vérifiable le développement des locuteurs apprenant une nouvelle langue, sachant quelle sont leur langue maternelle et la langue étant apprise. Cette thèse évalue les habiletés en perception et en production des francophones afin de comprendre pourquoi ceux-ci se retrouvent confrontés à de telles difficultés dans l'acquisition du /h/ anglais. Nous verrons que même si la représentation requise pour le /h/ anglais n'est pas possible pour les francophones, il existe d'autres représentations phonétiques pour le [h] qui auront le même effet acoustique, et (au moins) une de celles-ci devrait être possible. L'observation que les francophones ne peuvent utiliser aucune de ces représentations pour ce segment phonétique dans la grammaire est donc curieuse.

Les expériences rapportées dans cette thèse commencent par réfuter la possibilité que les propriétés acoustiques du [h] sont telles que les francophones ne peuvent pas le détecter dans la parole d'une manière fiable. Ensuite, nous démontrons qu'il s'agit d'un problème de représentation linguistique dans la grammaire: les francophones ne peuvent pas construire des entrées lexicales contenant des représentations phonologiques avec le /h/. Finalement, nous examinons les productions des francophones, où les résultats démontrent que la production de l'aspiration des occlusives sourdes est identique à la production observée du /h/, soutenant la proposition d'un seul problème de représentation pour ces troubles. De plus, nous examinons les propriétés acoustiques de la

production du /h/ par les francophones, et nous proposons que ceux-ci peuvent aider à expliquer pourquoi toutes les autres représentations possibles semblent ne pas être disponibles à la grammaire de l'apprenant: on soutient que le [h] n'est pas analysé en tant que consonne, mais en tant que voyelle partiellement muette.

Chapter 1 – Investigating phonological knowledge

1.0. Introduction

Research in phonological theory seeks to gain an understanding of what individuals know about the sound system of their language(s). Within segmental phonology, much attention has been given to sub-segmental features and their interaction: what features combine to produce a given segment? Are all or only some of a segment's features stored in segmental representations? If only some, what criteria determine which ones are stored, and which ones are introduced computationally? What constraints govern feature cooccurrence?

While these issues are central to discussion in theoretical phonology, they are also critical for research in second language (L2) phonology. Proposals concerning what native speakers unconsciously know about their language provide us with hypotheses about what the learner is trying to acquire, as well as what the learner already knows by virtue of having acquired a first language (L1). Examining L2 learners' grammatical knowledge in turn enables the development of proposals about the process of L2 acquisition: what grammatical properties are available at the initial state, what the source is for these, and how acquisition proceeds over the course of time. As we will see in greater detail in 1.1 below and in chapter 3, there is much evidence suggesting that the L1 grammar is an important source of information for the developing L2 grammar: representations from the L1 are transferred into the learner's interlanguage grammar, resulting in L2 learner behaviour that is not (initially) target-like precisely because it is constrained by the set of primitives (features) and representations from the L1

(Bley-Vroman 1990; Hawkins 2000, 2003; Schwartz & Sprouse 1994). As White (2003) notes, several researchers in the 1960s/70s (Corder 1967, Nemser 1971, Selinker 1972, and Adjémian 1976) independently argued that L2 learner behaviour was systematic in nature; this work led to the development of the notion of 'interlanguage grammars', rule-governed systems that contain elements of both the L1 and the target L2. Given that the L1 contributes to the interlanguage grammar through transfer, different proposals about the structure of the L1 grammar make testable predictions for L2 learner behaviour: if a given representation is available from the L1, then we would expect to find interlanguage behaviour that reveals this structure as well.

The developmental paths that interlanguage grammars take also figure prominently in discussions of access to Universal Grammar (UG) in L2 acquisition (see White 2003 for a review): is it possible to add new primitives and structures to the developing L2 grammar, and if so, what is the source of the new information? As will be seen in 1.2 below, various proposals exist in the literature concerning the sources that learners can use to extend the interlanguage grammar beyond what is available through transfer. There is much evidence suggesting that this is possible, though the limits on this seem to be more severe for phonology, as more often than not, L2 learners do not come to perform exactly like native speakers on phonological measures.

This thesis investigates a case of non-target-like L2 learner behaviour that is not predicted given our understanding of the learners' L1 grammar, transfer, and UG access: the case of French speakers acquiring English /h/. As will be

discussed in greater detail in chapter 3, while francophones are unable to transfer a target-like representation for English /h/ into the interlanguage grammar, L1 features that are available through transfer should make a workable representation available for this segment; the observed behaviour of persistent difficulties with /h/ in both perception and production runs counter to this prediction. The details of the problem are fully discussed in chapters 2 and 3: chapter 2 presents the theoretical possibilities for the representation of /h/ across grammars; chapter 3 presents an overview of our understanding of transfer and UG access in L2 phonology and identifies the predicted possibilities for francophone interlanguage grammars with respect to this segment. Chapters 4 and 5 present experimental data from two event-related potential (ERP) studies that show that francophone difficulties with English /h/ are indeed due to a problem in phonological representation: it is not the case that the segment is not sufficiently acoustically salient to be detected in the speech stream (chapter 4); rather, the problem lies in an inability to construct and store an appropriate phonological representation in lexical entries (chapter 5). Chapter 6 presents an analysis of elicited production data that, in combination with the ERP evidence, sheds light on the status of /h/ in the interlanguage grammars built by francophones: the evidence suggests that they are treating it as a partially devoiced vowel, and not as a consonant. All of the possible representations for /h/ that are available through recombination of transferred L1 features are representations for consonants, and are thus not considered by the interlanguage grammar.

Before turning to the principal topics discussed in this thesis, however, we must first consider in greater detail the notions of transfer and UG access in L2 acquisition.

1.1. L1 knowledge in L2 acquisition: the role of transfer

The fact that L2 learners are heavily influenced by the L1 grammar is particularly evident in the phonological domain (e.g., Lado 1957). Typically, L2 speakers do not sound like native speakers: crucially, segmental representations fail to become target-like, with target segments being replaced with segments from the learner's L1, resulting in characteristic non-native accents. We also find that syllable structure complexities of the L2 are modified to produce strings that are compatible with L1 constraints, and prosodic properties in L2 speech, such as stress, are distinct from those in the speech of native speakers. It is not the case that for a given target language, all L2 learners sound the same. Instead, because of transfer, an L2 learner will sound like and encounter the same difficulties as other L2 learners who share the same L1. In an L2 English classroom, for example, the L1 Japanese speakers will have difficulty with English /l/ and /r/, confusing the two in perception and production (e.g., Yamada 1995). L1 Spanish speakers, on the other hand, will encounter similar confusion with English /s/ vs. /z/ (e.g., Ortega-Llebaria, Faulkner, & Hazan 2001). Furthermore, in the event where speakers of different L1s share a common problem in the L2, the groups may make use of different solutions. For example, both Spanish and Japanese speakers use vowel epenthesis in their L2 English, but the location of the

epenthetic vowel differs between the two groups: for the target word 'spy', Japanese speakers place the vowel between the two consonants, as in [sɯpaj] (e.g., Dupoux et al. 1999), while Spanish speakers place it before the cluster, as in [ɛspaj] (e.g., Abrahamsson 1999). The properties of a learner's L1 thus appear to have consequences for how the interlanguage grammar will structure the L2 input at initial stages of acquisition. Essentially, L2 learners begin by assuming that the L2 grammar will be structured exactly as their L1 grammar (Bley-Vroman 1990; Schwartz & Sprouse 1994).

As mentioned above, the grammars built by L2 learners have come to be referred to as interlanguage grammars precisely due to the presence of not only properties of the target L2, but also properties of that speaker's L1 (see White 2003 for a review). The claim is that the L1 knowledge is transferred to the interlanguage grammar. How much of the L1 grammar is transferred remains an open question:[1] some researchers argue that the entirety of the L1 grammar undergoes transfer, as in the Full Transfer Full Access Hypothesis of Schwartz & Sprouse (1994), while others claim that only a subset of the information contained in the L1 grammar is transferred, as in the Minimal Trees Hypothesis of Vainikka & Young-Scholten (1994). The notion of (full) transfer seems well-motivated within L2 phonology (e.g., Lado 1957, Eckman 1977, Broselow & Finer 1991, Archibald 1994, Brown 2000, among others). Indeed, without transfer, L2

[1] This is not to say that L1 transfer into the interlanguage grammar is a foregone conclusion in the literature: the Full Access Hypothesis specifically rejects L1 transfer into the interlanguage grammar (Epstein et al. 1996: 751; see White (2003) for discussion). However, given the abundance of evidence supporting transfer of the phonological component of the grammar, approaches that assume no transfer are excluded from the discussion presented here.

speakers who share an L1 would not be expected to pattern together as they do. We would instead expect to see a general pattern (or, at least, a small set of patterns) among all non-native speakers, regardless of L1, which is clearly not the case. Therefore, it is assumed here that a transferred L1 grammar forms the initial state of the interlanguage grammar in L2 acquisition.

1.2. Beyond L1 transfer: the role of UG access

Accepting that transfer plays a role in L2 acquisition does not, of course, mean that the L1 is the single source contributing to the shape of the interlanguage grammar; the L1 is simply the foundation upon which the developing interlanguage grammar is built. The presence of sufficient L2 input works to drive changes to the system, though researchers disagree on what types of changes can be effected. One major point of difference is about whether L2 acquisition makes use of the same learning mechanisms as L1 acquisition does; intimately connected to this is the question of what sorts of changes can be made to the interlanguage grammar. While the proposals that are compared here were originally developed in the literature on L2 syntax, they are also applicable to L2 phonology, which we return to below.

Bley-Vroman's (1990) Fundamental Difference Hypothesis argues that adult L2 learners, unlike children acquiring their L1, make use of general problem solving strategies in attempting to build a grammar that will allow them to produce target-like structures, possibly resulting in grammars that are not like those found in natural languages; it is thus possible for a learner to construct a

'wild' grammar, i.e., one that is not constrained by UG. Others argue that interlanguage grammars are always constrained by UG, but differ with respect to how much the transferred L1 system can be changed when presented with L2 input. On the one hand is the view that the learner no longer has access to information contained within UG that has not been instantiated in the L1 (e.g., Failed Functional Features Hypothesis[2] (Hawkins & Chan 1997)). That is, learners cannot add new features or change parameter settings in order to arrive at an interlanguage grammar that is increasingly target-like. They can, however, work with what is available from L1 transfer in order to arrive at a (UG-constrained) system that allows them to appear increasingly target-like in production, even though the underlying grammar is not. This view can be characterized as partial access: UG itself is not directly accessible, but the components of the transferred L1 representations can be used, wherever possible, in order to accommodate the requirements of the L2. The result is an interlanguage grammar that includes representations beyond those transferred directly from the L1, and that are still UG-constrained. On the other hand is the view that, given sufficient input, learners can access UG directly and add new features and representations to the interlanguage grammar, allowing them to perform as native speakers do because the underlying systems are the same (e.g., Full Transfer Full Access Hypothesis (Schwartz & Sprouse 1994)).

[2] A more recent version of this proposal is the Representational Deficit Hypothesis (Hawkins 2000, 2003), specifying that adult L2 learners fail to acquire new uninterpretable formal features. This results in permanent misrepresentation or non-representation of certain L2 features.

The persistent nature of non-native accents suggests that expanding the interlanguage grammar beyond L1 transfer is not possible for L2 segmental phonology, which in turn suggests that access to UG is severely restricted in this domain. While the general tendency of L2 learners to fail to become target-like on phonological measures has been interpreted as evidence of complete unavailability of UG access (e.g., Long 1990), there is also a growing body of work indicating that a no-access position is too severe (see, for example, Young-Scholten (1994) for a review of some earlier studies). Some previous work in L2 segmental phonology (e.g., Brown 1997, 2000), which will be discussed in greater detail in chapter 3, provides support for the partial access position: essentially, learners appear to be 'stuck' with whatever segmental representations can be constructed using the features made available through L1 transfer. With very few exceptions (e.g., Bongaerts, Mennen, & van der Slik 2000) , even very advanced L2 speakers do not sound exactly like native speakers, suggesting that Full Transfer Full Access may not be an appropriate hypothesis for L2 segmental phonology. Furthermore, I know of no evidence from the phonological domain suggesting that L2 learners are constructing rogue grammars in an attempt to produce something that is more target-like. Thus the possibilities considered for interlanguage grammars in chapter 3 reflect the assumption of transfer of L1 knowledge, and the assumption that learners will be operating within the constraints of both UG and the inventory of features available through L1 transfer when making changes to the interlanguage grammar in order to appear more target-like.

1.3. Summary

Research in theoretical linguistics informs our understanding of L2 acquisition by providing accounts of the target of acquisition, and the formal constraints on grammars, including, by hypothesis, developing interlanguage grammars. This has enabled the development of proposals about the nature of the interaction between the L1 and the interlanguage grammar, as well as claims about what limits could potentially exist in ultimate attainment in L2 acquisition. Within the domain of segmental phonology, most evidence appears to be consistent with the assumption of full transfer of the L1 into the interlanguage grammar and partial access to UG: the learner cannot add new linguistic properties directly from UG, but instead is limited to working with whatever features are made available via the L1, yielding a grammar that is nevertheless UG-constrained throughout.

The specific implications of this theoretical stance will be further explored in chapter 3. With this background in mind, we now turn to the case investigated in this thesis: francophones' difficulties with English /h/.

Chapter 2: On the representation of English /h/

2.0. Introduction

There has been some discussion of the properties of laryngeals in the literature; however, relatively little of this has focused on English /h/. Much of this work examines the articulatory properties of laryngeals, and close examination of the behaviour of laryngeals in segmental interactions allows for identification of the features that are plausibly found in segmental representations. The available evidence supports the existence of two types of laryngeals with respect to the place dimension in the world's languages: Pharyngeal laryngeals, which belong to the natural class of gutturals, along with pharyngeals and uvular fricatives, and placeless laryngeals, which arguably lack place features altogether.

This chapter begins with a review of the evidence supporting both placeless /h/ and Pharyngeal /h/. The behaviour of English /h/ is then evaluated with respect to the properties that have been argued to be characteristic of both placeless /h/ and Pharyngeal /h/. As we will see, at first glance English /h/ does not seem to be either: an absence of motivation for the presence of a pharyngeal feature in representations prevents us from accepting that English /h/ is Pharyngeal, yet at the same time it does not exhibit the properties of placeless /h/ either. Work on the representation of voicing contrasts, however, sheds some light on the apparently anomalous nature of English /h/: English /h/ must be placeless, but it does not show the same patterns of behaviour as other placeless segments cross-linguistically due to its specification for laryngeal features, namely [spread glottis] ([SG]). As discussed in section 2.1.2 below, claims that laryngeals are

placeless are frequently supported by data involving coda constraints on place: where a language does not tolerate segments with independent place in coda position, they will still tolerate a laryngeal, suggesting that laryngeals lack place. A number of languages neutralize not just place of articulation contrasts, but also laryngeal contrasts in coda position. The available evidence suggests that English /h/ is placeless, but does not appear in codas due to the presence of laryngeal features: English /h/ is also [SG].

2.1. /h/ is placeless

The representations adopted in this thesis assume a Feature Geometric organization of segments, with features organized into various nodes and dependency relationships (Sagey 1986; Clements & Hume 1995). All representations include a ROOT node, which dominates all other features and organizing nodes (e.g., Place, Laryngeal).[1]

Laryngeal segments /h, ʔ/ have been argued to be completely lacking place features; in Feature Geometric terms, the claim is that they lack a Place node entirely, as in (1) (Steriade 1987, McCarthy 1988). The evidence cited for placeless laryngeals comes from analyses of translaryngeal harmony, coda constraints on place, debuccalisation, and consonant epenthesis. We will examine each of these in turn.

[1] While I follow these assumptions, it should be noted that whether or not features are hierarchically organized is less critical to the experimental work reported in this thesis; I am principally concerned with the particular features that are available for /h/, rather than how they are organized.

(1) *Placeless laryngeals*

/h, ʔ/
|
ROOT

2.1.1. Translaryngeal harmony

Translaryngeal harmony is a process in which vowels share all place features across a laryngeal segment; critically, no other consonants permit this shared identity.[2]

In Arbore, adding the present or past tense morpheme to a laryngeal-final root results in total place assimilation between the two vowels, as in (2a) below. The phenomenon is observed with both [ʔ] and [h]. Where the root ends in a non-laryngeal consonant, however, as in (2b), no assimilation occurs: the non-laryngeal consonant serves to block the process (Steriade 1987; data from Hayward 1984).

(2) *Arbore*[3]

a. *Translaryngeal harmony*

/ma beh-o/	[ma boho]	'he is not going out'
/ma beʔ-i/	[ma biʔi]	'he did not go out'
/ʔan keːʔ-a/	[ʔan keːʔe]	'I plant'
/ʔay zeːh-a/	[ʔay zeːhe]	'it (masc) melts'

b. *Opacity of non-laryngeals*

/foːl-a/	[foːla]	'(it) is a face'
/ʔan hiːk'-a/	[ʔan hiːk'a]	'I grind'
/ʔay gos-a/	[ʔay gosa]	'he sows'

[2] At first glance, transguttural harmony appears to be an exception to this; we return to a discussion of these systems in 2.2 below.
[3] Here and throughout the thesis, data appear as transcribed in the original source.

In Gitksan, translaryngeal harmony is observed when the first singular possessive pronominal suffix /-ẏ/[4] is added to nouns ending in either [ʔ] or [h]: a vowel is epenthesized to avoid a consonant cluster, and the epenthetic vowel shares all place features with the stressed vowel in the stem-final syllable, as in (3a). Where the final consonant of the stem is a non-laryngeal consonant, epenthesis still occurs, but the epenthetic vowel is consistently realized as [i] (3b) (Rigsby 1986, Yamane-Tanaka 2006).

(3) *Gitksan*

a. *Translaryngeal harmony*

/nuχ-ẏ/	[nɔhɔẏ]	'my mother'
/peːχ-ẏ/	[bɛhɛẏ]	'my lungs'
/tsʼaʔ-ẏ/	[tsʼaʔaẏ]	'my eyes (face)'
/siseʔ-ẏ/	[sɪsɛʔɛẏ]	'my feet'

b. *Opacity of non-laryngeals*

/stuːp-ẏ/	[sduːbiẏ]	'my stove'
/qoːt-ẏ/	[ɢɔːdiẏ]	'my heart'
/wak-ẏ/	[wagiẏ]	'my (man's) brother'
/luːx-ẏ/	[luːxiẏ]	'my alder tree'

In Acoma (Miller 1965), vowels that flank a glottal stop strongly tend to be identical for place, both in monomorphemic forms, as in (4a), and in multi-morphemic forms, as in (4b); exceptions to this observation are rare. Crucially, the identity between the two vowels only holds for place features: as shown by the examples in (4c), the laryngeal features of a glottalized vowel are not shared across an intervening laryngeal.

[4] [ẏ] is a glottalized palatal sonorant, which contrasts with a corresponding plain sonorant.

(4) *Acoma*

a. *Monomorphemic translaryngeal harmony*

ya?ái	‘sand’
?ái?i̯cáadyáⁿi	‘clothespin’
c̓íuṯée?esṭíᵐi	‘dishwater’

b. *Translaryngeal harmony across morpheme boundaries*

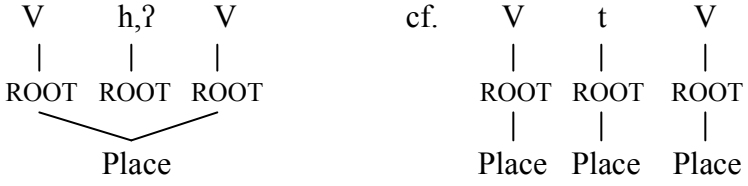
se?ê̯inazí	‘I ran over them (dual)’
si?íuᵐayanikuya	‘I made fun of them (dual)’
ka?áuyėeca	‘he made up his mind’

c. *Translaryngeal harmony only involves place features*

húu?u̯uka	‘dove’
ki?i̯isdyú	‘he defecated’
si?i̯ukača	‘I see them (dual)’

In each of the languages discussed above, as vowels share place features over an intervening laryngeal, laryngeals must lack all place features. The vowels are then ‘visible’ to each other, and able to share place. This is not possible with consonants that have their own place features, as the presence of these will block feature sharing. This is illustrated in (5) below.

(5) *Laryngeal transparency*



2.1.2. Coda constraints: laryngeals make good codas

A second phenomenon illustrating that laryngeals are placeless is the existence of coda constraints. Not all languages that permit codas will allow any consonant to appear in this position. Many languages restrict coda consonants with respect to place features: any non-laryngeal consonant that appears in coda position must share the place features of the following onset consonant. Both Selayarese ((6a), (7a), Mithun & Basri 1986) and Macushi ((6b), (7b), Abbott 1991) are languages with these types of constraints: the only possible coda-onset sequences are geminates (6) and homorganic nasal-stop sequences (7).

(6) *Geminates*

a. *Selayarese*

[sápˀpo]	‘missing front teeth’
[bátˀtu]	‘rock’
[túkˀkaŋ]	‘walking stick’

b. *Macushi*

[ujeppa]	‘my backbone’
[ujette]	‘my hammock’

(7) *Place-sharing coda nasals*

a. *Selayarese*

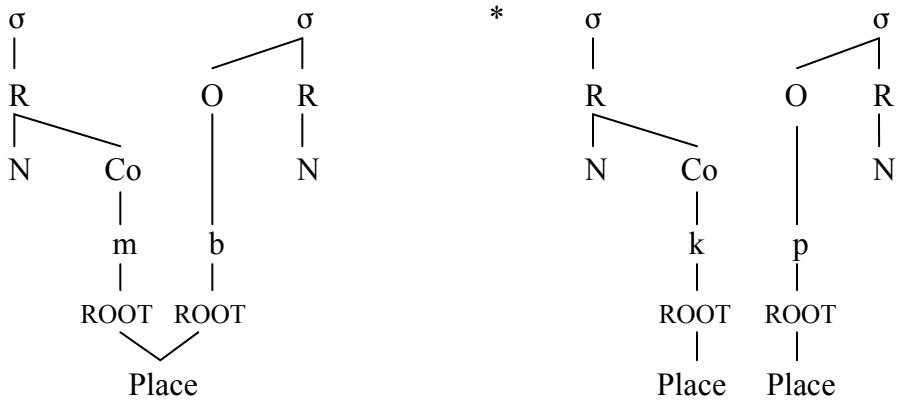
[lúmpaʔ]	‘jump’
[ʔíntu]	‘that (close to you)’
[láŋkasa]	‘tall’
[íɲjo]	‘that’

b. *Macushi*

[umbo]	‘my shoulder’
[unda]	‘my mouth’
[maŋga]	‘manga’

In both of these languages, it is clear that consonants in coda position may not bear their own place features, but instead are dependent on those of the following onset, as depicted in (8) below.

(8) *Place-sharing in coda position*



In word-final position, where there is no following onset, we would expect to find only those consonants that lack place. This is supported in both Selayarese (9a) and Macushi (9b): the only consonants that may appear word-finally are laryngeals and the placeless nasal [ŋ].[5]

[5] McCarthy (2008) notes that placeless nasals are often transcribed as [ŋ], as the lowering of the velum for nasal airflow during production creates a narrowing in the dorsal region. However, even though the point of maximal constriction is in the region where [ŋ] is articulated, there is no real oral closure. The implication of this is that there is a distinction between a word-final [ŋ] and the [ŋ] in a place-sharing cluster (i.e., [ŋk]): the former is placeless, while the latter shares Dorsal with the following onset consonant.

(9) *Word-final consonants*

a. *Selayarese*

[ʔátaʔ]	‘roof’	[ɲa̋mãŋ]	‘delicious’
[sássaʔ]	‘lizard’	[kánãŋ]	‘right’

b. *Macushi*

[moh]	‘worm’	[ameŋ]	‘recently’

The occurrence of laryngeals in these positions shows that laryngeals must be placeless, thereby allowing them to avoid violating any restrictions on place in coda position.

Analyzing laryngeals as being placeless makes two further predictions for coda constraints. First, there should be languages in which laryngeals appear in word-internal codas but do not share place with a following onset. This is the case in Macushi (10).

(10) */h/ in word-internal codas in Macushi*

[ahga]	‘light’	[ikuhbɨ]	‘lake’

Second, if a nasal appears in coda position with a laryngeal in the following onset, since there is no place to be shared, the only nasal found should be placeless [ŋ]. This is the case in Selayarese (11).

(11) *‘Sharing’ placelessness in Selayarese*

[ʔaŋhúkˇkuŋ]	‘punish (intr)’	*[VmhV]

2.1.3. Debuccalisation

Related to the discussion of coda constraints is the process of debuccalisation observed in many languages: consonants occurring in prosodically weak positions, such as codas, undergo a lenition process involving the loss of oral closure from the consonant. The result of debuccalisation is typically a laryngeal segment, either [ʔ] or [h], as seen in the data below.

In Kagoshima Japanese (Kaneko & Kawahara 2002: 23), final high vowels are subject to apocope, and the resulting coda consonants debuccalise to [ʔ].

(12) *Kagoshima Japanese*

/tobu/	[toʔ]	'fly'	/kutsu/	[kuʔ]	'shoes'
/kaki/	[kaʔ]	'persimmon'	/kutʃi/	[kuʔ]	'mouth'

In the history of Miami-Illinois, the first obstruent in a two-obstruent sequence from Proto-Algonquian debuccalised to [h] (Costa 1991: 376 – 378).

(13) *Diachronic debuccalisation*

a. *Proto-Algonquian*		b. *Miami-Illinois*	
*wexpweˑwa	'he smokes'	eehpwaačiki	'they smoke'
*axkyi	'land'	ahki	'field'
*ašiškiwi	'mud'	šihkiwi	'land, earth, dirt'
*meçkwi	'blood'	mehkoma	'vein, pulse'

In Kashaya, aspirated uvulars debuccalise to [h] (14a), and ejective uvulars debuccalise to [ʔ] (14b) (Fallon 2002: 171 – 172). (Concerning the intermediate stage given in (14): in (14a), voiceless stops and affricates in coda position are normally produced with aspiration; in (14b), the [CG] feature of a

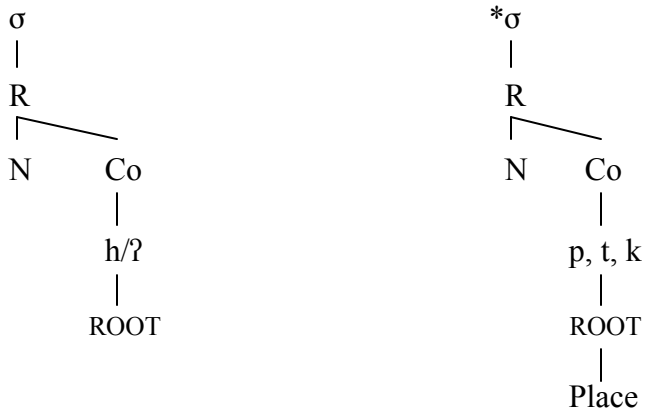
glottalized sonorant (transcribed on sonorants as subscript '~') is transferred to a preceding plain stop, which blocks the aspiration of the uvular in coda position.)

(14) *Kashaya*

	Underlying	Intermediate	Surface	
a.	/simaːq-meʔ/	simaːq^{h}meʔ	[simahmeʔ]	'go to sleep!'
	/mitʃ^{h}aːq-p^{h}i/	mitʃhaːq^{h}p^{h}i	[mitʃahp^{h}i]	'if he sweats'
b.	/simaːq-m̰a/	simaːq'ba	[simaʔba]	'having fallen asleep'
	/k^{h}unuːq-n̰o/	khunuq'do	[k^{h}unuʔdo]	'they say it spoiled'

The analysis given for debuccalisation in (15) below is essentially that given in (8) for coda constraints above: independent place features cannot be maintained in the targeted position, resulting in the complete loss of Place, and a laryngeal consonant, either [ʔ] or [h], is realized instead.

(15) *No place in coda position*



2.1.4. Epenthesis: laryngeals are good epenthetic segments

Lombardi (2002), in surveying epenthetic consonants in a number of languages, notes that laryngeals, especially [ʔ], occur frequently as epenthetic

segments, and presents evidence from languages such as Selayarese (Mithun & Basri 1986, Lombardi 2002) and Malay (Durand 1986, Lombardi 2002).

In Selayarese, [ʔ] is epenthesized to break up a sequence of identical vowels obtained through affixation of vowel-final prefixes to vowel-initial stems, as in (16a); it is not required in (16b), where the quality of the prefix vowel differs from that of the stem-initial vowel.

(16) *Selayarese*

a.	[ku-ʔ-uraŋi]	'I accompany him'
	[ri-ʔ-inuŋi]	'you (HON) drink it'
b.	[ri-uraŋi]	'you (HON) accompany him'
	[ku-inuŋi]	'I drink it'

In Malay, glottal stop epenthesis is used to avoid vowel hiatus at prefix-stem boundaries, as in (17a); compare (17b), where the stem is consonant-initial.

(17) *Malay*

a. *Epenthesis to avoid vowel hiatus*

/di-ikat/	[diʔikat]	'to tie (PASS)'
/di-ukir/	[diʔuke]	'to carve (PASS)'

b. *No vowel hiatus*

/di-pukol/	[dipukol]	'to beat (PASS)'
/di-daki/	[didaki]	'to climb (PASS)'

While Lombardi (2002) only discusses epenthesis of glottal stop, it is not the case that /h/ is never epenthesized. Blevins (2008) presents an impressive list of languages with /h/ epenthesis occurring at the right edge of some prosodic

domain, including Aceh (Durie 1985); /h/ was also epenthesized word-initially in the history of Yurok (Blevins & Garrett 2007).

In Aceh, /h/ is epenthesized onto enclitics when these are the final element of the phrase. In (18a), the clitics *neu*, *pi* occur phrase-finally, and thus are subject to /h/ epenthesis. In (18b), on the other hand, these same clitics are not phrase final, and thus no /h/ epenthesis takes place.

(18) *Aceh*[6]

a. */h/ epenthesis*

droe=neuh ka=neu=jak	lôn=pih sakêt
self=2 IN=2=go	I=EMPH sick
'you have gone'	'I am sick too!'

b. *No /h/ epenthesis*

ka=droe-neu-jak	peulandôk pi=ji-beudöh
IN=self-2-go	mousedeer EMPH=3-rise
'you have gone'	'The mousedeer got up.'

In the development of Yurok from Proto-Algonquian, vowel-initial Proto-Algonquian words acquired an initial /h/, as shown by the pairs in (19).

(19) *Diachronic /h/ epenthesis*

a. *Proto-Algonquian*		b. *Yurok*		
*eːwa	'he goes'	ho-	(in [heɣok'])	'I go'
*ekwa	'the other says so to him'	hek		'I say'
		hiʔ		'it is said'

[6] IN = inchoative, EMPH = emphatic.

Epenthetic segments are viewed as being insertions of segmental material to ensure well-formedness with respect to prosodic constraints: vowels are inserted to allow for syllabification of otherwise unsyllabifiable consonants, and consonants are inserted to satisfy requirements for onsets, as in Malay, or to demarcate phrase boundaries, as in Aceh. As laryngeals lack place features, they have the least amount of structure of all consonants in a given language's inventory.[7] This makes them ideal epenthetic consonants: inserting a laryngeal will therefore incur the smallest faithfulness violation in the evaluation of the candidate. Epenthesizing laryngeals also incurs minimal perceptual cost (Steriade 2001).

In sum, there is considerable evidence in support of the proposal that laryngeals, including /h/, lack any and all place features in their representation, as shown earlier in (1).

2.2. /h/ is Pharyngeal

Standing in contrast to the data amassed in favour of placeless laryngeals are languages in which laryngeals behave as though they belong in a natural class with pharyngeals and uvular fricatives, a group often referred to as 'gutturals'.

In addition to the translaryngeal harmonies such as those discussed in 2.1.1 above, transguttural harmonies are also attested in the world's languages. In transguttural harmony, vowels are identical when not only laryngeals, but also pharyngeals and uvular fricatives intervene; other consonants, however, block

[7] Lombardi (2002) argues that the claim that coronal consonants are frequently used as epenthetic consonants in the world's languages is poorly supported, and presents alternate analyses for the known examples.

harmony. The analysis given for transguttural harmony involves spreading of oral place features, while pharyngeal place features are transparent (McCarthy 1994). Transguttural harmony has been observed in Jibbāli ((20a), Hayward et al. 1988; Rose 1996) and Iraqw ((20b), Mous 1993; Rose 1996); some speakers of Gitksan[8] have transguttural harmony rather than the translaryngeal harmony discussed earlier in (3) ((20c), Yamane-Tanaka 2006).

(20) *Examples of transguttural harmony*

a. *Jibbāli*

s'aʁal	'busy'	cf.	ðekər	'be mean/greedy'
ðaħal	'urinate'		feðər	'shiver with fear'
saʕaf	'remove husks'		serəd	'be lit'

b. *Iraqw*

/ufaaħ-iim/	[ufaħaam]	'blow (DURATIVE)'
/waʔalah-iim/	[waʔalahaam]	'exchange (DURATIVE)'
cf. /tutuuw-iim/	[tutuwiim]	'open a new farm (DURATIVE)'
/baal-iim/	[baaliim]	'defeat (DURATIVE)'

c. *Gitksan*

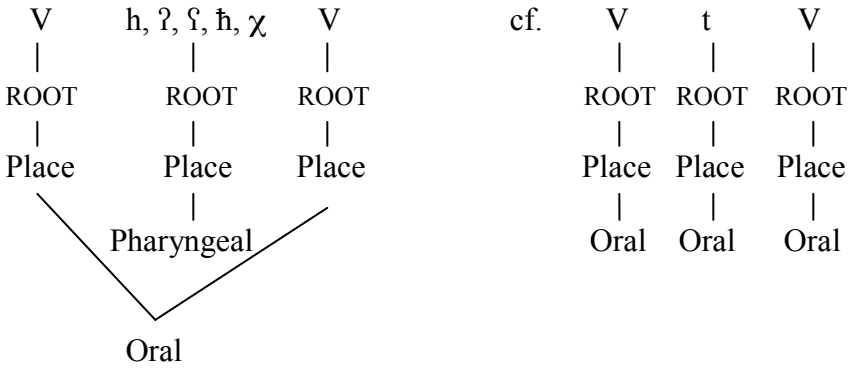
/pé:χ-y̓/	[bɛ́:χɛy̓]	'my lungs'
/núχ-y̓/	[nɔ́χɔy̓]	'my mother, mother's sister'

With the existence of transguttural harmony systems, and McCarthy's (1994) account given for these, it no longer follows that translaryngeal harmony is only possible with placeless laryngeals. Rather, one could argue that laryngeals (and

[8] Yamane-Tanaka (2006) also found evidence of harmony across uvular stops [q, ɢ], and some of her younger consultants allowed for harmony across [x].

other gutturals) are specified with a Pharyngeal place feature, which does not block the sharing of oral place features.[9]

(21) *Guttural transparency*



Other evidence of laryngeals behaving as gutturals comes from morpheme structure constraints in Semitic languages. McCarthy (1994) analyzes the consonant cooccurrence constraints observed in Arabic roots as a result of the Obligatory Contour Principle (OCP), a prohibition on identical feature specifications within a given domain (Leben 1973, McCarthy 1986). In Arabic roots, sequences of adjacent consonants drawn from the groups given in (21) never or rarely occur. This is analyzed as an OCP effect for Place on roots: in Arabic, roots may not contain adjacent consonants with identical Place specifications, unless the two consonants are completely identical.

[9] As we will see in 2.3 below, the available evidence indicates that there are two types of laryngeals: placeless laryngeals and Pharyngeal laryngeals.

(21) *Arabic root cooccurrence constraint groupings*

a.	Labials	=	f, b, m
b.	Coronal sonorants	=	l, r, n
c.	Coronal stops	=	t, d, ṭ, ḍ
d.	Coronal fricatives	=	θ, ð, s, z, ṣ, ẓ, ʃ
e.	Velars	=	k, g, q
f.	Gutturals	=	χ, ʁ, ħ, ʕ, h, ʔ

Noteworthy in (21) is the grouping of laryngeals /h, ʔ/ with the pharyngeals and uvular fricatives. This is only possible if these segments all share a place feature: the claim is that they must all be Pharyngeal. If laryngeals lacked Pharyngeal, they would be expected to freely cooccur with uvular fricatives and pharyngeals in Arabic roots. Though McCarthy focuses his discussion on the pattern found in Arabic, he notes that other researchers have found similar patterns in other Semitic languages, and thus it seems to be a property of Semitic languages more generally.

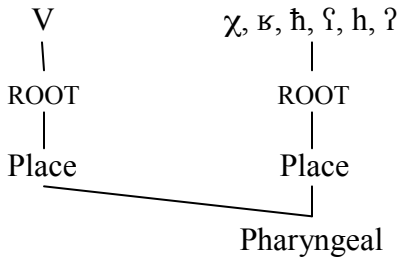
Further arguments for laryngeals being specified as Pharyngeal come from examination of interactions between guttural consonants and vowels (McCarthy 1994). Arabic verbs are grouped into ablaut classes depending on the identity of the final vowel of the stem in its perfect and imperfect forms, as in (22) below (McCarthy 1994: 207).

(22) *Arabic ablaut classes*

Ablaut class (perf/imperf)	Example		Frequency
a/u	katab/jaktub	‘write’	1029
a/i	ḍarab/jaḍrib	‘beat’	842
i/a	ʃarib/jaʃrab	‘drink’	518
a/a	faʕal/jafʕal	‘do’	436
u/u	balud/jablud	‘be stupid’	191

For some ablaut classes, membership is unpredictable; however, for one class, the a/a class where both perfect and imperfect verb forms contain [a] as the final vowel of the stem, nearly all members contain a guttural consonant that is adjacent to the [a]. Also noteworthy is the fact that Arabic imperfect forms much more frequently have either [i] or [u] as the final vowel of the stem (see final column in (22)). There thus appears to be a connection between [a] and an adjacent guttural consonant. McCarthy analyzes this as vowel lowering in a guttural context, achieved through spreading of Pharyngeal from the guttural consonant to the adjacent vowel. Critically, roots containing laryngeals [h, ʔ] adjacent to vowels also trigger lowering of the vowel; therefore they must also be specified as Pharyngeal, as in (23).

(23) *Vowel lowering by Pharyngeal*



The guttural-adjacent vowel lowering effects are not specific to Arabic: McCarthy (1994) shows that in Tiberian Hebrew, schwas are subject to lowering following guttural consonants. In (24a), vowels reduce to schwa in short, unstressed syllables. In (24b), a schwa obtained through vowel reduction is additionally subject to lowering due to a preceding guttural consonant; [ă] is described as an 'a-colored schwa' (McCarthy 1994: 209).

(24) *Tiberian Hebrew*

a. *Vowel reduction*

melek	'king'	məla:ki:m	'kings'
qeber	'grave'	qəba:ri:m	'graves'
se:per	'book'	səpa:ri:m	'books'

b. *Lowering of schwas in guttural context*

ʔeben	'stone'	ʔăba:ni:m	'stones'
hebel	'vapour'	hăba:li:m	'vapours'
ħeder	'room'	ħăda:ri:m	'rooms'
ʕeder	'flock'	ʕăda:ri:m	'flocks'

Again, the lowering effect of gutturals, laryngeals included, is attributed to the spread of a Pharyngeal feature from the consonant to the adjacent vowel. Though McCarthy (1994) restricts his more detailed discussion of guttural lowering effects to Arabic, Tiberian Hebrew, and Bedouin Arabic, he states that the pattern is more widespread, not just within Semitic languages (citing Lebanese Arabic, Tigrinya, Harari, Gafat and Amharic), but also more generally, citing D'opaasunte (Cushitic), Kera (Chadic), Carrier (Athapaskan) and Nisgha (Tsimshian).

2.3. Two types of laryngeals

We have seen that there appears to be strong evidence in support of both placeless laryngeals and Pharyngeal laryngeals. Rose (1996) considers these two options and argues that both are correct: there are two possible representations for laryngeal segments in the world's languages, yielding segments that behave differently in phonological systems. The two types are articulatorily identical, however, as neither is produced with any appreciable constriction in the pharynx

(McCarthy 1994). Rather, Rose argues that the determining factor in whether a language will have placeless or Pharyngeal laryngeals is that language's post-velar consonant inventory. Those languages with uvular fricatives or pharyngeals, that is, other consonants specified with Pharyngeal features, have Pharyngeal laryngeals in their inventories, while those languages without post-velar consonants have placeless laryngeals instead.

To support the claim that laryngeal type is driven by post-velar inventories, Rose sets out to find a system that under her proposal should not exist: a language with post-velar consonants, but laryngeals that behave as though they are placeless. Rose reexamines the Interior Salish languages analyzed by Bessell & Czaykowska-Higgins (1992) as having extensive guttural inventories, but placeless laryngeals (Lillooet, Coeur d'Alene, Thompson, and Moses-Columbian). While Rose agrees with Bessell & Czaykowska-Higgins' analysis that Salish languages involve vowel retraction triggered by the Pharyngeal feature [Retracted Tongue Root] ([RTR]), she argues that it does not necessarily follow that laryngeals are placeless.

In several Salish languages (Rose specifies Thompson, Moses-Columbian, Lillooet, Colville, and Shuswap), uvulars, pharyngeals, and pharyngealized consonants (emphatics) all cause retraction of a preceding vowel, but laryngeals do not, as in the Thompson examples in (25a) below. Furthermore, laryngeals are transparent to retraction triggered by a non-laryngeal guttural (25b) (Bessell & Czaykowska-Higgins 1992: 40-41; Rose 1996).

(25) *Thompson non-laryngeal guttural vowel retraction*

a. *Laryngeals are not triggers*

	/məʕ't/	[mʌʕ't]	'broken'
	/ʔiq't/	[ʔeq't]	'scraped off'
	/ʔuq^{w}eʔ/	[ʔoq^{w}eʔ]	'drink'
cf.	/niʔhelus/	[niʔhélus]	'good-natured'

b. *Laryngeals are transparent*

/miceʔq/	[mícæʔq]	'sit'
/snəʔẓ/	[snʌʔẓ]	'mountain goat hair blanket'

Since laryngeals do not pattern with other gutturals in triggering retraction in Salish, they are viewed by Bessell & Czaykowska-Higgins as being placeless.

Rose argues, however, that the transparence of laryngeals in Salish vowel retraction does not necessarily indicate that laryngeals are placeless. Citing Afroasiatic languages, she points out that the Salish pattern parallels the retraction effect of 'emphasis' in Moroccan Arabic and Tamazight Berber, where uvulars, pharyngeals, and pharyngealized consonants all cause retraction of adjacent vowels, while laryngeals never do. The Afroasiatic vowel retraction is attributed to an [RTR] feature, which is specified on uvulars, pharyngeals, and pharyngealized segments. Laryngeal segments, however, cannot be [RTR], as they are not articulated with any appreciable tongue root retraction or other constriction in the pharynx (McCarthy 1994). Thus, Rose argues that laryngeals in these languages are still Pharyngeal, as one would expect with a post-velar consonant inventory, but they are transparent to guttural vowel retraction by virtue of the fact that they are not [RTR].

Given Rose's (1996) proposal and the typological predictions it makes, English /h/ must be placeless: English completely lacks uvular and pharyngeal segments, making it impossible to motivate activation of the Pharyngeal node needed for a Pharyngeal laryngeal. In the next section, we examine whether English /h/ follows the pattern of behaviour established for placeless /h/ in section 2.1.

2.4. Which /h/ is English /h/?

As mentioned, English /h/ is expected to be placeless, as English lacks post-velar consonants. Furthermore, Keating (1988) presents acoustic evidence of English /h/ being underspecified for place features in surface phonetic representations. Yet when one considers the behaviour of English /h/, we encounter a problem: English /h/ does not seem to pattern with placeless /h/ in the world's languages more generally.

In sections 2.1.1 – 2.1.3 above, three properties of placeless /h/ were discussed: placeless /h/ allows for translaryngeal harmony, placeless /h/ makes a good coda, and placeless /h/ is the result of debuccalisation. English does not exhibit vowel harmony, so we will not find any evidence of placelessness in translaryngeal harmony, nor do most dialects exhibit debuccalisation.[10] The observation that placeless /h/ is a preferred coda segment, however, is

[10] Harris (1990) reports that in Liverpool vernacular English, a final /t/ undergoes spirantisation and debuccalisation in function words to surface as [h] (Harris 1990: 266).

[æh]	*at*	[nɒh]	*not*
[ðæh]	*that*	[bʊh]	*but*

informative, because in English, /h/ is surprisingly banned from codas: other than interjections such as *oh*, *uh*, *ah*, and *eh*, which have an orthographic *h* that is not realized as [h], the only words in the lexicon with potential coda *h* are loanwords, and none of these are ever realized with [h] ((26), Davis & Cho 2003: 610).

(26) *Unrealized coda /h/ in loanwords in English*

Te~~h~~.ran
bra~~h~~.min
Ya~~h~~.we~~h~~
Fa~~h~~d

Additionally, it has been noted (Jensen 1993, Davis & Cho 2003) that English /h/ does not freely occur in onsets either: neither /h/ as the second member of a complex onset, as in (27a), nor /h/ at the beginning of an unstressed syllable following a stressed syllable (27b) is realized (Davis & Cho 2003: 610). Interestingly, the words in (27b) are morphologically related to the forms in (27c), where the /h/ is realized due to a difference in the location of stress.

(27) *Unrealized /h/ in onsets*

a. *No /h/ as second member of complex onset*

B~~h~~utan
ex~~h~~ibition
ex~~h~~ibit

b. *No /h/ as onset of unstressed syllable following stressed syllable*

vé.~~h~~i.cle
prò.~~h~~i.bí.tion
prè.~~h~~i.stó.ric[11]
ìn.~~h~~i.bí.tion

[11] Some speakers do produce [h] in *prehistoric* and *inhibition*, however, when they do they also place secondary stress on this syllable: prè.[h]ì.stó.ric, ìn.[h]ì.bí.tion.

c. */h/ realized with stress shift*

ve.[h]í.cu.lar pro.[h]í.bit pre.[h]í.sto.ry in.[h]í.bit

It would seem, then, that in certain positions in English, an underlying /h/ cannot be realized and is subject to deletion.

The main purpose of Davis & Cho's presentation of the patterns of English /h /is to show that this segment's distribution parallels that of aspirated stops: both appear at the beginning of a stressed syllable (28) and at the beginning of an unstressed word-initial syllable (29). Similarly, both are banned in coda position (30), at the beginning of unstressed non-initial syllables (31), and as non-initial members of complex onsets (32) (Davis & Cho 2003: 609 – 610).[12]

(28) */h/ and aspiration at the beginning of a stressed syllable*

a.	b.
[h]ábit	[k^h]ándy
ma[h]ógany	ma[t^h]érial
ad[h]érence	a[p^h]éar
álco[h]òl	dáven[p^h]òrt
[h]ỳpótenuse	[t^h]ìtánic
Ída[h]ò	cú[k^h]ùmber

(29) */h/ and aspiration at the beginning of an unstressed word-initial syllable*

a.	b.
[h]orízon	[p^h]otáto
[h]abítual	[t^h]omáto
[h]ypócrisy	[k^h]onnéct

[12] Davis & Cho also note that both /h/ and aspiration are realized at the beginning of a word-internal unstressed syllable when this is immediately preceded by an unstressed syllable and followed by a stressed one, as in *lòla[p^h]alóoza* and *àbra[k^h]adábra*. Only one example of this type is given for /h/: *Tàra[h]umára*.

(30) *No /h/ or aspiration in coda*

a.		b.	
	Te~~h~~.ran		a[tʾ].las
	bra~~h~~.min		a[kʾ].ne
	Ya~~h~~.we~~h~~		la[pʾ]se
	Fa~~h~~d		hy[pʾ].nosis

(31) *No /h/ or aspiration at the beginning of an unstressed non-initial syllable*

a.		b.	
	vé.~~h~~i.cle		á[ɾ]om
	prò.~~h~~i.bí.tion		Mí[k]ey
	ní.~~h~~i.lism		rá[p]id

(32) *No /h/ or aspiration as non-initial member of complex onset*

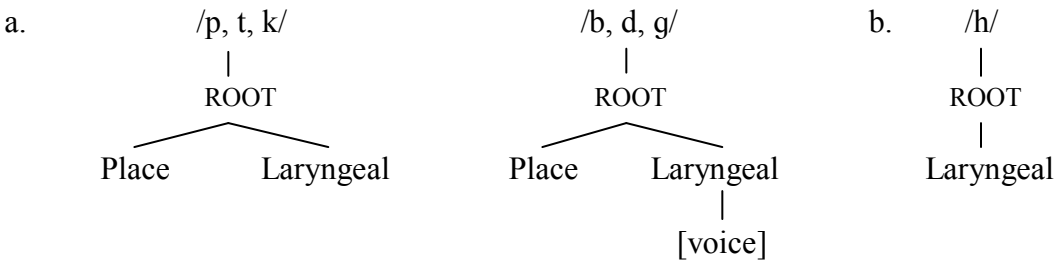
a.		b.	
	B~~h~~utan		s[k]í
	ex~~h~~ibition		ex[p]osítion
	ex~~h~~ibit		ex[t]ínguish

It would seem, then, that whatever featural attributes are appropriate for aspirated stops in English are also appropriate for English /h/, as these segments pattern together. We take this up further in the next section.

2.5. English as an 'aspiration' language

The discussion thus far has focused on the features associated with /h/ on the place dimension. Entirely separate from place specification is the issue of what laryngeal features might be associated with /h/. Indeed, the laryngeal features that are associated with /h/ in a given language are dependent on how voicing contrasts are represented in that language more generally. In languages with a two-way contrast between voiced and voiceless obstruents, this is typically captured as the presence of [voice] on voiced obstruents, as in Japanese ((33) e.g., Itô & Mester 1986).

(33) *Two-way voicing contrasts: [voice] languages (e.g., Japanese)*



Strong evidence in support of these representations comes from analysis of the Rendaku voicing phenomenon and its pattern of exceptions, known as Lyman's Law. In Yamato Japanese compounds, Rendaku voicing causes the initial voiceless obstruent of the second member of the compound to surface as voiced, as shown in (34a) below. If, however, the second member of the compound contains a voiced obstruent in another position, as in (34b), Rendaku voicing is blocked as per Lyman's Law. Itô & Mester (1986, 1989) analyze this as an OCP effect: the presence of [voice][13] on the voiced obstruent prohibits the addition of [voice] to the initial voiceless obstruent. Crucially, sonorant consonants, which are voiced, do not trigger Lyman's Law (34c), indicating that voicing in obstruents is represented differently than it is in sonorants.

[13] Whether these features are binary or unary is not critical; what matters here is that they are active in the grammar of the language. I will use unary features from this point on.

(34) *Rendaku voicing and Lyman's Law in Japanese (data: Itô & Mester 1986)*

a. *Rendaku voicing*

(i)	de 'leave'	+	kutʃi 'mouth'	degutʃi 'exit'
(ii)	e 'picture'	+	tako 'kite'	edako 'picture kite'
(iii)	hanaʃi 'talk'	+	heta 'bad'	hanaʃibeta 'poor talker'

b. *Lyman's Law*

(i)	kami 'god'	+	kaze 'wind'	kamikaze 'divine wind'	*kamigaze
(ii)	siro 'white'	+	tabi 'tabi'	sirotabi 'white tabi'	*sirodabi
(iii)	maru 'completely'	+	hadaka 'naked'	maruhadaka 'completely naked'	*marubadaka

c. *Sonorants do not trigger Lyman's Law*

(i)	iro 'colour'	+	kami 'paper'	irogami 'coloured paper'	*irokami
(ii)	garasu 'glass'	+	tana 'shelf'	garasudana 'glass shelf'	*garasutana
(iii)	mizu 'water'	+	hana 'nose'	mizubana 'running nose'	*mizuhana

Notice that (34aiii) shows that /h/ patterns with other voiceless obstruents, and is subject to Rendaku voicing when at the left edge of the second member of a compound, where it is voiced to [b].

In some languages, rather than finding behaviour like the Japanese case illustrated above, we find that voiced obstruents pattern with sonorant consonants. This is the case in some dialects of Spanish: in (35a), /s/ surfaces as [z] when followed by a sonorant; (35b) shows that this also occurs when it is followed by a voiced obstruent (data from Avery 1996). Avery (1996) interprets these facts as evidence that voicing in obstruents in Spanish is captured using the Sonorant Voice (SV) node (Piggott 1992, Rice 1993).

(35) */s/ realized as [z]*

a. *before sonorants*

i[zl]a	'island'
mi[zm]o	'same'
a[zn]o	'donkey'

b. *before voiced obstruents*

di[zg]usto	'trouble'
e[zb]ozo	'sketch'
de[zd]eñar	'to scorn'

In terms of the representation of voicing, voiced obstruents are thus specified for an SV node; voiceless obstruents lack this node (Avery 1996). This is shown in (36).

(36) *Two-way voicing contrasts: SV languages (e.g., Spanish)*

a. /p, t, k/ — ROOT — Place

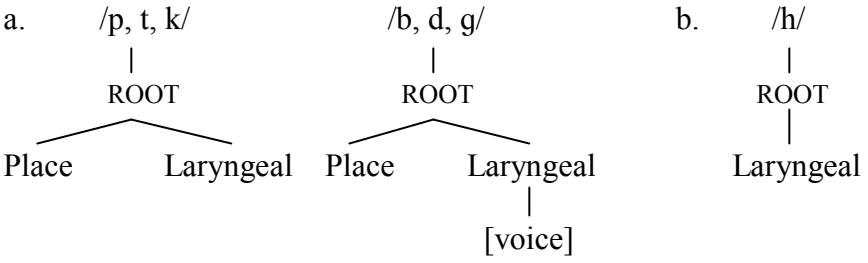
/b, d, g/ — ROOT — Place, SV

b. /h/ — ROOT

In dialects of Spanish with [h], arising either from orthographic <j> and <g> before <e> or through debuccalisation (/s/ > [h] in coda), [h] would thus lack both the Place node and the Laryngeal node.

Given that English employs a two-way voicing contrast but lacks a system like the one found in Spanish, the voicing contrast is traditionally assumed to be represented as in Japanese, with voiced obstruents bearing a [voice] ([+voice]) feature, and voiceless obstruents bearing a Ø ([-voice]) feature (e.g., Chomsky & Halle 1968, Spencer 1996). Thus English has been viewed as having voicing (and not aspiration) contrasts among its obstruents, as aspiration on voiceless stops is fully predictable: as shown earlier, aspirated stops occur in foot-initial and word-initial position while unaspirated stops occur elsewhere. This is a classic case of allophonic distribution, hence the analysis that aspirated and unaspirated stops are both allophones of a single set of phonemes, the plain voiceless stops. In feature geometric terms, English stops on this view are analyzed as having representations along the lines of those in (37a); given the lack of post-velar consonants, /h/ would have the representation given in (37b).

(37) *English 'voicing' as [voice]*

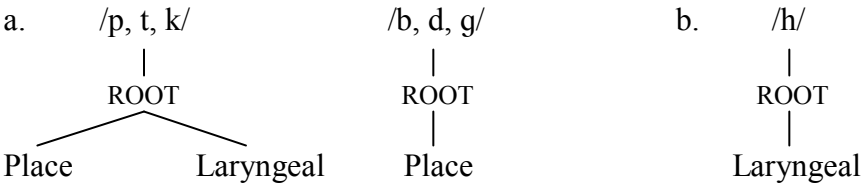


Under this view, the [SG] feature that characterizes aspiration is added in phonetic implementation.

More recently, a number of researchers examining voicing contrasts (Iverson & Salmons 1995, Avery 1996, Avery & Idsardi 2001) have challenged this view. They have proposed that the traditionally termed 'voicing' contrast for English obstruents is not really voicing, but aspiration.[14] That is, the distinction is not between voiceless and voiced obstruents as described above, but between aspirated [SG] and plain Ø obstruents. Here, two distinct proposals have been developed: English as a contextual voicing language (Avery 1996), and English as an [SG] language (Iverson & Salmons 1995).

Avery (1996) departs from the view presented in (37) above, arguing that English is a contextual voicing language, with representations as in (38a) below; the representation for /h/ in (38b) is consistent with Avery's proposals for the representation of other voiceless consonants.

(38) *English 'voicing' as contextual voicing (Avery 1996)*



Though the representation of voiced consonants has changed, the representation of voiceless consonants and the implementation of aspiration as a phonetic process are essentially as they were viewed previously: Avery's (1996) Laryngeal

[14] Avery & Idsardi (2001) propose that English 'voicing' be expressed by the Laryngeal dimension of Glottal Width (GW). Here I will continue to make use of the more frequently used [SG].

Enhancement Rule ensures that any bare Laryngeal node is enhanced with [SG]. Though Avery does not discuss /h/ explicitly, under the proposal that all other voiceless consonants have a Laryngeal node, it is reasonable to expect that /h/ would also be specified for Laryngeal, as in (38b), and thus would also be subject to the Laryngeal Enhancement Rule, thereby being phonetically [SG].

Drawing on evidence from the phonetics literature, however, Iverson & Salmons (1995) argue that it cannot be the case that [SG] is added to the representation of voiceless stops by rule. Citing Kim (1970), who analyzes aspiration as a function of glottal opening at the time of release, they point out that experimental work using photoelectric glottography (see Kingston 1990 for a review) shows that in the production of fricative-stop clusters, where no aspiration is produced, as in the word *spit*, a peak in glottal opening that is associated with [SG] typically occurs internal to the fricative, close to the boundary between the fricative and the stop. This same peak in glottal opening occurs in the production of both voiceless fricatives and voiceless aspirated stops, though with different timing: for fricatives, the peak in glottal opening is coordinated with the beginning of oral constriction, whereas for stops it occurs at the point of oral release, thereby producing audible aspiration.

If [SG] is absent from underlying representations, added later in phonetic implementation, then it is unclear why the gesture associated with this feature is found in contexts where no aspiration is being produced. If, however, [SG] is present underlyingly for all voiceless consonants in English, as in Iverson & Salmon's analysis, then the presence of its associated gesture in the production of

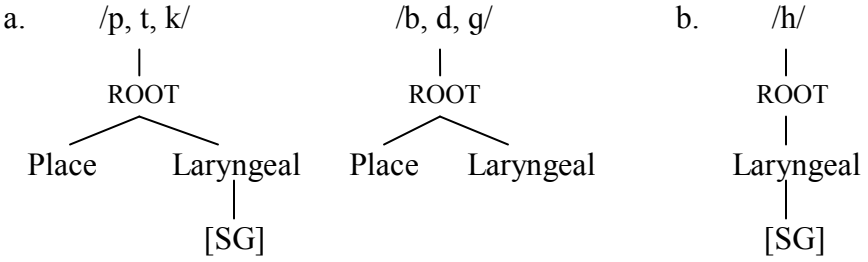
spit is accounted for: both /s/ and /p/ are underlyingly specified as [SG], but the OCP forces removal of one instance of this feature, so that the two segments share a single [SG] feature. The result is one peak in glottal opening during the production of the cluster, and the timing of this peak (near the boundary between fricative and stop) reflects that the feature is shared between two segments, hence no audible aspiration on the stop.

To account for the observation that unaspirated voiceless stops in English occur, as in *alter* (*al[t^h]er) and *satyr* (*sa[t^h]yr), here in spite of an underlying [SG] specification, Iverson & Salmons cite Kingston & Diehl (1994), noting that the degree of vocal fold abduction, or peak glottal opening, is tied to metrical prominence. In the most prominent position, foot-initial in a word-level prominent foot, the [SG] feature can be implemented with the greatest degree of glottal opening. If a stop is in a foot-initial position that is not prominent at the word-level, it will still be produced with aspiration, but a lesser degree, as less vocal fold abduction is achieved. Those stops in non-prominent positions (e.g., codas) are produced with weak implementation of [SG], resulting in no aspiration, in spite of being specified as [SG]. Thus Iverson & Salmons argue for step-wise decreases in the implementation of [SG] as determined by metrical prominence, as opposed to arguing for presence or absence of [SG] depending on metrical prominence.

If English 'voicing' is truly aspiration, then the representations for voiceless and voiced stops would be as in (39a) below. Given that /h/ and

aspirated stops have identical distributions, the representation for /h/ given in (39b) follows from (39a).

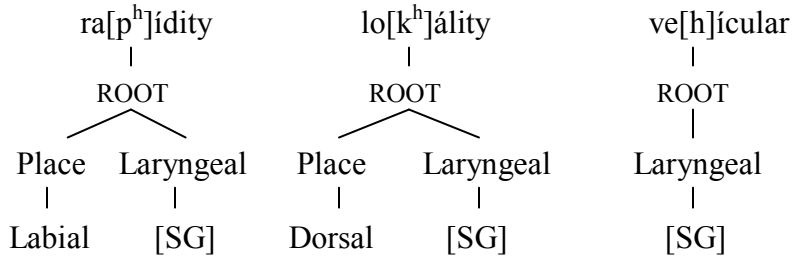
(39) *English voicing as [SG]*[15]



While I adopt Iverson & Salmons' proposal that [SG] is present underlyingly for voiceless stops as well as /h/ in English, I argue that their claim that this feature is always present for these segments is incorrect, as it makes the wrong predictions in some contexts, both for voiceless stops and for /h/. Consider first the pairs given in (40): on their view, the underlying [SG] is present in all instances, but is not audible in (40b) due to a lack of metrical prominence.

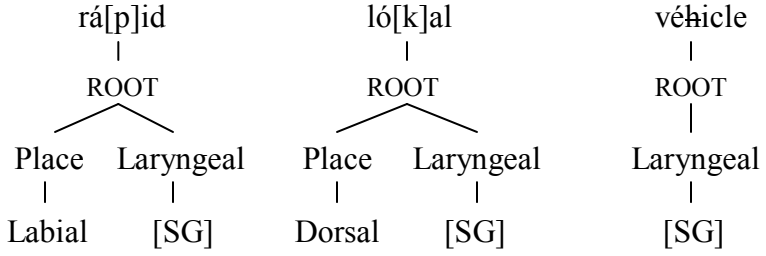
(40) *[SG] is always present in representations*

a. *Audible [SG]*



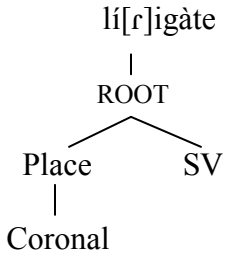
[15] The representations in (39a) are not those given by Iverson & Salmons (1995): I have adapted them to reflect my assumption that [SG] is a dependent of Laryngeal.

b. *Inaudible [SG]*



For these pairs, Iverson & Salmons' analysis appears to be correct. A problem arises, however, when one considers the voiceless coronal stop /t/: in many dialects of English, /t/ is subject to flapping in prosodically weak onsets, as shown for *litigate* in (41).

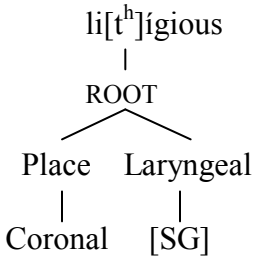
(41) *Flapping of /t/ in 'litigate'*



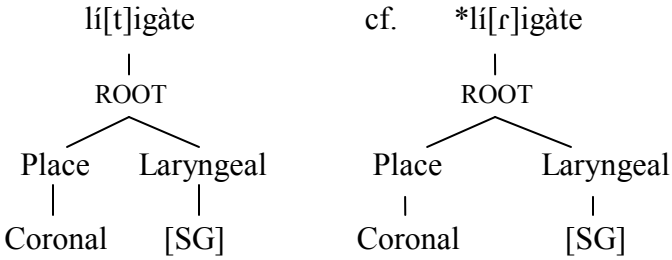
Iverson & Salmons' analysis predicts an unaspirated [t] in this context, as the underlying [SG] is not audible due to a lack of metrical prominence. This is the right result for non-flapping dialects, but for flapping dialects the problem is that it is not clear how to account for the appearance of [ɾ], which is typically analyzed as a sonorant (Chomsky & Halle 1968, Avery 1996), if /t/ maintains its [SG] specification.

(42) */t/ and [SG]*

a. *Audible [SG]*



b. *Inaudible [SG], but no flapping*

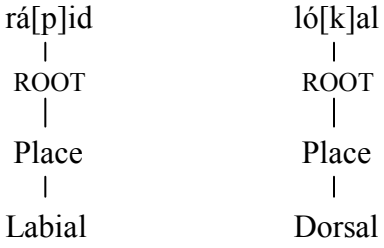


It has been observed that sonorants and obstruents differ in their voicing gesture, resulting in an acoustic difference between voiced obstruents and sonorants (see Avery 1996). I adopt the position that voicing in obstruents is Laryngeal voicing, while voicing in sonorants is due to the SV node (Piggott 1992; Avery 1996), as these segments are inherently voiced cross-linguistically (Chomsky & Halle 1968). In dialects with flapping, the coronal stop acquires an SV node from adjacent vowels; this would not be possible if the Laryngeal node and [SG] feature remained in the representation. Flapping, then, stands as evidence for delinking of both [SG] and Laryngeal in positions that lack metrical prominence; speakers who do not have flapping delink [SG], but not Laryngeal, resulting in a voiceless unaspirated stop.

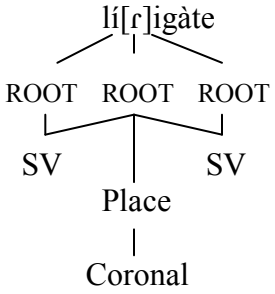
With both Laryngeal and [SG] delinking in flapping dialects, the representation of noncoronal unaspirated stops would be as in (43a); the coronal flap would be as in (43b). Unaspirated stops in non-flapping dialects would be as in (43c). The representation of aspirated stops in both dialects remains unchanged from those given above in (39a).

(43) *Representation of unaspirated stops*

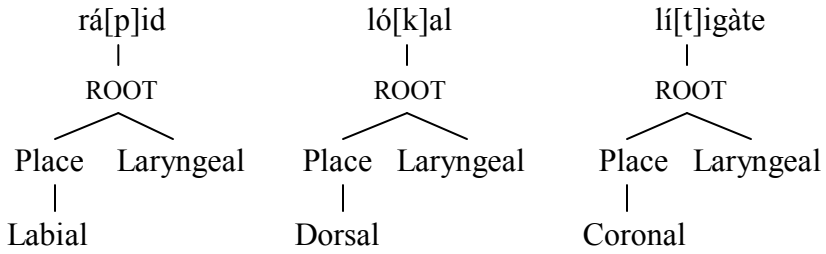
a. *Noncoronal stops – flapping dialects*



b. *Coronal stop – flapping dialects*



c. *Non-flapping dialects*

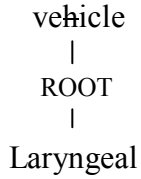


Under the approach that both Laryngeal and [SG] delink in prosodically weak positions for voiceless stops in flapping dialects, /h/ is also subject to delinking of Laryngeal and [SG] in these positions, leaving behind a bare root node, as in (44a). For non-flapping dialects, /h/ is still subject to delinking of [SG], resulting in the representation in (44b).

(44) *Representation of phonetically unrealized 'h'*

a. *Flapping dialects*

b. *Non-flapping dialects*



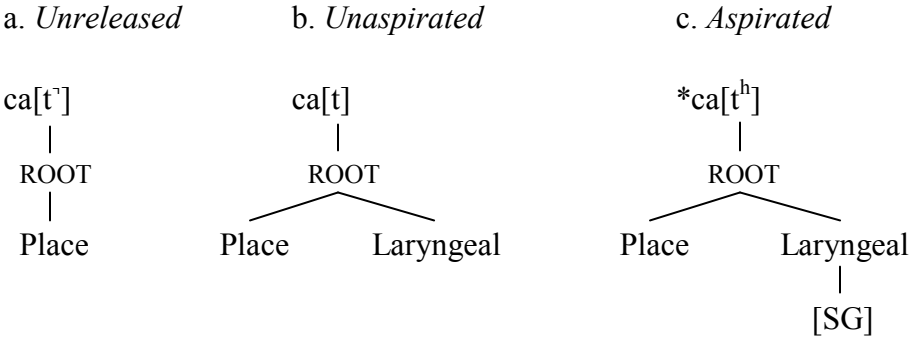
As /h/ lacks place features, the features that remain once [SG] is removed are insufficient for phonetic implementation, resulting in silence. That is, the parallel between the representation of aspirated consonants and the representation of /h/ leads to the conclusion that the apparent disappearance of /h/ in positions that lack metrical prominence, as in *véhicle*, are not actually cases of /h/-deletion. Rather, the segment remains, but without features that allow for phonetic realization.

This analysis is reminiscent of analyses proposed for the phenomenon of *h-aspiré* in French, where processes that repair vowel hiatus do not apply due to the presence of an empty consonantal position (Clements & Keyser 1983; see

Anderson 1982, Tranel 1995 for discussion). We return to the significance of this in chapter 3.

The proposed link between [SG] and metrical prominence also allows us to develop an account for the ban on /h/ in coda position in English: codas are not prosodically prominent positions, so it is not surprising that [SG] should be banned from these positions if it is also banned from non-prominent onsets. Let us first consider voiceless stops in coda position. Recall that in Iverson & Salmons' analysis, [SG] is still present for coda consonants, but it is not realized due to the absence of metrical prominence. Under the current account, by contrast, there are two options available for the realization of voiceless stops in coda in English: Laryngeal delinks (along with [SG]) to yield an unreleased stop, as in (45a), or [SG] alone delinks to yield an unaspirated (released) stop, as in (45b). Aspirated stops do not occur in coda position, as English bans [SG] here (45c). Notice that for both unreleased and unaspirated voiceless stops, the presence of place features remaining in the representation of these segments in coda position results in phonetic implementation of some information, resulting in an audible articulation.

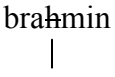
(45) *Representations for voiceless stops in coda*



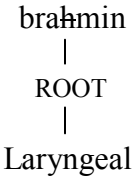
For /h/, the same ban on [SG] in coda position holds, and both options observed for removing [SG] from codas are available for /h/ as well, as illustrated in (46) below. As was seen above in (44) for /h/ in non-prominent onsets, removing [SG] from a placeless segment has the effect of removing all audible information for /h/, resulting in the apparent absence of the segment.

(46) *[SG] ban in codas silences potential coda /h/*

a. *Delink Laryngeal node*



b. *Delink [SG] only*



2.6. Summary

Thus far we have examined the possibilities for the representation of /h/ and compared the available typological information with the properties of English, coming to the conclusion that English /h/ must be a placeless /h/, and cannot be a Pharyngeal /h/. Yet, English /h/ does not seem to exhibit the properties typically associated with placeless /h/: most strikingly, English /h/ is banned from codas, whereas placeless /h/ is cross-linguistically a preferred coda segment. The observation that /h/ has a precisely identical distribution to that of aspirated stops in English suggests that in addition to being placeless, English /h/ is also [SG]. The observed restrictions on the distribution of /h/ are then not related to place, but instead are due to conditions on where [SG] can appear.

L2 acquisition scenarios present researchers with a unique opportunity to examine what learners know about their first language, their second language, and how the knowledge of native speakers differs from that of L2 learners. Given that several options exist for the representation of /h/ in languages, the same number of possibilities should exist for interlanguage grammars as well. As will be shown in chapter 3, not all of these options are available to speakers of a given L1, and each possible representation makes its own set of concrete predictions for L2 phonology scenarios. L2 learner behaviour, then, can serve as supporting evidence for proposals about the knowledge contained in grammars: if an L2 learner is shown to lack knowledge of property *x* in his interlanguage grammar, then this supports the claim that *x* is unavailable for transfer from his L1. If, on the other hand, an L2 learner is shown to possess knowledge of property *y* in his interlanguage grammar, then this supports the claim that *y* is available for transfer from his L1, assuming that the learner does not have full access to UG. In chapter 3, we will present the case of francophone learners of English, examine the predictions made by the different possible representations of /h/, and evaluate the availability of these to the interlanguage grammar.

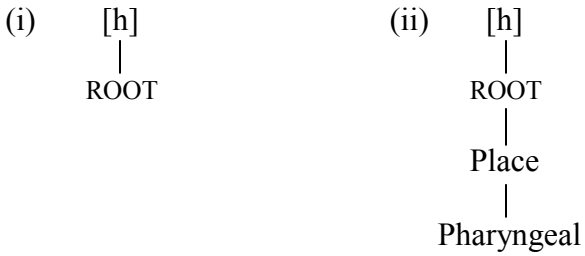
Chapter 3: Transfer and representations in L2 phonology: the case of francophones and English /h/

3.0. Introduction

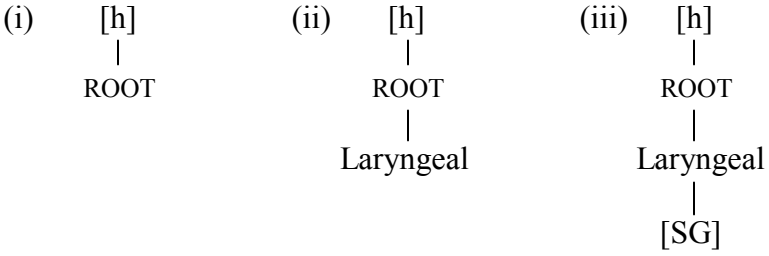
The cross-linguistic survey of laryngeal behaviour in chapter 2 indicates that there are two possibilities for the representation of laryngeals on the place dimension: in languages with post-velar consonants, they are Pharyngeal; otherwise, they are placeless. As English lacks post-velar consonants, English /h/ was argued to be placeless. With respect to its laryngeal specification, there appear to be three options for [h]. In languages like Japanese, [h] and other voiceless obstruents are specified for a bare Laryngeal node. Avery (1996) argues that in languages like Spanish, voicing in obstruents is captured through the SV node, leaving voiceless obstruents without a Laryngeal node: in dialects with [h], arising either from orthographic <j> and <g> before <e> or through debuccalisation (/s/ > [h] in coda), [h] would thus lack both the Place node and the Laryngeal node. An examination of the distribution of [h] in English, however, suggests that here it must be specified for laryngeal features; namely, [SG]. Consequently, a number of representational options are available for [h]; the options for Place are given in (1a), while the options for Laryngeal are in (1b) below.

(1) *Representational options for [h]*

a. *Place*



b. *Laryngeal*



In the context of L2 acquisition, the various options available for /h/ reflect a number of possibilities for the representation of laryngeals in interlanguage grammars, each making different predictions for observed L2 behaviour. Which option(s) the learner entertains will largely depend on the learner's L1. Assuming that learners transfer their L1 phonological representations into the interlanguage grammar, in order to make any changes to this system, any novel L2 segment that presents a challenge must be analyzed as being incompatible with the transferred knowledge: it seems to require something in its representation that the system does not provide. Learners' behaviour can thus shed light on what alternate representation they may be using in their interlanguage grammars when the target representation is not available.

We now turn to discuss the case of francophones acquiring L2 English /h/, where the results to date suggest that an appropriate representation is particularly difficult to attain.

3.1. Francophones and the trouble with 'h'

3.1.1. 'h' is problematic in both production and perception

The fact that francophones struggle with English /h/ is apparent to casual observers. Interestingly, francophones do not routinely omit /h/, but rather omit it in some cases while sometimes epenthesizing [h] with vowel-initial words (Janda & Auger 1992, John 2006; see also Friesner (2009) for discussion of /h/ in loanword phonology), thus producing utterances like those given in (2) ((2a) Janda & Auger 1992; (2b) my own recordings (see chapter 6)).[1] Furthermore, this difficulty is persistent, observed in even very high proficiency L1 French L2 English speakers who have been living and working in a primarily English-speaking environment for several years. Though /h/-omission is observed more frequently than [h]-epenthesis, it seems that francophones do not know which words should have an [h], and which ones should not.

(2) *[h] errors produced by francophones*

a. "...'ead[h]ache..."
"...[h]ass'ole..."

b. "Be careful [h]as you sip this..."
"...I will 'elp you..."

[1] The apostrophe in (2a) does not indicate the use of a glottal stop, only the absence of [h] (Auger, p.c.). For consistency, I follow Janda & Auger's apostrophe usage in (2b).

The observation that [h] is epenthesized inappropriately suggests that the root of the problem lies in perception. LaCharité & Prévost (1999) examined the discriminatory abilities of francophones who were very advanced English learners, having completed a course on English phonetics and preparing to teach English as a second language. The segments they chose to examine were [ŋ], [θ], and [h], all of which are absent from French, and must therefore be acquired in L2 English. On an AX discrimination task, they found that while these very advanced learners performed like native speakers on /n/ vs. /ŋ/ pairs (*fan* vs. *fang*) and /t/ vs. /θ/ pairs (*tin* vs. *thin*), they were significantly less accurate on Ø vs. /h/ pairs (*eat* vs. *heat*). Furthermore, when asked about English /h/, francophones frequently complain that this segment is difficult to hear.[2]

3.1.2. The significance of francophone difficulties with 'h'

Much research in L2 phonology has sought to understand why certain new segments are susceptible to perceptual difficulties, which in turn lead to difficulties in production (Flege 1987, 1995; Best 1995; Major & Kim 1996). That is, researchers are interested in identifying the properties of the interlanguage grammar, how these differ from the grammars of native speakers, and what role the learner's L1 grammar plays in accounting for these differences. Typically, difficulty with a novel L2 segment is interpreted as the absence of an appropriate representation for this segment in the L1 grammar (Flege 1995, Major & Kim 1996, Brown 1997). Since the learner is unable to employ the new segment's

[2] I am basing this statement on comments made by francophone students in English pronunciation classes I have taught at l'Université du Québec à Montréal.

target representation, yet must lexically store something in the phonological representation of words containing this segment, the learner must rely on other available segmental representations. Storing one representation for two distinct target segments leads to the observed inability to discriminate between them: the learner has no way to distinguish between them, and thus confuses them in both perception and production.

The case being examined in this thesis, however, differs from the scenario examined elsewhere in the L2 phonology literature, in which two segments are funneled into one representation. As we will see in greater detail in 3.3 below, Japanese speakers encounter great difficulty distinguishing between English /l/ vs. /r/, as these two segments are assigned a single representation in their interlanguage grammar. Francophones, however, are not confusing English [h] with another segment; rather, they are confusing it with silence. The theoretical implications of this differ, depending upon the level of analysis one considers to be of consequence: a segment-based analysis will make different predictions for acquisition than will a feature-based analysis.

3.2. Segment-level approach to L2 phonology

In Flege's Speech Learning Model (SLM; Flege 1995), a segment-level analysis of L2 phonology, difficulty or inability to acquire a new segment reflects an inability to create a new abstract phonetic category for that segment: a mechanism of equivalence classification[3] causes the new segment to be treated as

[3] Though equivalence classification is based on phonetic similarity, phonetic similarity is not defined, nor does Flege mention the degree of similarity that must exist before two segments will be deemed to be members of a single phonetic category.

an instance of an existing phonetic category, resulting in non-discrimination of the new contrast. The often-cited case of L1 Japanese L2 English speakers and their difficulties with the English liquid contrast is thus analyzed as an inability to create distinct phonetic categories for /l/ and /r/. Japanese has only one liquid phoneme, hence one liquid phonetic category. The phonetic similarity of /l/ and /r/ causes these two segments to be subject to equivalence classification by Japanese speakers: they are both included in the single liquid phonetic category, and as a result learners are unable to distinguish between the two.

For francophones acquiring English /h/, the problem involves a single segment, which they appear to have difficulty detecting in the speech stream. That is, it is not the case that there are two phonetic segments that L2 learners are unable to distinguish, resulting in their being assigned to a single category and thus having identical stored representations. Rather, francophones' inability to discriminate /h/-initial words from corresponding vowel-initial words would be interpreted under the SLM as /hV.../ and /V.../ sequences being stored with identical representations through equivalence classification: they would all be represented as /V.../. In other words, the SLM suggests that English /h/ is too similar to silence for francophones to be able to differentiate between the two and create a novel category for /h/. For perception, this predicts that francophones should be unable to detect the presence of /h/, which seems to be true. For production, given that all instances of /hV.../ are being represented as /V.../, this also predicts that francophones should consistently delete /h/ from their productions. While this pattern is observed for some speakers (see chapter 6), it is

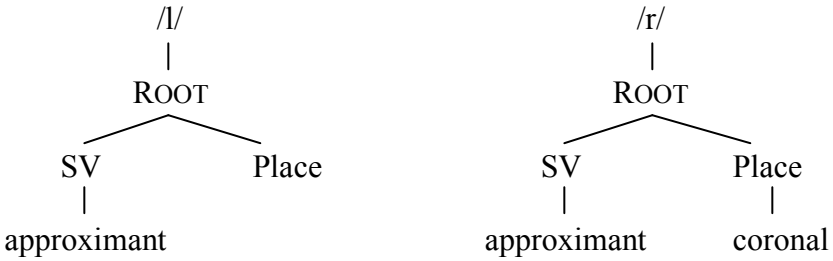
not the only pattern of behaviour: crucially, the analysis does not predict [h]-epenthesis, which is also attested.

3.3. Feature-level approach to L2 phonology: Full transfer partial access

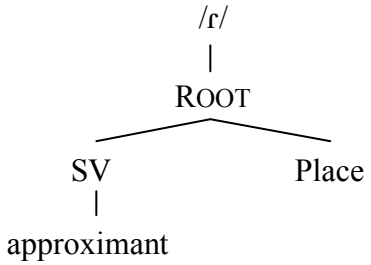
A different approach to L2 segmental acquisition is feature-based. We first consider the full transfer partial access feature-based approach of Brown (1997, 2000). Brown argues that learners can construct phonological representations for novel L2 segments, but only using those features that are contrastively used in the learner's L1. If the L1 does not supply a feature required in the L2, the learner will be unable to construct an appropriate representation, resulting in non-discrimination of the new contrast. For the case of L1 Japanese L2 English speakers and English /l/ vs. /r/, Brown assumes that the critical feature that allows for distinct representation of /l/ and /r/ in English is [coronal], as in (3a) below. Brown also assumes that Japanese has the single liquid representation given in (3b), and that the [coronal] feature is entirely absent from the Japanese grammar, as there are no place contrasts dependent on sub-coronal features in the language.

(3) *Segmental representations (Brown 2000: 11)*

a. *English approximants*



b. *Japanese approximants*



As Brown argues that new features cannot be acquired in L2 acquisition, this means that Japanese speakers will never be able to construct two distinct liquid representations as in (3a), and thus the only representation available for both /l/ and /r/ in their L2 English grammar is the one given in (3b). Their difficulties with this contrast are therefore predicted to persist despite increasing proficiency.

Experimentally, this prediction is borne out: on a 4IAX discrimination task, L1 Japanese speakers were significantly worse than native English speaker controls at discriminating between English /l/ and /r/. These same speakers were, however, as good as the native English speaker controls at discriminating between English /f/ and /v/, as well as English /p/ and /f/, even though these two contrasts are also absent in Japanese. Brown argues that the crucial difference between the acquirable /f/ vs. /v/ and /p/ vs. /f/ and the non-acquirable /l/ vs. /r/ is in the features required to build appropriately distinct representations. Both /f/ vs. /v/ and /p/ vs. /f/ require features that are present and manipulated in Japanese, [voice] and [continuant], respectively; acquisition of these segments thus requires demotion of highly ranked constraints barring the relevant combinations of features. As mentioned above, /l/ vs. /r/, on the other hand, requires [coronal],

which the Japanese grammar fails to supply, hence Japanese speakers' difficulty with this contrast.

While Brown argues that it is the L1 feature inventory that plays the deciding role in determining which segments can and cannot be acquired in L2 acquisition, her work does not address the question of how those features are transferred into the interlanguage grammar. There are two possibilities here. On the one hand, segmental representations are transferred as wholes that can only later be subjected to disassembly into component features and recombination into new representations as necessary, once the relevant markedness constraints against those feature combinations have been sufficiently demoted in the ranking.[4] On the other hand, the feature inventory itself is initially transferred, and new feature combinations can be built early on in acquisition. Evidence presented in Matthews (1997), however, supports the first option: the rearranging of transferred L1 features does seem to come at some cost, as noticeable improvement on new segments that can be built from L1 features is observed only with increasing proficiency.

Brown's proposal, then, involves full transfer from the L1 and partial access to UG: learners are able, with increasing proficiency, to recombine transferred L1 features into new combinations, but they cannot acquire new features. Applying this proposal to the case at hand, the difficulties francophones encounter with English /h/ would then be analyzed as being due to the

[4] A similar proposal for morphosyntactic features in interlanguage grammars appears in Lardiere (2009).

unavailability of some feature required for the representation of /h/ that is not supplied by the French grammar. In order to make sense of the problem, we must consider the inventory of features available for transfer from the grammar of French.

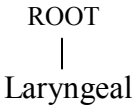
3.4. What could transfer from French?

In order to establish what features could be transferred into the interlanguage grammar from French, we will consider the maximum number of possibilities available. In French, obstruents contrast for voicing: the phoneme inventory includes both voiced and voiceless stops and fricatives (Walker 2001). Further, there are no aspirated stops in either the phonemic or the phonetic inventory: French voiceless stops are produced with a short-lag VOT, while voiced stops are prevoiced (Lisker & Abramson 1970, Caramazza et al. 1973, Caramazza & Yeni-Komshian 1974). The French grammar could therefore make use of the feature [voice][5] to capture voicing contrasts, yielding voicing representations as in (4), as observed for Japanese in chapter 2.

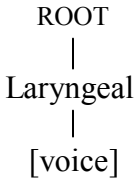
[5] If one were to assume binary features, as opposed to my assumption of unary features, then voiceless obstruents in French would have a [-voice] feature dependent on the Laryngeal node in (4a), along with a [+voice] feature rather than the [voice] that appears on (4b). This assumption would then have the consequence of both [+voice] and [-voice] being available for transfer into the interlanguage grammar. Importantly, the predictions for interlanguage grammar behaviour are not affected by this.

(4) *The representation of voicing in French obstruents employing [voice]*

a. *Voiceless obstruents*



b. *Voiced obstruents*



The feature [voice] and a bare Laryngeal node are thus potentially available for transfer from L1 French into the interlanguage grammar; [SG], however, is not.

Alternately, if French is like Spanish, and its voiced obstruents receive their voicing value not through a laryngeal feature, but through the Sonorant Voice (SV) node (Piggott 1992, Rice 1993, Avery 1996), then the representation of voicing changes, with the consequence of changing the features available for transfer into the interlanguage grammar. With SV voicing, the representations would be as in (5).

(5) *The representation of voicing in French obstruents employing SV*

a. *Voiceless obstruents*

b. *Voiced obstruents*

If one assumes these representations are correct, then only the SV node is available for transfer from L1 French into the interlanguage grammar; a bare Laryngeal node is not available, nor is [SG].

With respect to place features, the phoneme inventory of French includes the uvular rhotic [ʀ], which may be phonetically realized as a uvular fricative [ʁ] (Walker 2001). Assuming that uvulars are represented as dorso-pharyngeal

segments, this suggests the availability of Pharyngeal for transfer from the L1 French grammar, in addition to the more typical major place features Labial, Coronal, and Dorsal.[6] As discussed in chapter 2, in some languages laryngeals are specified for Pharyngeal place of articulation, suggesting that Pharyngeal laryngeals should be acquirable for francophones.

As mentioned in chapter 2, French also has a phenomenon known as 'h-aspiré', affecting a class of words beginning with orthographic <h>. As French lacks [h] altogether, the usual case with orthographic <h> initial words is that these behave as though they are vowel initial, and thus trigger the same phonological processes as vowel-initial words. One such process is elision, which deletes the vowel of the article *le* [lœ] before vowel-initial nouns in order to avoid vowel hiatus; the remaining consonant of the article is syllabified as the onset of the vowel-initial word, as in (6a). Words belonging to the 'h-aspiré' class, however, behave as though they are consonant-initial and do not trigger elision, resulting in vowel hiatus, as in (6b).

[6] Alternately, it may be that French [ʀ] is only uvular in its phonetic realization: it is the only uvular segment in the phoneme inventory, and rhotics have been shown to behave in similar ways cross-linguistically regardless of phonetic place of articulation and some have thus interpreted this as indicating that rhotics are permanently placeless (Rice 1992, Goad & Rose 2004). In this case, the underlying representation for [ʀ] would lack Pharyngeal; under this view, this feature would be absent from the grammar and thus unavailable for transfer. In the interest of considering the greatest number of possible options for francophone learners of English, we will not rule out the possibility that Pharyngeal may be available for transfer.

(6) *French 'h-aspiré' (Walker 2001)*

a. *Non-h-aspiré words trigger elision*

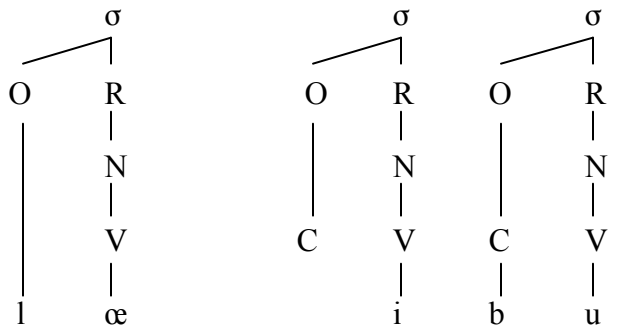
l'hiver 'the winter'		cf. l'automne 'the fall'	
[li.vɛʁ]	*[lœ.i.vɛʁ]	[lo.tɔn]	*[lœ.o.tɔn]
l'hôtel 'the hotel'		cf. l'enfant 'the child'	
[lo.tɛl]	*[lœ.o.tɛl]	[lɑ̃.fɑ̃]	*[lœ.ɑ̃.fɑ̃]

b. *h-aspiré words do not trigger elision*

le haut 'the top'		cf. le printemps 'the spring'	
[lœ.o]	*[lo]	[lœ.pʁɛ̃.tɑ̃]	
le hibou 'the owl'		cf. le chien 'the dog'	
[lœ.i.bu]	*[li.bu]	[lœ.ʃjɛ̃]	

Given that 'h-aspiré' words behave as though they are consonant-initial, and not vowel-initial, the analysis typically given to this phenomenon is that of an empty consonant position in the skeletal tier: that is, the word is truly consonant-initial, but the initial consonant has no segmental material associated with it (Anderson 1982, Clements & Keyser 1983, Sung 1989; see Tranel 1995 and Côté 2008 for discussion). This is illustrated in (7) for *le hibou*.

(7) *'h-aspiré' as an empty consonant position*



The ‘h-aspiré’ phenomenon reveals that the French grammar provides for a way of storing two sets of phonetically vowel-initial words that behave differently phonologically, and this is thus available for transfer. That is, the French grammar ranks the markedness constraint(s) against empty consonant positions relatively low, allowing violation in the case of ‘h-aspiré’; we would therefore expect this ranking to be available for English /h/.

3.5. Predictions for L2 English under Transfer

Let us now consider the predicted scenarios for francophones acquiring English /h/, given the information potentially available for transfer from L1 French and given the cross-linguistically possible representations seen in chapter 2.

Let us start with the scenario in which French voicing is represented using SV, with voiceless obstruents lacking a Laryngeal node altogether. English /h/ would be analyzed as the sort of laryngeal found in languages like varieties of Spanish with derived or underlying [h]: a bare ROOT node, lacking both place features and the Laryngeal node, as in (8) below.

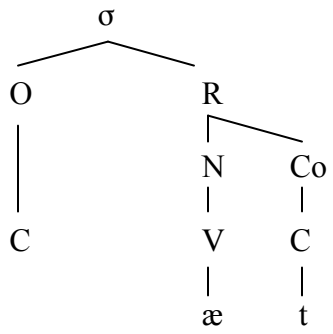
(8) *Interlanguage /h/ as bare ROOT node*

Under Brown’s proposal, the representation in (8) should be fully acquirable for francophones, as the French grammar supplies all the necessary features: every segment has a ROOT node. This means that we would predict francophones to be

able to demote any constraint requiring that consonants consist of more than the ROOT node, enabling speakers to strip all features from existing L1 representations in order to arrive at the representation in (8). However, the representation will presumably not be available at earlier stages of acquisition (as demonstrated by Matthews (1997) for Japanese learners of English). Since this representation is available to the interlanguage grammar, this in turn predicts that learners will be able to reliably perceive /h/: crucially, we would predict that francophones will come to consistently perceive this segment in English, as the interlanguage grammar would allow for some way to distinguish /h/-initial words from vowel-initial words in their underlying representations. Note that this prediction is at odds with observed learner behaviour: LaCharité & Prévost (1999) found that even with training in English phonetics, advanced speakers performed poorly on Ø vs. /h/ pairs in discrimination. With the eventual availability of this representation in the interlanguage grammar, we would also expect francophones to consistently produce this segment, though they may not always produce it in a target-like fashion: the absence of place features on (8) may be phonetically implemented as a uvular fricative (as per note 6), and may even surface as a phonetically empty position thereby exhibiting similar behaviour to 'h-aspiré' words in French. What is not predicted, however, is the appearance of [h] on vowel-initial words; the fact that these do occur, as exemplified in (2), in conjunction with the observed perception difficulties, suggests that the representation in (8) is not being employed in the interlanguage grammar of francophones.

A similar scenario involves English /h/ being analyzed as 'h-aspiré', represented as an empty consonant position as in (9) below. This option is fully available to francophones through transfer, with no further recombination or removal of features necessary (i.e., no adjustments to the constraint ranking are required), thus making them able to reliably perceive the segment even in very early stages of acquisition. As was the case with the /h/-as-bare-ROOT option, this representation makes the wrong prediction, as it seems that francophones do not reliably perceive /h/ in the input at *any* stage.

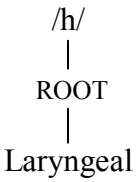
(9) *Interlanguage /h/ as 'h-aspiré' (target: 'hat' /hæt/)*



In this scenario, however, they are no longer expected to consistently produce a segment in this position, but rather consistently produce nothing, as is the case with 'h-aspiré' in French. The observation, however, is that the segment is frequently, but not consistently omitted; furthermore, francophones also inconsistently epenthesize [h] on vowel-initial words. This mismatch between predicted and observed behaviour suggests that francophones are not transferring the L1 representation for 'h-aspiré' into their interlanguage grammars.

If French voicing is represented with [voice], francophones may also analyze English /h/ as being placeless, but specified with a bare Laryngeal node, as would be the case for voiceless obstruents in French. The resulting representation would be like that found for /h/ in Japanese, given in (10).

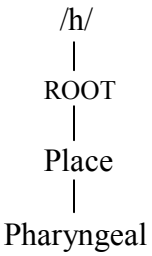
(10) *Interlanguage /h/ as Laryngeal*



In this scenario, francophones would again be predicted to be able to perceive this segment, as all necessary features can be transferred from French, as seen in (4a) above, though the representation may not be available in earlier stages of acquisition, as it requires demoting any constraints enforcing that consonants bear place features in order to enable removal of these. Due to the absence of place features, the segment may be correctly realized as a glottal fricative, or it may be realized as a phonetically empty segment. While this matches up with francophone performance on /h/-initial words, where /h/ is subject to optional deletion, the analysis crucially does not predict [h] epenthesis on vowel-initial words, which is also attested, as indicated in (2) above. Furthermore, like the other options explored thus far, this analysis predicts good performance in perception, whereas available evidence indicates that francophones' perceptual abilities with respect to /h/ are poor.

Turning to the place dimension, English /h/ could be analyzed as being Pharyngeal, as in Semitic languages, with a representation such as that given in (11); the presence of place features may occur with or without laryngeal features. This is the representation assumed by LaCharité & Prévost (1999).

(11) *Interlanguage /h/ as Pharyngeal*



As mentioned above, their study compares francophone perceptual abilities on [h] vs. Ø, [t] vs. [θ], and [n] vs. [ŋ] in order to test the hypothesis that some types of features are acquirable, while others are not. That is, counter to Brown's original proposal, LaCharité & Prévost propose that new features can be acquired, but major articulators, such as Pharyngeal, are more difficult to acquire than terminal features, such as [distributed], which is needed for [θ]. The finding that francophones with very advanced L2 English performed like native English speakers on [t] vs. [θ] but were unable to discriminate [h] vs. Ø was interpreted by them as evidence that the feature Pharyngeal presents a greater challenge in acquisition than does [distributed].

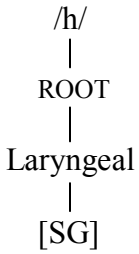
As previously discussed in chapter 2, the analysis of English /h/ as Pharyngeal is problematic on typological grounds as English lacks the other post-velar consonants found in languages with Pharyngeal /h/. The analysis of

Pharyngeal as the feature that is unavailable for transfer from French is also problematic: as discussed in 3.4 above, the French phoneme inventory includes the uvular rhotic /ʀ/, which suggests that Pharyngeal may be present in the L1 phonology and thus should be available for transfer. Again, this predicts that francophones should be able to construct a representation like that in (10), and therefore perceive and produce this segment, though production need not necessarily be target-like: with the availability of Pharyngeal, francophones would be expected to produce a voiceless uvular fricative [χ] or even a voiceless pharyngeal fricative [ʕ]. Crucially, transfer of features from the L1 grammar allows some way to distinguish /h/-initial from vowel-initial words in lexical representations. Again, this scenario appears at odds with the reported observations.

3.6. Predictions for L2 English under Full Transfer Full Access

The final option, which is also the target representation, is that of /h/ as being placeless, with a Laryngeal node, and [SG], as in (12). This option is not available to francophones as per Brown, as it requires a feature that the French grammar does not supply: [SG]. This feature is, however, acquirable if learners have access to UG. A Full Transfer Full Access approach would predict that while learners would perform poorly at earlier stages of acquisition, they should improve in both perception and production with increased proficiency as the feature is eventually acquired; this prediction is at odds with reported observations of persistent difficulties with /h/.

(12) *Interlanguage /h/ as [SG]*



3.7. Summary of predictions

The availability of each representation to the interlanguage grammar built by francophones, and the predictions each option makes, are summarized in Table 3.1 below.

	Interlanguage /h/	Transfer from French?	Perception	Production
segment-level	absent from representations	no	poor	consistent deletion of /h/; no [h] epenthesis
feature-level	bare ROOT	yes; constraint demotion required	target-like at later stages	inconsistent production of glottal or uvular; no [h] epenthesis
feature-level	empty C ('h-aspiré')	yes	target-like from onset	consistent deletion; no [h] epenthesis
feature-level	Laryngeal	yes; constraint demotion required	target-like at later stages	inconsistent production of glottal; no [h] epenthesis
feature-level	Pharyngeal	yes	target-like from earlier stages, but not from onset	consistent production of uvular or pharyngeal; no [h] epenthesis
feature-level	[SG] (partial access)	no	not target-like at later stages	not target-like at later stages
feature-level	[SG] (full access)	no	target-like at later stages	target-like at later stages

Table 3.1. Summary of representations and predictions

Although a target-like (i.e., [SG]) representation is not available to francophones through transfer, other options are. None of these, however, predict the pattern of behaviour thus far attested in the literature. The segment-level analysis correctly predicts poor perception, but wrongly predicts consistent deletion of /h/ in production. The feature-level analyses all correctly predict inconsistent suppliance of some segment, though the specific place of articulation of this segment differs from one representation to another; however, they all share the flaw of predicting that perceptual abilities should be target-like, either right from the start (where /h/ is represented as 'h-aspiré'), or as proficiency improves, as the learner is (eventually) able to build a representation for /h/. Furthermore, none of the available representations predict [h] epenthesis, which is attested. It would seem, then, that none of the available options for the representation of English /h/ are in fact being used in the interlanguage grammars constructed by francophones.

3.8. Ultimate attainment

As observed in section 3.1.1 above, the difficulty that francophones encounter with English /h/ persists despite years of experience with the language, including immersion in an anglophone environment. Generally, individuals who acquire a second language as adults (i.e., after the onset of puberty) retain persistent non-native accents (but see Bongaerts et al. 2000), suggesting the existence of a critical period, after which some information necessary for successful phonological acquisition is unavailable (see Birdsong 1999). Flege's

SLM acknowledges that age of acquisition plays a role in successful acquisition, though the precise nature of the mechanism is not specified.

Brown's (1997, 2000) proposal assumes full transfer of the L1 grammar and partial access to UG; age effects are predicted for all adult L2 learners. Though we can see from Table 1 above that the various options for representation under this view do not seem to make the right predictions, a position of full transfer partial access at least seems to make predictions that are closer to what is observed than does an approach like Full Transfer Full Access, given the persistent nature of the problem. As discussed above, the proposal claims that difficulties in perception with a new segment are due to the unavailability of some feature required for the segment's representation. Furthermore, learners are hypothesized to never acquire new features: if the L1 grammar does not supply a given feature, then it will never be available to the learner. If English /h/ is [SG], then the representation in (12) above will never be available to francophones, and will thus be missing from the lexical entries of words containing /h/. Further, learners will never be able to formalize the link that exists in English between /h/ and voiceless aspirated stops which, recall from chapter 2, have the same distribution in English.

3.9. A non-linguistic option?

The discussion presented in this chapter has described the perceptual and productive difficulties that francophones encounter with English /h/, and explored what these problems can tell us about our assumptions about the representation of

this segment in interlanguage grammars: different representations make different predictions about learners' behaviour. Learners' actual behaviour, then, can be used to argue in favour of one representation, or against several others. As suggested in 3.8 above, Brown's proposal of full transfer partial access comes closer to making the right predictions than Full Transfer Full Access, but full transfer partial access is still challenged by francophones' abilities with respect to English /h/, as none of the representations explored here that are consistent with Brown's proposal are being used in the interlanguage grammar. This then raises the question: why are four of the representations in Table 1 unavailable to francophones, when they are predicted to be available through transfer? Two possibilities exist here: either Brown's full transfer partial access proposal is incorrect, or we do not fully understand the status of /h/ in francophone interlanguage grammars. As will become evident in chapter 6, this thesis argues for the latter of the two possibilities: we will argue that francophones are analyzing /h/ as a vowel, rather than a consonant.

Before exploring this matter further, however, we must first consider another possibility. That is, before we can conclude that the observed difficulties with /h/ are truly due to problems with *linguistic* representation, to the manner in which this segment is stored in the interlanguage grammar, we must examine whether they could instead be due to the physical properties of the segment itself. Chapter 4 thus seeks to establish whether francophone difficulties with /h/ could be due purely to the acoustic properties of this segment; that is, we investigate the possibility that francophones literally cannot *hear* [h]. Chapter 5 then returns to

the question of whether a representation for /h/ exists in the interlanguage grammars of francophones by probing the lexical entries that are constructed for words containing /h/.

Chapter 4: An acoustic problem? Evidence from ERPs

4.0. Introduction

As previously discussed in chapters 1 and 3, L1 transfer plays a significant role in the initial state and ultimate attainment within the phonological component of the interlanguage grammar. As per Brown's (1997, 2000) proposal of full transfer partial access, detailed in chapter 3, L2 learners are predicted to arrive at target-like representations of new segments provided that all required features are available through L1 transfer. Any segment that requires a feature that is not available from the L1 is predicted to present persistent difficulty to learners. The observed persistent difficulty francophones encounter with English /h/ is particularly interesting because it represents a scenario that is unexpected under this approach: though the target representation is not available, other possible representations can be constructed using only features that are supplied via transfer.

In investigating this problem further, however, we must examine an alternate acoustic account for francophones' trouble with /h/: we need to first establish that the trouble with /h/ is indeed a problem with this segment's phonological representation. That is, we need to locate the problem in the interlanguage grammar.

4.1. An acoustic alternative

The observation that /h/ is difficult for francophones (Janda & Auger 1992, LaCharité & Prévost 1999, John 2006) is puzzling given the traditional

assumption that English /h/ lacks place features: the representation is so impoverished that no feature could be required that the French grammar would fail to supply. As we have seen in chapter 3 (section 3.5), LaCharité & Prévost assume that francophones' difficulties with English /h/ are due to this segment's requirement of a Pharyngeal feature (dependent on the Place node) that is not supplied by the French grammar. This assumption, however, is problematic: English lacks pharyngeals in its phoneme inventory, so the presence of this feature in representations is unmotivated (Rose 1996). If English is an aspiration language, with voiceless consonants being specified as [SG], then the representation for /h/ would require [SG]. Since French lacks [SG], under an assumption of full transfer partial access francophones are unable to construct an appropriate representation for this segment; this correctly predicts that francophones will encounter difficulty with /h/. However, we have also seen that other representations yielding the same phonetic effect are available, yet francophones are not making use of them. This raises the question of why no representation for /h/ seems available to the interlanguage grammar.

There is, however, an alternative account available: it may be the case that English /h/ is simply too quiet. /h/ is a voiceless, non-strident fricative with low overall intensity (Ladefoged 2001). These acoustic properties may conspire to render /h/ insufficiently salient in the speech stream, such that francophones are unable to reliably detect it and consequently do not construct any representation for it. In this scenario, francophones' difficulties with English /h/ have nothing to do with problems with its representation, and everything to do with its acoustic

properties. Some support for this possibility comes from Mielke's (2003) account of Turkish /h/: this segment is subject to deletion in prosodically weak positions, where it is more difficult to perceive.

If francophones' difficulties with English /h/ are indeed due to this segment's acoustic properties, then they should find the segment equally problematic regardless of whether it is being perceived as part of a linguistic speech stream. To test this, we made use of the experimental design of Werker & Tees (1984). In their study, Werker & Tees demonstrated that adults are better able to discriminate segmental contrasts not found in their L1 when these were presented in such a way that they would not be identified as linguistic data. Native speakers of English performed poorly in discriminating the Thompson Salish uvular /q/ vs. ejective uvular /q'/ contrast when these were presented in simple CV syllables, but these same speakers performed well when the syllables were truncated to remove the vowel portion, leaving only the noise burst of the stop release, which resembled clicks more than they did English. This same difference in ability to perceive non-native contrasts was also found with respect to the Hindi dental /t/ vs. retroflex /ʈ/ contrast.

In the current study, both linguistic and non-linguistic stimulus items were created using sound samples recorded as speech: the linguistic items were full syllables, while the non-linguistic items were fricative noise bursts. These test items were then used to examine francophones' perceptual abilities with respect to /h/, using event-related brain potentials (ERPs). Specifically, we elicited the mismatch negativity (MMN) in order to assess discrimination.

4.2. Experimental design

4.2.1. The mismatch negativity (MMN)

The present study seeks to elicit the mismatch negativity (MMN) as a measure of discrimination. The MMN is a response manifested by a negative-going component occurring approximately 200 milliseconds after stimulus presentation that indicates automatic detection of physical deviance in a stream of acoustic stimuli (Näätänen 1999, Coles & Rugg 1995, Phillips, Pellathy, Marantz, Yellin, Wexler, Poeppel, McGinnis, & Roberts 2000, Poeppel & Marantz 2000, Dehaene-Lambertz et al. 2000, Dehaene-Lambertz 1997). There is evidence that the MMN is modulated, or even exclusively elicited, by changes which cross a phonological category boundary: Phillips et al. (2000) found that voice onset time (VOT) differences that resulted in stimulus items being categorized as separate instances of a single phoneme did not elicit the magnetic equivalent of the MMN (the mismatch field); VOT differences that resulted in stimulus items being categorized as instances of two distinct phonemes did elicit the response (but see also Sharma & Dorman 1999).

If francophones' difficulties with /h/ are due to difficulties with phonological representation, then they should be able to perceive this segment when it is presented non-linguistically (as Werker & Tees found English speakers could do with Thompson Salish uvulars and Hindi coronals), but not when it is presented linguistically. This would be revealed by an asymmetry in the elicitation of the MMN: we would expect to find a robust MMN response in the non-linguistic condition paired with a lack of MMN response in the linguistic

condition. If, however, their difficulties with /h/ are due to its physical acoustic non-salience, then no MMN should be obtained in either condition, as the problem lies in the acoustic signal of /h/ itself, which does not vary between the non-linguistic and linguistic conditions.

4.2.2. Stimuli

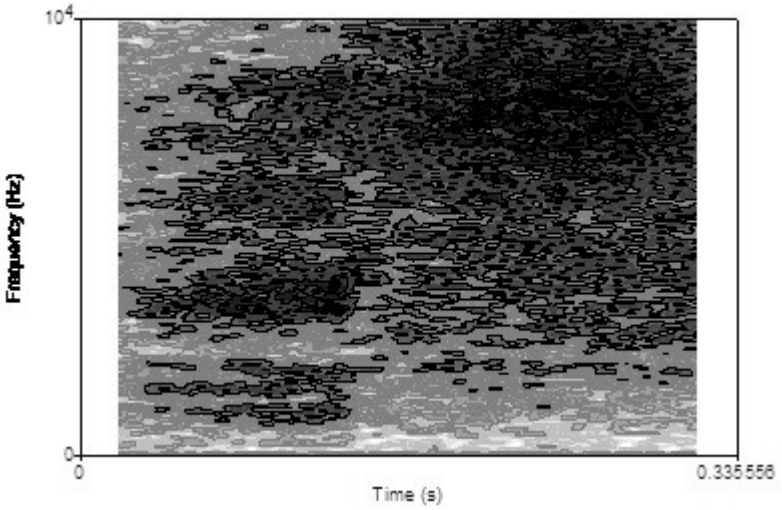
For the linguistic condition, the syllables /ʌm/ 'um', /hʌm/ 'hum', and /θʌm/ 'thumb' were used. The vowel /ʌ/ was selected in order to minimize potential coarticulation effects on /h/: given that /h/ is manifested acoustically as a voiceless vowel, /ʌ/ was selected as its articulation most closely approximates a positionally-neutral vocal tract. /θ/ was selected as an additional distractor consonant since it, like /h/, is a low-intensity fricative and it is also missing from French. It therefore serves as an interesting comparison for /h/. Three instances of each item were recorded by a female native speaker of English, each with a falling intonation, and all tokens were used in the task in an adapted oddball paradigm as described in 4.2.4 below (Phillips et al. 2000). Table 4.1 provides each consonant's duration, as well as the total duration of each linguistic condition stimulus item.

Token		Initial consonant duration	Vowel duration	Total duration
um1	[ʌm]	0 ms	188 ms	416 ms
um2	[ʌm]	0 ms	203 ms	439 ms
um3	[ʌm]	0 ms	187 ms	441 ms
hum1	[hʌm]	106 ms	162 ms	479 ms
hum2	[hʌm]	133 ms	185 ms	516 ms
hum3	[hʌm]	92 ms	181 ms	497 ms
thumb1	[θʌm]	149 ms	201 ms	554 ms
thumb2	[θʌm]	218 ms	222 ms	636 ms
thumb3	[θʌm]	179 ms	192 ms	580 ms

Table 4.1. Linguistic condition stimuli

For the non-linguistic condition, the 'linguistic' recordings of /hʌm/, /θʌm/, and an additional syllable /fʌn/, were manipulated to create fricative noise bursts corresponding to /f/, /hf/, and /θf/. /f/ was used as it is another low-intensity fricative, as illustrated by the spectrogram of /hf/ shown in (1) below; it is also present in both English and French. Two tokens of each fricative noise burst sequence were created, and both tokens were used in the task. Table 4.2 provides the duration of each initial consonant, as well as the total duration of each non-linguistic condition stimulus item.

(1) *Spectrogram - /hf/*



|----------[h]---------|---------------[f]-------------|

Token		Initial consonant duration	Total duration
f1	[f]	133 ms	133 ms
f2	[f]	198 ms	198 ms
hf1	[hf]	104 ms	306 ms
hf2	[hf]	132 ms	336 ms
thf1	[θf]	215 ms	417 ms
thf2	[θf]	140 ms	330 ms

Table 4.2. Non-linguistic condition stimuli

4.2.3. Participants

Two groups of francophone learners of English were recruited for this study: seven lower proficiency L2 English speakers, who were recruited from Elementary level English language classes at l'Université du Québec à Montréal, and ten advanced L2 English speakers, who were recruited in Calgary, Alberta. No differences were found between the two proficiency groups, and their data are thus grouped together in the results section below. Two groups of native English speakers were recruited as controls: a group of nine undergraduate students at

McGill University, and a group of fifteen undergraduate students from the University of Calgary.

The Montreal francophones were right-handed native French speakers who, as mentioned, were recruited from l'Université du Québec à Montréal, where students must complete a placement test before being allowed to register for any English class. This ensures that all students within a class are of similar proficiency: the only way to register for an Elementary class is to either be placed there following a placement test, or to have completed the level that is the prerequisite (in this case, Beginner). Two participants were French (on exchange from France), while the remaining five were Canadian. The Calgary francophones were right-handed native French speakers who had been living in Calgary for a minimum of two years. Three were originally from Québec, five were from France, one was from Switzerland (but does not speak Swiss German), and one was from Morocco (but does not speak Arabic).

4.2.4. Procedure

All participants were fitted with an electrode cap (silver-silver chloride electrodes) that recorded activity from eleven scalp electrodes (Fz, Cz, Pz, FP1, FP2, F3, F4, C3, C4, F7, F8) with a forehead ground and earlobes reference. EOG channels (both horizontal and vertical) were also recorded to monitor eye movement, and an additional electrode was attached to the nose of the participants in Montreal as an alternative offline reference electrode. All participants were then seated comfortably for the duration of the experiment, during which they

watched a silent video with subtitles. Auditory stimuli, which participants were instructed to ignore, were presented by insert earphones to both ears. Participants in Montreal were seated in an electrically-shielded sound attenuated booth; participants in Calgary were seated in a quiet room.

The test syllables were presented using EEvoke software (Advanced Neuro Technology ANT, the Netherlands) in Montreal, and using Stim^2 software (Neuroscan, USA) in Calgary. Stimuli were presented in an adapted oddball paradigm (Phillips et al. 2000): at the acoustic level, since multiple tokens of each test syllable were used, no single token occurs with sufficient frequency to be considered a standard. At an abstract representational level, however, a clear pattern of standard (or frequent) and deviant (or infrequent) tokens emerges. This paradigm was chosen in order to ensure that any effect observed in the data reflects consultation of stored representations. Four blocks of stimuli were presented: a linguistic condition block with /hʌm/ items as standards (80%) and both /ʌm/ and /θʌm/ items as deviants (10% each), a linguistic condition block with /ʌm/ items as standards (80%) and both /hʌm/ and /θʌm/ items as deviants (10% each), a non-linguistic condition block with /hf/ items as standards (80%) and both /f/ and /θf/ items as deviants (10% each), and a non-linguistic condition block with /f/ items as standards (80%) and both /hf/ and /θf/ items as deviants (10% each). All participants were presented alternating blocks of linguistic and non-linguistic stimuli, and the order of presentation of blocks was counterbalanced to create four versions of the experiment in order to avoid

sequence effects such as the confound of fatigue effects with a given condition; this is shown in Table 4.3.

Test version	Block 1	Block 2	Block 3	Block 4
A	standard /hʌm/	standard /hf/	deviant /hʌm/	deviant /hf/
B	standard /hf/	deviant /hʌm/	deviant /hf/	standard /hʌm/
C	deviant /hʌm/	deviant /hf/	standard /hʌm/	standard /hf/
D	deviant /hf/	standard /hʌm/	standard /hf/	deviant /hʌm/

Table 4.3. Test versions

Stimulus onset asynchrony (SOA) was set to vary between 750 ms and 850 ms, with an average of 800 ms; a variable SOA was used to prevent participants from using a perceived delay in stimulus presentation (due to non-perception of /h/) as a reliable identifying cue for /h/-initial items.

EEG data were recorded continuously using a Neuroscan SynAmps 2 amplifier in Montreal and a Neuroscan NuAmps amplifier in Calgary, with a sampling rate of 500 Hz. Data was analyzed offline using the EEProbe software package (Advanced Neuro Technology, ANT, the Netherlands): the data were subject to offline bandpass filtering (0.5 to 30 Hz), and averages for each test condition were computed separately. Due to the large number of trials (each block presented over one hundred tokens of each deviant item and over a thousand tokens of the standard item), the data were not subjected to eyeblink or movement artefact rejection. ERP averages were time-locked to the onset of the stimulus item; epochs (750 ms) included a 50 ms pre-stimulus baseline.

4.3. Results

4.3.1. Non-linguistic condition

Figure 4.1A below shows the responses of the native English speaker control group to /hf/ items, comparing /hf/ as a standard and /hf/ as a deviant. Note that comparisons are always made between identical physical stimuli in the standard versus deviant conditions in order to rule out any confound of the mismatch effects with ERP effects due to physical differences between the stimuli.

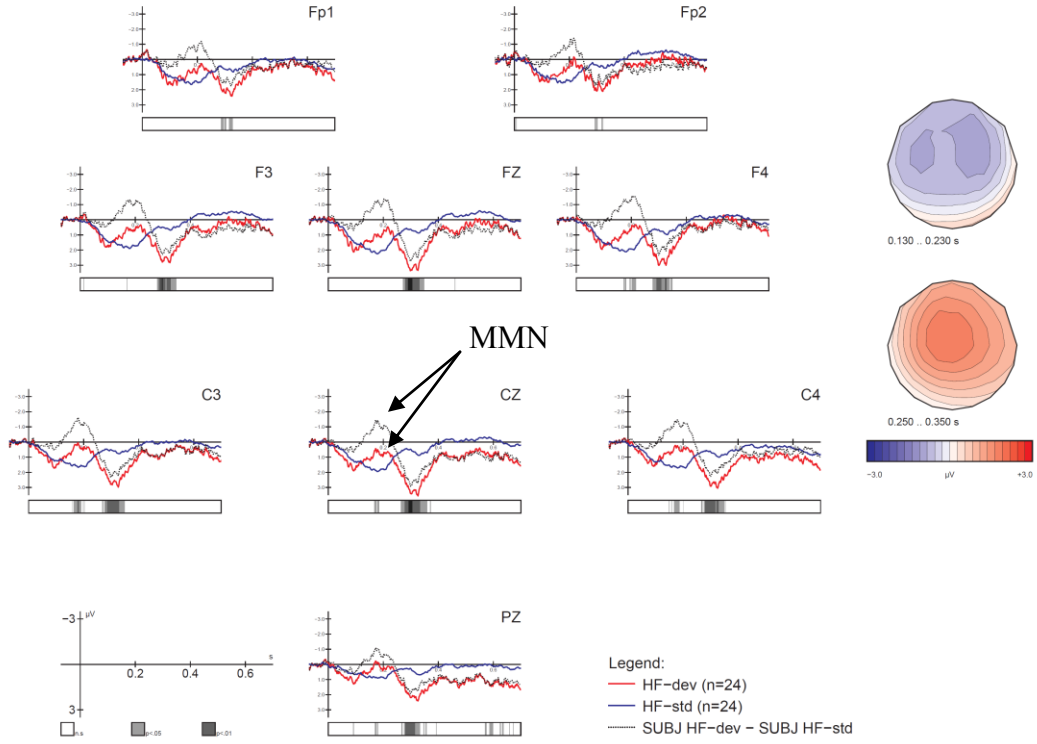


Figure 4.1A: native English speaker responses to /hf/ items, both standards and deviants. Negativity is plotted upwards; vertical axis at 0 ms indicates stimulus onset; areas where the brain response to /hf/ as a standard differs significantly (as revealed through t-tests) from that to /hf/ as a deviant are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

As figure 4.1A shows, /hf/ as a deviant elicited a large significant MMN, indicating that the presence of /h/ in /hf/ was detected by these participants (dark grey shading indicates $p<0.01$; light grey shading indicates $p<0.05$). The results also show a large significant fronto-central P3a component near the midline (i.e., at Fz and at Cz). This component is somewhat surprising: though the P3a (as a subcomponent of the P300) is elicited by mismatches, much like the MMN, it is generally linked to an orientation response (shift of attention) and only found when participants attend to the stimuli (Sutton, Braren, Zubin, & John 1965; Näätänen, Paavilainen, Rinne, & Alho 2007). The participants for this study were instructed to ignore the acoustic stimuli and simply watch the silent subtitled movie; thus we were not expecting any P3a. Figure 4.1B is a larger version of the waveform plot at Cz in figure 4.1A; the MMN and P3a are shown in greater detail.

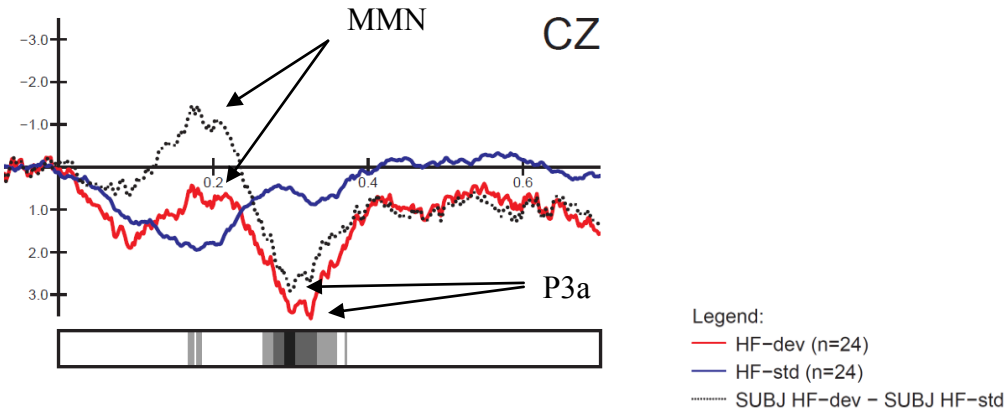


Figure 4.1B: native English speaker responses to /hf/ items, both standards and deviants, as recorded at Cz. Negativity is plotted upwards; vertical axis at 0 ms indicates stimulus onset; areas where the brain response to /hf/ as a standard differs significantly (as revealed through t-tests) from that to /hf/ as a deviant are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

Figure 4.1C shows the responses of the francophone group to /hf/ items, comparing /hf/ as a standard and /hf/ as a deviant.

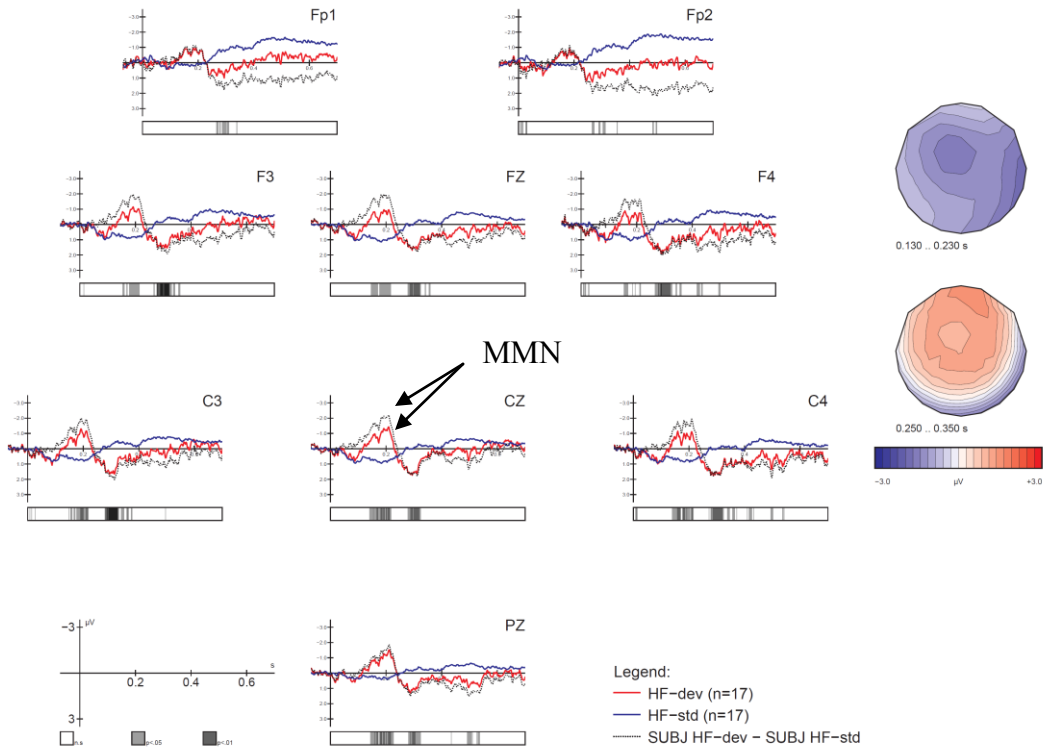


Figure 4.1C: francophone responses to /hf/ items, both standards and deviants. Negativity is plotted upwards; vertical axis at 0 ms indicates stimulus onset; areas where the brain response to /hf/ as a standard differs significantly (as revealed through t-tests) from that to /hf/ as a deviant are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

Much like the native English control group, /hf/ as a deviant also elicited a large significant MMN for the francophones. This suggests that the francophones were also able to detect the presence of /h/ in /hf/. Again like the native English speaker controls, the francophones also show a large significant P3a component. Both of these components are highlighted in figure 4.1D, which is a larger version of the waveform plot at Cz.

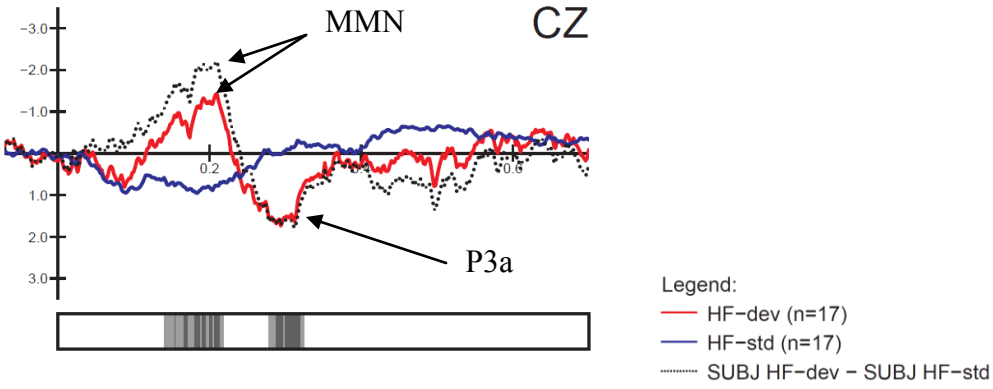


Figure 4.1D: francophone responses to /hf/ items, both standards and deviants, as recorded at Cz. Negativity is plotted upwards; vertical axis at 0 ms indicates stimulus onset; areas where the brain response to /hf/ as a standard differs significantly (as revealed through t-tests) from that to /hf/ as a deviant are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

Figure 4.2A below shows the native English control group's responses to /f/ items, comparing /f/ as a standard and /f/ as a deviant.

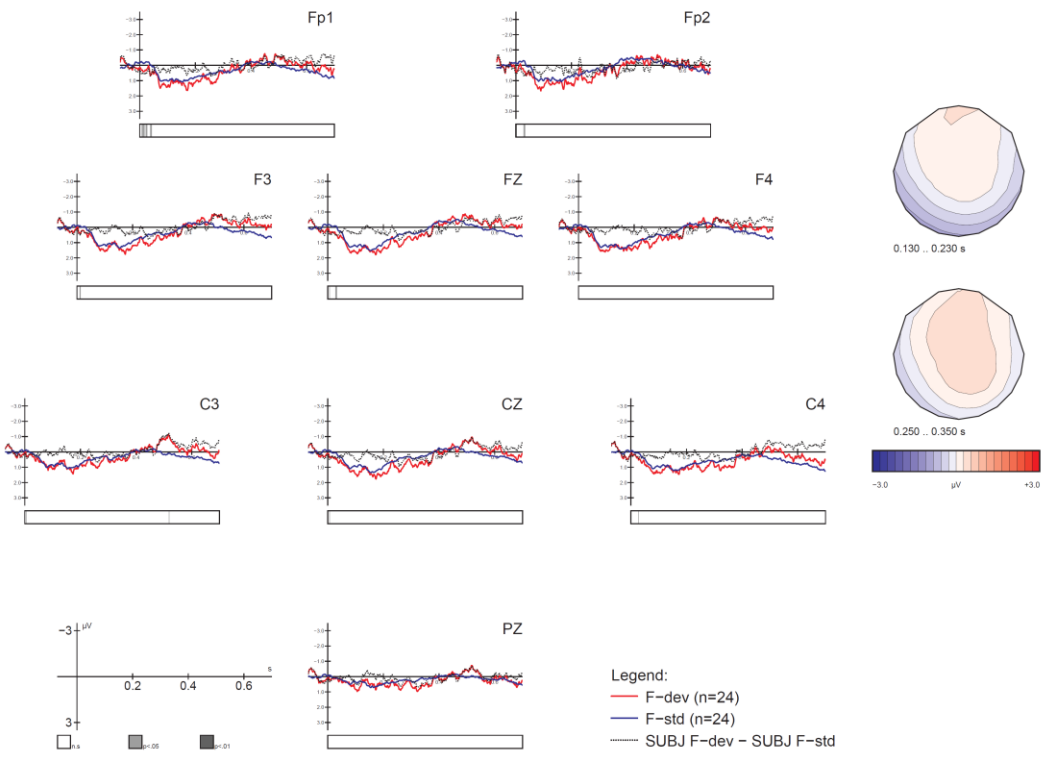


Figure 4.2A: native English speaker responses to /f/ items, both standards and deviants. Negativity is plotted upwards; vertical axis at 0 ms indicates stimulus onset; areas where the brain response to /f/ as a standard differs significantly (as revealed through t-tests) from that to /f/ as a deviant are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

Here we do not find an MMN; this is surprising, as it suggests that participants were unable to detect deviant /f/ tokens among standard /hf/ tokens. Figure 4.2B provides a more detailed view of the waveform plot at Cz.

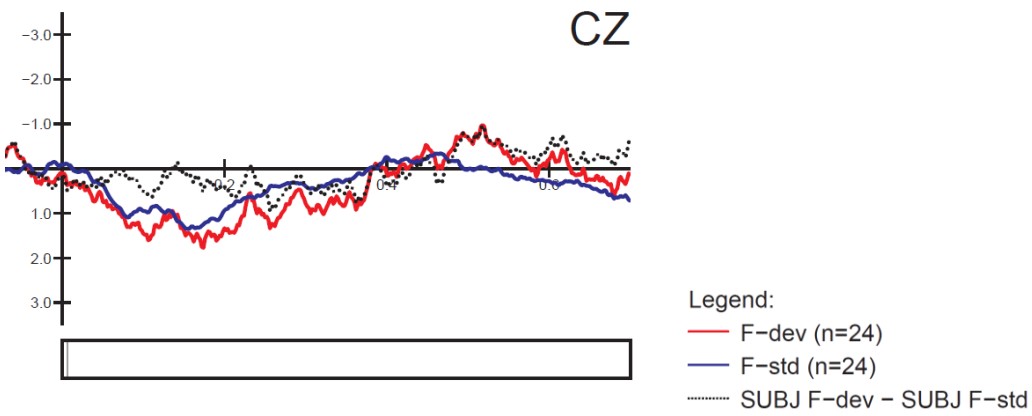


Figure 4.2B: native English speaker responses to /f/ items, both standards and deviants, as recorded at Cz. Negativity is plotted upwards; vertical axis at 0 ms indicates stimulus onset; areas where the brain response to /f/ as a standard differs significantly (as revealed through t-tests) from that to /f/ as a deviant are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

Figure 4.2C below shows the francophones' responses to /f/ items, comparing /f/ as a standard and /f/ as a deviant.

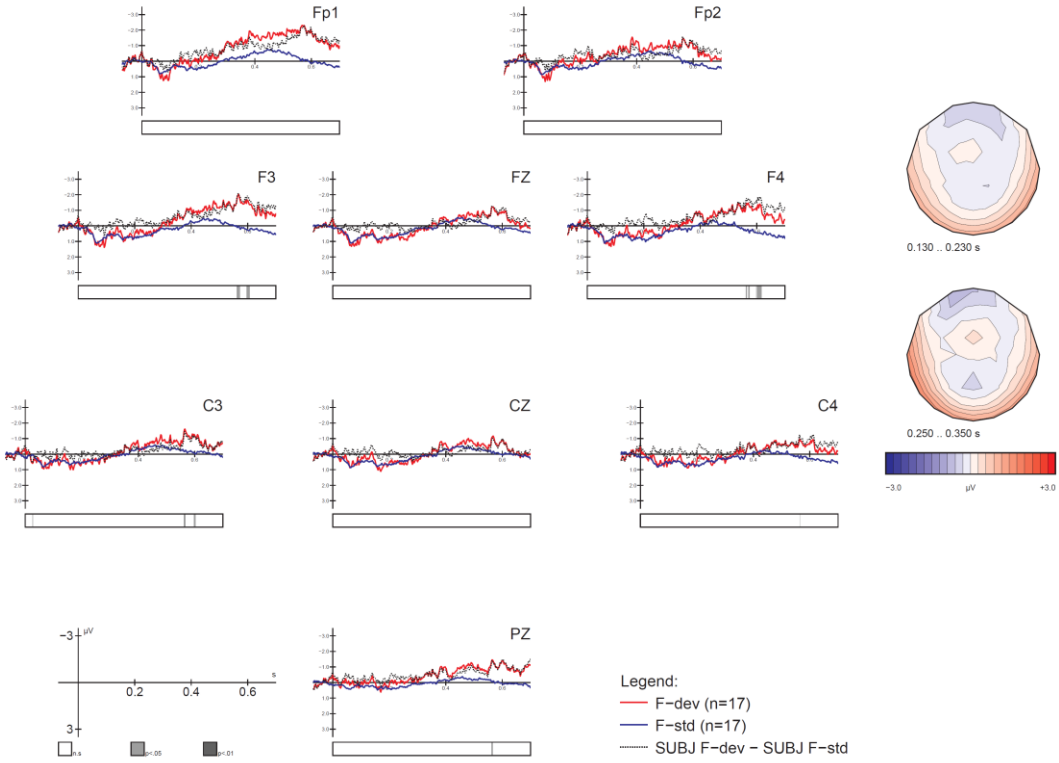


Figure 4.2C: francophone responses to /f/ items, both standards and deviants. Negativity is plotted upwards; vertical axis at 0 ms indicates stimulus onset; areas where the brain response to /f/ as a standard differs significantly (as revealed through t-tests) from that to /f/ as a deviant are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

Again, much like the native English control group, the francophones do not show an MMN response, suggesting that /f/ as a deviant was not detected among /hf/ standard items. Figure 4.2D provides a more detailed view of the waveform plot at Cz.

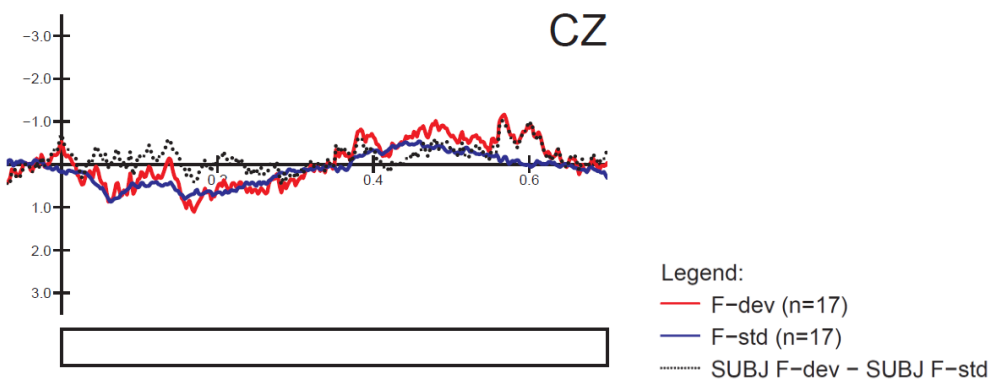


Figure 4.2D: francophone responses to /f/ items, both standards and deviants, as recorded at Cz. Negativity is plotted upwards; vertical axis at 0 ms indicates stimulus onset; areas where the brain response to /f/ as a standard differs significantly (as revealed through t-tests) from that to /f/ as a deviant are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

To summarize briefly, we have seen thus far that both native English speakers and francophones show significant MMN and P3a components in their responses to deviant /hf/ items among /f/ standards, suggesting that the presence of /h/ on deviant items was acoustically detectable. Surprisingly, however, neither group showed an MMN component in response to deviant /f/ items among /hf/ standards. We now turn to the results from the linguistic condition.

4.3.2. Linguistic condition

Figure 4.3A below shows the native English control group's responses to /hʌm/ items both as standards and as deviants.

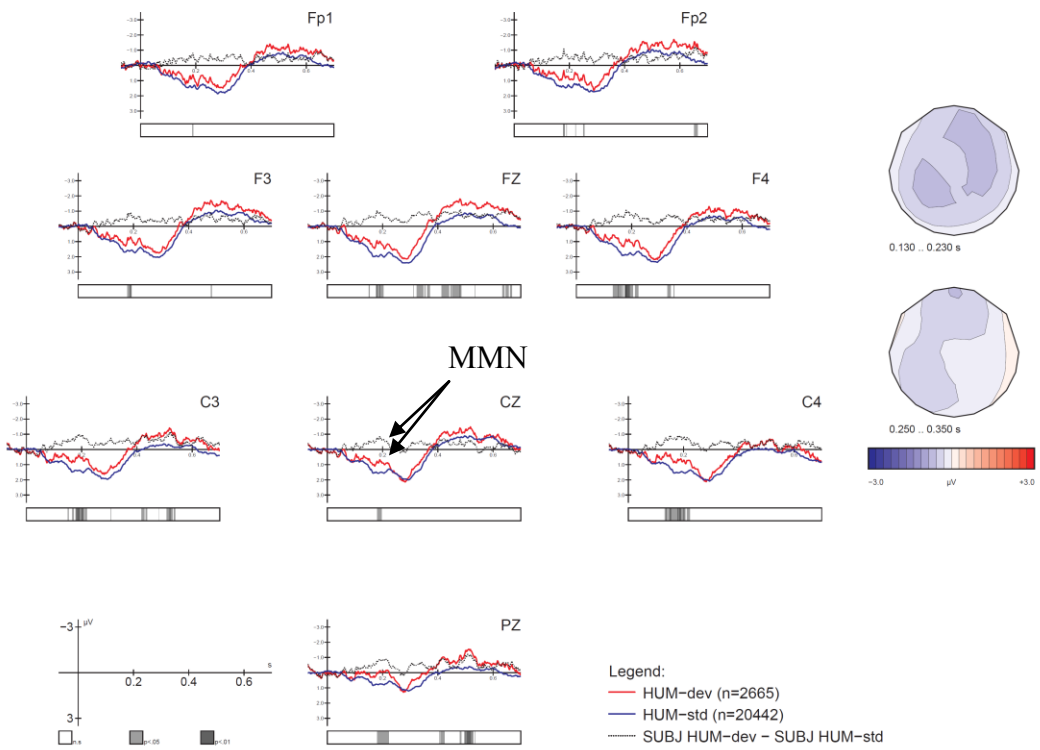


Figure 4.3A: native English speaker responses to /hʌm/ items, both standards and deviants. Negativity is plotted upwards; vertical axis at 0 ms indicates stimulus onset; areas where the brain response to /hʌm/ as a standard differs significantly from that to /hʌm/ as a deviant are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

The responses obtained here differ from those obtained in the non-linguistic condition in that the amplitude of the MMN is not as large; it is, however, significant, suggesting that these participants were able to detect the /h/ in deviant /hʌm/ items where /ʌm/ served as the standard. Figure 4.3B shows the waveform plot at Cz in greater detail.

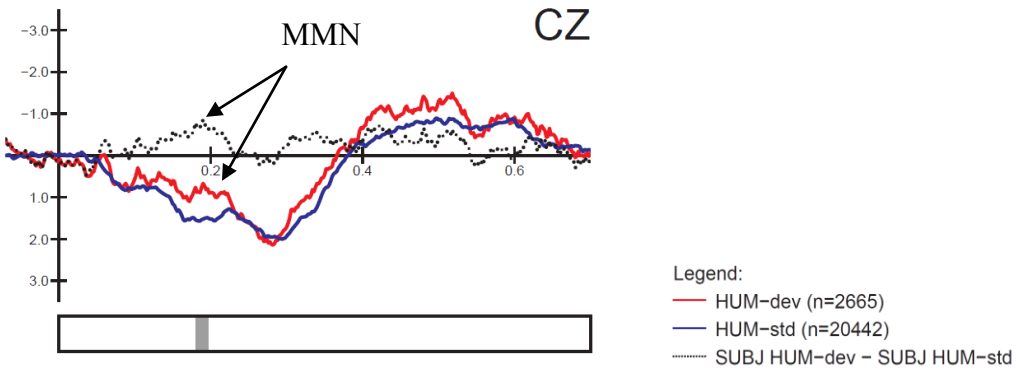


Figure 4.3B: native English speaker responses to /hʌm/ items, both standards and deviants, as recorded at Cz. Negativity is plotted upwards; vertical axis at 0 ms indicates stimulus onset; areas where the brain response to /hʌm/ as a standard differs significantly from that to /hʌm/ as a deviant are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

Figure 4.3C shows the francophones' responses to /hʌm/ items as standards and as deviants.

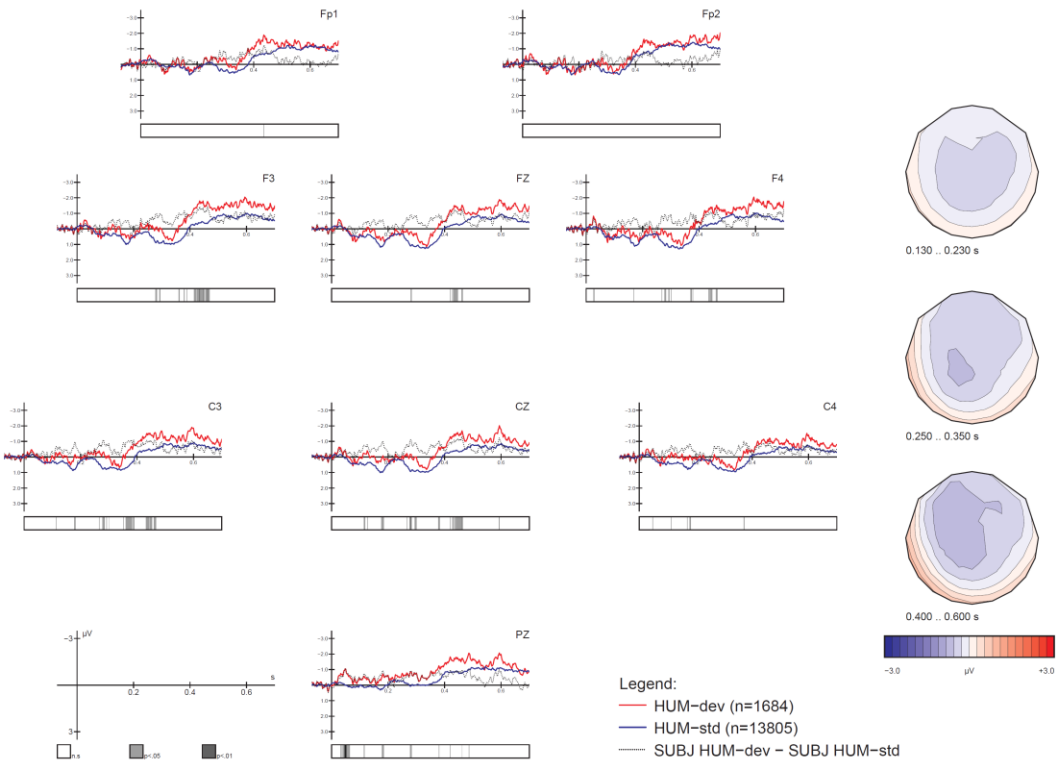


Figure 4.3C: francophone responses to /hʌm/ items, both standards and deviants. Negativity is plotted upwards; vertical axis at 0 ms indicates stimulus onset; areas where the brain response to /hʌm/ as a standard differs significantly from that to /hʌm/ as a deviant are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

While the native English control group showed a small but defined and significant MMN, the francophone data is less clear. Though there is significantly greater negativity in the brain response to deviant items in the time window of the MMN, the pattern is atypical, and appears to be part of a larger overall increase in negativity on deviant items, including late-developing negativities that were absent from native English speaker responses. Figure 4.3D below is a larger view of the waveform plot recorded at Cz.

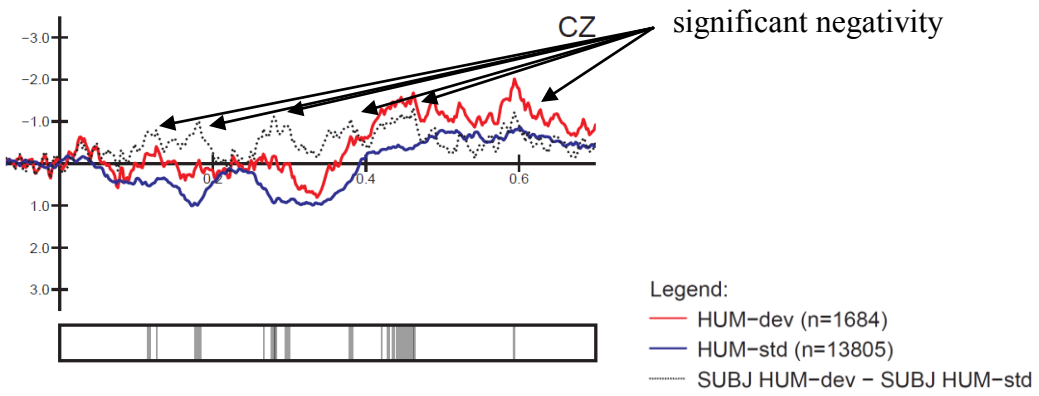


Figure 4.3D: francophone responses to /hʌm/ items, both standards and deviants, as recorded at Cz. Negativity is plotted upwards; vertical axis at 0 ms indicates stimulus onset; areas where the brain response to /hʌm/ as a standard differs significantly from that to /hʌm/ as a deviant are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

The absence of a clear MMN response in the presence of later differences at certain electrodes suggests that francophones did not detect the presence of /h/ in /hʌm/ among /ʌm/ standards relying on the same pre-attentive processing mechanisms typical for native speakers. Patterns of late negativity elicited in discriminatory tasks have been reported in the literature (e.g., Molnar 2010; see Cheour, Korpilahti, Martynova, & Lang 2001 for a review). In those studies the late negativity was associated with discrimination of a contrast; Molnar (2010) observed that the late negativity could occur independently of the MMN, and concluded that it was an indicator of some detection of deviance, likely associated with change detection in the auditory input. We will return to this in the discussion in 4.4 below.

Figure 4.4A below shows the native English control group's responses to /ʌm/ items, both as standards and as deviants.

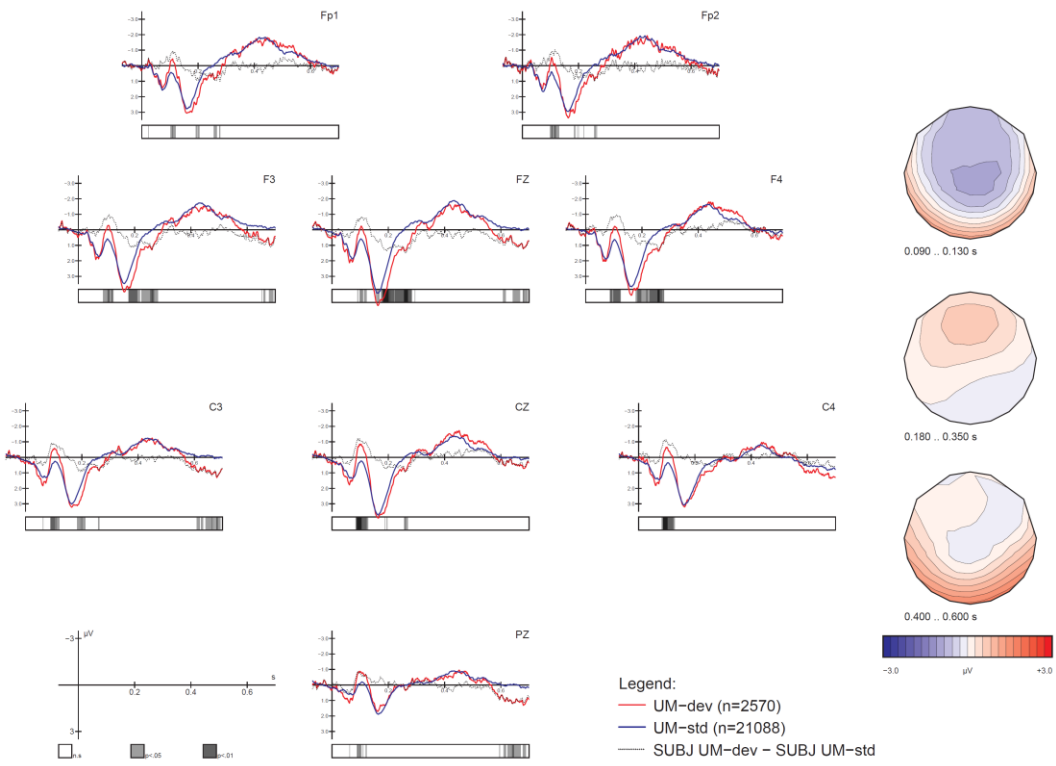


Figure 4.4A: native English speaker responses to /ʌm/ items, both standards and deviants, with difference wave. Negativity is plotted upwards; areas where the brain response to /ʌm/ as a standard differs significantly (as revealed through t-tests) from that to /ʌm/ as a deviant are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

Much like what was observed in the non-linguistic condition in 4.3.1 above, no typical MMN in the range of 200 ms is elicited by deviant /ʌm/ among standard /hʌm/ items. However, a highly significant effect was observed on the N100 component in the deviant condition, suggesting a reliable early difference in processing. Figure 4.4B is a larger view of the waveform plot at Cz, and shows this in greater detail.

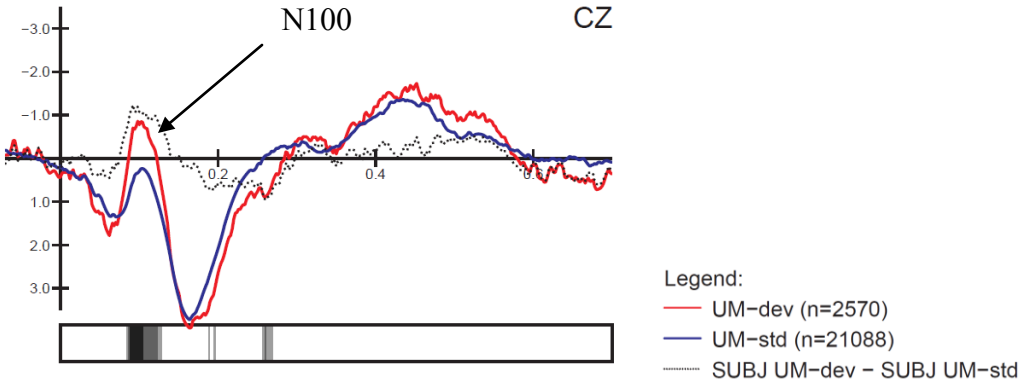


Figure 4.4B: native English speaker responses to /ʌm/ items, both standards and deviants, as recorded at Cz. Negativity is plotted upwards; areas where the brain response to /ʌm/ as a standard differs significantly (as revealed through t-tests) from that to /ʌm/ as a deviant are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

The N100 is thought to reflect the physical and temporal characteristics of the auditory stimulus (Näätänen & Picton 1987). Molnar (2010), in her work on vowel discrimination, also found an N100 effect like that observed in our data, with a significantly greater N100 amplitude for a given stimulus item type in the deviant condition as compared to the standard condition.

Figure 4.4C below shows the francophones' responses to /ʌm/ items, both as standards and as deviants.

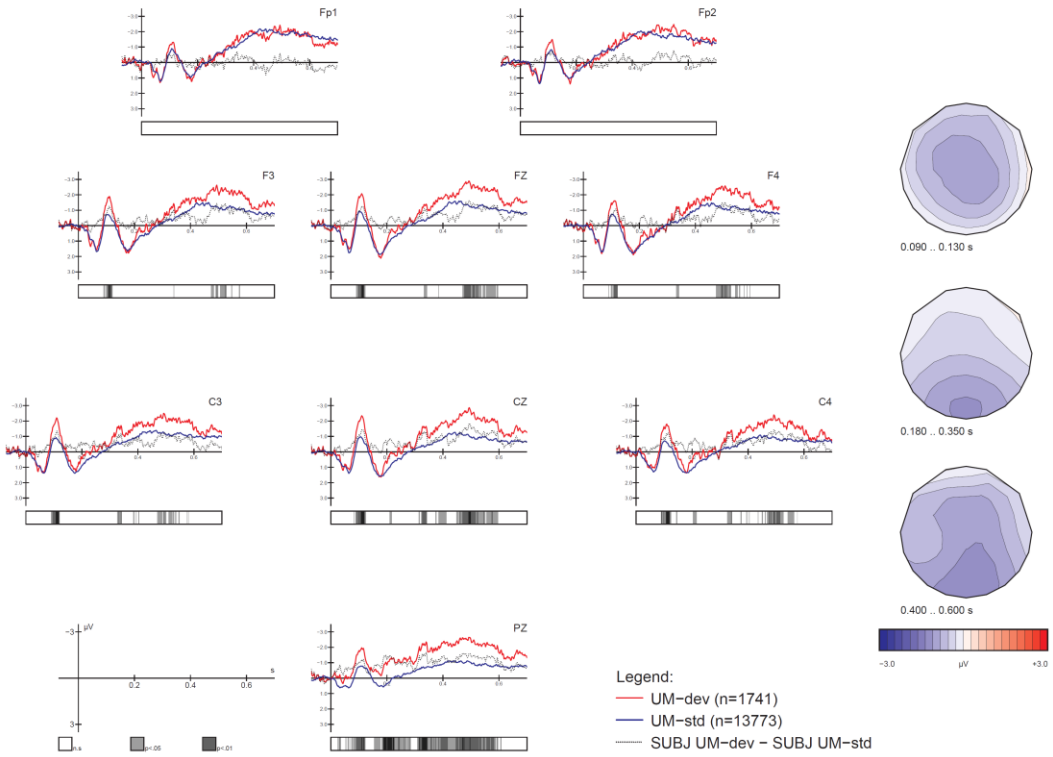


Figure 4.4C: francophone responses to /ʌm/ items, both standards and deviants. Negativity is plotted upwards; areas where the brain response to /ʌm/ as a standard differs significantly (as revealed through t-tests) from that to /ʌm/ as a deviant are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

Much like what was seen with the anglophones, again we see an absence of an MMN component, and instead we find the N100 effect of increased negativity in the deviant condition. Additionally, the previously seen pattern of overall increased negativity elicited by deviant /hʌm/ is seen here as well. Figure 4.4D shows these components in greater detail, with a larger view of the waveform plot at Cz.

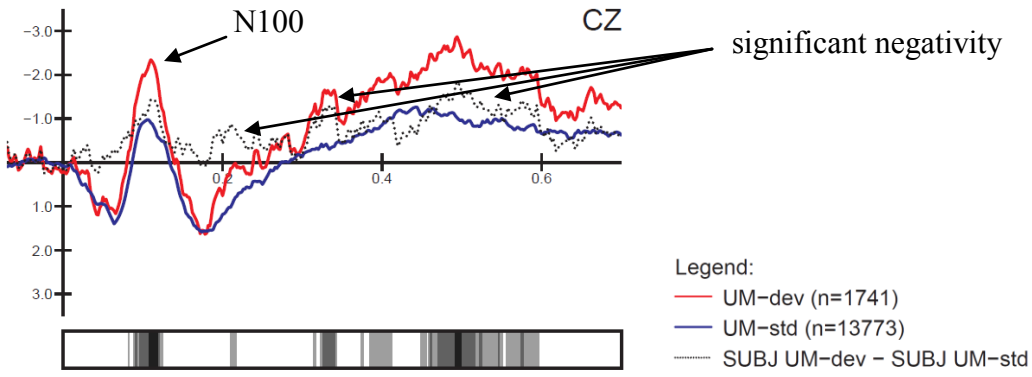


Figure 4.4D: francophone responses to /ʌm/ items, both standards and deviants, as recorded at Cz. Negativity is plotted upwards; areas where the brain response to /ʌm/ as a standard differs significantly (as revealed through t-tests) from that to /ʌm/ as a deviant are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

To summarize briefly, here native English speakers and francophones differed in their responses. Where /hʌm/ items served as deviants among /ʌm/ standards, native English speakers showed a significant MMN, suggesting that they were able to detect the presence of /h/ on the deviant items, while francophones did not show a clear MMN component, which in turn suggests that they were unable to automatically detect the presence of /h/ on the deviant items; however, the deviant condition response had a general increase in negativity, in particular during later time windows following stimulus onset. Where /ʌm/ items served as deviants among /hʌm/ standards, neither the native English speakers nor the francophones showed a significant MMN component in their responses; however, both groups did show an N100 effect, and the francophones also showed greater overall negativity in the response, again particularly in later time windows.

4.4. Discussion

With respect to the /h/ stimulus items, the results of this study are consistent with the hypothesis that francophones' difficulties with English /h/ are not due to this segment's acoustic properties: in the non-linguistic condition, they performed like native English speakers, in that a deviant /hf/ item elicited both a large significant MMN as well as a large significant P3a. In the linguistic condition, however, only the anglophones showed clear evidence of a significant MMN response. This finding supports the hypothesis that francophones' difficulties with /h/ are due to problems with its linguistic representation.

The responses obtained for non-/h/ items are not as straightforward: neither the native speakers nor the francophones showed an MMN in either the linguistic or the non-linguistic condition. This result is surprising for the anglophones, as we would expect them to have good discriminatory abilities with respect to /h/ owing to its phonemic status in English, and it is also surprising for the francophones in the non-linguistic condition as they were shown to behave like native speakers on the /h/ stimulus items. Essentially, these results suggest that the unexpected presence of /h/ was salient, but its unexpected absence was not.[1]

The results, then, are consistent with what was observed in LaCharité & Prévost's perception study: francophones are unable to perceive /h/ in the speech stream. The fact that they were able to perceive its presence in the non-linguistic

[1] It is possible that the increased N100 effect for deviant /ʌm/ may be viewed as a very early MMN; however, given that other studies (e.g., Molnar 2010) found both N100 and MMN effects, this is rather unlikely.

condition provides strong evidence against an account relying on acoustic non-salience of the segment as the cause of the problem. The francophones did, however, show an overall pattern of increased negativity on deviant items in the linguistic condition, and late negativities have been associated with detection of deviance (e.g., Molnar 2010, Cheour et al. 2001). This finding seems to be at odds with the observed perceptual problem.

Consider the results for /h/ items in the non-linguistic condition. Here, francophones performed like native English speakers, demonstrating that they were capable of physically detecting the acoustic signal associated with /h/, and they were able to construct an abstract representation for this so long as it was not linguistic in nature. Where the memory trace that is established in order to evaluate deviance is based purely on acoustic properties of the stimulus items, both anglophones and francophones exhibit a significant MMN. The absence of MMN in the linguistic condition for the francophones is interpreted as an indicator that francophones are unable to formalize the nature of the deviant stimuli into an abstract representation, as in this condition the stimulus items are clearly linguistic, and thus require the use of phonological representations. A possible interpretation here is that the late negativity that is observed reflects that some physical deviance has been detected (i.e., acoustically or phonetically), but they are not able to map it to a (phonological) representation.[2] Where the MMN reflects automatic processing of sounds in the primary auditory cortex, the late

[2] Given that little is well-understood about the late negativity, further research is needed to reliably establish the interpretation of this component as suggested in the present analysis.

negativities may reflect more controlled processes involving comparisons based on conscious memory of the previous stimulus items. Here, the comparisons may have been made on the basis of estimated duration: though a variable SOA was used to minimize participants' ability to rely on length differences, the fact remains that /ʌm/ items were all shorter than /hʌm/ items. This pattern may therefore be interpreted as additional evidence supporting the hypothesis that francophones' difficulties with English /h/ are due to a problem with this segment's phonological representation, and not acoustic difficulties.

The results obtained here provide strong evidence against the hypothesis that francophones cannot hear English /h/ in a strict acoustic sense; though its acoustic properties conspire towards non-salience, francophones are able to detect it in a non-linguistic task. Our results suggest that the trouble with /h/ is in its phonological representation. To probe this further, an additional experiment that definitively accesses phonological representations by making use of lexical access was carried out: we created an experimental task designed to investigate whether francophones were capable of storing phonological representations in lexical entries that included /h/, which we discuss in chapter 5.

Chapter 5: A representation problem? Evidence from ERPs

5.0. Introduction

The experimental work described in chapter 4 found evidence against the hypothesis that francophones' difficulties with English /h/ are due to this segment's acoustic properties: our ERP results suggest that francophones are able to detect /h/ when this segment is perceived as noise, but not when it is perceived as language. In order to strengthen this claim, we must establish that francophones are unable to construct an appropriate phonological representation for /h/, demonstrating that this segment is truly missing from lexical entries. To do so, we make use of an experimental task that taps lexical representations, which allows us to examine francophones' phonological representations as they are stored in the lexicon. This work is the focus of the present chapter.

5.1. Experimental design

5.1.1. The N400

In order to determine whether francophones are able to construct an appropriate phonological representation for English /h/ for storage in lexical entries, we required a task that would elicit behaviour from participants based solely on the information stored in the lexicon. Earlier work (Kutas & Hillyard 1980, Kutas et al. 1984) has found that when participants are presented with an unexpected word given the context built up thus far in a sentence, the semantic incongruity is reflected in recorded EEG data by an enhanced negativity occurring

approximately 400 milliseconds after the word that incurs the incongruity. Consider the following pair of sentences:

(1) a) He spread the warm bread with butter.
b) He spread the warm bread with *socks.

Upon hearing or reading a sentence like (1a), no semantic incongruity is computed at any point, as no unexpected words are present. With a sentence like (1b), however, the word *socks* is unexpected. The semantic incongruity that is computed upon presentation of the word *socks* is reflected by enhanced negativity approximately 400 milliseconds after presentation of this word. This negative-going component is referred to as the N400, and is interpreted as an indicator of the computation of semantic incongruity.

Here, we are concerned with whether or not francophones are able to construct and store appropriate phonological representations for English /h/. We present participants with sentences like the pair given in (2):

(2) a) Lots of girls want to have long shiny hair.
b) Lots of girls want to have long shiny *air.

Native English speakers are expected to show an enhanced negativity following the unexpected word *air* in (2b) as compared to the response obtained by the expected word *hair* in (2a). For francophones, however, if their difficulties with English /h/ are due to an inability to construct an appropriate phonological representation for this segment, resulting in an inability to store this segment in lexical representations, then the phonological representations for *hair* and *air* will be identical: both words will be stored as /ɛr/. In this case, upon hearing *air* in a

sentence like (2b), no semantic incongruity will be computed, as the phonetic form [ɛr] corresponds to the phonological forms for both *hair* and *air*. When these sentences are presented in a reading task, however, francophones should show N400 response patterns like those of native English speakers as the visual modality provides an orthographic cue indicating which lexical item is intended in the sentence.

5.1.2. Stimuli

A total of 216 sentences, consisting of 108 sentence pairs, were created for this task. The sentences were created using nine /h/ vs. Ø word pairs, each controlled for word category such that both members of the pair belonged to the same lexical category. For half the sentence pairs, the semantic violation occurred on the target /h/ vs. Ø word at the end of the sentence, as in (3a) below; for the other half, the semantic violation did not occur on the target /h/ vs. Ø word, but rather on a subsequent word in the sentence, as in (3b). The word preceding the target word was controlled such that the segment that immediately preceded the target word was either a vowel or a sonorant consonant (a nasal or liquid).

(3) *Sample stimulus items*

a. *Target /h/ vs. Ø condition*

i) Lots of girls want to have long shiny hair.
ii) Lots of girls want to have long shiny *air.
iii) Children need lots of exercise and fresh air.
iv) Children need lots of exercise and fresh *hair.

b. *Non-target /h/ vs. Ø condition*

i) In the summer, I tend to eat lots of popsicles.
ii) In the summer, I tend to heat lots of *popsicles.
iii) We'll have to heat the milk for the baby.
iv) We'll have to eat the *milk for the baby.

Including both of these conditions allows us to confidently interpret our results: had only stimuli of the type in (3a) been included, this leaves open the possibility that any N400 observed may not reflect computation of semantic incongruity, but some other unexpected aspect of the target word.

Test sentences were recorded by a native speaker of English in a sound attenuated booth onto a Marantz digital recorder using an external microphone. Care was taken to ensure that glottal stops were not inserted at the beginning of vowel-initial target words.

5.1.3. Participants

A total of 33 francophones participated in this study. Two were lower proficiency learners, individuals who had been placed at either the elementary or intermediate level on a standardized proficiency test administered by l'Université du Québec à Montréal. The remaining 31 were higher proficiency francophone L2 English speakers, who were individuals who had all attended English-language post-secondary institutions in the Montreal area, or had been living in Calgary, Alberta, a primarily anglophone area, for a minimum of eight months.[1] Five of the Calgary francophones were originally from Québec, while the remaining nine

[1] Of the Calgary participants, only one had been in Calgary for less than two years: an undergraduate university student on exchange from France.

were from France. In addition to the L2 participants, 48 native English speakers participated as controls.

Once the data had been collected and processed, it became apparent that several participants would need to be excluded from analysis, due to technical problems with the data files. The results presented here are based on data collected from 38 anglophones (18 in the visual condition, 20 in the auditory condition) and 23 francophones[2] (10 in the visual condition, 13 in the auditory condition).

5.1.4. Procedure

Participants were assigned to either the auditory condition or the visual condition upon their arrival at the lab. All participants were fitted with an electrode cap (silver-silver chloride electrodes) and then seated comfortably facing a computer monitor. Those recruited in Montreal were seated in an electrically shielded sound attenuated booth; due to differences in available facilities, those recruited in Calgary were seated in a quiet room. Stimuli for both versions of the task were presented using Presentation (version 12.2, NeuroBehavioural Systems). The computer monitor provided visual instructions about the task in English, and once participants had read through the instructions, they were given ten practice sentences (in the same modality as the actual test items) in order to familiarize themselves with the specifics of the task. For each test item, participants were presented with a fixation cross in the centre of the

[2] One of the lower proficiency francophones was excluded due to technical issues. The other was found to behave like the other francophones.

screen; in the auditory version, this fixation cross remained during the presentation of stimuli, while in the visual version it was replaced by a word-by-word presentation of the test sentence, with each word appearing on the screen for 300 ms, followed by a delay of 200 ms before presentation of the next word. Once presentation of the test sentence was completed, the words "GOOD OR BAD?" appeared in the centre of the screen, and participants indicated their response using the computer mouse: a left click indicated that they felt they had heard or seen a felicitous sentence of English, while a right click indicated that the sentence was infelicitous. Participants were given five seconds to indicate their judgments, after which the symbols "!!!" appeared in the centre of the screen for two seconds, indicating that participants could blink their eyes. The fixation cross then reappeared and the next test item would be presented.

For the auditory version of the task, ear insert headphones were used to present auditory stimuli to both ears; no visual information was presented. For the visual version of the task, the computer monitor presented the test sentences in a word by word presentation, with each word appearing one at a time, centered on the screen; no auditory information was presented. Two randomizations of test items were created, then each one was reversed to avoid sequence effects in the averaged data, yielding four identical test versions in both modalities; the presentation of test versions was counterbalanced across participants.

EEG data was recorded continuously from nine scalp electrodes: Fz, Cz, Pz, F3, C3, P3, F4, C4, and P4, with a forehead ground and earlobes reference. Data were recorded using a Neuroscan SynAmps 2 amplifier in Montreal, and a

Neuroscan NuAmps amplifier in Calgary. A sampling rate of 500 Hz was used, and all analyses were performed offline using the EEProbe software package (Advanced Neuro Technology, ANT, the Netherlands): the data were subject to offline bandpass filtering (0.5 to 30 Hz) and eyeblink artefact rejection. ERP averages were time-locked to the onset of the target word and were computed separately for each test condition; epochs (1100 ms) included a 100 ms pre-stimulus baseline.

5.2. Results

5.2.1. Visual condition

The results for native English speakers in the visual condition are shown in figure 5.1A below.

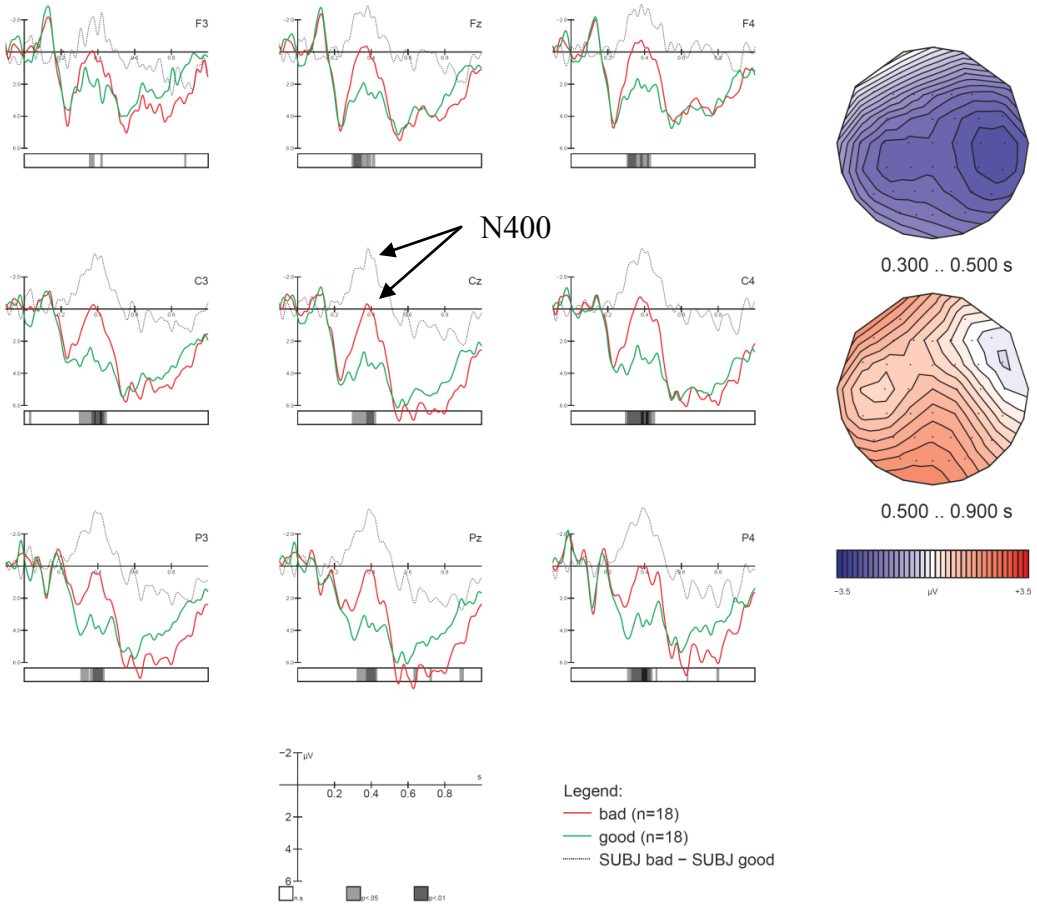


Figure 5.1A: native English speaker responses to felicitous (good) and infelicitous (bad) sentences presented visually. Negativity is plotted upward; the vertical axis at 0 ms indicates the onset of the target word. Areas where the brain response to an expected lexical item differs significantly (as revealed through t-tests) from the response to an unexpected lexical item are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

As figure 5.1A shows, sentences containing a semantic incongruity, whether the /h/ vs. Ø item was the target word or was critical to the semantic-conceptual context into which the target word was to be integrated, elicit a significant N400 response from native English speakers in a visual mode of presentation (light grey shading indicates $p<0.05$, dark grey shading indicates $p<0.01$). The scalp

distribution map in the upper right of figure 5.1A shows that the N400 is maximal over central electrodes (C3, Cz, C4) and somewhat right-lateralized. We can also note that the N400 is followed by a small P600 component, which is elicited by syntactic violations and garden path sentences (Osterhout & Holcomb 1992). These components are identified in figure 5.1B below, which is a larger version of the waveform plot at Cz from figure 5.1A above.

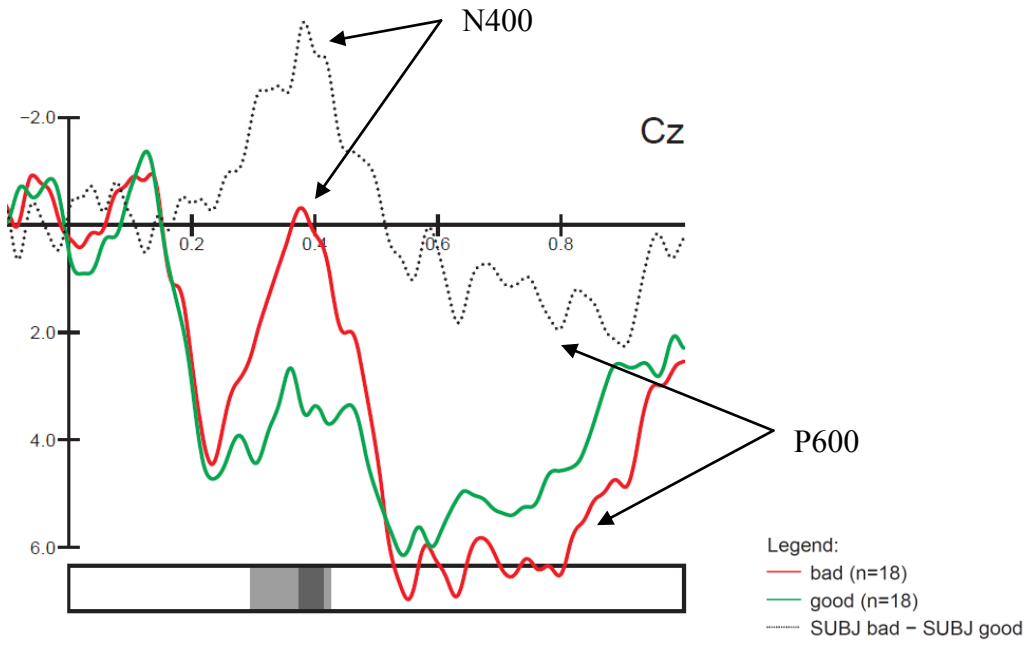


Figure 5.1B: native English speaker responses to felicitous (good) and infelicitous (bad) sentences presented visually, as recorded at Cz. Negativity is plotted upward; the vertical axis at 0 ms indicates the onset of the target word. Areas where the brain response to an expected lexical item differs significantly (as revealed through t-tests) from the response to an unexpected lexical item are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

The N400 is as expected: anglophones are sensitive to the unexpected presence of the target word. That is, they recognize that in a sentence like *Lots of girls want to*

*have long shiny *air*, the word *air* is unexpected given the context established by the rest of the sentence. The P600 (not significant at Cz, but significant at Pz) may reflect additional processing as participants check for alternate structural parses and repair strategies that might yield a felicitous English sentence (Hagoort, Brown, & Osterhout 1999). The N400 was elicited both by target /h/ vs. Ø words (figure 5.1C), as well as by unexpected words in sentences in which /h/ vs. Ø items were critical to the semantic-conceptual context into which the target word was to be integrated (non-target /h/ vs. Ø, figure 5.1D).

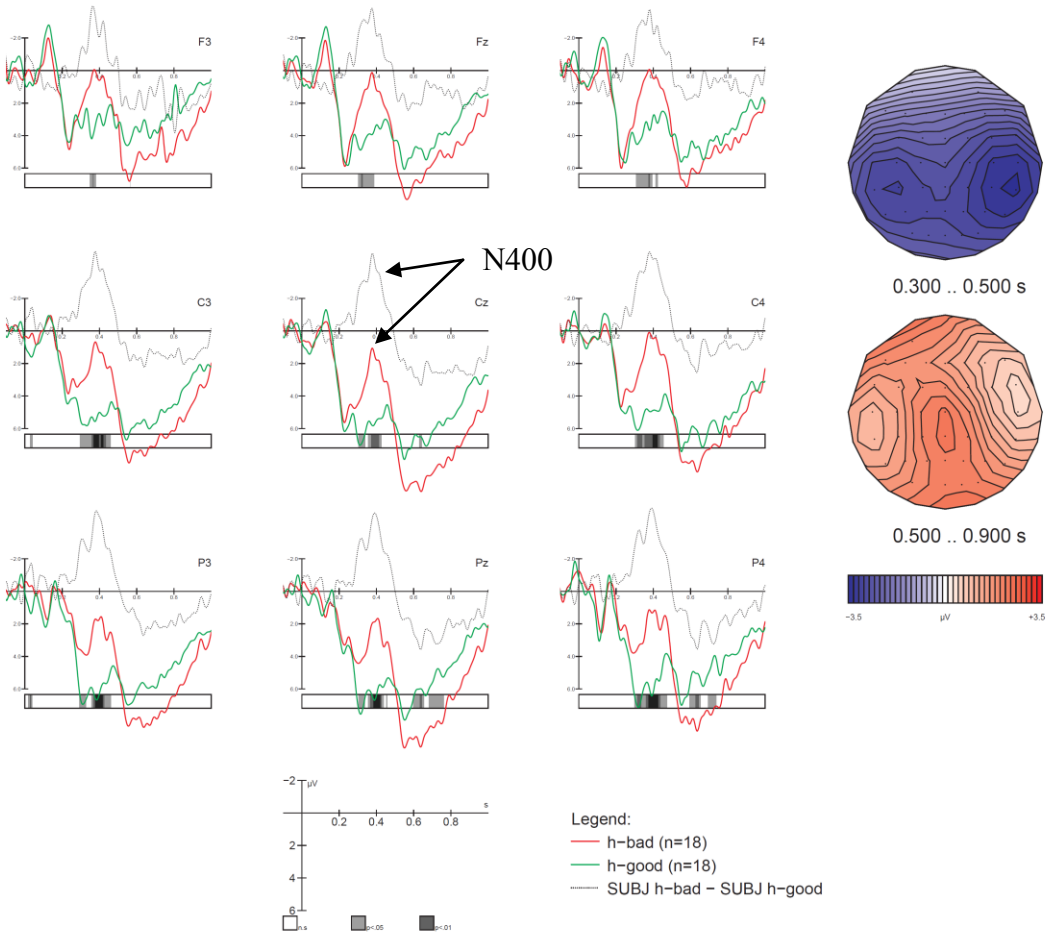


Figure 5.1C: native English speaker responses to felicitous (good) and infelicitous (bad) sentences presented visually, target /h/ vs. Ø condition. Negativity is plotted upward; the vertical axis at 0 ms indicates the onset of the target word. Areas where the brain response to an expected lexical item differs significantly (as revealed through t-tests) from the response to an unexpected lexical item are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

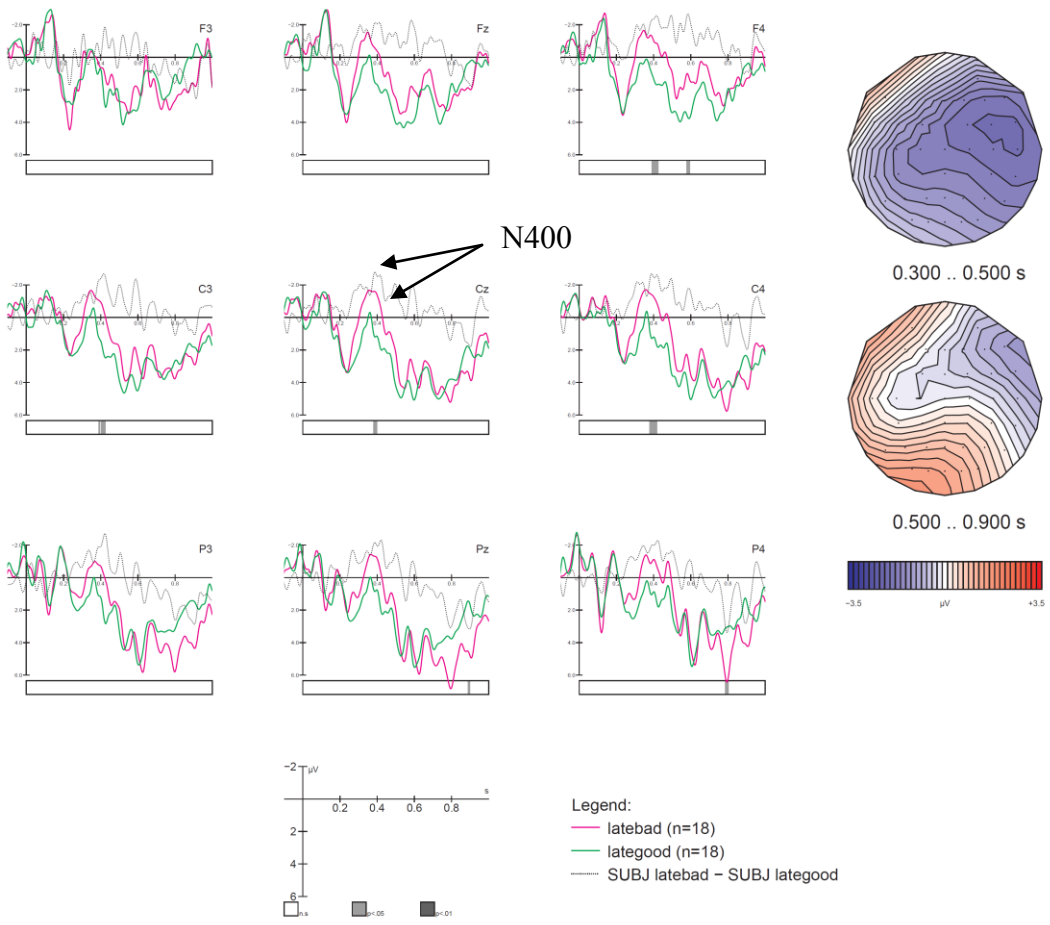


Figure 5.1D: native English speaker responses to felicitous (good) and infelicitous (bad) sentences presented visually, non-target /h/ vs. Ø condition. Negativity is plotted upward; the vertical axis at 0 ms indicates the onset of the target word. Areas where the brain response to an expected lexical item differs significantly (as revealed through t-tests) from the response to an unexpected lexical item are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

We can note that an /h/ vs. Ø item as the target word elicits both the N400 and a P600, though the sentences using /h/ vs. Ø items to establish context did not elicit

a significant P600.[3] Crucially, a significant N400 was elicited by all unexpected words.

The results for francophone learners of English in the visual condition are shown in figure 5.2A below.

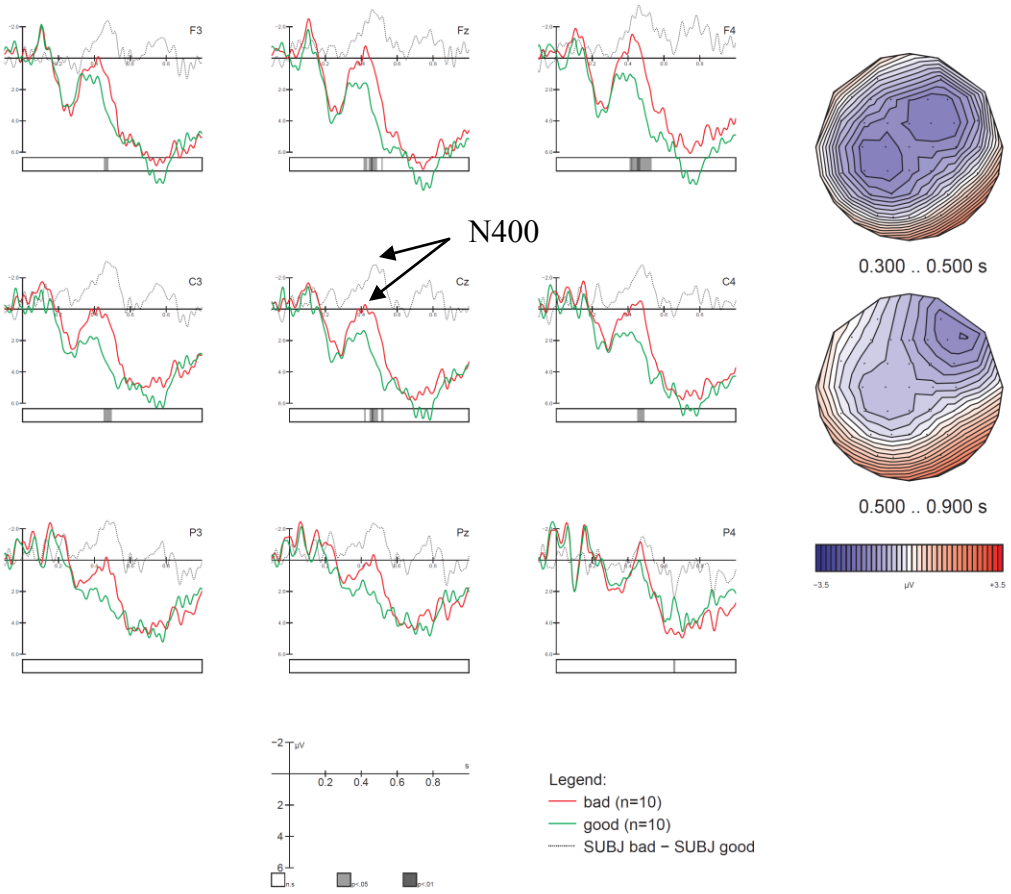


Figure 5.2A: francophone speaker responses to felicitous (good) and infelicitous (bad) sentences presented visually. Negativity is plotted upward; the vertical axis at 0 ms indicates the onset of the target word. Areas where the brain response to an expected lexical item differs significantly (as revealed through t-tests) from the response to an unexpected lexical item are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

[3] The task was designed to elicit the N400 component, though P600 components in the responses to unexpected stimuli are not uncommon (e.g., Coulson, King, & Kutas 1998). I leave the interpretation of the observed P600 asymmetry here (i.e., on target /h/ vs. Ø items) to future research.

Much like what was observed for anglophones, francophones also show a significant N400 component when presented visually with sentences containing a semantic incongruity, whether the /h/ vs. Ø item was the target word or involved in setting up the overall meaning of the sentence; it is, however, slightly more frontal in its scalp distribution. Figure 5.2B is a larger version of the waveform plot at Cz from figure 5.2A, showing the elicited component in greater detail.

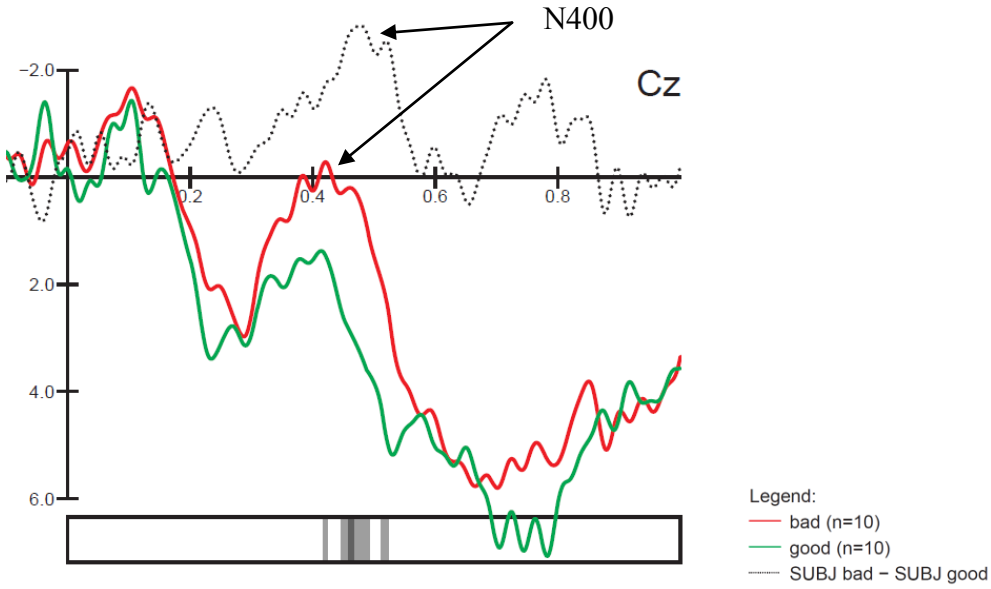


Figure 5.2B: francophone speaker responses to felicitous (good) and infelicitous (bad) sentences presented visually, as recorded at Cz. Negativity is plotted upward; the vertical axis at 0 ms indicates the onset of the target word. Areas where the brain response to an expected lexical item differs significantly (as revealed through t-tests) from the response to an unexpected lexical item are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

The francophone N400 component is significant and has a similar scalp distribution to that observed with anglophones. Again, this indicates that francophones recognized the infelicitous words, whether these were /h/ vs. Ø

items, as shown in figure 5.2C, or whether the /h/ vs. Ø items were critical to the semantic-conceptual context into which the target word was to be integrated (non-target /h/ vs. Ø), as in figure 5.2D.

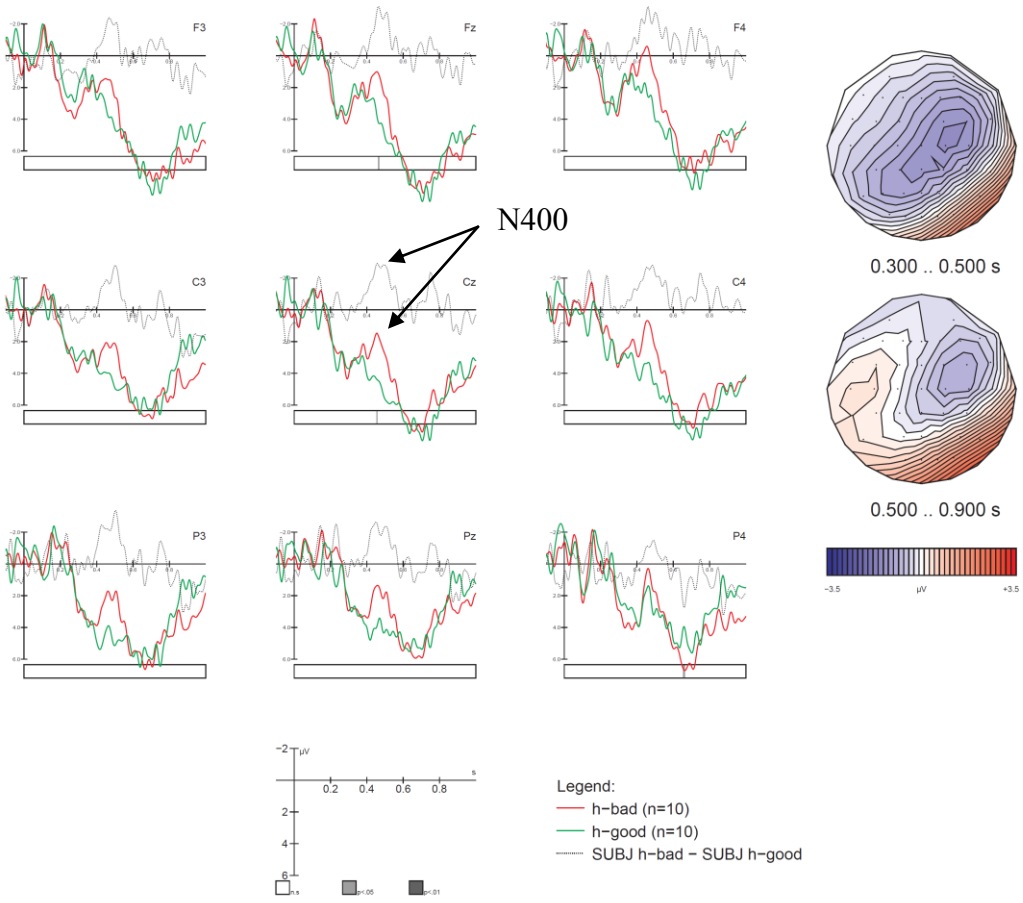


Figure 5.2C: francophone responses to felicitous (good) and infelicitous (bad) sentences presented visually, target /h/ vs. Ø condition. Negativity is plotted upward; the vertical axis at 0 ms indicates the onset of the target word. Areas where the brain response to an expected lexical item differs significantly (as revealed through t-tests) from the response to an unexpected lexical item are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

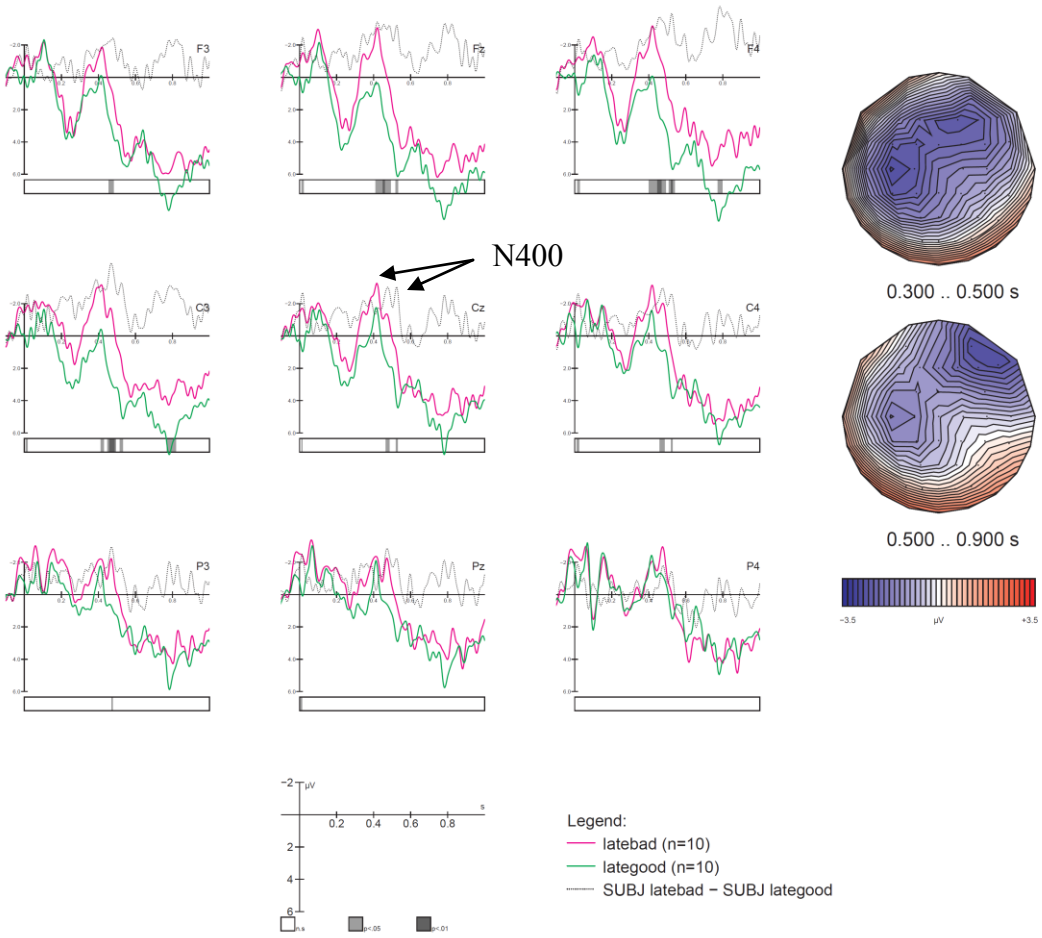


Figure 5.2D: francophone responses to felicitous (good) and infelicitous (bad) sentences presented visually, non-target /h/ vs. Ø condition. Negativity is plotted upward; the vertical axis at 0 ms indicates the onset of the target word. Areas where the brain response to an expected lexical item differs significantly (as revealed through t-tests) from the response to an unexpected lexical item are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

Ultimately, these results suggest that when the sentences are presented visually, francophones behave much like native English speakers: the presence (or absence) of <h> in the orthography has consequences for which lexical entry is accessed, and unexpected words elicit a significant N400 component. This is not a surprising result, as <h> provides a clear and unequivocal cue to the intended

lexical entry, and given that most English-speaking francophones (certainly all of the participants in this study) are literate and have learned their English in a classroom setting, once they have learned how to spell a given English word, they should be able to recognize when it has been misspelled.

Recall that the experimental results from chapter 4 suggest that francophones have difficulty perceiving [h] in a linguistic context, which would contribute to an inability to store this segment in lexical – as opposed to orthographic – entries. As a result, we would expect that francophones would not be able to detect the semantic incongruities presented in the infelicitous sentences of the auditory version of this task, as the targeted lexical entries should have phonological representations that are identical to the corresponding felicitous words. We now turn to the results from the auditory condition, which are consistent with this prediction.

5.2.2. Auditory condition

The results for native English speakers in the auditory condition are shown in figure 5.3A below.

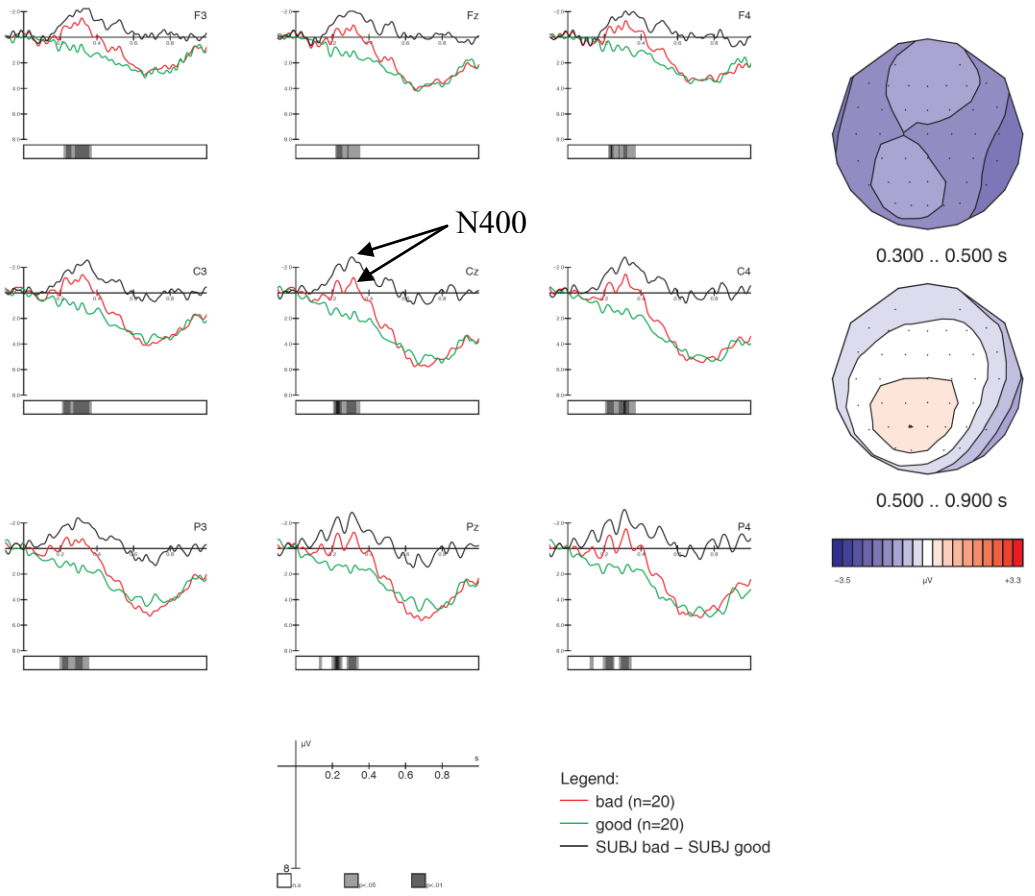


Figure 5.3A: native English speaker responses to felicitous (good) and infelicitous (bad) sentences presented auditorily. Negativity is plotted upward; the vertical axis at 0 ms indicates the onset of the target word. Areas where the brain response to an expected lexical item differs significantly (as revealed through t-tests) from the response to an unexpected lexical item are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

As figure 5.3A shows, sentences containing a semantic incongruity, whether the /h/ vs. Ø item was the target word or was critical to the semantic-conceptual context into which the target word was to be integrated, elicit a significant N400 response from native English speakers in an auditory mode of presentation. The scalp distribution map in the upper right of figure 5.3A indicates that the N400

was broadly distributed over the scalp, however with a more lateral distribution over both hemispheres than what was found in the visual condition. The N400 component itself is highlighted in figure 5.3B, which is a larger version of the waveform plot from Cz in figure 5.3A.

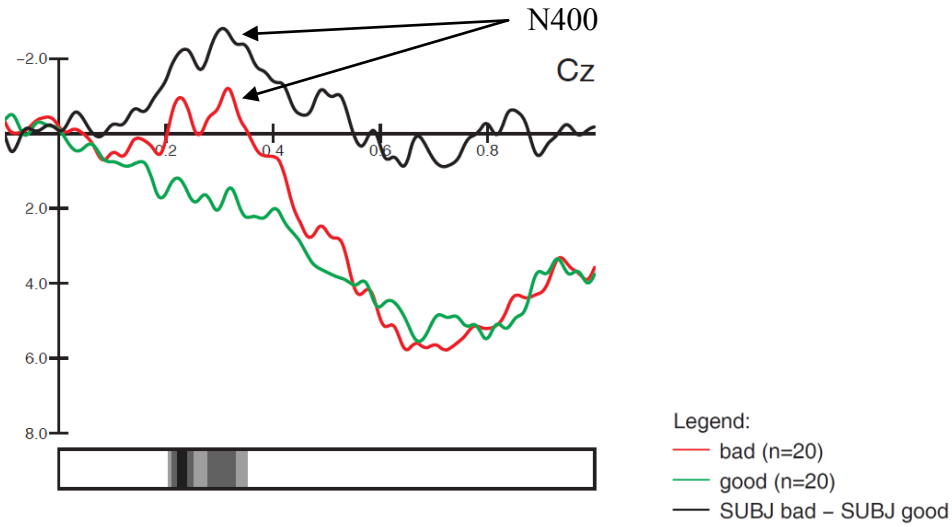


Figure 5.3B: native English speaker responses to felicitous (good) and infelicitous (bad) sentences presented auditorily, as recorded at Cz. Negativity is plotted upward; the vertical axis at 0 ms indicates the onset of the target word. Areas where the brain response to an expected lexical item differs significantly (as revealed through t-tests) from the response to an unexpected lexical item are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

As in the visual condition, the presence of the N400 component in the auditory condition is not surprising for anglophones, as the presence or absence of [h] in the speech stream will prompt retrieval of different lexical entries, thereby allowing for recognition of semantic incongruity in the case of an infelicitous target word. The N400 is significant when the /h/ vs. Ø item is the target word, as shown in figure 5.3C, as well as when it was critical to the semantic-conceptual

context into which the target word was to be integrated (non-target /h/ vs. Ø), as in 5.3D.

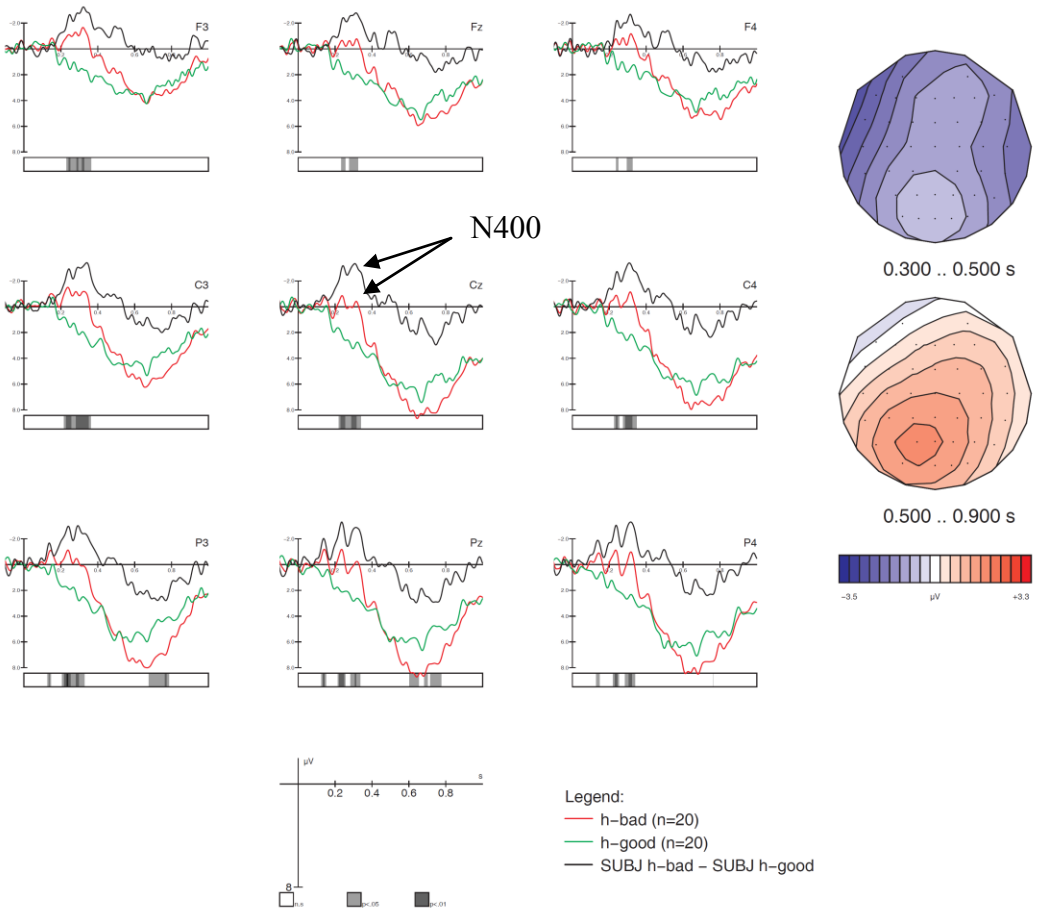


Figure 5.3C: native English speaker responses to felicitous (good) and infelicitous (bad) sentences presented auditorily, target /h/ vs. Ø condition. Negativity is plotted upward; the vertical axis at 0 ms indicates the onset of the target word. Areas where the brain response to an expected lexical item differs significantly (as revealed through t-tests) from the response to an unexpected lexical item are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

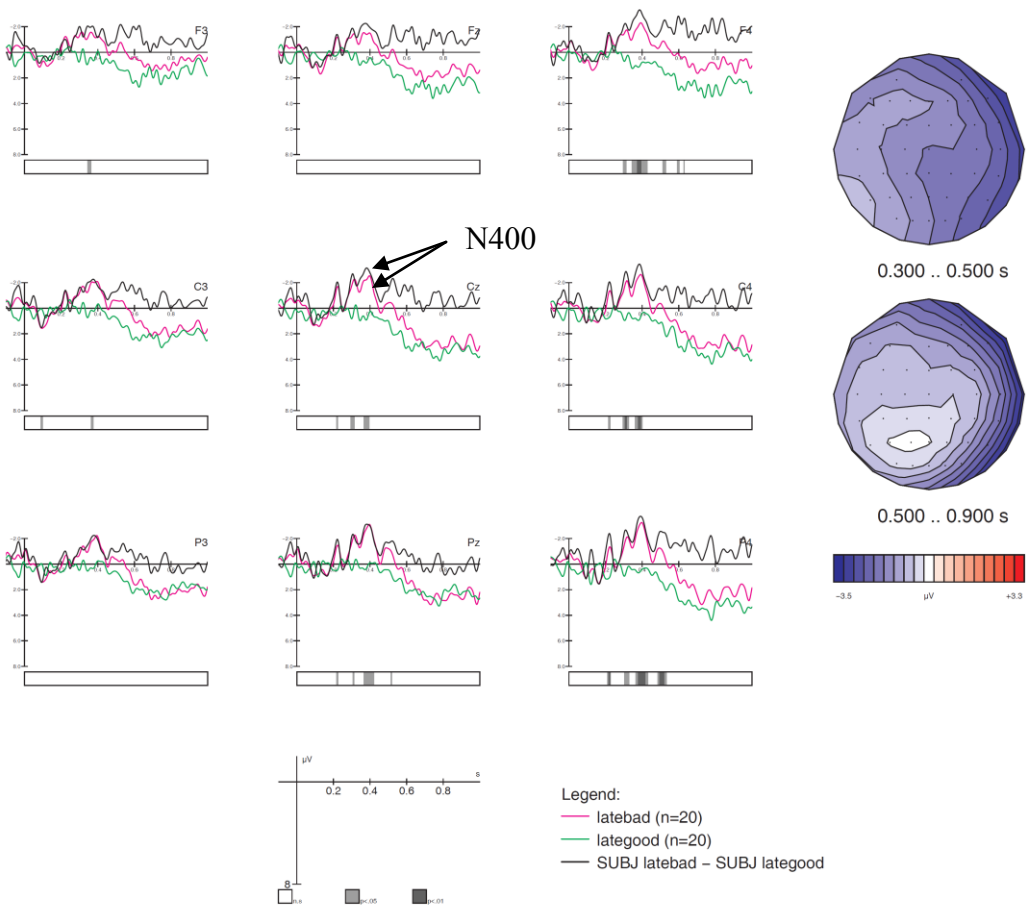


Figure 5.3D: native English speaker responses to felicitous (good) and infelicitous (bad) sentences presented auditorily, non-target /h/ vs. Ø condition. Negativity is plotted upward; the vertical axis at 0 ms indicates the onset of the target word. Areas where the brain response to an expected lexical item differs significantly (as revealed through t-tests) from the response to an unexpected lexical item are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

Figure 5.4A below shows the results obtained for the francophone learners of English in the auditory condition.

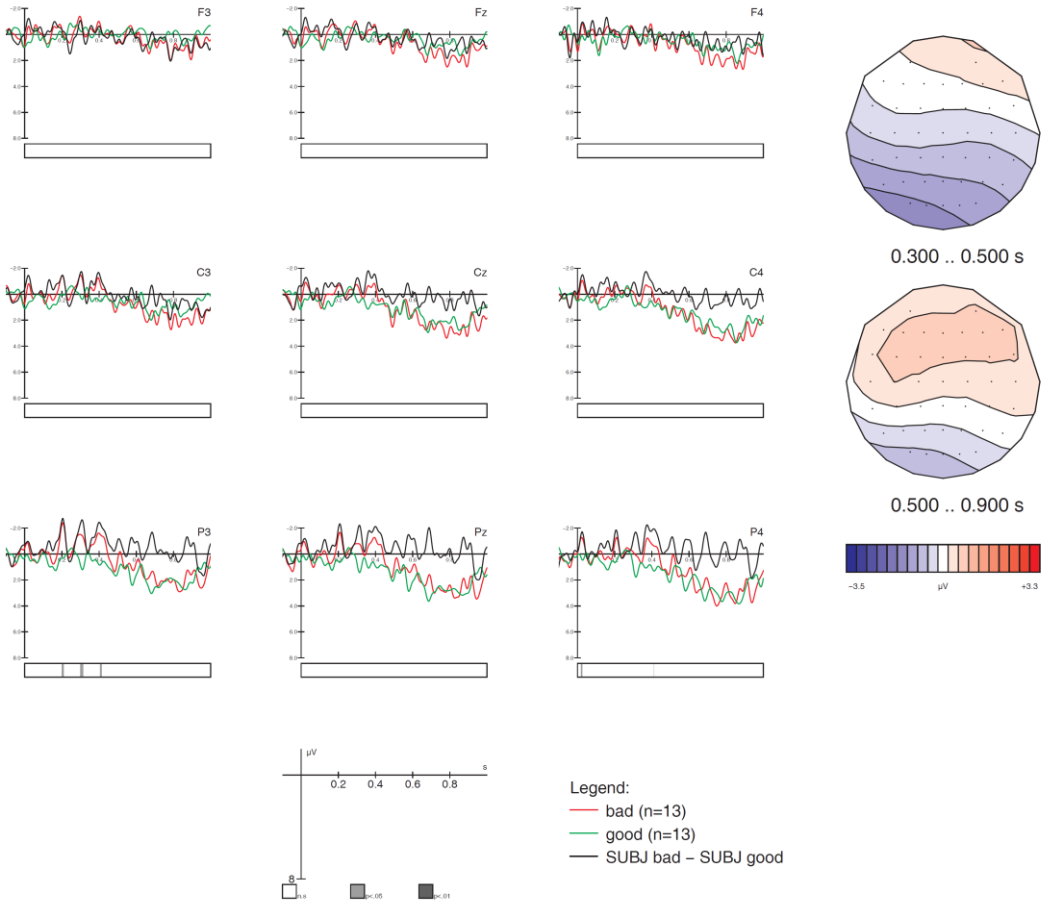


Figure 5.4A: francophone responses to felicitous (good) and infelicitous (bad) sentences presented auditorily. Negativity is plotted upward; the vertical axis at 0 ms indicates the onset of the target word. Areas where the brain response to an expected lexical item differs significantly (as revealed through t-tests) from the response to an unexpected lexical item are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

Unlike the results obtained with native speakers, francophones do not show a significant N400 response to infelicitous sentences, suggesting that they do not compute semantic incongruity while performing this task. This is the outcome that is expected if francophones are unable to construct an appropriate phonological representation for /h/, with the result being that the form stored for /h/ items may

be identical to that stored for Ø items. There is some increased negativity in the time frame for the N400 on infelicitous sentences, though this increase does not reach significance. Furthermore, the scalp distribution map in the upper right of figure 5.4A is quite unlike the maps seen in previous figures: here, the increase in negativity has a strongly posterior distribution, unlike the central-lateral distribution seen for the anglophones in the auditory condition. Figure 5.4B is a larger view of the waveform plot at Cz in figure 5.4A, showing the non-significant increase in negativity.

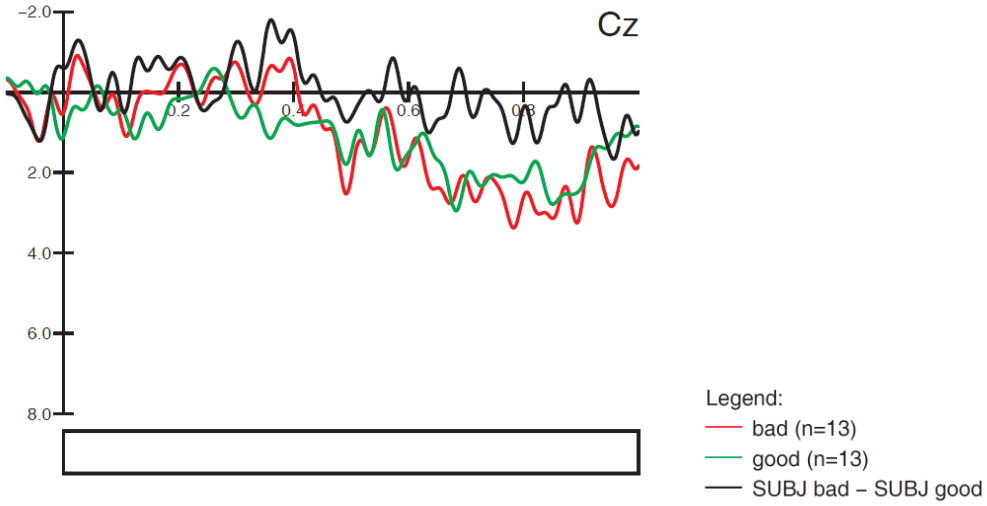


Figure 5.4B: francophone responses to felicitous (good) and infelicitous (bad) sentences presented auditorily, as recorded at Cz. Negativity is plotted upward; the vertical axis at 0 ms indicates the onset of the target word. Areas where the brain response to an expected lexical item differs significantly (as revealed through t-tests) from the response to an unexpected lexical item are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

Figure 5.4C shows francophones' responses to target /h/ vs. Ø items; figure 5.4D shows francophones' responses where the /h/ vs. Ø item was critical to the

semantic-conceptual context into which the target word was to be integrated (non-target /h/ vs. Ø).

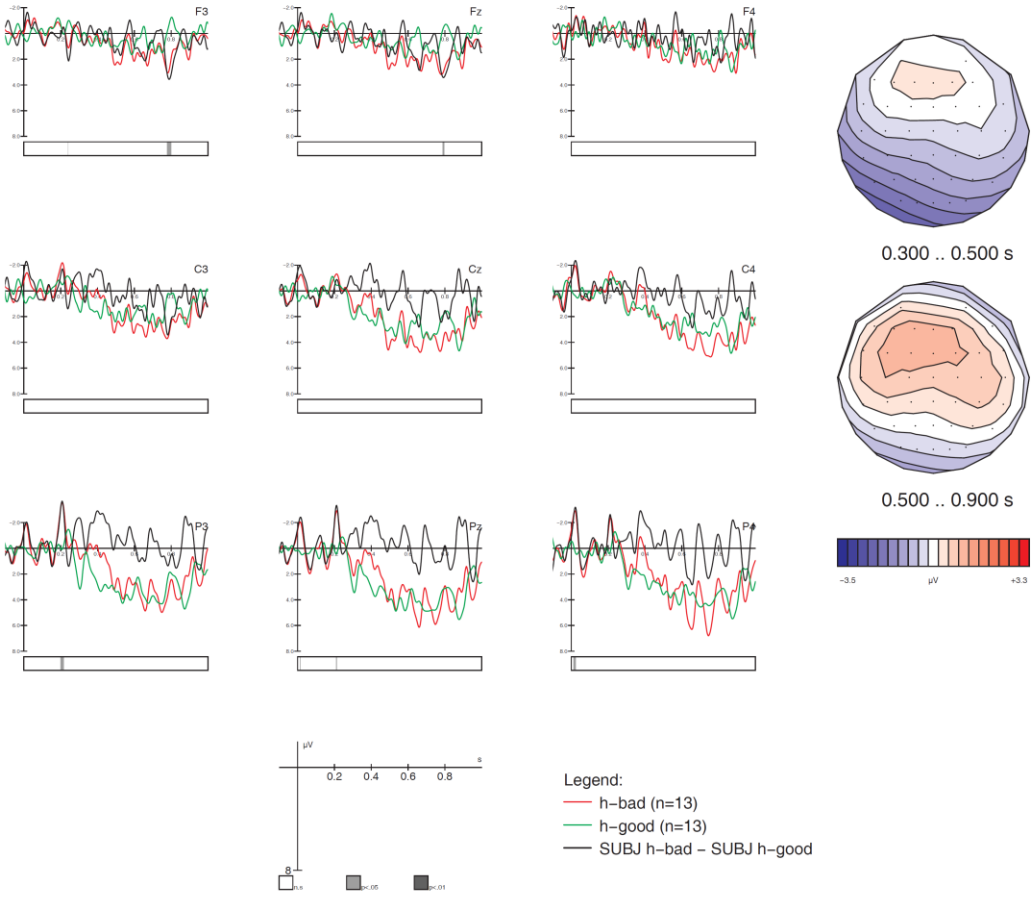


Figure 5.4C: francophone responses to felicitous (good) and infelicitous (bad) sentences presented auditorily, target /h/ vs. Ø condition. Negativity is plotted upward; the vertical axis at 0 ms indicates the onset of the target word. Areas where the brain response to an expected lexical item differs significantly (as revealed through t-tests) from the response to an unexpected lexical item are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

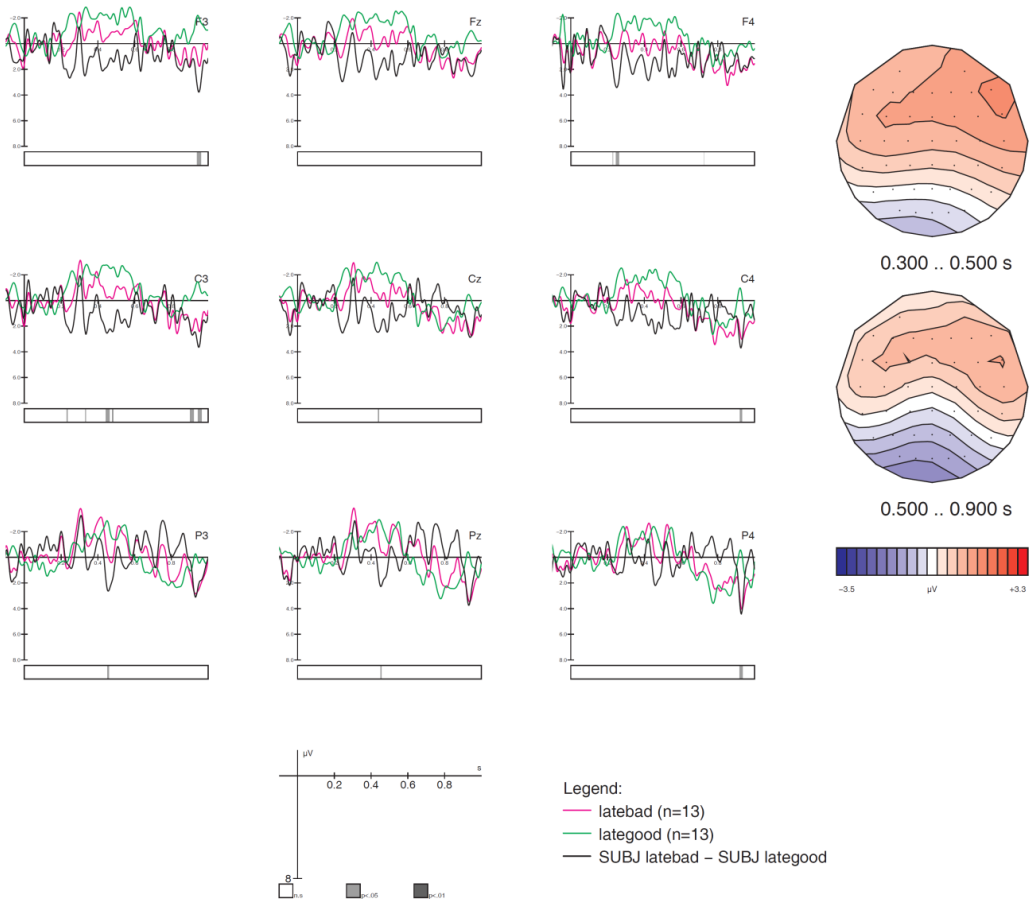


Figure 5.4D: francophone responses to felicitous (good) and infelicitous (bad) sentences presented auditorily, non-target /h/ vs. Ø condition. Negativity is plotted upward; the vertical axis at 0 ms indicates the onset of the target word. Areas where the brain response to an expected lexical item differs significantly (as revealed through t-tests) from the response to an unexpected lexical item are indicated by shading in the bar below the waveform (where light grey indicates $p<0.05$, dark grey indicates $p<0.01$).

In figure 5.4C, an increase in negativity is seen in the appropriate time frame for the N400; however, this does not reach significance. In figure 5.4D, we can note that there is positivity, rather than negativity, in the appropriate time window for the N400.

Our results thus indicate that while francophones are like native English speakers in their ability to detect semantic incongruity based on /h/ vs. Ø items in the visual modality, when the sentences are presented auditorily their behaviour changes. The absence of the N400 component is interpreted as indicating that the target words in these cases are not unexpected, suggesting that /h/ vs. Ø items are phonologically identical in the lexical entries of the interlanguage grammars constructed by francophones.

5.3. Discussion

The goal of the experimental work described here was to investigate whether francophones' difficulties with English /h/ could be characterized as a problem in constructing an appropriate phonological representation for this segment, with the result being that pairs of words like *hair* and *air* are stored in the lexicon with identical phonological representations. The results obtained support this hypothesis: while native English speakers show a significant N400 component in the auditory condition, francophones do not. This is interpreted as evidence that the phonological representation of /h/ is unavailable to francophones, and this unavailability is what renders this segment problematic in acquisition.

It is worth noting that the francophone group did show a negative-going deflection in the time range of the N400; this, however, cannot be interpreted as an N400, as it did not reach significance at any electrodes and its magnitude was

in the range of other differences that are obviously due to artefacts (alpha-rhythm in particular).

Given that these results suggest that francophones do not store any sort of phonological representation for /h/, we are now in a position to consider why this should be the case. Brown's (1997, 2000) full transfer partial access proposal only predicts the unavailability of a representation for /h/ that is specified as [SG]; it does not predict unavailability for the other representations seen in chapter 2. Returning to the possible representations for English /h/ from earlier discussion in chapter 2, recall that the proposal adopted here claims that English /h/ is [SG], formally linking this segment with aspirated stops. If [SG] is truly (part of) the problem, then francophones are predicted to encounter difficulty in their production of both /h/ and aspirated stops, since the French grammar fails to supply this feature for construction of target-like representations. Additionally, as both aspiration and [h] are implemented as a period of low intensity voiceless fricative noise preceding a vowel, examining the production of both [h] and aspiration can shed light on any strategies or alternate representations francophones may be making use of in the interlanguage grammar.

The next task, then, is to establish that francophones do encounter difficulty with aspiration in their L2 English, and to examine their productions of both aspiration and [h]. These are the goals of the study reported in chapter 6.

Chapter 6: Francophones' production of /h/ and aspiration

6.0. Introduction

The evidence presented in this thesis thus far suggests that while francophones encounter considerable difficulty with English /h/, it is not the case that this is due to this segment's acoustic properties: when presented in a non-linguistic context, their behaviour on a discrimination task does not differ from that of native English speakers. It is only when /h/ is presented in a linguistic context, i.e., in a syllable, that francophones' performance in discrimination differs from that of native English speakers. Furthermore, we have seen evidence suggesting that francophones' difficulties with English /h/ are due to this segment's phonological representation: they appear to be unable to store /h/ in lexical entries, so words like *hair* and *air* are both stored as /ɛr/. These findings bring us back to the question first posed in chapter 2: what, exactly, is proving to be so problematic for francophones in the representation of English /h/?

Previous discussion in chapter 2 identified several representations for /h/, and chapter 3 noted that many of these should be available to francophones, counter to what observed behaviour would suggest. Indeed, only one of the proposed representations for /h/ was predicted to be unavailable to francophones for representation of this segment in the interlanguage grammar, the target English representation in which /h/ is specified with the laryngeal feature [spread glottis] ([SG]) (Avery 1996, Iverson & Salmons 1995); this feature is not active in French and is therefore unavailable for transfer from the L1 grammar, thus making it unavailable for constructing segmental representations for L2 segments.

/h/ is not, however, the only segment in English that requires the use of this feature: English also has aspirated voiceless consonants. If [SG] is part of the problem underlying francophones' observed difficulties with English /h/, then these same speakers should also encounter difficulties with aspiration.

In this chapter we present evidence gathered from an examination of the production of aspirated and unaspirated stops by francophones, measuring the duration of aspiration when produced in several different positions. The results suggest that aspiration presents a similar difficulty as English /h/, consistent with the proposal that [SG] is needed for both. We also examine francophones' productions of /h/ in a reading task, both in terms of rate of suppliance and the acoustic properties of the segments that were produced, in order to shed light on why francophones are unable to make use of any of the representations presented in chapter 3 that were predicted to be available to the interlanguage grammar.

6.1. Previous studies on VOT

A number of studies (Lisker & Abramson 1964, 1967, 1970, 1971; see Keating 1984 for a review) have established that an important acoustic cue for signaling voicing contrasts in prevocalic positions is Voice Onset Time (VOT), the time elapsed between the release of stop closure and onset of voicing: voiceless stops produced with a long VOT are described as 'aspirated', voiceless stops produced with a short VOT are described as 'unaspirated', and stops produced with the onset of voicing preceding the release of the stop are described as 'voiced'. These studies demonstrate not only that VOT is an important cue to

voicing contrasts in many languages, but that VOT category boundaries tend to be similar across languages (that is, languages do not select arbitrary points on the VOT continuum as category boundaries). This is not to say that all languages make use of the exact same VOT categories, however: an English speaker will perceive an alveolar stop produced with a VOT of 25 milliseconds as a voiced stop (/d/), whereas that same phonetic segment will be perceived by a Thai speaker as a voiceless unaspirated stop (/t/), reserving the category of voiced stops for those phonetic segments with negative VOT values (i.e., pre-voicing) (Lisker & Abramson 1964).

These early findings prompted researchers to consider the implications of this dimension of categorization of speech sounds in the context of multilingualism: if languages differ in how VOT is used to categorize stops, what are the consequences of this for individuals who speak more than one language? Are L2 learners sensitive to differences in how VOT is used in a new language? Do they learn to perceive and produce L2 stops with native-like VOT values? We focus here on research which has examined French-speaking learners of English. French voiceless stops are produced with a shorter VOT than English voiceless stops, and there are no long-lag VOT (aspirated) stops in French, but these are present in English, as discussed in chapter 2.

An early study by Caramazza, Yeni-Komshian, Zurif, & Carbone (1973) examined the production and perception of stops by (Québec) French speakers, (Canadian) English speakers, and French-English bilinguals: individuals who were L1 French speakers who had started acquiring English no later than the age

of 7, had self-rated their knowledge of English as being advanced (a score of at least 5 out of 7) with this self-report being confirmed through a reading task: participants were asked to read a passage from Jane Austen's *Sense and Sensibility*, and only those who read at a rate of at least 180 words per minute were selected to participate. Bilingual participants were tested twice, with a delay of two to three weeks between sessions: one session was conducted in English, while the other was conducted in French. Their perception results suggested that the bilinguals did not perceive VOT boundaries in the same way that monolingual French and monolingual English speakers did, but rather seemed to perform in a manner intermediate between the two in both of their languages. In production, the bilinguals did not make use of one intermediate VOT category boundary in both languages; however, their performance was not exactly like that of the monolinguals as their English VOT values were significantly shorter than those of monolingual English speakers.

Flege (1987) also examined the VOT values produced by language learners in their L2: he examined L2 French VOT produced by L1 (American) English speakers and L2 English VOT produced by L1 (European) French speakers. We focus here on the results of the French learners of English. The aim of this research was to determine whether the learners could adjust their phonetic categories in order to accommodate those of the L2. In acquiring English, then, the French speakers would need to establish new phonetic categories (e.g., create a new category for [t^h] in addition to existing [d] and [t]) and determine the distribution of these segments in order to achieve an 'authentic' pronunciation.

Flege focused on production of /t/ in phrase initial position: in English, it is realized as aspirated [t^h], while in French it is realized as unaspirated [t]. Like Caramazza et al.'s perception results, Flege's results suggest that learners make use of intermediate VOT values as phonetic categories are reorganized to accommodate those of the L2. Both of these studies provide evidence that aspiration is indeed difficult for francophones, suggesting that whatever feature is used to capture aspiration in English is unavailable for transfer from French; however, the results also suggest that some novel representation has been acquired, as the learners are not behaving as monolinguals do in either language, indicating that some reorganization has taken place in the interlanguage grammar.

A later study by Curtin, Goad, & Pater (1998) examined learners' abilities with respect to novel voicing contrasts; here we focus on their results for the acquisition of the three-way contrast in Thai by L1 French speakers. A group of eight participants were taught 18 Thai words that formed minimal sets of three items each. They were given a lexical identification test: an auditory token was presented with three pictures, two corresponding to items that formed a minimal pair, with the third being a foil, and the participant was to indicate which picture corresponded to the word he had heard. The test was administered at the end of a review session the day after the first day of training, on the day following the third day of training, and again one week later. As no effect of learning was found in the francophone results, all data were reported in aggregate. The results indicated that accuracy was significantly higher on unaspirated vs. voiced minimal pairs than it was on aspirated vs. unaspirated pairs. This suggests that French speakers

were able to create new lexical entries for the Thai words with non-identical phonological representations for the unaspirated vs. voiced pairs, but not for the aspirated vs. unaspirated pairs. In other words, the results lend support to the hypothesis that the feature needed to distinguish an unaspirated voiceless stop from a voiced stop, [voice], is available for transfer from the L1 for these speakers.[1] The feature required to distinguish an unaspirated voiceless stop from an aspirated stop, [SG], however, is not available for transfer, thus leading to low accuracy on these test pairs. Whether this feature can ever be acquired is not a question that can be answered by this study, as participants were not tested beyond the 11 day mark. The available evidence does, however, suggest that the feature [SG] is not available to francophones for construction of novel L2 representations, as francophones perform significantly worse on precisely those contrasts that require the use of [SG] in stored representations, and this did not improve over the duration of the study. The training method used by Curtin et al. provided positive feedback to participants to ensure that they correctly learned the word meanings of the test items; however, there was no explicit training on the contrast being tested. It may be the case that participants perform better when

[1] Recall from chapter 2 that I adopt the position of Iverson & Salmons (1995) that voiceless obstruents in prosodically prominent positions in English are marked with the laryngeal feature [SG] and that it is this feature that is used to capture the voicing contrast in this language. Since word-initial position is a metrically prominent position, this predicts that anglophones should perform better on the Thai aspirated vs. unaspirated pairs than on the unaspirated vs. voiced pairs; Curtin et al.'s anglophones, however, performed better on the latter. The stimuli consisted of natural speech tokens, and a group of native Thai controls performed perfectly on all contrasts, suggesting that the anglophone performance is due to the nature of the interlanguage grammar. Exactly how these results can be reconciled with the position that English uses [SG] to mark voicing contrasts is not clear. I leave this problem to future research. For further discussion, see Pater (2003) and Goad (2008).

their attention is drawn to the critical items. We now turn to such a study: Swanson (2006).

In her semi-longitudinal study, Swanson (2006) examined the production of aspiration by francophones and investigated the possible influence of training: participants received training aimed at improving their authenticity in producing aspiration in L2 English. Swanson's study departs from the other work discussed here in that she examined not only word-initial stops, but also stops in /sC/ clusters, an environment where stops are unaspirated in English. Eight L1 French L2 English speakers were recruited from undergraduate English classes at the University of Lille III, and of these eight, four received training on aspiration; the other four received training on palatalization. While no independent measure of proficiency was used, Swanson notes that all eight participants performed about equally poorly when it came to producing aspiration before training began. The four participants whose performance was the poorest on palatalization received training on this, while the remaining four received training on aspiration. Results on aspiration from only three participants are reported due to irregularities in the training schedule for the fourth participant. On the initial probe test, two francophones produced unaspirated stops in both word-initial position and in sC clusters; the third francophone produced aspirated stops in both of these positions. Following training, the two francophones who had been producing only unaspirated stops were observed to significantly increase the mean VOT of word-initial (aspirated) stops, but not the mean VOT of stops in /sC/ clusters. The third francophone, on the other hand, continued to produce aspirated stops in both

contexts, though a non-significant decrease in mean VOT was found for stops in /sC/ clusters. Swanson's results, in keeping with the results of the other studies reviewed here, indicate that aspiration in English is problematic for francophones, as all eight participants recruited did not produce aspirated stops in a target-like fashion. Further, her results suggest it may be possible to overcome this difficulty with training. Swanson's study does not, however, provide any evidence on whether the training effected any lasting changes on the representations in the interlanguage grammar: the last post-test session was conducted only a week after all training had been completed, with training sessions running from one to three weeks, depending on how quickly a participant's accuracy improved.

The available data suggests, then, that francophones do indeed encounter difficulty with aspiration both in their perception and production of L2 English; with either increased experience with English or specific training, they more closely approximate native-like production of aspirated stops, indicating that they may be sensitive to the category boundaries found in the L2 input, and are able to adjust the category boundaries in the interlanguage grammar. This does not necessarily indicate, however, that they have acquired a new feature: if francophones have merely shifted their VOT boundaries in the interpretation of [voice], there should be evidence of this reorganization appearing in their native language productions as well, a pattern reported by both Caramazza et al. (1973) and Flege (1987). Further, we would expect to also find voiceless stops being produced with aspirated VOT values in positions where aspiration is not expected. Indeed, this is precisely the pattern observed by Swanson, and though there is

very little discussion of this in the existing literature, which focuses almost exclusively on production of aspiration in contexts where it is expected, I have also observed this pattern in the speech of my francophone ESL students, and it is also apparent in the production data discussed in section 6.3.1 below (see also Friesner (2009) for discussion of aspiration in loanword adaptations in French). In order to address the question of whether new features can be acquired with increasing proficiency, we need to examine the production of aspiration and /h/ in a variety of contexts, in order to establish that the distribution of these segments is as one would expect with access to target-like representations.

We now turn to the present study, which seeks to examine the L2 English productions of high intermediate to advanced francophones. Here, we compare francophones' production of aspirated stops to their production of unaspirated stops across a range of contexts in order to determine whether the distribution of these is target-like after an extensive period of immersion in English. We also examine francophones' productions of /h/ and compare them qualitatively to those produced by native speakers, for example looking for evidence of substitution (e.g., a Pharyngeal [h] in place of a placeless [h]).

Recall from discussion in chapter 3 that if English is an aspiration language, /h/ would be analyzed as requiring [SG]: L1 learners would make use of the distributional facts about aspirated stops and [h] in English to arrive at the conclusion that these should share laryngeal representation (see Goad 2011 for evidence). For francophone L2 learners, these distributional parallels are unavailable, as the perceptual difficulties observed in chapters 4 and 5 prevent

them from reliably perceiving [h]. Consequently, they will never restructure the interlanguage grammar so that /h/ and aspirated stops are both specified as [SG]. This not only predicts that francophones should encounter difficulty in producing [h] in a target-like fashion, as the interlanguage grammar lacks an appropriate representation for this segment, but they may also encounter difficulty in producing voiceless aspirated stops. Furthermore, improvement with one (either [h] or aspiration) will not be linked with improvement on the other, since no featural link is established between the two. Using [voice] via L1 transfer to capture L2 voicing contrasts will allow for representation of voiced vs. voiceless stops, but not unaspirated vs. aspirated voiceless stops. That is, they are predicted to use a single representation for both unaspirated and aspirated voiceless stops, and thus produce both types with similar VOT values: stops in both word-initial onsets as well as in /sC/ clusters should be produced with similar VOT values.

6.2. Methodology

6.2.1. Participants

Twenty-four adult L1 French L2 English speakers participated as francophones, as well as six native English speakers who served as controls. All francophones and five of the native English controls were participants in either the MMN study described in chapter 4 or the N400 study described in chapter 5.

The native English speakers were all adults, ranging in age from 20 to 34 years of age, with self-reported normal hearing and no history of language impairment. All had spent their childhood and adolescent years in Alberta,

Canada; one was born in India, but came to Canada at the age of six months, when he was adopted by English speaking Albertans, and he was raised as a monolingual English speaker in rural Alberta. All six had acquired French as a second language in school, though to varying proficiency levels by self-report: three reported high beginner proficiency, two reported low-intermediate proficiency, and one reported high-intermediate proficiency.

The native French L2 English speakers were all adults, ranging in age from 21 to 63 years of age, with self-reported normal hearing and no history of hearing or language impairment. Fourteen francophones were from France, had begun learning English in a classroom setting for approximately three hours a week around the age of 11, and later moved to an English-speaking environment as adults. Eight francophones were from Québec, had begun learning English in a classroom setting for approximately three hours a week around the age of 9, and had later moved to an English-speaking environment as adults. One francophone was from Morocco, but did not speak Arabic; she began learning English in a classroom setting at the age of 12 and later moved to an English-speaking environment as an adult. One francophone was from Switzerland, began learning English in a classroom setting at the age of 13 and later moved to an English-speaking environment as an adult. All francophones had been living in or near Calgary, Alberta, a primarily English-speaking city, for at least eight months,[2] and reported high-intermediate to advanced proficiency in English. In addition to self-

[2] The vast majority of the francophones who participated had in fact been living and working in Calgary and the Calgary area for at least two years; the one who had only been in Calgary for eight months was an exchange student from France.

report, L2 English proficiency was assessed with a cloze test; the scores suggest that the participants form two proficiency groups, one being advanced and the other being high-intermediate.

6.2.2. Stimuli

Stimuli consisted of 44 target words contained inside 22 sentences. The 44 target words contained either an aspirated stop (n=18), an unaspirated stop (n=18), or an /h/ (n=8). Two tokens each of bilabial, alveolar, and velar stops were included for all environments; three tokens of /h/ were elicited in word-initial stressed syllable and word-medial stressed syllable position, while two tokens were elicited for /h/ in word-initial unstressed position. A number of environments were included for both aspirated and unaspirated stops. In table 6.1 below, sample items for aspirated and unaspirated stops as well as /h/ are provided.

Aspirated	Word-initial, stressed syllable	Bilabial	pot
		Alveolar	tell
		Velar	cold
		/h/	hot
	Word-medial, stressed syllable	Bilabial	apart
		Alveolar	detect
		Velar	become
		/h/	behave
	Word-initial, unstressed syllable	Bilabial	potato
		Alveolar	tomatoes
		Velar	control
		/h/	hello
Unaspirated	sC cluster, stressed syllable	Bilabial	spin
		Alveolar	steam
		Velar	school
	Word-medial, unstressed syllable	Bilabial	simple
		Alveolar	planting
		Velar	blanket
	Word-final	Bilabial	snap
		Alveolar	seat
		Velar	bake

Table 6.1. Sample items for production task

The sentences were created to control the phonetic environment of word-initial and word-final target segments. Where the target segment occurred word-initially, the preceding word ended in a vowel or a consonant that could not be resyllabified into a complex onset with the target segment. Similarly, where the target segment occurred word-finally, the following word began with a consonant that would not allow for resyllabification of the target segment into a complex onset. The sentences also varied considerably in their thematic content; the goal here was to avoid making participants aware of which aspect of their English pronunciation was being examined.

6.2.3. Procedure

Given that the critical items were placed in controlled phonetic environments, and that the items themselves were selected for specific phonetic properties (e.g., position of aspirated stop), it was important to ensure that all participants would produce the selected items in their task sentences without making any changes (i.e., a story-telling task would not have allowed for sufficient phonetic control). Further, as francophones are known to have difficulties in perceiving [h] in the speech stream, production of this segment could not be reliably assured in a sentence repetition task. The stimuli were thus presented visually, with the expectation that the presence of the orthographic cue for /h/ might result in greater suppliance than that typically found in spontaneous speech. The participant was seated at a table in a quiet room, with the sentences, printed in a large font (20 pt) on two sheets of paper, placed on the table. The participant was then asked to read each of the sentences aloud once, at whatever pace they felt most comfortable with, and they were also told that if they liked they could take a moment to look over the sentence before beginning to read it out loud. Participants were not informed of what the critical items were, nor were they told that this task was designed to examine their production of voiceless stops and /h/; no attempt was made to draw their attention away from their voiceless stop and /h/ production either.

Recording was done using an Edirol R-09 24 bit digital recorder, using a sampling rate of 48 kHz, and the Edirol's built-in stereo microphone. The sound files were then transferred to a laptop PC and acoustic measurements were taken

with the aid of spectrograms and oscillograms generated using Praat (Boersma & Weenink 2010). Aspiration was measured as the period from the noise burst of the stop's release up to the onset of voicing for the following vowel. /h/ was measured as the period of low-intensity fricative noise up to the onset of voicing for the following vowel.

6.3. Results

We begin with discussion of the aspiration results in 6.3.1; the /h/ results will be discussed in 6.3.2 below.

6.3.1. Aspiration

In order to reduce the effect that varying rate of speech may have on the results, analysis of measurements taken was performed within subjects. Additionally, the data reported here involve a comparison of word-initial stressed syllable stops vs. stops in /sC/ clusters to allow for the clearest interpretation of the results. Grouping all aspirated stops produced by each participant together in contrast to all unaspirated stops proved to be problematic: significant differences between aspirated and unaspirated stops were found for nearly all participants, but this was due to the inclusion of word-final position for unaspirated stops. The task of reading aloud tends to prompt participants to be more attentive to their pronunciation, and both native English speakers and francophones tended to produce strongly released stops followed by a pause in word-final position, resulting in a large range of values being recorded for this position; values recorded in all other positions were much more consistent for the native English

speakers. Furthermore, word-internal onset stops are being excluded from statistical analysis as the francophones were inconsistent in the stress patterns they used in these words, often shifting the stress to another syllable, or stressing adjacent syllables. In these cases, interpretation of the data is no longer clear: it may be that the stress shift occurs in order to avoid attempting to produce an aspirated stop, or it may be that the lack of aspiration occurs because the environment in which aspiration is found is suddenly absent due to incorrect calculation of stress placement. Data from word-initial unstressed position are also excluded from analysis, as the statistical test employed requires paired samples: since only one context was available for unaspirated stops, only one context could be used for aspirated stops for statistical comparisons.

Since the data were not pooled into groups for analysis, the sample sizes being compared were small (6 tokens per condition per participant), so statistical significance was calculated using the Mann-Whitney *U* test, a non-parametric test used to determine whether two samples of observations come from the same distribution; significance level was set at 0.05.

6.3.1.1. Anglophone results

Table 6.2 below lists the minimum, maximum, and mean duration of aspiration produced by the six native speakers on word-initial stops (n=6) and stops in /sC/ clusters (n=6), both in stressed syllables, along with the significance results.

		Min. duration (ms)	Max. duration (ms)	Mean (ms)	*U*	*P* (two-tailed)
E1	asp	55	93	68.833	36	0.002
	unasp	11	34	19.333		
E2	asp	29	101	62.667	36	0.005
	unasp	0	22	11.833		
E3	asp	44	105	65.167	35	0.004
	unasp	0	48	17		
E4	asp	59	93	74.333	36	0.002
	unasp	0	27	15.667		
E5	asp	52	95	72.667	36	0.002
	unasp	0	33	17.333		
E6	asp	44	72	60.167	36	0.002
	unasp	13	37	21.5		

Table 6.2. Native speakers: word-initial stops vs. stops in /sC/ clusters

These results clearly illustrate that in stressed syllables, native speakers produce word-initial stops that are significantly more aspirated than those stops produced in /sC/ clusters. With the exception of E3, the maximum duration of an unaspirated stop was always shorter than the minimum duration of an aspirated stop. The different ranges of VOT values for aspirated and unaspirated stops are illustrated more clearly in figure 6.1 below.

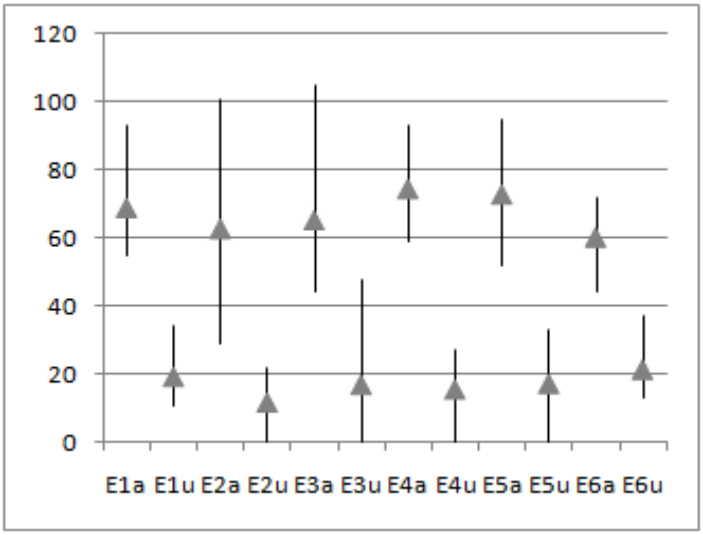


Figure 6.1. Production of aspirated and unaspirated stops by anglophones. Duration in milliseconds is plotted on the *y* axis; participants are arranged along the *x* axis, where 'a' represents aspirated stops, and 'u' represents unaspirated stops.

Each vertical line in figure 6.1 represents the range of duration values produced by a given participant in a given condition. The triangle represents the mean duration value produced by a given participant in a given condition (aspirated vs. unaspirated).

6.3.1.2. Francophone results

Table 6.3 below lists the minimum, maximum, and mean duration of aspiration produced by the francophones on word-initial stressed syllable stops and stops in /sC/ clusters, along with the significance results. Individual results are presented in order of increasing proficiency, as determined by cloze test results.

		Min. duration (ms)	Max. duration (ms)	Mean (ms)	*U*	*P* (two-tailed)
F12	asp	16	74	49	28	0.132
	unasp	0	43	26		
F8	asp	24	60	41.167	20.5	0.725
	unasp	16	62	37.5		
F21	asp	22	87	50.667	27	0.180
	unasp	13	67	33.667		
F3	asp	42	79	54.833	31.5	0.032
	unasp	18	50	32.333		
F5	asp	38	100	63.833	15	0.699
	unasp	18	106	67.667		
F1	asp	0	70	38.5	12.5	0.42
	unasp	25	88	51.833		
F17	asp	20	75	43.333	31	0.035
	unasp	14	36	19.667		
F14	asp	28	75	53.833	24	0.394
	unasp	15	86	42.833		
F19	asp	38	81	61.167	29.5	0.071
	unasp	17	78	39.333		
F23	asp	30	112	77.5	32	0.026
	unasp	22	60	40		
F13	asp	21	57	39.167	16.5	0.842
	unasp	21	66	40.5		
F10	asp	19	90	48.5	18	0.937
	unasp	12	74	44.333		
F24	asp	33	90	57.667	23.5	0.42
	unasp	15	87	45.5		
F6	asp	27	120	58.333	24.5	0.329
	unasp	10	57	37		
F11	asp	15	66	47.333	24	0.394
	unasp	16	58	36		
F16	asp	24	77	49.167	25	0.31
	unasp	18	70	36.833		
F20	asp	18	87	49.667	18.5	0.974
	unasp	22	73	46.667		
F2	asp	18	67	44.833	25	0.31
	unasp	16	59	33.833		
F7	asp	18	54	38.167	27	0.18
	unasp	14	45	27.5		
F18	asp	22	47	37.333	24	0.366
	unasp	18	46	31.833		

		Min. duration (ms)	Max. duration (ms)	Mean (ms)	*U*	*P* (two-tailed)
F9	asp	10	58	36.5	21.5	0.619
	unasp	17	54	32.833		
F4	asp	25	69	43.833	24	0.372
	unasp	16	66	36.333		
F15	asp	0	79	42.833	20.5	0.729
	unasp	14	68	34.5		
F22	asp	12	50	30.5	18	0.961
	unasp	13	48	30.167		

Table 6.3. Francophones: word-initial stressed syllable stops vs. stops in /sC/ clusters

These results suggest an entirely different profile than that seen for the native English speakers: of the 24 francophones who were recorded, only three (F3, F17, F23) produced a difference between their aspirated and unaspirated stops that reached significance, and a fourth (F19) approached significance. This suggests that, with a handful of exceptions, L2 English francophones with higher proficiency levels still do not produce aspirated stops that are significantly more aspirated than unaspirated stops. Recall that the native English speakers produced two distinct ranges of VOT values for aspirated and unaspirated stops: the longest VOT unaspirated stop produced was still shorter than the shortest VOT aspirated stop, as illustrated in figure 6.1 above. Examination of table 6.2 here shows that this is not true for the francophones. Instead, nearly identical ranges of VOT values are seen: for all francophone participants, the longest unaspirated stop is produced with a greater VOT lag than the shortest aspirated stop, as illustrated in figure 6.2 below.

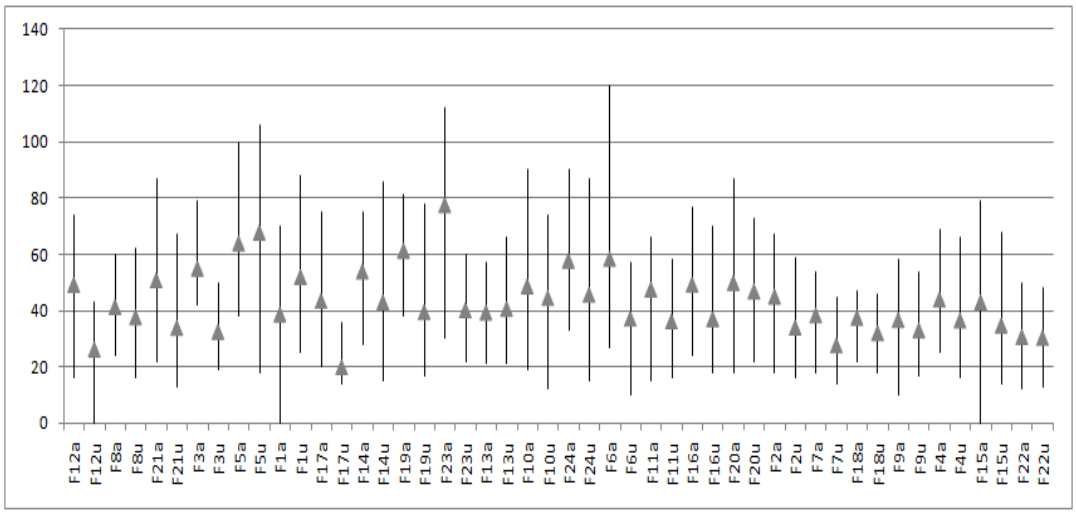


Figure 6.2. Production of aspirated and unaspirated stops by francophones. Duration in milliseconds is plotted on the *y* axis; participants are arranged along the *x* axis, where 'a' represents aspirated stops, and 'u' represents unaspirated stops.

As in figure 6.1 for anglophones above, in figure 6.2 each vertical line represents the range of VOT values produced by a given participant in a given condition; again participants are sorted by proficiency as indicated by cloze test scores, with lower scores on the left and higher scores on the right. The triangles again represent the mean VOT values produced by a given participant in a given condition. Notice, in contrast to the anglophones above, the large degree of overlap in VOT values produced in aspirated and unaspirated conditions. Furthermore, when examining the actual VOT values produced by francophones, we see that they are producing both aspirated stops in unaspirated contexts, and unaspirated stops in aspirated contexts.

Figure 6.3 presents the results for F3, F17, and F23, all of whom reached significance in their aspirated vs. unaspirated stop production, alongside the results obtained from the anglophones.

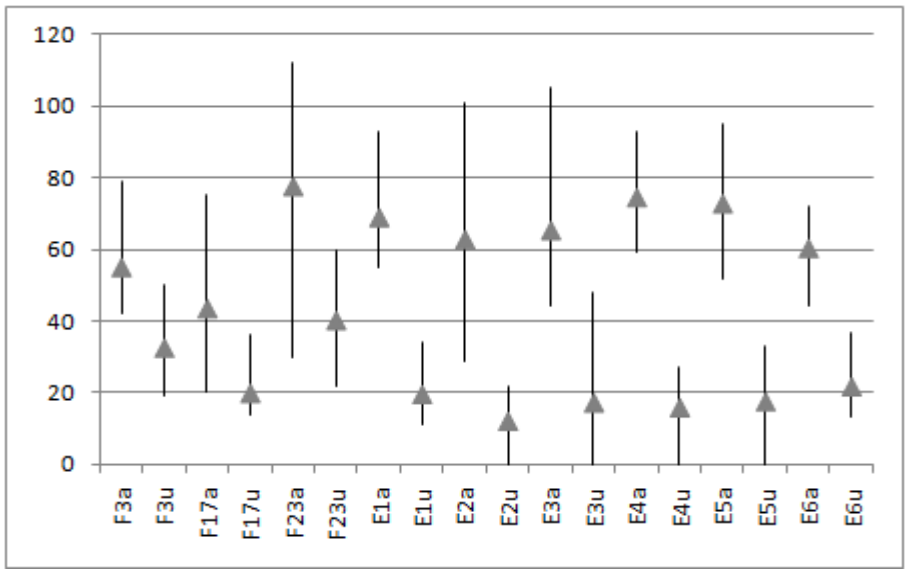


Figure 6.3. Production of aspirated and unaspirated stops: significant difference. Duration in milliseconds is plotted on the *y* axis; participants are arranged along the *x* axis, where 'a' represents aspirated stops, and 'u' represents unaspirated stops.

Note that although these francophones reached significance, their results are still not like those of the native speakers: where anglophones show virtually no overlap in their categories in production, these most target-like of the francophones do. This suggests that these francophones are not truly target-like: they are developing a system that allows them to approximate the surface behaviour of the anglophones.

The overlap in VOT values in both aspirated and unaspirated contexts, along with the wide range of values recorded, indicate that it is not the case that francophones simply lack aspiration in their L2 English. Rather, they are able to produce both aspirated and unaspirated stops, but have not mastered the distribution of aspiration in English and thus produce both unaspirated stops word-initially before a stressed vowel, and aspirated stops in /sC/ clusters. We

will return to the implication of these findings in section 6.4 below, following discussion of the results for the production of /h/.

6.3.2. Production of /h/

As mentioned above, the production task used to elicit aspirated and unaspirated stops from francophones included 8 /h/ items: three in word-initial position before a stressed vowel, three word-medially before a stressed vowel, and two word-initially before an unstressed vowel. Again, since rate of speech was not controlled, we cannot reliably pool together data from different participants for statistical comparisons. Additionally, we cannot set up comparisons within subjects as was done in the analysis of aspiration; during construction of the sentences used in the task, it was thought that the visual cue of the orthographic *h* would prompt participants to produce [h] in appropriate contexts, and thus no vowel-initial words were included as targets for analysis.[3] We can, however, examine any errors in suppliance that occur in spite of the visual cue, and we can also perform an acoustic analysis of the tokens of /h/ that were produced in order to determine whether these are truly target-like, or if they are in fact substitutions of another segment (e.g., a Pharyngeal /h/).

[3] Since all participants were also taking part in the one of the ERP studies detailed in chapters 4 and 5, the aspiration and [h] elicitation tasks were combined into a single task, which, as discussed previously, used orthographic presentation of sentences in order to control for the phonetic environments of the target items. While this same degree of control is not strictly necessary for elicitation of [h], using one task for elicitation simplified the testing procedure, and had the added benefit of drawing attention away from /h/ without requiring additional filler items that could lead to fatigue effects.

Table 6.4 below details francophones' suppliance of /h/ in each of the contexts where /h/ was elicited. As above, participants are organized by order of increasing proficiency.

Participant	Word-initial stressed syllable (n=3)	Word-medial stressed syllable (n=3)	Word-initial unstressed syllable (n=2)
F12	3	3	2
F8	0	0	0
F21	3	3	2
F3	3	3	1
F5	2	1	1
F1	0	0	0
F17	3	3	2
F14	3	3	2
F19	3	2	2
F23	3	3	1
F13	3	3	2
F10	3	3	2
F24	3	2	2
F6	3	3	2
F11	3	3	2
F16	3	3	2
F20	3	2	2
F2	3	3	1
F7	3	3	2
F18	3	3	2
F9	3	3	2
F4	3	3	2
F15	3	3	2
F22	3	2	1

Table 6.4. Francophones' suppliance of /h/

While more than half of the francophones performed as expected, supplying /h/ in appropriate contexts, not all did. Two participants (F1 and F8) never produced /h/, one (F5) did half the time, and seven occasionally deleted /h/ when it was word-medial or word-initial before an unstressed vowel. Interestingly, of the three francophones who were found to produce aspirated stops with significantly

greater VOT than their unaspirated stops, only one (F17) was accurate in producing all eight tokens of /h/. Where /h/ was missing in production, for some tokens a glottal stop was observed in its place, though a variety of profiles emerge in the data: F1 produced a glottal stop only in word-initial stressed syllable position, but in all other positions /h/ was deleted; F3 produced a glottal stop in word-initial unstressed syllable position (but was target-like in supplying /h/ in all other tokens); F5 and F8 produced glottal stops in word initial positions for both stressed and unstressed syllables, but deleted word-medial /h/. For others, /h/ was never replaced with a glottal stop, and again a variety of profiles are observed: F19 deleted /h/ in word-medial stressed syllable position once, but was target-like in suppliance for all other tokens; F22 deleted /h/ from two tokens, one from a word-medial stressed syllable and one from a word-initial unstressed syllable; F23 and F24 deleted /h/ from one word-initial unstressed syllable.

As noted previously, francophones' /h/ suppliance rates are generally quite high, presumably due to the presence of the orthographic cue in the stimuli; indeed, several participants are target-like in their suppliance. Differences may appear, however, upon examination of the quality of /h/ as produced by francophones. Some francophones did show a tendency to produce a breathy [h], with some vocal fold vibration; however, each of the native English controls also did this for at least one of the tokens produced. A more detailed examination of [h] quality was thus carried out: duration, intensity, and formant structure were considered.

The range of duration values produced by francophones appears to be consistent with the range produced by native speakers; the only difference in duration is found in instances where francophones omit [h], as native speakers never do. Examination of /h/ production in each of the three phonetic contexts used for elicitation also suggests that with the exception of omission, when francophones produce an [h], its duration is like that of [h] as produced by anglophones, as illustrated in figures 6.4, 6.5, and 6.6 below, which show the results obtained from francophone participants on the left, and anglophone participants on the right. As with figures 6.1, 6.2, and 6.3 above for aspiration values, each line in these figures represents the range in duration values for /h/ produced by each participant, with the triangle representing the mean duration value for that participant.

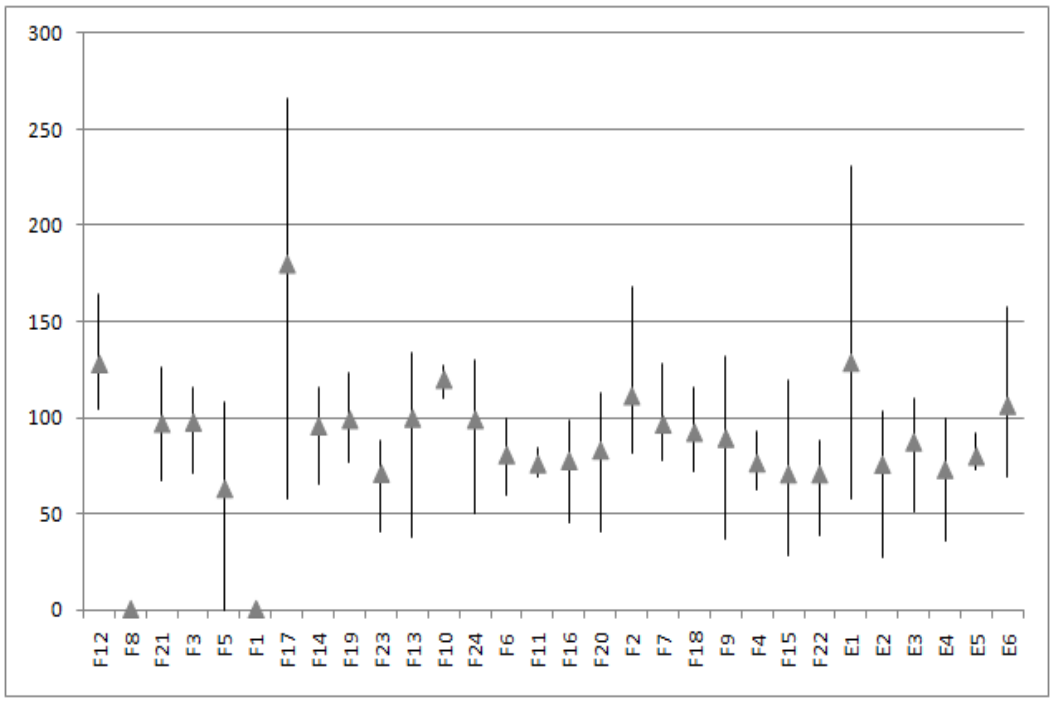


Figure 6.4. Duration of [h] in word-initial stressed syllables. Duration in milliseconds is plotted on the *y* axis; participants are arranged along the *x* axis.

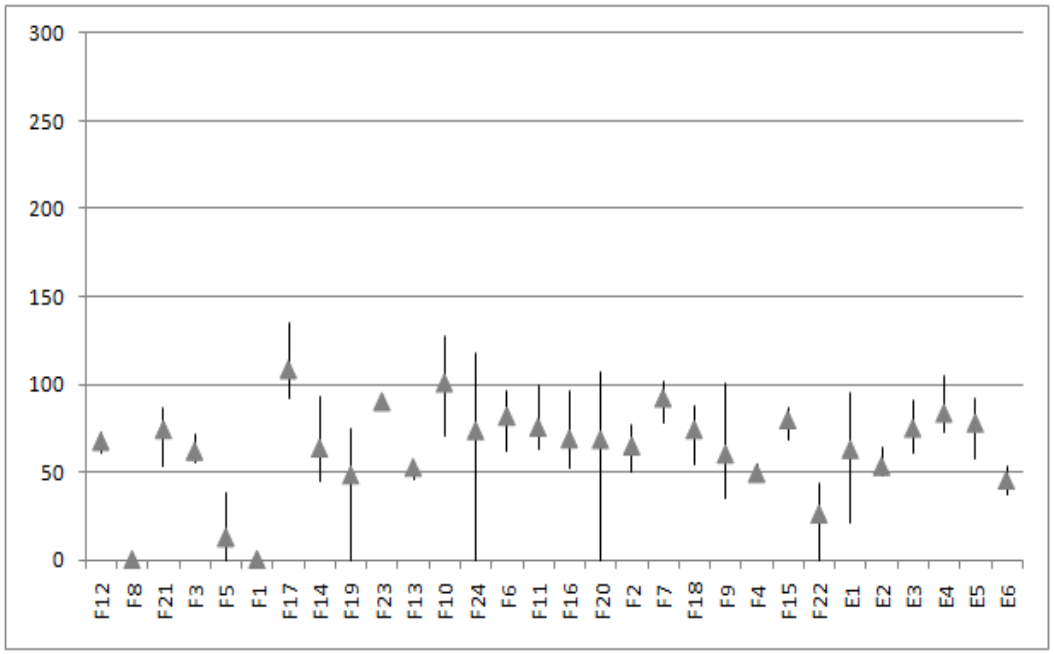


Figure 6.5. Duration of [h] in word-medial stressed syllables. Duration in milliseconds is plotted on the *y* axis; participants are arranged along the *x* axis.

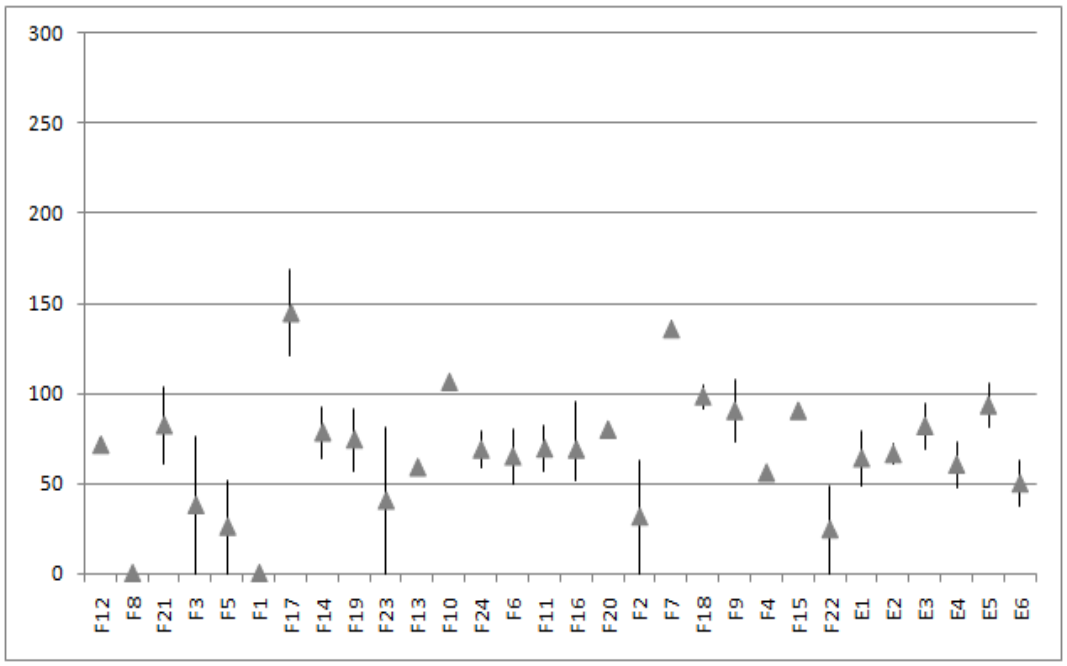


Figure 6.6. Duration of [h] in word-initial unstressed syllables. Duration in milliseconds is plotted on the *y* axis; participants are arranged along the *x* axis.

The intensity of [h] as produced by francophones is also not unlike that produced by native speakers: examining each of the phonetic contexts separately, as in figures 6.7, 6.8, and 6.9, does not reveal any pattern in which the francophones are not behaving as the anglophones do. Again, results from all participants appear in these figures, with the francophones grouped on the left, and anglophones grouped on the right.

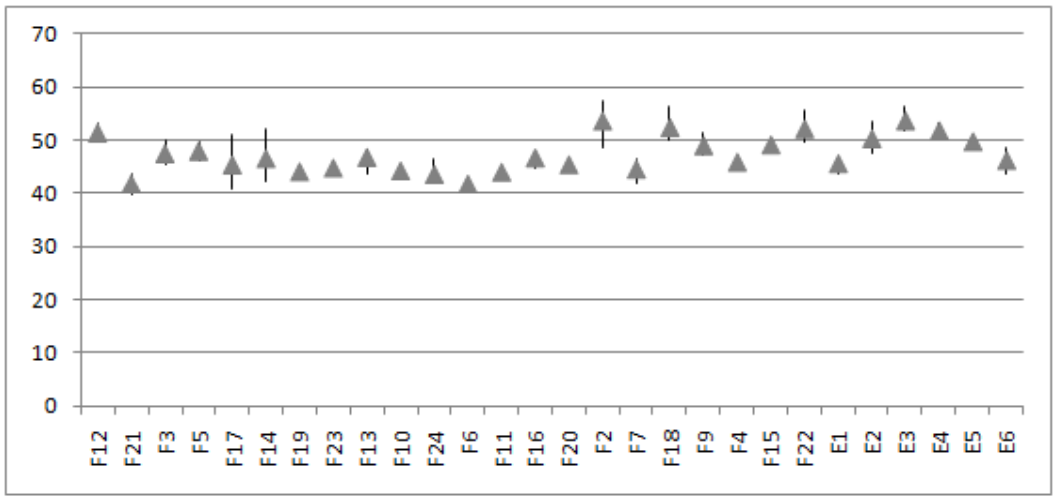


Figure 6.7. Intensity of [h] in word-initial stressed syllables. Intensity is plotted along the *y* axis in Hz.

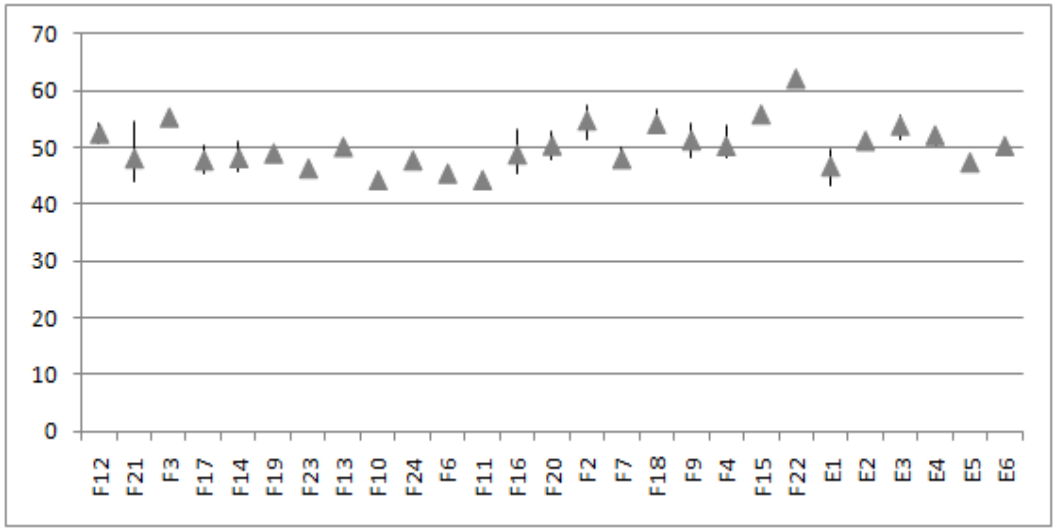


Figure 6.8. Intensity of [h] in word-medial stressed syllables. Intensity is plotted along the *y* axis in Hz.

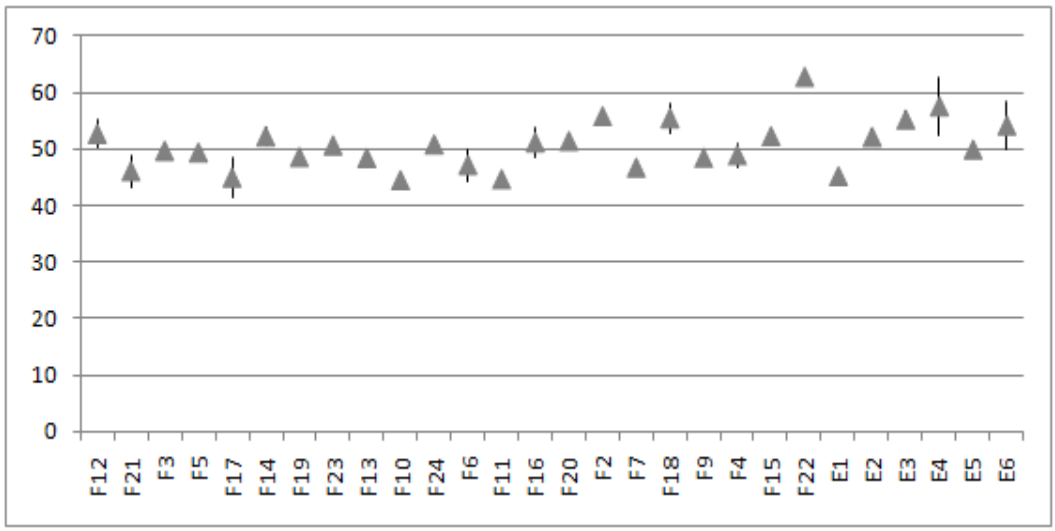


Figure 6.9. Intensity of [h] in word-initial unstressed syllables. Intensity is plotted along the *y* axis in Hz.

Furthermore, inspection of wide-band spectrograms reveals that both anglophones and francophones produce [h] as a voiceless vowel, with formants appearing throughout the duration of the fricative.

In sum, it appears to be the case that when francophones produce [h], acoustically speaking it is target-like: the segment produced is like that produced by anglophones. The key difference in behaviour appears to be suppliance: anglophones know exactly which words contain /h/, whereas francophones do not.

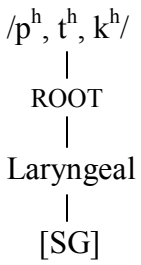
6.4. Discussion

The analysis of English as an [SG] language, with both voiceless aspirated stops and /h/ bearing [SG] in their representations, as given in (1a) below, together with Brown's (1997, 2000) proposal of full transfer partial access, predicts that these segments will be problematic for L2 speakers whose L1 does not permit transfer of [SG] into the interlanguage grammar; French is such a

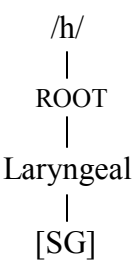
language. Under this analysis, then, francophones are predicted to encounter difficulty with voiceless aspirated stops, owing to their inability to represent these segments in the interlanguage grammar: since the only laryngeal feature that is available for transfer is [voice], aspirated stops would therefore be represented as being identical to voiceless unaspirated stops, as in (2a) below (note that voiced stops would include the feature [voice] in the representation, as in (2c)). With respect to English /h/, a target-like representation would be similarly unavailable in the interlanguage grammar, but an alternate representation (either a placeless /h/ as in (2b) or a Pharyngeal /h/) should be available, as discussed previously.

(1) *Target representations*

a) *Aspirated stops*

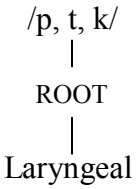


b) */h/*

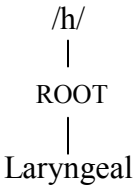


(2) *Transferred representations*

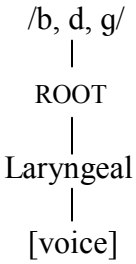
a) *Unaspirated stops*



b) */h/*



c) *Voiced stops*



While native English speakers are observed to produce two distinct categories of VOT values, francophones in the general case do not: of the 24 participants observed here, a significant difference in VOT between voiceless and unaspirated stops was only found for three. This finding suggests that where anglophones have established two separate phonetic categories for voiceless stops, with aspirated stops on the one hand and plain stops on the other, francophones place both types into a single phonetic category. This in turn suggests that the French grammar fails to supply an appropriate feature with which to divide that phonetic category into two as required for the target language, which leads to both the production of plain stops in aspirated positions, and aspirated stops in plain positions. These findings are thus consistent with the hypothesis that English makes use of [SG] in segmental representations, and, consistent with Brown's (1997, 2000) proposal of full transfer partial access, the absence of this feature in French is the source of francophones' difficulties with aspiration.

The results also suggest that it may be possible for some francophones to detect that VOT length has a predictable distribution in English and thus to divide voiceless stops into two categories, as three participants here did. There are three possibilities for how this could be accomplished. First, counter to our assumption of Brown's (1997, 2000) proposal of full transfer partial access, these francophones could have acquired [SG] for use in stored representations. Second, these speakers may have acquired an allophonic rule that introduces [SG] in phonetic implementation: in stored representations, these speakers may still be

making use of the two-way voicing contrast transferred into the interlanguage grammar from French, with the presence or absence of [voice] capturing this distinction between voiced and voiceless stops in underlying representations, but the allophonic rule introducing [SG] phonetically allows them to produce voiceless stops with longer VOT values in aspirated positions, and shorter VOT values in unaspirated positions. In terms of surface productions, there is no way to distinguish between these two possibilities. The third possibility, however, is one that does not involve the feature [SG] at all: francophones may be implementing a gestural timing rule that allows production of long-lag VOT in some phonetic contexts, and short-lag VOT in others. This analysis would suggest a different pattern of behaviour: where a feature (i.e., [SG]) is involved in characterizing the distinction, production is expected to be categorical, with aspirated and unaspirated stops forming two separate clusters of VOT values. Where a gestural timing rule is involved, categorical behaviour is not expected. When examining the range of VOT values produced in 6.3.1.2 above, it was noted that anglophones are categorical in their production, but these three francophones are not, instead producing overlapping ranges of VOT values, suggesting that no feature is involved in characterizing the distinction in the interlanguage grammar.[4]

Interestingly, of the three speakers whose performance on aspiration was closer to being target-like, only one was 100% accurate in supplying /h/ in their productions, suggesting that there may be no featural link in the interlanguage

[4] Swanson (2006) reports the range of VOT values produced by her francophone learners only at pre-test; post-test results are only reported in terms of mean VOT values.

grammar between /h/ and aspirated stops; this is as expected if [SG] is not available. That is, whatever mechanism is being used to differentiate between plain and aspirated stops, it is not being used to distinguish /h/-initial words from vowel-initial words. This is not to say that the accurate /h/ suppliance of some francophones is viewed here as evidence of these speakers having an appropriate representation for /h/, as the presence of the orthographic cue very likely had the effect of improving suppliance rates.

Let us now summarize what we have learned about the status of English /h/ in francophone interlanguage grammars. Recall from the experimental results presented in chapters 4 and 5 that francophones do not perceive [h] in linguistic input (no MMN component in the linguistic condition), nor do they appear to construct any abstract representation for this segment in lexical entries (no N400 component for unexpected [h]-initial or vowel-initial words with an auditory mode of presentation); yet, in production they are observed to produce voiceless glottal fricatives. This asymmetry is not predicted by any of the possible interlanguage grammars described in chapter 3. Furthermore, while francophones' difficulties with English /h/ are predicted by the analysis of English /h/ as specified for [SG] and Brown's (1997, 2000) proposal of full transfer partial access, what is not predicted is the unavailability of the other possible representations for laryngeals discussed previously in chapter 2. Indeed, in examining the L2 acquisition predictions that each representation made in chapter 3, we concluded that only the representation with [SG] is unavailable; the other options should thus be available to francophones, yet the data presented

throughout this thesis strongly suggests that francophones do not have any representation available to them for English /h/. This raises an important question: why are these alternatives not available?

The results of the acoustic examination of [h] as produced by both anglophones and francophones presented here are suggestive of an answer to this question. As noted in section 6.3.2 above, anglophones produce /h/ as a voiceless vowel, with formant structure throughout the duration of the fricative: that is, they are producing a segment that lacks an independent articulatory target for place. Where francophones supply [h], they also produce a voiceless vowel; no important differences are apparent in terms of either duration or intensity, suggesting that when francophones do produce [h], they are producing an acoustically target-like segment.

For anglophones, the acoustic event of the voiceless vowel (i.e., [h]) maps to a consonant representation in the grammar (i.e., /h/), whereas for francophones, the ERP evidence discussed in chapters 4 and 5 suggest that no such mapping takes place. I propose that the elicited production results indicate that francophones are misanalyzing instances of [h] in the input as partially devoiced vowels in phonological representations, due to the presence of formant structure on [h]: for example, they misanalyze [hæt] 'hat' as [æ̥t].[5] The French grammar does not supply any means of representing partially devoiced vowels in underlying representations, resulting in a failure to perceive [h], yet francophones

[5] Whether the partially devoiced vowel is long or short is a question that cannot be answered with the data gathered here, and I leave this to future research.

are made aware of this apparent property of English, either through explicit instruction in the classroom, comments from native English speakers, instruction in English orthography, or any combination of these. Francophones thus attempt to construct a gestural timing rule that will allow them to begin vocal fold vibration at the correct point in the production of the vowel, much like the rule that three of the francophones appear to be using to produce aspiration in a manner that approaches being target-like. Of course, unlike the case for aspiration, no such rule can be formulated to predict the appearance of [h], and the result is the observed problem in production: francophones do not know which words should have a partially devoiced vowel (i.e., /h/) and which words should not. Such a misanalysis would allow us to account for the apparent unavailability of alternate laryngeal representations that can be constructed entirely using features transferred from the French grammar. Simply put, francophones do not analyze [h] as a consonant, and therefore do not consider any consonant representations for it.

It was predicted that if English /h/ is [SG], and the French grammar fails to supply [SG], then francophones should encounter difficulty not only with /h/, but also with aspiration. This prediction appears to be borne out by the data discussed here: with the exception of three participants, francophones collapse plain and aspirated voiceless stops into a single phonetic category, producing aspirated stops in plain positions and plain stops in aspirated positions. Given the unavailability of [SG] to establish a featural link between /h/ and aspiration, it was predicted that there should be no simultaneous improvement on both; indeed, the

data presented here support this claim, as the francophones who do differentiate between plain and aspirated stops did not supply /h/ with complete accuracy, in the elicited production task as well as in a small sample of spontaneous speech. As mentioned above, these results suggest that these three francophones are transferring the feature [voice] to capture voicing contrasts from the L1, and are treating plain and aspirated stops in English as allophones of the voiceless stop phoneme, using a gestural timing rule to produce long- and short-lag VOT values where appropriate. As the distribution of plain and aspirated stops is predictable, it can be derived through computation, thus requiring no storage in abstract lexical representations. The same cannot be said for /h/: while unaspirated stops do not occur in aspirated positions, /h/ does not always appear where it might be expected, as there are a great many vowel-initial words in the English lexicon with the same distribution. The only way to be target-like in production of /h/ is to have the correct phonological representations in lexical entries: one must know which words have /h/, and which ones do not.

The production data reported here fall in line with previous studies on the L2 acquisition of aspiration by francophones, indicating that advanced speakers who have been living in a primarily anglophone environment for an extended period continue to encounter difficulty with the distribution of plain and aspirated stops. This outcome is expected if [SG] is needed to represent this contrast in lexical representations, and the results are consistent with Brown's proposal of full transfer partial access. These results thus lend support to the idea that English uses [SG] in representing its voicing contrasts, and that /h/ is also [SG].

Furthermore, the [h] production data reported here lend further support to the findings obtained in the ERP studies reported in chapters 4 and 5: a phonological representation for English /h/ is not available to francophones. They are therefore unable to store this segment in lexical entries, resulting in their observed difficulties with the segment in both perception and production.

Chapter 7: Concluding remarks

Throughout this thesis we have been examining the interlanguage grammars of francophone L2 English learners in order to determine why these speakers encounter such persistent difficulty with English /h/ (Janda & Auger 1992, John 2006, LaCharité & Prévost 1999). Research in L2 acquisition suggests that learners transfer the content of the L1 grammar into the interlanguage grammar, and expand upon that provided sufficient evidence from L2 input that this is necessary. This is not, however, without limitations: in the segmental realm, a body of evidence suggests that the interlanguage grammar allows for recombination of primitives (i.e., features) from the L1, but not the acquisition of new features (Brown 1997, 2000); this is consistent with a full transfer partial access approach to L2 phonology. This is a more conservative approach to segmental acquisition than Full Transfer Full Access, and I adopted it precisely because the literature has shown the persistent nature of francophone difficulties with English /h/. However, francophone difficulties with /h/ seemed to pose a problem for this approach, as it was not obvious why a representation for this segment should be unavailable to the interlanguage grammar.

In chapter 2, we saw that there are a number of possible phonological representations for /h/ in the world's languages, and reviewed evidence favouring a particular structure for English /h/: one that requires the feature [SG]. In chapter 3, we detailed the difficulties francophones encounter with English /h/, and evaluated the cross-linguistically possible representations for this segment and

their availability to the francophone interlanguage grammar under the assumption of Brown's full transfer partial access approach. We concluded that although a target-like representation (i.e., with [SG]) is not available, other options are, but the behavioural patterns predicted by these representations do not coincide with francophones' observed difficulties with /h/, suggesting that francophones are not making use of any of the possible representations.

Where other studies (e.g., LaCharité & Prévost 1999) have relied on behavioural responses provided in discrimination tasks to examine francophone perception of /h/, I chose to instead conduct an ERP study that would gather evidence of differences (or lack thereof) in automatic, pre-attentive processing of auditory stimuli. Doing so would allow us to avoid potential problems in interpreting the data due to response biases or participant inattention. Chapter 4 thus reported on an experimental study that is the first, I believe, to evaluate the possibility that francophones are not making use of any representation for /h/ because the segment is not sufficiently salient in the speech stream for them to detect it. A task designed to elicit the mismatch negativity (MMN) as a measure of perception (e.g., Näätänen 1999) found that in a non-linguistic mode of presentation (i.e., noise bursts), francophones perform like native English speakers: they are able to pre-attentively detect the presence of the acoustic signal of /h/ in the input, as reflected by an MMN component. In a linguistic mode of presentation (i.e., in syllables), however, perception differed, with only the native English speakers showing a clear and significant MMN. The francophone group exhibited a different pattern of increased negativity following presentation of

deviant stimulus items in the linguistic condition, including a significant late negativity similar to a component that others (Molnar 2010, Cheour 2001) have associated with discrimination. The use of linguistic recordings to create non-linguistic stimuli for presentation is a replication of a study by Werker & Tees (1984); to my knowledge, this study is, however, the first to use ERPs (i.e., the MMN) as the measure of perception with this comparison. It was suggested here that the deviant negativity reflects detection of /h/ in the linguistic condition at the phonetic level, but as no abstract representation can be associated with this segment, perception fails, resulting in the absence of an MMN. The results of the MMN study thus demonstrate that francophones do hear /h/, but they fail to linguistically perceive it due to an inability to create a distinct phonological representation for it.

Chapter 5 reported on an original experimental study that was designed to test the predicted outcome of the MMN study: if francophones cannot perceive /h/ due to a failure in constructing a phonological representation for this segment, then any English word requiring /h/ should be missing this segment in the phonological component of its lexical entry. This was tested by eliciting the N400 (Kutas & Hillyard 1980): if francophones' lexical entries do not contain /h/, then words like *hair* and *air* will be phonologically identical; presenting [ɛr] in the speech stream will access both lexical entries, so neither will be perceived as being anomalous in a sentence like *Many girls want to have long shiny hair/*air*. Results indicated that while francophones perform like native English speakers when the test sentences were presented visually, and the presence of the

orthographic cue <h> allowed retrieval of the correct lexical item, francophones do treat /h/-initial and their corresponding vowel-initial words as phonologically identical, as no N400 was elicited by semantically anomalous sentences in an auditory mode of presentation. This finding supports the proposal that francophones cannot perceive /h/ (hence its absence in lexical entries) due to a problem with its phonological representation.

Chapter 6 reported on an elicited production task that was designed with two goals in mind. The first was to test an additional prediction of Brown's full transfer partial access approach: if francophone difficulties with /h/ are due to the unavailability of [SG], then they should also encounter difficulty with aspiration in English, as this also requires [SG]. The second was to examine francophone productions of [h], looking for evidence indicating how they are able to produce this segment despite not having access to an appropriate representation for it. While others have examined the production of [h] (e.g., Janda & Auger 1992, John 2006) as well as the production of aspiration (e.g., Caramazza et al. 1973, Flege 1987), I am not aware of any studies attempting to link the two. Our results showed that francophones do indeed have difficulty with aspiration, and the error pattern mirrors that observed with /h/: that is, they do not systematically omit it, but instead exhibit a pattern in which they both fail to produce it where required and produce it inappropriately. Analysis of the acoustic properties of [h] as produced by francophones reveals that it has all the characteristics of [h] as it is produced by native English speakers: that is, the segment produced is target-like, even if its suppliance is not, a finding that represents a distinct contribution to our

understanding of francophone interlanguage grammars of English. It was proposed that francophones are recognizing the formants present on [h] and misanalyzing it as a partially devoiced vowel, which cannot be represented phonologically using the features for vowel representation available for transfer from French, as voiceless vowels are not used contrastively in French. Further, they are unable to successfully construct a rule that will allow them to reliably derive the appearance of [h] (which some speakers appear able to do for aspiration), as there are a great many vowel-initial words in the English lexicon with the same distribution; their attempt to do so results in the observed sporadic epenthesis of [h] onto vowel-initial words, alongside deletion of [h] from [h]-initial words.

We have thus seen evidence from advanced L2 English-speaking francophones supporting the claim that francophones' difficulties with /h/ are due to the inability to construct an appropriate segmental representation in the interlanguage grammar owing, in part, to the requirement of the feature [SG]; additionally, we have evidence suggesting that other possible representations are not considered due to misanalysis of the acoustic features of [h] (i.e., formant structure). In sum, with the work reported in this thesis we have developed an original account for francophone difficulties in perception and production of /h/: they are unable to perceive it due to an inability to construct a phonological representation for it, and they are therefore variable in their production of it as they are attempting to implement a predictive rule of partial vowel devoicing (that can never achieve target-like suppliance). We can note that [h] presents a unique

scenario in acquisition in that rather than confusing two distinct sounds (as Japanese speakers do with English /l/ and /r/, for example, as discussed in chapter 3), [h] is confused with silence. Further, the phonetic content of [h] can be interpreted in the phonology as either a consonant or a voiceless vowel. It may be the case that these properties are responsible for the problems examined in this thesis. It remains to be seen whether this situation is unique to [h], or whether we might expect to find other segments showing similar difficulties due to misanalysis; I leave this question to future research.

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Appendix A: N400 test items

My friend hates the fact that she has very fine hair.
My friend hates the fact that she has very fine *air.

Everyone loves to breathe clean air.
Everyone loves to breathe clean *hair.

Lots of girls want to have long shiny hair.
Lots of girls want to have long shiny *air.

Children need lots of exercise and fresh air.
Children need lots of exercise and fresh *hair.

I know lots of girls with naturally curly hair.
I know lots of girls with naturally curly *air.

I always sneeze when I breathe dusty air.
I always sneeze when I breathe dusty *hair.

They say that dry hair is more difficult to style.
They say that dry air is more difficult to *style.

Experts say that dry air is harder to breathe.
Experts say that dry hair is harder to *breathe.

For fresh-smelling air, use some scented candles.
For fresh-smelling hair, use some scented *candles.

My sister and I both prefer hair that is quite short.
My sister and I both prefer air that is quite *short.

My cousins like their hair to be spiky.
My cousins like their air to be *spiky.

To remove odours from air in the refrigerator, use baking soda.
To remove odours from hair in the *refrigerator, use baking soda.

When you have a sore throat, yogurt is the best thing to eat.
When you have a sore throat, yogurt is the best thing to *heat.

Most old houses are expensive to heat.
Most old houses are expensive to *eat.

It seems like candy is the only thing kids want to eat.
It seems like candy is the only thing kids want to *heat.

To save money, I'll pick two rooms in my home not to heat.
To save money, I'll pick two rooms in my home not to *eat.

I love a good caesar salad and lately it's the only thing I will eat.
I love a good caesar salad and lately it's the only thing I will *heat.

Make sure the animals are kept in a cage that you can heat.
Make sure the animals are kept in a cage that you can *eat.

Since it's so cold, we can heat the room.
Since it's so cold, we can eat the *room.

You have to heat the kettle until the water boils.
You have to eat the *kettle until the water boils.

Because the freezer is broken we will have to eat all the ice-cream.
Because the freezer is broken we will have to heat all the *ice-cream.

We'll have to eat the milk for the baby.
We'll have to eat the *milk for the baby.

I'm sure they are going to eat all of those bananas.
I'm sure they are going to heat all of those *bananas.

In the summer, I tend to eat lots of popsicles.
In the summer, I tend to heat lots of *popsicles.

Last winter was so cold I spent a fortune on the bills for heating.
Last winter was so cold I spent a fortune on the bills for *eating.

By then we were exercising more and had begun watching what we were eating.
By then we were exercising more and had begun watching what we were *heating.

Waiters don't like me because I always ask about all the ingredients of what I'm eating.
Waiters don't like me because I always ask about all the ingredients of what I'm *heating.

In the winter I always dress warmly so I won't have to pay more for heating.
In the winter I always dress warmly so I won't have to pay more for *eating.

Potato chips aren't good for you, so pay attention to the snacks that you're eating.
Potato chips aren't good for you, so pay attention to the snacks that you're *heating.

Now that oil is so expensive, I'm glad I don't use a gas stove for heating.
Now that oil is so expensive, I'm glad I don't use a gas stove for *eating.

You'll know you're done heating the solution when it changes colour.
You'll know you're done eating the *solution when it changes colour.

My aunt loves eating her dinner in restaurants even though it can be expensive.
My aunt loves heating her dinner in *restaurants even though it can be expensive.

You need to be careful when eating your ice-cream cone.
You need to be careful when heating your *ice-cream cone.

I know heating your food in the microwave is very convenient.
I know eating your food in the *microwave is very convenient.

During cold winters, heating your home is absolutely essential.
During cold winters, eating your *home is absolutely essential.

During our time in the tropics we were always eating lots of mangos.
During our time in the tropics we were always heating lots of *mangos.

In the corner of my garden is a prize-winning hedge.
In the corner of my garden is a prize-winning *edge.

You should be careful while walking along the water's edge.
You should be careful while walking along the water's *hedge.

Sharp kitchen knives have dangerous edges.
Sharp kitchen knives have dangerous *hedges.

To give our yard some privacy, we planted some leafy hedges.
To give our yard some privacy, we planted some leafy *edges.

The walls were painted with a different colour around their edges.
The walls were painted with a different colour around their *hedges.

For outdoor parties, my parents play music from speakers hidden in their hedges.
For outdoor parties, my parents play music from speakers hidden in their *edges.

I like these hedges because they grow so quickly.
I like these edges because they *grow so quickly.

In Mike's garden there are two hedges that died last year.
In Mike's garden there are two edges that *died last year.

I'm almost done now, there are only two edges left to paint.
I'm almost done now, there are only two hedges left to *paint.

All along this street, those hedges would sway on windy days.
All along this street, those edges would *sway on windy days.

I really like the fine edges on that blade.
I really like the fine hedges on that *blade.

The fancy edges of the shelf are all worn out from use.
The fancy hedges of the *shelf are all worn out from use.

When he hurt his paw, my dog gave a great long howl.
When he hurt his paw, my dog gave a great long *owl.

For Halloween, I'll put up a picture of a big scary owl.
For Halloween, I'll put up a picture of a big scary *howl.

Last night my drunk neighbour woke me up with a long mournful howl.
Last night my drunk neighbour woke me up with a long mournful *owl.

I've never seen such a strange looking owl.
I've never seen such a strange looking *howl.

This feather must have come from a large grey owl.
This feather must have come from a large grey *howl.

The wolf called out to his pack with a low howl.
The wolf called out to his pack with a low *owl.

The two owls were difficult to sketch in the dark.
The two howls were difficult to *sketch in the dark.

A little while later, there were two howls from the children.
A little while later, there were two owls from the *children.

My cousins told me a story about a funny owl that flew by yesterday.
My cousins told me a story about a funny howl that *flew by yesterday.

I heard those scary howls from the coyotes.
I heard those scary owls from the *coyotes.

Every night, the same owl will fly past my bedroom window.
Every night, the same howl will *fly past my bedroom window.

As we walked, we could hear howls from nearby wolves.
As we walked, we could hear owls from nearby *wolves.

During that storm, my car was damaged by hail.
During that storm, my car was damaged by *ale.

The king announced that his knights needed more ale.
The king announced that his knights needed more *hail.

I hurried inside when I heard thunder, because I was afraid there would be hail.
I hurried inside when I heard thunder, because I was afraid there would be *ale.

Many college parties feature a keg of ale.
Many college parties feature a keg of *hail.

At certain times of year, thunderstorms always bring hail.
At certain times of year, thunderstorms always bring *ale.

Only a few bars serve this particular ale.
Only a few bars serve this particular *hail.

Large quantities of hail can damage your rooftop.
Large quantities of ale can damage your *rooftop.

Large quantities of ale are best bought in kegs.
Large quantities of hail are best *bought in kegs.

By midnight there was hail pouring from the clouds.
By midnight there was ale pouring from the *clouds.

I'm amazed at the amount of ale my brother can drink without getting sick.
I'm amazed at the amount of hail my brother can *drink without getting sick.

It was definitely hail that dented your car.
It was definitely ale that *dented your car.

I'm sure having that much ale is bad for your liver.
I'm sure having that much hail is bad for your *liver.

It may be an unusual pet, but my cousin loves her eel.
It may be an unusual pet, but my cousin loves her *heel.

I need some new shoes because I've broken my heel.
I need some new shoes because I've broken my *eel.

I've never liked snakes, and I'm really afraid of eels.
I've never liked snakes, and I'm really afraid of *heels.

Because my boots don't fit well, while walking I hurt my heel.
Because my boots don't fit well, while walking I hurt my *eel.

My mother is short, so she likes wearing high heels.
My mother is short, so she likes wearing high *eels.

That sushi restaurant keeps live eels.
That sushi restaurant keeps live *heels.

I know that some eels have huge teeth.
I know that some heels have huge *teeth.

My brother is an expert on heels since he does research on feet.
My brother is an expert on eels since he does research on *feet.

My brother is an expert on eels since he does research on marine life.
My brother is an expert on heels since he does research on *marine life.

With some heels, you can hardly even walk.
With some eels, you can hardly even *walk.

These types of eels are almost always hunting fish.
These types of heels are almost always *hunting fish.

Some women buy heels for fashion, not comfort.
Some women buy eels for *fashion, not comfort.

My brother's tattoo is something that my parents really hate.
My brother's tattoo is something that my parents really *ate.

The cook was serving my favourite food, so that's what I ate.
The cook was serving my favourite food, so that's what I *hate.

My friends always seem to want to watch movies that I hate.
My friends always seem to want to watch movies that I *ate.

I usually love all of the things that I ate.
I usually love all of the things that I *hate.

Foreign films are one of the things my brothers definitely hate.
Foreign films are one of the things my brothers definitely *ate.

Since I trust restaurant reviewers I always order whatever it is that they ate.
Since I trust restaurant reviewers I always order whatever it is that they *hate.

After spending the day shopping, many people said they hate big crowds.
After spending the day shopping, many people said they ate big *crowds.

It is because you ate sugary things that your teeth are rotting.
It is because you hate sugary things that your teeth are *rotting.

My nephews told me they hate all of those books.
My nephews told me they ate all of those *books.

My cousins ate most of the things that they like.
My cousins hate most of the things that they *like.

I want to go shopping because I hate all of my clothes.
I want to go shopping because I ate all of my *clothes.

I ate just those things that are my favourites.
I hate just those things that are my *favourites.

He left without saying goodbye, and it broke her heart.
He left without saying goodbye, and it broke her *art.

This painting is her most powerful work of art.
This painting is her most powerful work of *heart.

Whenever I go visit the doctor, he always checks my heart.
Whenever I go visit the doctor, he always checks my *art.

This marble statue is a culturally important piece of art.
This marble statue is a culturally important piece of *heart.

A poor diet and lack of exercise can lead to problems with your heart.
A poor diet and lack of exercise can lead to problems with your *art.

A local museum will buy almost all of her art.
A local museum will buy almost all of her *heart.

To me, the most beautiful art is this self-portrait.
To me, the most beautiful heart is this *self-portrait.

It's important to make sure that your heart is in good health.
It's important to make sure that your art is in good *health.

Her art is mostly sculptures, but she has done a few paintings.
Her heart is mostly *sculptures, but she has done a few paintings.

She will donate her heart for surgical research.
She will donate her art for *surgical research.

They expect that her art will sell well at tomorrow's show.
They expect that her heart will *sell well at tomorrow's show.

We are certain her heart will need surgery next year.
We are certain her art will need *surgery next year.

Appendix B: Elicited production task items

This game is simple, and doesn't require much skill.

On that bulletin board, use these pins instead of staples.

Set the oven timer to bake the cookies for twenty minutes.

We decided to spin a bottle to select our team captains.

Be careful as you sip this, as it's quite hot.

When I snap my fingers, start taking apart the puzzle.

I leaned back in my seat while listening to the recording.

She thinks she's helping, but she's really become a nuisance.

Sometimes you can spot bored children at the playground.

Parents often tell their children that they must behave at school.

The bank robber will pretend he is making a deposit.

The air is so cold it looks like there's steam rising from the river.

You should let that pot soak for a few minutes in hot soapy water.

This winter I will buy an expensive heavy wool blanket.

The man thought he could detect a difference between the two colours.

I'm thinking of planting some roses in my garden next year.

I think the potato salad they're serving is just terrific.

Performers use rehearsals to make sure everything is under control.

My neighbour correctly guessed that I was growing tomatoes.

I'm going to say hello to the potential candidates.

No one wants to be harassed at work.

She searched everywhere, even behind the bookshelves.