THE UNIVERSITY OF CALGARY

On the Perception and Production of Non-Terminal Intonation in English and French

BY

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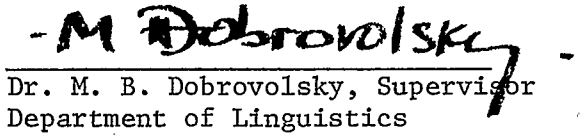
The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled, "On the Perception and Production of Non-Terminal Intonation in English and French", submitted by Cynthia Grover in partial fulfillment of the requirements for the degree of Master of Arts.



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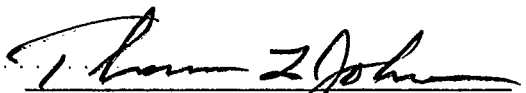

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ABSTRACT

This thesis investigates the perception and production of native and non-native continuative intonation by English and French speakers.

The speech of native French, English and German speakers was submitted to a pitch analysis. Statistical analysis showed that the terminal intonation contours did not vary significantly among the languages studied. Continuative intonation patterns (the non-terminal contours found at a clause or phrase boundary) did show significant differences among the languages. The change in fundamental frequency over time over the continuative intonation pattern (slope) was found to be particular to each language and was used as an analytical basis for a perception and a production experiment.

Sentences based on these speakers' utterances were synthesized twice, so that for every original sentence, one version with original and one version with non-native continuative intonation were created. A forced choice identification task was devised using these sentences. It was presented to 83 English and French monolinguals and English students learning French in the French immersion programs (the immersion students), aged 6 to 18. A

production experiment was also conducted. Speech samples were elicited from all subjects and the slopes over the continuative intonation patterns were analysed.

The results of this experiment suggest that continuative intonation is potentially a linguistically significant cue for native speakers of English and French when they identify non-native speakers of their language. French immersion students when speaking French master this cue by age 10 (after 4 or 5 years of immersion) and produce continuative intonational slopes similar to those of native French speakers. The fact that the older immersion students produce typically English slopes when speaking French may be explained on non-linguistic grounds. At the same time, the older immersion students improve at the discrimination of native and non-native intonation in French.

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To my parents and my husband

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INTRODUCTION

This thesis attempts to determine whether the intonation of a speaker's native language contributes to his perception and production of a non-native accent. Intonation may be defined as pitch movement in speech as it reflects both linguistic and expressive functions. Other aspects of the speech signal which are sometimes taken into consideration, such as timbre and voice quality, (Crystal 1981) will not be considered here. The intonational effects have frequently been shown to be primarily attributable to pitch movement (fundamental frequeny, abbreviated F0).

The experimental research presented and discussed here concerns the relationship between the perception and production of appropriate French intonation by English speakers. This work is motivated by theoretical and perceptual studies of synthesized intonation which suggest that certain components of an intonation are linguistically significant, and by production studies, which debate the role of age in second language acquisition.

In chapter one, the linguistic and expressive functions of intonation within a language will be described. The potential of these functions to mark

speakers of different languages will be discussed. This discussion will introduce the literature in the field of second language acquisition. The critical period hypothesis will be reviewed in reference to learning the intonation system of a second language.

The manifestation of two linguistic functions of intonation, continuity and termination, in English, French and German is compared in chapter two. I present and discuss various components of an intonation, such as pitch movement, loudness and duration, as they relate to intonational measurement. Four hypotheses about second language intonation will be stated. Data pertaining to them is gathered, and then discussed in chapter three. The results of an analysis of this collection are used to provide a basis for the experiments described in chapter four.

Chapter four elaborates upon the design and implementation of a perception and production experiment on second language students. The results of these experiments will be discussed with reference to the hypotheses presented in chapter two. The final conclusions in chapter five attempt to place the findings in a perspective encompassing the field of intonation theory and the theory of second language acquisition.

CHAPTER ONE

THE FUNCTIONS OF INTONATION

1.0 The Major Functions of Intonation

It is essential to know what the functions of intonation are before describing the intonation system of any language. Any act of verbal communication requires a sender, a receiver and a message. Intonation is said to function linguistically when it conveys information about the structure of the message. Intonation is said to function expressively when it conveys information about the sender of the message (for example, about his emotional state).

The model of intonation function adopted here has two major branches, linguistic and expressive. These branches further subdivide into branches representing syntactic marking and semantics, and the emotive, attitudinal and identificatory functions (see Figure 1.0). Each of these branches will be discussed in detail. I shall first describe the linguistic functions of intonation.

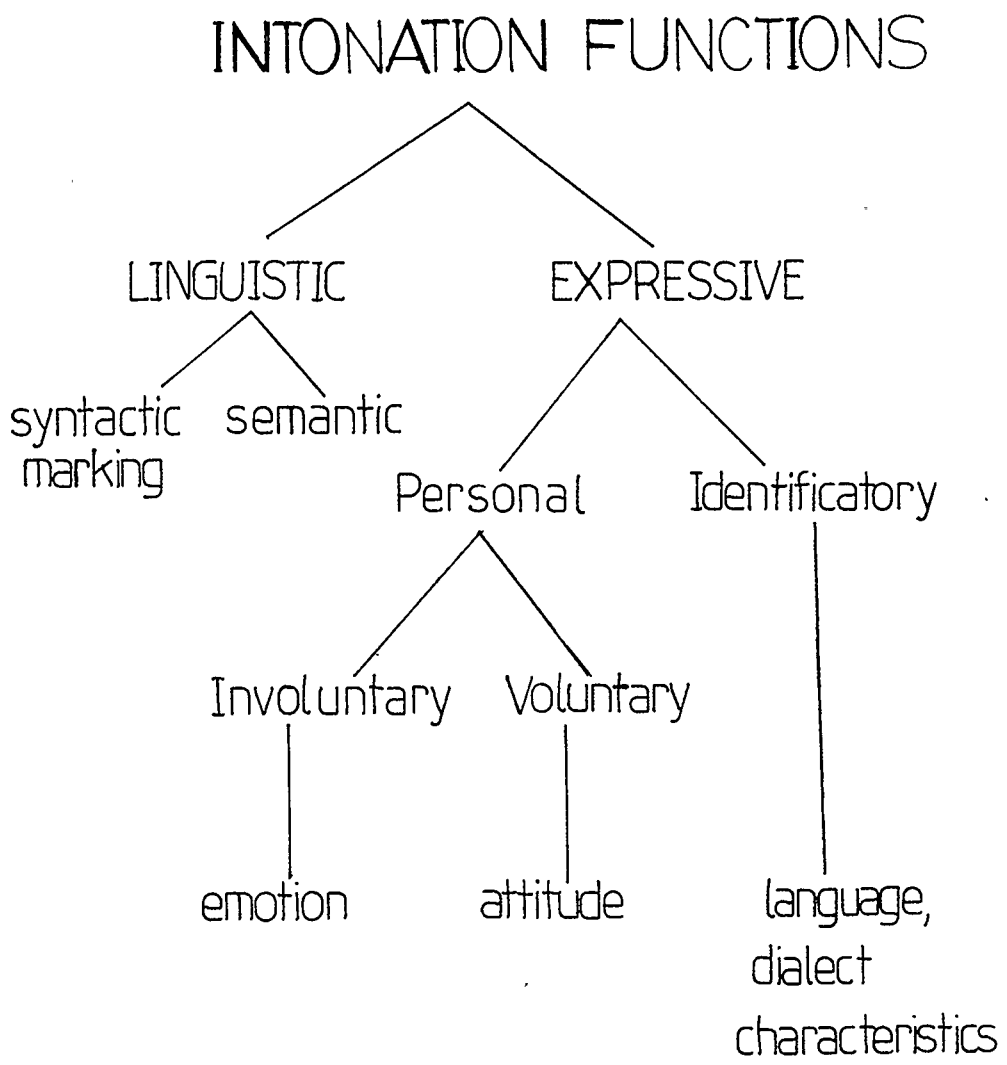


Figure 1.0. The main model of intonation function within a language.

1.1 Linguistic Functions

There are two types of grammatical intonation function: the association of a certain intonation pattern with certain sentence types, and the delineation of surface structure components within a sentence. Intonation

patterns also may be associated with a meaning, and so be said to have a semantic function.

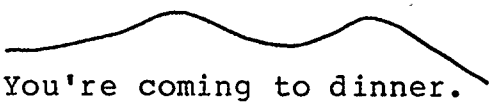
1.1.1 Intonation and Sentence Type

A particular intonation or pitch pattern may cooccur with certain types of sentences in English. For example, an interrogative intonation is said to occur with questions (Crystal 1969, p 254). The intonation pattern fulfils a function analogous to that of the question particles found in some languages, such as Chipewyan, and thus be said to have a quasi-morphemic status. Researchers are not in accord about the linguistic status of the correspondence of intonation and sentence type; some would classify it as semantic rather than syntactic (see section 1.1.3).

The linkage between sentence type and intonation pattern is best described as pluralistic:

> "there is no one-to-one correspondence between the categories of prosodic form and prosodic function, nor between any of the individual features subsumed within these categories. A rising tone, for example, signals far more than a questioning meaning, and a grammatical question may be uttered using other tones than rising ones" (Crystal 1981; p37)

While an interrogative intonation will force one to interpret the following sentence (with the wavy line representing pitch movement)

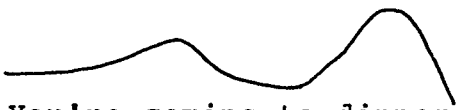


You're coming to dinner.

as a simple question:

You're coming to dinner ?

an exclamation of surprise may also cause one to interpret the utterance as a question, although the intonation is different yet again:



You're coming to dinner ?!

The lack of one to one correspondence between intonation pattern and sentence type makes it difficult to confidently speak of `interrogative' or `declarative' intonation patterns.

1.1.1.1 Neutral Declarative Intonation

The concept of `neutral' intonation has furnished many workers with a starting point for research on intonation. The particular type of intonation generally associated with the declarative sentence type is called the `neutral declarative' intonation pattern. It is an emotively `neutral' intonation pattern, and is associated with an utterance in which no element is contrastively emphasized.

Most researchers have focussed on some sort of `unmarked' (neutral) intonation to be used in comparison to other, more `marked' intonation patterns in their models of intonation. For example, Chomsky and Halle (1968) attempt to generate a `neutral declarative' intonation pattern from syntactic deep structure. This pattern (which is composed of stress levels) serves as an abstract basis for the phonetic intonation pattern, which is ultimately realized after an overlay of expressive intonation is generated by rule. In their model, linguistically `neutral' automatically implies emotively `neutral' because emotive marks are added to an intonation later than linguistic marks are, as the following diagram of utterance generation shows.

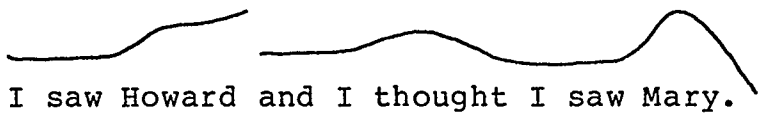
1. Underlying Intonation (generated from syntax)
2. Linguistic features added to intonation
3. Emotive features added to intonation
4. Personal features added to intonation

In contrast to the preceding approach, the literature also contains versions of `basic' intonation which include both linguistic and expressive functions (Delattre, 1966 and 1972; Bolinger, 1970; Cruttenden, 1981). These types of `basic' intonation are more phonetic in nature than Chomsky and Halle's. They are abstracted from contour

types such as falling or rising, but without reference to any syntactic base. This more phonetic approach provides a framework for the continuative and terminal intonation patterns at the heart of this thesis.

1.1.2 Structure marking within sentences

Intonation may delineate sentence constituents and demarcate constituent boundaries. For example, in many languages coordinate structure is marked by a pitch rise between clauses, as in the following English sentence.



I saw Howard and I thought I saw Mary.

1.1.3 Marking Semantics

An intonation pattern may be associated with a meaning, without necessarily indicating the presence of any particular grammatical configuration. Cruttenden (1981), for example, states that any intonation has one of two possible meanings: `complete' or `incomplete'. These are very broad semantic terms which embrace other, more precise semantic labels. The category `complete' includes an intonation conveying abruptness, while `incomplete' shows politeness. `Complete' is associated with a fall in pitch, `incomplete' with a pitch rise. These intonation patterns may, in theory, be connected with any type of sentence

pattern, that is, with a grammatical question, command or statement, for example.

There is a certain amount of overlap between semantic and syntactic intonation functions. Bolinger's (1970) Accent B shows `continuation' through a rise in pitch occurring before a clause boundary. Delattre's `major continuation' for French also occurs before a clause boundary and is shown by a rise in pitch. Delattre, Bolinger and Cruttenden are referring to that property of an intonation which shows that a speaker's utterance has not yet ended and that more will be said.

Cruttenden attributes approximately the same powers to intonation as do the more syntactic treatments; the difference between the points of view varying from more to less grammatical is more one of emphasis than one of substance. Thus a syntactician would view the first two functions defined by Cruttenden below as grammatical, although by Cruttenden's standards they are semantic:

1. Intonation functions to bind the group of words under an intonation together, so as to emphasize the coherence of their meaning.

2. It shows by means of main accent placement, which member of the group is most important.

3. It lends one of two basic meanings to the message, which may be further refined by the listener when he interprets the segmental message.

The function is then more important than the label `semantic' or `syntactic'. The continuation and termination functions explored later in this thesis will simply be called `linguistic'.

`Continuation' is the label which will be associated with the intonation pattern which chiefly shows that the utterance will continue. `Termination' is conveyed by an intonation pattern which mainly indicates that the utterance has finished.

1.2 Expressive Functions

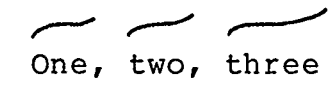
An intonation pattern may convey meanings which are expressive rather than linguistic. Intonation may provide information about a speaker's attitude or his dialect, in addition to providing information which pertains exclusively to the linguistic structure of the speaker's message.

Bolinger (1970) hypothesizes that the expressive functions are communicated by differences in the gradience of the pitch, whereas the linguistic functions are conveyed by distinctive contrasts in pitch. This means that the difference between a steep rise and a shallow rise in pitch can convey an impression of different emotional states of the speaker. The difference between a rise and a fall in pitch would convey a linguistic function, such as

continuation. For example, a high rise in pitch might suggest anger as well as continuation in this utterance:

One, two, three ...

versus continuation alone:



One, two, three ...

where the rise in pitch is not so high.

Two types of expressive function, personal and identificatory, may be further broken down into three major functions: the emotive and attitudinal functions and the mediation of language or dialect characteristics (see Figure 1.0).

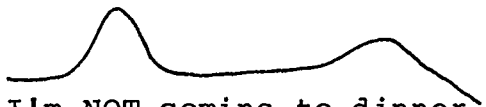
1.2.1 Conveying Emotion

Intonation performs an emotive function when it divulges the speaker's emotions. Intonation directly reflects emotions, which are states of physical arousal related to the adaptive behaviours of our primitive ancestors. Emotion may be treated as a function of an arousal continuum, and one may speak of `low' arousal states, such as depression, or of `high' arousal states, such as rage, or of `neutral' arousal states, which show no

specific emotion. The involuntary revelation of emotion is due to the physiological state of the speaker and is not under his control (Trojan, op cit Dobrovolsky, 1980), although emotions may be feigned in some circumstances.

Emotion is thought to be manifested globally, that is, across the whole intonation. The tangent between the peaks of the pitch pattern may be taken to indicate the emotional state of the speaker, according to some linguists (Bolinger 1970; Dobrovolsky 1980 - see Figure 1.4.2).

Irritation or anger, among other emotions, is expressed by the extended pitch obtrusion on the capitalized syllable and the steep overall fall of the pitch contour in the following example:



I'm NOT coming to dinner.

1.2.2 Displaying Attitude

Intonation performs an attitudinal function when it serves as the medium for a speaker's display of his attitude toward his message, himself or his interlocutor. For example, a speaker may show by his intonation that he does not believe his own words when he says sarcastically:

Nice day, isn't it ?

when it is raining cats and dogs. The speaker controls the exhibition of his attitudes and so this function is considered to be voluntary.

1.2.3 Speaker Identification

A speaker may be identified as a member of a certain linguistic group by his intonation. This identificatory function of intonation identifies the speaker to his listeners without imparting any information about the speaker's message or about his personal feelings. The identificatory function is conveyed through the production of a non-native linguistic intonation pattern. Figure 2.3 shows the linguistic functions of continuation and termination as they convey the identificatory function. The French and German patterns for continuation and termination could mark both the French and the German natives as non-native English speakers. A faulty attempt at conveying a linguistic intonation function in one's second language may then show that one is not a native speaker.

It is not known how widely intonation is used to identify speakers of a different language or dialect. This unanswered question forms the central inquiry of this thesis. In chapter two it will be converted into a hypothesis central to this thesis.

1.3 Convergence

As we have seen, a given intonation may mark the sentence syntactically, express a speaker's attitude or emotion and reveal his language background. Counting

with pitch rises conveys syntactic information, namely, that the list will continue. These rises may also show that the speaker is coaxing someone, or that he is excited. They may also indicate that he is the speaker of a particular dialect of English. Often, the intonation patterns used by speakers of an unfamiliar dialect will be misinterpreted as signaling an emotion or an attitude (Cruttenden 1981), rather than simply marking the speaker as non-native. This convergence of function is typical of intonation in all languages.

1.4 The Mediation of Function

While there is general agreement concerning the functions of intonation, there is widespread disagreement on how intonation is to be formally represented. The search for minimally significant intonation units has resulted in a number of analyses varying in both degree of

abstraction and claims to psychological reality. I shall review two of the more commonly used analytical approaches: the `global' and the `atomistic' treatments.

1.4.1 Global Analysis

An intonation pattern communicates information of the sort described in sections 1.1 and 1.2. Exactly what it is in the intonation which encodes this information is a subject of much theoretical speculation. Those with a global view hold that the intonation in its entirety encodes this information. The intonation over the whole utterance is considered to be a distinctive morpheme in its own right. These linguists refuse whatsoever to analyse an intonation pattern into any subordinate units and deal only in `tunes' or intonation `contours' (Sag and Liberman, 1975; and Cruttenden, 1981). See Figure 1.4.1 for an example of a tune. Other linguists, while allowing that the whole intonation is a distinctive morpheme, have insisted that units analogous to segmental phonemes must constitute the pitch morpheme. Trager and Smith's (1951) and Delattre's (1963) sequences of pitch levels provide examples of these `pitch phonemes' combining to form a `pitch morpheme'.

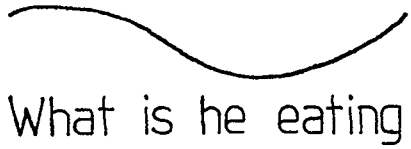


Figure 1.4.1 Example of a `tune'. The contour line above the words represents pitch movement (adapted from Sag and Liberman, 1975, p 488).

1.4.2 The Atomistic Tradition

Atomists hold that intonation-borne information is derived from specific parts of the intonation pattern and so break down intonation contours into subunits. It is the arrangement of these component parts and their pitch, loudness and duration relative to each other which bear information from speaker to hearer.

Kingdon (1958), Crystal (1969 and 1972), and Dobrovolsky (1980) represent the atomistic tradition. An example of this type of analysis is provided in Figure 1.4.2.

The relative height of the letters in the sentence shows the pitch movement, while the branching diagram shows how this intonation pattern is analysed into units.

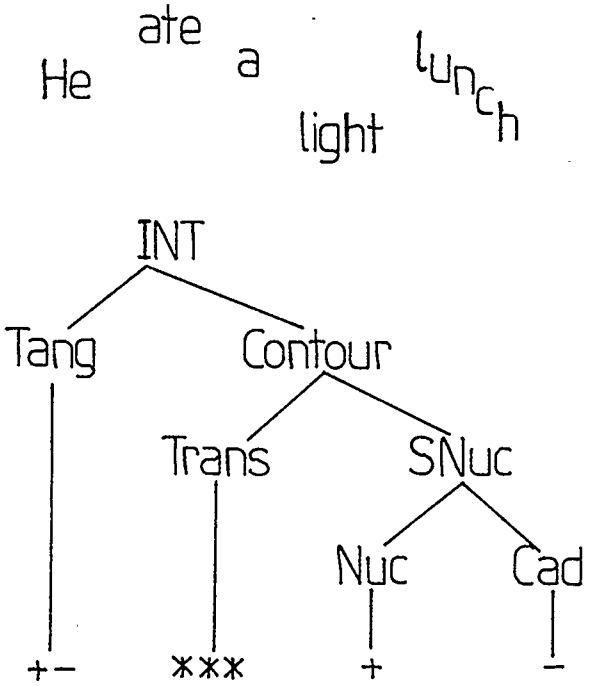


Figure 1.4.2. Example of an atomistic analysis (adapted from Dobrovolsky, 1980; p 201 - see text below for explanation).

The line which may be drawn between the pitch peaks is called the tangent (TANG in the diagram). Following Bolinger (1970), Dobrovolsky (1980) claims that the attitudinal or emotional content of an intonation is reflected in the tangent. Here the tangent is falling, which the (+-) value represents. The transition (TRANS) into the sentence nucleus (SNUC) or main sentence stress is an optional element and here it is claimed to be phonetically predictable, so it has not been assigned a value. The nuclear pitch on `lunch' rises from the pitch on `light'. This is represented by the positive value

under NUC. The pitch on `lunch' is falling, and this is shown by the (-) under CAD (cadence).

I shall be using an atomistic analysis, as I assume that linguistic functions such as continuation and termination are manifested in the pitch over single words (see Figure 2.3).

1.5 Intonation across languages

Having briefly dealt with the major functions of intonation, I shall now view in greater detail intonational function across languages.

1.5.1 Universality of Function

I have implicitly claimed that the functions discussed in sections 1.0, 1.1 and 1.2 are universal. No function of intonation unique to a single language has been found. Consequently, universality of function is an assumption that I have made throughout this thesis.

1.5.2 Language-Specific Form

There are phonetic differences in the manifestation of intonation function across languages. For example, Figure 2.3 shows a steeper terminal fall in French than in English. Delattre (1963) explicitly characterizes some of these differences across English, French, Spanish and

German. He states that speakers tend to impose their native intonation patterns on their second language. This is called intonational interference and, according to Delattre, contributes to the perception of non-native accent. Although Delattre does not provide any empirical evidence to back up his remarks, there is still some reason to expect that listeners of various languages may exploit intonational faults of non-native speakers in the latter's second language to identify them as non-native. This is to say that the use of an inappropriate intonation to show a linguistic function, such as continuity or termination, can identify a speaker as non-native.

Work by some researchers sheds some light on the possibility of identifying non-native speakers by their intonation, although there are no tests specifically aimed at testing intonation's potential in this respect. The literature in this area will now be reviewed.

1.6 Identification of non-native speakers

Testing subjects' mimicry or identification of foreign intonation patterns presumes that subjects can perceive the differences between the intonation patterns of different languages, and so suggests that these perceived differences could be used to identify a non-native speaker.

Neufeld and Schneidermann (1980) and Tahta, Wood and Loewenthal (1981) used just such a set of assumptions in their scoring procedures: native speaker judges assigned subjects a score or labelled them as native/non-native speakers with confidence ranks based on how well they imitated native intonation patterns.

Regrettably, this method is open to the criticism that judges may be swayed by a subject's non-native pronunciation when supposedly attending only to his intonation. The one other study in this area, Gilbert (1980), may be faulted for using subjects whose exposure to the intonation patterns being learnt varied greatly, and for judging subjects on their production of intonation on a non-linguistic task, the use of a kazoo. Good performance on such a task does not necessarily have implications for linguistic performance.

1.7 Second Language Intonation Acquisition

Many of the research questions in the field of second language acquisition draw breath from the much noted differences between first and second language acquisition. It has long been noted that adults rarely master their second language while children are at home in their first language within six years of birth and make very few mistakes in it. Some researchers feel that the crucial

factor is age. This question of age-imposed limitations is the driving force behind Tahta, Wood and Loewenthal's (1981) work and Neufeld and Schneidermann's (1980) research. These two groups of people argue the opposing sides of the critical period hypothesis.

1.8 The Critical Period Hypothesis

The critical period hypothesis posits that the acquisition of certain skills is very difficult, if not impossible, after a certain age (in reference to humans, usually thought to be puberty). This hypothesis finds support in certain theories about neural organization. The brain plasticity theory (Penfield and Roberts 1959) proposes that young children have greater `brain plasticity'. `Plasticity' refers to the ease of reorganization of neural connections in the brain. A certain time after birth, the neural connections cannot be easily interrupted and reconnected differently, thus inhibiting the acquisition of a second language, which would require just such a new organization of neural connections. This would explain why children become fluent in several languages while an adult does so only rarely.

The brain lateralization theory (Lenneberg 1967) also supports the critical hypothesis. Brain lateralization is said to occur at puberty. Languages learned are assumed to

be stored in one hemisphere (conventionally the left) at puberty. After that, new languages learnt have to be stored elsewhere, and so they are learned in a different fashion to the ones acquired before puberty. Thus a second language acquired later in life is not acquired, stored or accessed in the same way as the first. It is assumed that this later type of acquisition is in some respects inferior to the earlier type of acquisition.

Tahta, Wood and Loewenthal (1981) suggest that the persistence of a non-native accent due to intonation interference is extremely likely if exposure to the non-native language occurs after 8 years of age. On the other hand, the critical period hypothesis is refuted by Neufeld and Schneidermann (1980), who insist on the adult's ability to learn appropriate second language intonation. They trained adult subjects using a limited set of sentences to pass as natives in second language intonation tests.

Those who do not feel age is to blame for adults' failure to master a second language attribute their poor showing to poor second language teaching methods (Neufeld and Schneidermann, 1980; James, 1976). Copious experimentation in all aspects of second language acquisition notwithstanding (Oyama, 1976; Snow and Hoefnagel-Hoehle, 1977 and 1978; Fathman, 1975; Cook, 1969;

and others), this debate about the role of age in second language acquisition is far from settled.

1.9 Summary

This chapter provides a point of departure for the rest of the thesis. I have established the multiplicity of functions of intonation within spoken English, and the role of intonation in cross-linguistic non-native speaker identification.

There are four major functions of intonation in any language: linguistic, attitudinal, emotive and identificatory. One grammatical function of an intonation (elaborated in section 1.1) is to define the syntactic constituents of a sentence and lend the desired interpretation to surface structure ambiguities. The other is to help indicate the syntactic sentence type. In section 1.2 I explained how a speaker may voluntarily express an attitude to his utterance via an intonation. In addition to this attitudinal function, an intonation may perform an emotive function by revealing emotions the speaker expresses involuntarily, but which the listener may pick up.

Beside these three functions, intonation has an identificatory function, in that it may inform a listener about the linguistic origin of the speaker. All these

functions occur across languages, but different intonations may perform these functions in different languages, as section 1.5.2 suggests. Studies in this area support both sides of the critical age hypothesis and neither side can summon an irrefutable collection of results in its defence, as section 1.8 showed.

In the next chapter I consider in detail Delattre's proposed cross-linguistic intonation patterns and the elements comprising them. I formulate five hypotheses concerning issues of interest to researchers in the field of intonation acquisition.

CHAPTER TWO

CROSS-LINGUISTIC INTONATION MEASUREMENT

2.0 Introduction

The previous chapter introduced the field of intonation study and briefly described the functions of intonation common to all languages. In this chapter, I shall concern myself solely with intonation across languages. In particular, the mediation of intonation's identificatory function will be a central topic for this chapter. This will lead to a discussion of the important elements in an intonation across three languages: English, French and German. I will then consider the problems researchers have encountered in this area and propose five hypotheses to be tested.

2.1 Variation due to Emotion

The mediation of the emotive function does not vary greatly across languages. Fónagy and Magdics (1972) show that emotions, such as joy or tenderness, are expressed in similar ways in German, French, English and Hungarian. Their results are further supported by Léon et Martin

(1980), who conclude that the conveyance of the emotive function varies less across languages than does that of other intonation functions.

Cross-linguistic variation in the form of the intonation functions may therefore be thought of as being due to differences in each language's communication of linguistic continuation or termination, and not to variations in emotive intonation pattern. I shall consider the performance of these two functions, continuation and termination, in sentences with an emotively neutral intonation.

2.2 Cross-Linguistic Interpretation of Intonation

Some studies (Tahta, Wood and Loewenthal, 1981; Neufeld and Schneidermann, 1980; Delattre, 1966) take as their premise the existence of cross-linguistic differences in neutral intonations. Only a few have sought to prove this tenet, with the classic example being Hadding-Koch and Studdert-Kennedy (1964). They were able to show that speakers of Swedish and English do not interpret certain intonations in the same way. What is definitely an `interrogative' intonation in one language may not so clearly signify a question in the other. Cruttenden (1981) also notes that speakers of different British speech varieties, Scottish, Belfast and southern English,

misinterpret each other's intonation patterns, but he has not amassed any data on this matter. Delattre (1972) established that the continuative function is manifested differently in several different languages.

Having established that different forms may accomplish the same function in different languages, I shall now inquire more closely into the nature of the differences between functionally similar intonations in English, French and German. First, I present several examples of intonational interference; I then elaborate upon the factors creating the impression of a `non-native' speaker.

2.3 Interference

Interference by one's native language in one's second language is an acknowledged stumbling block in the acquisition of a second language (Dulay and Burt 1972; Taylor 1975), although there is now some debate as to its pervasiveness at all age levels or in all areas of second language acquisition (Cook 1973; Palermo and Howe 1970). Interference may be defined as:

> "errors that occur in the learning of a second language (B) that reflect the acquisition of a previous language (A) and that are not found in the normal development of those who acquire that language (B) as a first language." (McGlaughlin 1978, p66)

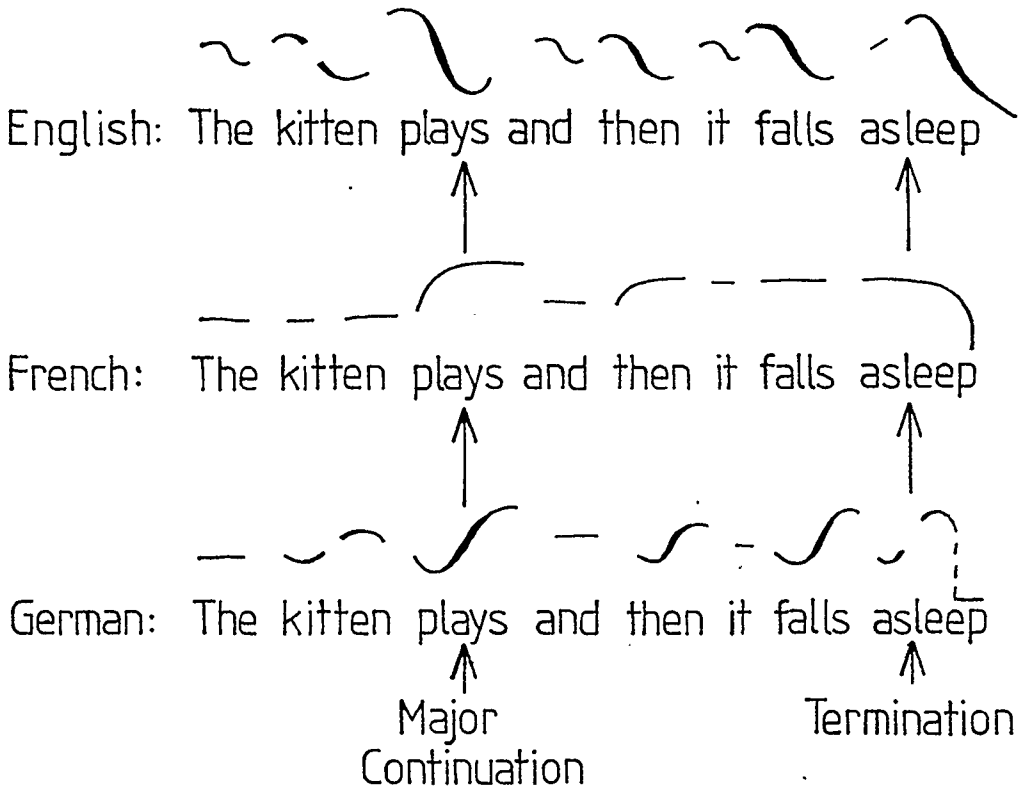


Figure 2.3 Examples of the interference of native French and German intonation patterns with English intonation. The height of the wavy lines above words indicates pitch movement and the thickness of the lines represents intensity. (adapted from Delattre 1963, p 194)

Delattre 1963 suggests this phenomenon also renders the acquisition of second language intonation difficult. He claims that the above patterns (Figure 2.3) are typical of native speakers of English, French and German, respectively, as they utter the same English sentence.

2.4 The Components of Cross-Linguistic Intonation

The important differences between English, French and German intonation patterns depicted in Fig. 2.3 may be described as differences in the values of the following intonational components (Delattre 1963).

1. Direction of Pitch Movement

   Humans perceive pitch subjectively as rising, falling or level. These pitch movements in speech may be measured physically as increases, decreases or minimal changes, respectively, in the fundamental frequency (F0) of sound and represented visually by plotting F0 against time.

   Delattre (1963) claims that in English, French, Spanish and German syllables, words, and phrases are characterized by language-specific pitch patterns. As Figure 2.3 suggests, pitch falls predominate on English syllables, and may indicate continuation or termination. Both pitch falls and rises occur frequently in French; continuation is conveyed by a rise, and termination by a fall, as the French interference pattern in Figure 2.3 shows. Rises before an abrupt fall to a level pitch characterize German termination (see Figure 2.3), whereas rises to a high level pitch typify continuation.

2. Intensity

Loudness is the perceptual correlate of the physical intensity of sound as measured in decibels (dB).

As was the case with pitch movement, Delattre has claimed that the use of intensity varies distinctively across different languages. He also notes that certain sections of an intonation are predictably louder than others, depending on the language. For example, the loudest section of an English intonation coincides with a falling pitch on a voiced sound. This is represented graphically by the increased thickness of the lines showing falling pitch in English in Figure 2.3. Intensity variation cannot be correlated with the direction of pitch change in this manner in French, hence the uniform thickness of the lines representing French pitch movement in Figure 2.3. In German, the greatest intensity cooccurs with rising pitch (Figure 2.3).

3. Shape Defined by Pitch Movement

'Pitch shape' means the visual shape described when F0 movement is plotted against time. Delattre (1963) claims that it is an important element in second language intonation production. The visual shapes may be labelled descriptively and broken down

into three component parts: slope gradience, slope dip and hook addition. The slope gradience is the steepness of the rise or fall in pitch over time. The slope dip is the direction or type of preliminary deviation from a linear rise or fall in pitch. The German pitch rises in Figure 2.3 start with a slope dip. A hook is an ultimate small pitch movement contrary to the general pitch direction. In Figure 2.3, the French intonation has steep convex rises and falls without final hooks, and the English continuative pattern ends with a small hook upward.

The slope gradience may be measured as the maximum change in pitch over time, that is, maximum change in F0/minimum t, where t = time in seconds. In this thesis, I accept Delattre's (1972) contention that continuative and terminal functions are manifested minimally over syllables, usually over words, and sometimes even over phrases. For consistency's sake, I shall measure the slope gradience only over words. An example of the slope gradience measurement over a single German word is given in Figure 3.2 (p.47).

Other researchers have attempted to determine the contribution F0 movement, intensity and duration make to the perception of an intonation within languages. For French it has been established (Léon et Léon, 1979; Robinson, 1968; Holder, 1968; Warren and Santerre, 1979; Léon et Martin, 1980; L'Hôte, 1979) that it is mainly F0 and duration which signal differences in emphasis and the grammatical functions of intonation, while intensity is a subsidiary cue. F0 movement is the major cue to intonational difference in English. Intensity is less important and durational increase is viewed as trivially necessary to support an increase in F0 variation (Bolinger, 1958). For German, Dælattre states that the intensity of the rises in F0 is regular and predictable. However, the priority of the three factors, F0, intensity and duration is not treated in the literature.

As pitch, or F0, is considered important across languages to mediate intonational function, I shall focus on F0 movement from now on. In particular, I shall examine cross-linguistic differences in the slope of F0, and shall further restrict myself to examining the role of the slope of the pitch in conveying continuation and termination.

2.5. Problems

Three problems can be enumerated which must be taken into consideration when designing a study to examine cross-linguistic differences in continuative and terminal intonation patterns.

The first problem concerns the influence of other aspects of speech production on intonation. It is claimed that some of the variation in F0, intensity and/or duration is due to the effect of syllable stress (Ladd, 1980). In this thesis, I assume that the pitch prominences of an intonation curve are correlated with the placement of lexical stress, and do not consider the effects syllable stress may have on an intonation. The major pitch prominence of an intonation (the sentence stress) is assumed to be determined by factors other than lexical stress assignment.

A second problem is that differences in F0 are not invariably controlled by the speaker. Certain differences in F0 help to communicate segmental information to the hearer, and these are thought to be controllable only to a limited extent by the speaker (Ohala, 1978; Cheesman, 1985). For example, in a male speaker F0 will be lower by up to 12 Hz after a voiced stop, as in /ba/, than F0 after a voiceless stop, such as /pa/, given that the vowels are

identical in both cases (Lehiste and Peterson, 1961). A difference in vowel quality is also correlated with F0 differences; high vowels, such as /i/, have a higher F0 than the lower vowels, like /a/. The magnitude of such vowel-conditioned F0 may be as large as 10 Hz (Peterson and Barney, 1952) or 25 Hz (Lehiste and Peterson, 1961). This also must be accounted for when comparing intonation patterns of different utterances.

A third difficulty is that there appear to be a wide variety of acceptable intonations for the same function. Although speakers recognize a given intonation pattern as native, they may use a somewhat different pattern for the same function in their own speech. Sag and Liberman 1975 note that all that can be said with assurance is that speakers always use intonation patterns which are acceptable to other native speakers.

2.6 Measurement in Real Speech

A number of studies have dealt with terminal and continuative intonations in specific languages (see, for example, the collection by Grundstrom and Léon, 1973; also Holder, 1968;). This thesis investigates terminal and continuative intonation across languages. There is little published material on this topic, with the exception of Delattre's work, which has been reviewed here.

2.6.1 Results from Studies on Synthetic Speech

In view of the lack of quantitative models for intonation production in real speech, it is valid to consider the progress made in devising intonation patterns to accompany synthetic speech.

Researchers have generally been concerned with creating acceptable synthetic `neutral' (cf section 1.1.1.1) declarative intonation patterns. Pierrehumbert (1981) claims to have successfully created such a pattern for one English sentence, using a pitch target model based on a Trager and Smith (1951) style pitch treatment, involving two `phonemic' pitch targets (`high' and `low' pitch) and two `allophonic' variants of these pitch target levels. This resulted in variable slopes between targets, since the sole purpose of the slopes was to act as transitions between target pitches of various heights. The shape of the curve was ignored to some extent, as Pierrehumbert considered it unimportant, being only a function of the separation in time between the targets.

Pierrehumbert has provided some support for Ladd's contention that syllable stress and the intonation identifying sentence type are not easy to separate in the domain of pitch measurement. In addition to using simple target pitch levels, she had to mark words for nuclear

stress. In Crystal's (1972) treatment of intonation, nuclear stress is a function of both sentence stress and intonation. Nuclear stresses coinciding with the last content word in each phrase had to be identified to the synthesizer for the intonation to sound natural. On a physical level this meant that the peak F0 for a vowel had to be placed a certain distance into the vowel when pitch could be attributed to nuclear stress. On some syllables, syllable stress and the more global type of intonation pattern were both represented by pitch obtrusion, and for continuative intonation both were characteristically obtrusions upward from the pitch baseline.

Both Witten (1979) and Pierrehumbert (1981) state that one may ignore segmental influences upon F0 with no risk of producing artificial sounding intonation patterns. However, syllable structure and stress must be incorporated into a model for synthetic intonation. It is worth noting also (Witten, 1979) that people find synthetic intonation patterns most acceptable when the synthetic intonation patterns on a sentence have been transferred from a sentence with similar semantic content and identical syntactic form.

In sum, the theoretical work has ushered in little or no direct testing, although it has participated in practical applications in the field of synthesized speech.

The results of studies on synthesized intonation call into question some aspects of traditional theory and support others.

First, it appears that although intonation and stress are treated separately by some theories (Trager and Smith, 1951; Lieberman, 1967; Chomsky and Halle, 1968), they must be considered together for practical applications, such as creating synthetic neutral declarative intonation patterns.

Second, various theories are in some practical respects plausible. Pierrehumbert has incorporated some aspects of Trager and Smith's pitch levels, Liberman and Prince's (1977) metric stress treatment, Chomsky and Halle's (1968) stress levels and O'Connor and Arnold's (1961) and Crystal's (1969) nuclear accent into her acceptable simulation of a normal English intonation pattern.

Third, there is disagreement about proposed intonation patterns. Pierrehumbert (1981) and Bolinger (1959 and 1970) suggest that the continuative intonation pattern rises in pitch in English, while Delattre states that it falls. Delattre's `shape' is considered circumstantial by Pierrehumbert, thus implying that slope is an irrelevant characteristic of an English intonation. Whether slope is unimportant when comparing intonations across languages remains to be seen. It is entirely possible that an

element which is not used distinctively within a language might well be employed by native speakers comparing their own language intonation patterns to those of other languages.

2.7 Formulation of Hypotheses

A set of hypotheses about non-native intonation perception and production can be formulated from reported results and theoretical proposals in the literature.

1. Each language may employ different intonation patterns to show continuation and termination (Delattre, 1963 and 1966).

2. A speaker imposes his native intonation patterns upon a second language which he has not mastered (Delattre, 1963 and 1966).

3. A native listener will realize that his interlocutor is not native by attending to his non-native intonation. Thus intonation provides one sufficient cue to the perception of a non-native accent (implied, but not proven by Tahta, Wood and Loewenthal, 1981 and Neufeld and Schneidermann, 1980).

4. A second language intonation system is most successfully acquired early, up until about age 8. (Tahta, Wood and Loewenthal, 1981)

It is necessary to first consider the following hypothesis about the measurement of cross-linguistic intonation, so as to have a basis for investigating the four hypotheses listed above.

5. Slope is significantly different between English, German and French intonations for both the continuative and the terminal functions. (Delattre, 1963 and 1966) If this is so, then slope might potentially serve as one intonational cue speakers could use to identify non-native speakers.

The following chapter will describe a preparatory experiment designed to investigate the last hypothesis, and in doing so, provide a body of data with which to explore the first four hypotheses later.

CHAPTER THREE

EXPERIMENT 1

3.0 Experiment 1

Before undertaking a test of hypotheses 2, 3, or 4, it was necessary to collect data which would shed light on the correctness of hypothesis 5. The data on the production of the maximum slope of F0 across languages were intended to serve as a basis for experiments designed to investigate the other hypotheses.

To compare the slopes of the intonation patterns, two adult male native English speakers, one adult male German speaker and a single male adult native French speaker were required to read a corpus of 33 sentences for recording and analysis (see Appendix 2). Adult males provided the data for pitch analysis because the pitch analysis algorithm works best for voices whose F0 covers the range between 90 and 200 Hz. Statistical tests were run to determine whether the slopes of the continuative and terminal patterns differed from each other significantly across languages. It was assumed that speakers were making these intonational differences on a language-specific basis.

I assumed that any declarative sentence would end with a terminal intonation, indicating that the speaker had finished his message. I attempted to elicit continuative intonation patterns by creating bi-clausal or bi-phrasal sentences where the described activity continued over the clause or phrase boundary, or where there was a pair of semantically linked propositions. The semantic and syntactic patterns shown in Table 3.0 were used in all three languages. One pattern, number 5, was exclusively German. It was intended to substitute for the inapplicability of pattern 4 to German. I attempted to keep the semantic content and the number of syllables constant for each sentence across the languages. As well, content words, usually nouns, were placed just before phrasal and clausal boundaries, so that the same degree and type of stress would always be present for the English and German words under investigation. In the (German) cases where this was not possible, the penultimate content word as well as the pre-boundary particle was included in the analysis.

Continuative Patterns

1.	X	V	X	and/or	X	
	I	like	apples	and	bananas	
2.	(X)	V	(X)	and	V	(X)
At night he		eats		and	plays	his records
3.	X	V	(X)	and then	V	(X)
The kitten		plays		and then	falls	asleep

In English and French only:

4.	X	V	(X)	before/ after	V	(X)
Ray		drew	pictures	after	buying	new pens

In German only:

5.	X	(V)	V	X
Bevor er		abfuhr	las	er das Buch

Terminal Patterns

6.	(X)	V	(X)
The kitten		plays	
7.	S	V	O
	I	want	the blue dress

plus this later addition, replacing 4 and 5:

X	V	(X)	but	(V)	X
I	saw	Anne	but		not Eric

Legend : V = verb, S = subject, O = object
X = verb, noun phrase, prepositional or adverbial phrase, particle or pronoun

Table 3.0 Syntactic Patterns used in a data collection in English, French and German. An English example follows each syntactic pattern.

3.1 Recording Procedure

All audio recording for the preliminary analysis was carried out with an AKG condenser microphone located approximately 13 cm in front of the speaker's mouth. The microphone output was amplified by an AMCRON D-75 amplifier

prior to being recorded on a Revox B710 audio cassette recorder with Dolby C-type filtering.

The speakers read aloud each typed sentence once from a 5" by 8" index card. They were instructed to speak with normal intonation at a normal, but relaxed conversational speaking rate. They read the first few sentences several times, so that the audio equipment could be calibrated for their voice. Any sentences with mispronounced words or hesitations were redone after the whole set had been completed.

All sentences which sounded natural to the experimenter were used in the analysis. Most of the German speaker's data had to be rejected, as he very heavily emphasized the first content word of every sentence. The greater part of one English speaker's data also had to be discarded, because his articulation was so energetic that pitch patterns following stop consonants were often incorrectly analysed or altogether obliterated. A second German speaker was hired to record a new set of 33 sentences. The English and the French model speakers were also required to record this new set in their own languages. The following results are based on five male adult speakers' utterances, with most of the corpus coming from three of these people. The numbers of sentences used in the analysis were as follows: for continuation, 22

French, 23 English and 26 German sentences; for termination, 21 French, 22 English and 22 German sentences.

3.2 Analysis

The taped sentences were played back on a Revox B710 audio tape deck using a C-type Dolby filter. They were first amplified by an AMCRON D-75 amplifier at the optimum sound level, and then passed through a 4.5 KHz and an 8 KHz low pass Butterworth filter set. The sentences were then transformed into digital signals by a Digital Electronic Corporation VAX 11/730 computer interfaced to the audio equipment. I used the ILS (Signal Technology Inc. 1983) package for this and all other pitch analyses in this thesis.

Once digitized, the words in clause- or phrase-final position were analysed using the ILS API auto-correlational speech analysis method with pitch extraction. This method of speech analysis takes a sample of speech once every 3 milliseconds (msec) and yields a value for every parameter which is considered important in the synthesis of human speech, such as pitch and voicing energy. There are 128 variables produced for every sample taken, but approximately 50 of these actually vary from sample to sample and are vital to the resynthesis of acceptable speech. Two of these variables, parameters 119 and 120,

represent pitch in Hertz (Hz) and pitch period in tenths of a millisecond. The pitch is the inverse of the pitch period. Dividing the sampling rate (SR; always 10,000 samples/sec in this thesis) by the pitch period (P) yields the pitch (F0).

$$F0 = SR/P$$

The API pitch extraction algorithm produces a value for pitch in Hz for the convenience of the user. However, the computer uses only the value of the pitch period in any calculations it may make. This algorithm requires an initial set of several frames after a stretch of voiceless speech before it can accurately calculate the fundamental frequency of a voiced segment. This and segmental effects may both be responsible for the variability of the F0 values over initial and final frames of the greater part of the data. The first and last three or four frames of any pitch analysis file were not included in calculations when they differed from the following or preceding five frames of pitch, because the pitch in these frames was often influenced by the quality of the neighbouring word-initial or word-final consonants. When less than five frames of pitch occurred in isolation, they were ignored. This is a trivial amount of pitch to ignore; three frames equals nine milliseconds of time, and words where less than twenty

frames (60 msec) of pitch occurred were in any case not included in the statistics. Most words had voiced sections, and therefore pitch, over 50 or more frames (over 150 msec).

Either the pitch period or the pitch may be plotted in graphic form on a Houston Instrument plotter, or printed out as a sequence of values across any number of samples on a Digital Equipment Corporation DECWRITER III line printer. All equipment was interfaced to the VAX 11/730 computer system.

Both graphs and printed numerical values were obtained. The printed values were used to calculate the maximum slope of F0 over the single words before either the clause or phrase boundary. The graphs were used to monitor the shape of the intonation pattern.

The change in F0 on the clause- and phrase-final words, and the number of frames required to house this change in F0 were used in calculating the slope for each sentence pattern outlined above for each language (Table 3.0). The time elapsed in msec was calculated from the change in the number of frames, and then divided into the change in F0 thus:

1. maximum F0 - minimum F0 = dF0 (in Hz)

2. minimum change in frames x 3 = dt (in msec)

3. dF0/dt = maximum slope in Hz/msec

where `d' stands for `difference' or `change', and `t' stands for `time'. A fall in F0 is represented by a negative value and a rise by a positive value. An example of this measurement is provided in Fig 3.2.

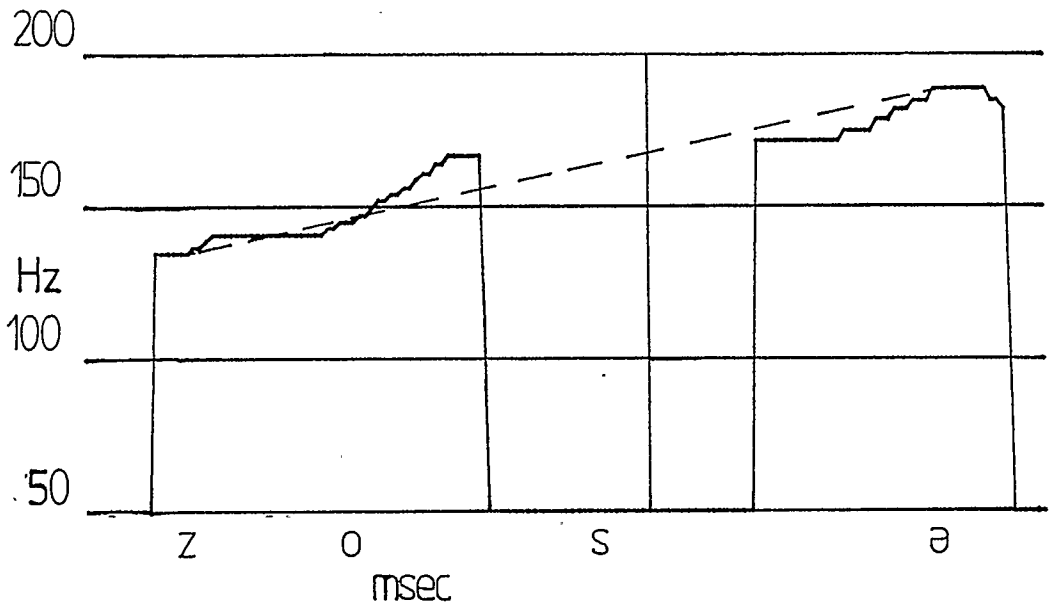


Figure 3.2 An example of the measurement of the maximum slope of F0. Typically, the slope of the steepest line between the highest and lowest F0 values was taken over a single word, here `Sosse' (German, `sauce' in English).

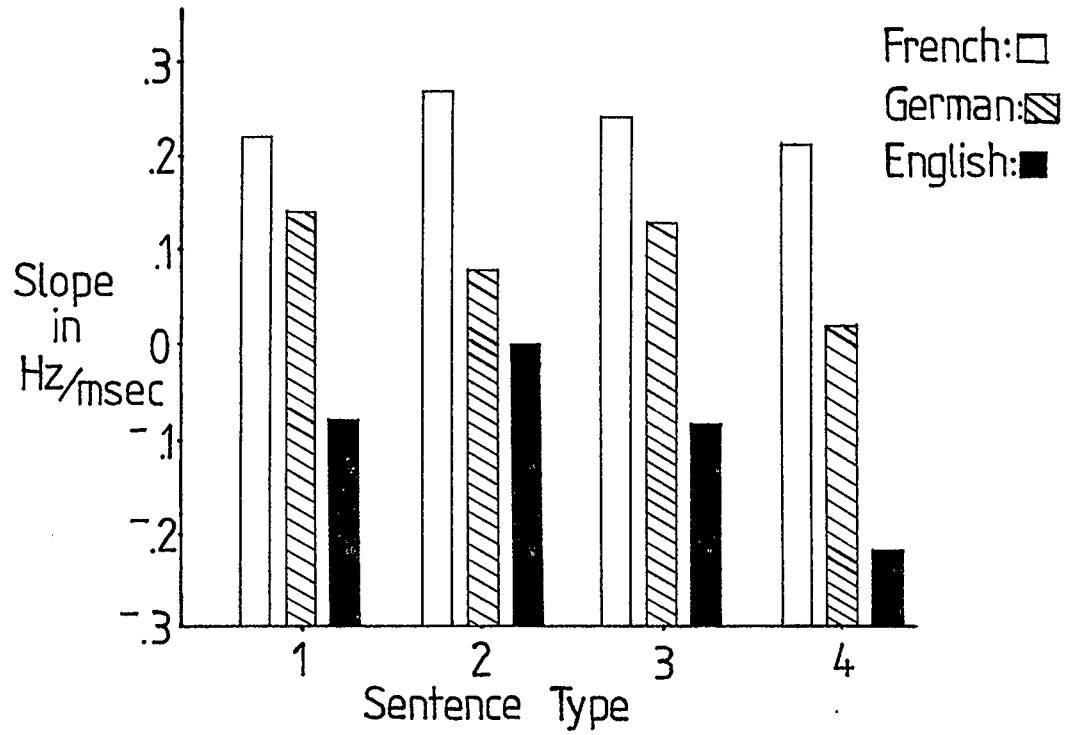
3.3 Results and Discussion

The results sshowed that the slopes for major continuation differed significantly across all three languages at the .05 level (Chi Square test).

	Chi Square Values
English vs French:	38.46 with 5 d.f.
English vs German:	27.19 with 4 d.f.
French vs German:	11.12 with 5 d.f.

Table 3.3 The Chi Square values for the maximum slope of F0 in English, French and German continuation patterns.

Means for the slopes of continuation patterns are given in Figure 3.3. The V (X) before/after V (X) sentence type is excluded from all tables and statistics in this thesis, as the French and English subjects did not make a break between phrases, and their intonations did not resemble those over the other sentence types. This syntactic pattern was not used in any analysis in the rest of the thesis. Instead, the pattern V (X), but (V) X was introduced in the second recording session. An example of this type would be `I saw Anne, but not Eric'. It contributes to all statistical results in this thesis.



Sentence Pattern

1. (X) V X and/or X
2. (X)V(X) and V(X)
3. (X)V(X) and then V(X)
4. (X)V(X), but (V)X

Legend : X: verb, noun phrase, prepositional or adverbial phrase, or pronoun
V: verb

Figure 3.3 The sentence patterns used as a basis for eliciting continuative intonation in English, French and German. The mean maximum slope of F0 on the word before the conjunction is given for each sentence type in each language.

In every case, the slope value for German continuation is less than the French value, but greater than the English value for the same sentence pattern. This helps account for the gradience in the

chi square statistics in Table 3.3. English and French have maximally different slopes, with French pitch inevitably rising, and English pitch usually falling. The English/German and French/German contrasts are not so polarized. Given this, one might expect that English and French continuation patterns could be more easily distinguished from each other than could be either the French or English patterns from German.

Delattre (1963 and 1966) claims that the terminal intonation patterns across English, French and German may be distinguished from each other on the basis of slope. However, the results of the experiment reported here show that the terminal intonation patterns of the three languages cannot be statistically distinguished from each other on the basis of slope alone. Chi square tests failed to reach or even approach significance on this measure.

If one measures the final drop in F0 relative to the average F0 over the final clause, one approaches a significant difference between English and French (at the .10 level at 6 d.f.). It is however unlikely that German and French may be distinguished even on this basis, as both show dramatic terminal falls over the final word in the sentence (-.16 Hz/msec for both

German and French). This parameter, average F0 - dF0, is in any case not mentioned in the literature as a primary cue to non-native intonation identification. The terminal patterns did not promise to yield many insights with regard to slope production across languages and so the continuation patterns were chosen to act as the foundation for further experiments.

3.4 Summary

The hypothesis that the maximum slope of F0 in intonation patterns is significantly different for the performance of the same functions, continuation and termination, across English, French and German, was supported by the data for continuation patterns only. It was rejected for termination intonation patterns. As the slopes of the continuative intonation patterns were significantly different from each other in each of the three languages, the continuative function was adopted as the basis for the experiments described in chapter four.

The next chapter presents a perception and a production experiment which seeks to explore the hypotheses set out in chapter two.

CHAPTER FOUR

A PRODUCTION AND PERCEPTION EXPERIMENT

4.0 The Experiments

Given the results from the comparison of the maximum slope of F0 across English, French and German intonation patterns (section 3.3), it is possible to accept a reduced version of hypothesis 1: continuative intonation patterns across English, French and German differ significantly in their slope. I shall now treat hypotheses 2, 3 and 4.

4.0.1 Hypothesis 2: Interference

To see whether speakers impose their native intonation patterns upon their second language I compared speech samples of English children learning French in the French immersion programs in Calgary (the `immersion students' henceforth) to those of monolingual French and English students.

4.0.2 Hypothesis 3: Assessing native speaker status

In order to discover whether listeners will decide that their interlocutor is not a native speaker

by attending to his intonation, it was necessary to have listeners judge speech with native and non-native intonation patterns.

To this end two versions of a speech sample were prepared, identical in every respect except intonation pattern. Native speakers would be expected to prefer the version with the original, unchanged intonation to the version with the altered intonation.

4.0.3 Hypothesis 4: Early acquisition

It was not possible to explicitly test the hypothesis that younger children more easily and successfully acquire second language intonation patterns than do older speakers, because nearly all children start in the immersion programs at age 6. However, if children do acquire a second language intonation system before age 8, then all the immersion students tested should produce acceptable French intonation patterns. Therefore, it was decided to elicit French speech from immersion students of different ages, and to compare their intonation patterns to those of monolingual English and French control subjects. The youngest group was 6 years old, as children could be safely assumed to have mastered

their native intonation patterns by that age (Crystal 1972).

4.1 Experimental Design

4.1.1 Production

To elicit sentences with a continuative intonation pattern, five simple two-part pictures were drafted in which a sequence of events was depicted. Immersion students were asked to describe these pictures in French and the English and French control subjects described them in their native language. The pictures were designed so that the words occurring under the continuative intonation differed as little as possible in the two languages, thus reducing the likelihood of segmental quality differences causing pitch perturbations which would confound pitch analysis results. Among the most common words analysed were: branche "branch", table "table", bateau "boat", plante "plant".

4.1.2 Perception

To study the different perceptions of continuative patterns by the English, the French and the immersion students, I selected 8 English, 8 French and 7 German sentences from those described in Chapter

3. Sentences were chosen so as to provide a range of slope differences. These are shown in Table 4.1.2. Eight was considered a sufficient number of sentence pairs if there were to be approximately eight subjects in a statistical cell (age by language). With 256 responses per language group, a 15% mean difference in score between speakers of two different language backgrounds was likely to be significant, depending on the variance of the two sets of scores. This remark is based on a Chi square analysis.

Each French and English sentence was submitted to an API pitch analysis. These sentences were then resynthesized via the SNS synthesis method (ILS, Signal Technology Inc. 1983). These became the `unchanged', or `native' sentences. The intonation patterns on these sixteen English and French sentences were identical to those on the original taped sentences.

Then, the pitch was altered in the analysed versions of these English and French sentences with the help of a pitch modification and transfer program (Esau 1985). This program transposed the F0 and pitch period values on the words which bore continuative patterns, in such a way that they assumed a continuative pattern typical of one of the other two

languages. For example, in the sentence: `I saw Anne, but not Eric', the continuative pattern on `Anne' was replaced by the French continuative pattern on `Anne' in this sentence: `J'ai vu Anne, mais pas Eric' (see Figure 4.1.2).

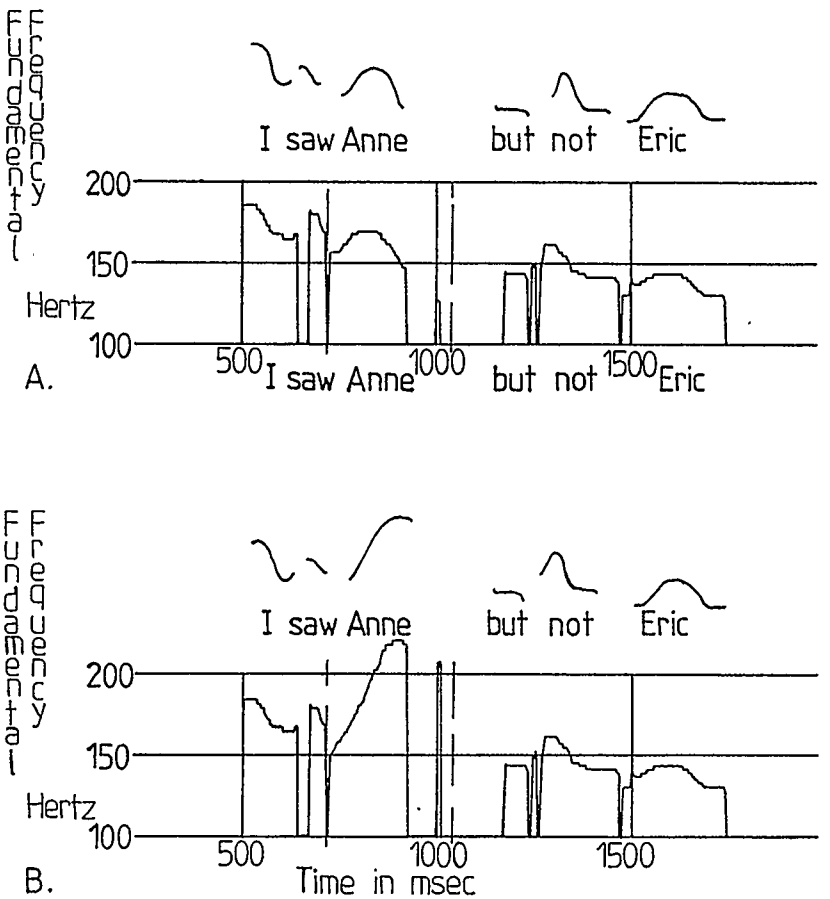


Figure 4.1.2 The pitch patterns on two versions of the same sentence on the perception test. A. shows the original English pitch pattern with a falling continuative slope (between the dotted lines). B. shows the altered pitch pattern with rising French slopes (between the dotted lines).

The sentences which contained these altered F0 values became the `non-native' sentences, once they too had been resynthesized via SNS (ILS, Signal Technology Inc. 1983). There were then two versions of each of the eight French and eight English sentences shown in Table 4.1.2.

	Sentence	Slope in the original version	Slope in the new version
1.	I saw Anne, but not Eric	-.17	+.39(F)
2.	The dog chased Marie and frightened Christina	0.0	+.21(F)
3.	I played hockey with Karl, but didn't enjoy it	-.19	+.21(F)
4.	It was hot in Panama, and the insects were ferocious	-.08	+.55(F)
5.	I used to live in Calgary and then I moved to Toronto	-.02	+.15(G)
6.	They saw a film and then they went to dinner	-.28	+.08(G)
7.	I bought a telephone and then I took it home	-.17	-.11(G)
8.	First they toured Canada and then they toured Alaska	-.13	+.10(G)
1.	J'ai acheté un téléphone, puis je l'ai apporté chez moi	+.13	-.11(E)
2.	D'abord ils ont fait le tour du Canada, puis ils sont allés en Alaska	+.41	-.10(E)
3.	J'habitais à Calgary, mais maintenant j'habite à Toronto	+.21	-.01(E)
4.	Donna aime bien la clarinette, mais elle déteste le violon	+.22	-.08(E)
5.	Le chien a chassé Marie et a fait peur à Christine	+.21	+.15(G)
6.	Le chien jouait d'abord avec Marie et puis avec Louise	+.16	+.04(G)
7.	C'était chaud à Panama et les mouches étaient féroces	+.53	+.02(G)
8.	J'ai vu Anne, mais pas Eric	+.35	+.10(G)

Table 4.1.2 Sentences on the perception test. E=English; F=French and G=German.

In addition to the eight sentences synthesized without any

F0 changes, there were four in each language whose intonation had been altered to German values, and four whose intonation had been altered to the values of the other test language (English to French and French to English).

All the synthesized sentences in each language were recorded using the equipment mentioned in section 3.1 at uniform amplitude onto a Sony UCX-S 90 cassette in pairs. Each pair comprised an unchanged and an altered version of the same sentence. Sentences were recorded in two different orders of presentation. Order of presentation within pairs also varied. To ensure that the synthesized sentences sounded natural, the unchanged versions were played to native speaker judges. Both the English and the French judge said that the quality of the speech was generally excellent, and that the sentences were comprehensible and sounded like the speech of a native.

It was intended that subjects should state whether the first or the second sentence in each pair was the `more natural, more normal' example of spoken English/French. Immersion students and French speakers were to hear the eight French pairs, while English speakers heard the eight English pairs. So that auditory memory and unfamiliarity with the task should not influence decision making,

subjects were allowed to hear the sentences on the perception test as often as they liked.

To see what differences subjects were consciously listening for in the tokens, the experimenter asked the subjects whether the perception test was easy or hard, and why this was so. Some subjects believed that they were forming their decisions on the basis of segmental cues, although this was not possible, since only the F0 parameter had been altered by resynthesis.

4.2 Procedure

Interviews were conducted in the control subjects' native language and in French for the immersion students. For 6 year old immersion students the interviews were held in English instead, since these children did not have sufficient French at their command to understand instructions or describe the pictures. They described the pictures in English and their production sentences were not used in the analysis. There is then no production data for the 6 year old immersion students.

In half the interviews the cassette was played first, and in half the pictures were presented first. Half of the interviews used one order of sentence pair presentation, and the other half used the other order. There were approximately equal numbers of males and females in each

age group, except the oldest (at 6-7 years, 9 males and 11 females; at 10-11 years, 12 males and 10 females; at 14-15 years, 14 males and 10 females; at 16-24 years, 5 males and 14 females).

A Sony portable cassette tape recorder and a portable General Electric AM/FM Radio cassette player were used in the interviews in the schools. All school-age subjects received the perception test on the General Electric cassette player and their responses were recorded on the Sony cassette recorder and on an answer sheet by the experimenter. The subjects' description of pictures and answers to questions were recorded on either the Sony or the General Electric cassette player. The General Electric was the only cassette recorder used with the adult French speakers and their responses were recorded manually. The entire test took less than twenty minutes for each subject.

4.3 Subjects

A total of 83 subjects participated. It was considered desirable to have eight subjects in each language group at each of the four age levels: 6 to 7, 10 to 11, 14 to 15 and 16 to 24 years. In fact, one group had as few as four members, and one as many as ten.

Although there was no overlap in age between groupings, there were a few 12 year olds in the 10 to 11

year old group, a few 13 year olds in the 14 to 15 year group and a number of 16 year olds in the oldest group. It was held justifiable to maintain the four groupings originally proposed, as the children who fell between the outlined age categories were in the same school grades as the children of the desired ages. The four educational grades represented are grade one, grade five, grade nine and grade eleven onward.

The control subjects were monolingual speakers of English and French. A number of the French speakers in the 14-15 age bracket said that they were exposed to English a great deal, even though the language spoken at home and in school was French. The experimental subjects were English children who had entered the French immersion programs in the schools at age 5-6.

4.4 Data Analyses

4.4.1 Analysis of the Production Data

Sentences showing any of the four syntactic patterns in Figure 3.3 were accepted for analysis. These were sentences containing the conjunctions: `and', `but', `and then' or `or' between phrases or clauses. About 5% of the sentences had to be rejected because the child used interrogative intonation and waited for the experimenter to indicate that the description was adequate. This pattern

rarely prevailed beyond the first sentence spoken by the child. Other grounds for rejection were background noise and use of English words instead of French ones by the immersion students. The latter was very rare (one subject's data). Some subjects' sentences could not be analysed because the subject spoke too softly. This means that subjects are represented unequally in the production data. There were as many as eight usable sentences for some subjects, and none for others. In total, 315 samples were used in compiling the statistics.

The sentences of all subjects were digitized using the equipment mentioned in section 3.1. The pitch over the word before a clause boundary was submitted to an API pitch analysis. A curve had to be extrapolated across the 8 Hz steps which this pitch extraction algorithm yields for high voices. This was necessary in about 15 cases of the younger children's speech. The values for the maximum slope of F0 were coded according to the subjects' language group, age and sex, and submitted to an SPSS (Nie, Hull, Jenkins and Steinbrenner, 1982) analysis of variance on a Honeywell computer. Since there was no data for the 6 year old immersion students, the youngest age group was entirely omitted from a second analysis of variance to give a truer picture of the immersion students' performance against the controls. Oneway analyses of variance for age and language

were run on all the data after the first analysis showed that there were main effects for both these factors. Post-hoc t-tests (see Appendix 1) were run on two pairs of interesting means.

It was thought that results ascribed to the children's learning the intonational slopes of their second language might be a trivial consequence of their attending to a different intonational component, such as the change in F0 over the continuative pattern. To investigate this, the change in F0 in the production of the continuative patterns was also coded according to the subjects' language background, sex and age.

4.4.2 Analysis of the Perception Data

Subjects' judgments on the sentences presented to them were marked right if they indicated that the synthetic sentence with unchanged pitch was the more natural in a pair. In total, 664 responses were collected, that is, 8 from every subject. These responses were divided into two scores out of four for every subject. Thus an English subject might have a score of 2/4 correct on the sentence pairs with (native) English versus (non-native) German continuative intonation, and a score of 1/4 correct on the sentence pairs with (native) English versus (non-native) French continuative intonation. These answers were coded

according to the subjects' age, language group, sex and the pair type (native language vs German; native language vs other Canadian native language). These coded scores were entered into a Honeywell computer and submitted to an SPSS (Nie, Hull, Jenkins and Steinbrenner, 1982) analysis of variance (see Appendix 1).

This analysis of variance revealed an interaction between age and language which was pursued further by using Newman-Keuls studentized range tests (Mendenhall, McClure and Ramey, 1977 - see Appendix 1).

4.4.3 Correlation

The relationship between perception and production in language is a major issue in current research. There are two major questions in the field of second language learning. First, must perception precede production in the acquisition of all aspects of one's second language ? Goto (1971) argues that a non-native phonemic distinction may be produced correctly in the second language even though a speaker does not perceive the distinction. Second, can perception of any aspects of one's second language be improved, leading to improved production ? Kalikow and Swets (1972) claim that non-native speakers' perception of second language phonemic contrasts can be improved with

visual feedback. This leads to improved production of the second language distinction.

To investigate the first question, it was decided to see if there were a correlation between the results of the perception and the production tests. A Pearson Product-Moment correlation test (see Appendix 1) was run on the scores on the perception test and the mean slope of F0 produced by subjects on the production test. To prepare data for comparison, a mean slope was calculated for each subject. For the English subjects, `number of answers correct' on the perception test was converted to `number of mistakes' for the purpose of the correlation test. This was necessary because the typical English continuative slope was expected to be falling, or negative, while for the other two groups rising pitch and positive slopes were expected. Subjects for whom there was no production data could not be included in this test. T tests (see Appendix 1) were run on three correlation coefficient values to establish whether they were significantly different from a value representing no correlation (i.e. $r = 0$).

4.5 Results and Discussion

The results of the experiments will be discussed as they reflect upon the four major hypotheses.

4.5.1 Hypothesis 1 - Results

The results discussed in chapter three support the idea that intonation patterns may differ across languages in regard to slope. ('Slope' will be used throughout the results section to refer to the maximum slope of the fundamental frequency for the full range of pitch over the word before a mid-sentence clause or phrase boundary.) An analysis of variance on the slopes produced by the English and French control subjects reinforces that support. Native French speakers produced significantly more positive intonational slopes than did English speakers ($F(2,312) = 13.87$, $p<.01$).

4.5.2 Hypothesis 2 - Results

Overall, it does not appear that these speakers impose their native intonation patterns upon their second language. The immersion students did not differ significantly from the native French speakers in their production of the maximum slope of F0, but both the French and the immersion students produced significantly more positive slopes than did the English ($F(2,312) = 13.87$, $p<.01$).

The above remark would suggest a false uniformity in the data, however. Although immersion students at 10 have

an excellent command of the French continuative pattern and are not significantly different from the native French speakers at 10 years in this matter, gradually the slope of their second language continuative intonation drifts toward English values (Refer to Figure 4.5.2). At age 16, the immersion students' French continuative intonation is not significantly different from the English 16 year olds' in English.

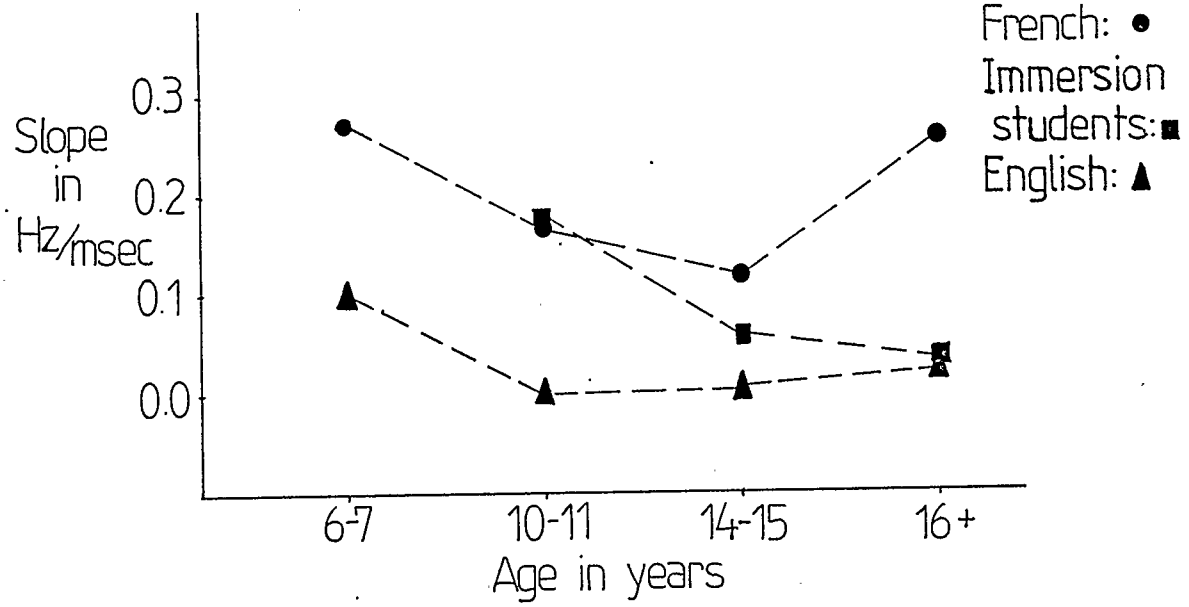


Figure 4.5.2 Graph of the English, the French and immersion students' production of the mean maximum slope of F0 by age group for continuative intonation. There is no production data available for the 6 year old immersion students.

A number of extra-linguistic factors may account for the apparent deterioration in the performance of the older

immersion students. The dominance of the English culture is perhaps partly responsible for the older immersion students' drift toward English slope values. This would imply that the younger immersion students are less influenced by, or exposed to, the cultural world outside the classroom. Another reason for this drift might be the closer attention paid to various aspects of the second language they are trying hard to acquire so as to be able to function comfortably in it.

Social factors may also facilitate this drift. Milon 1974, Bruck, Lambert and Tucker 1974 and Plann 1977 suggest that children learn the language of their peers. One of the main reasons for this is the child's constant exposure to the faulty second language of his classmates. Another reason is the pressure to conform which a peer group exerts upon its members. The interlanguage of the peer group becomes the acceptable, and perhaps, the preferable form of the target language, rather than the teacher's form of the target language. The social status of the language being learnt is also crucial. If learners have no desire to be identified as native speakers of a language they consider less prestigious, it is hardly surprising that they do not maintain a native accent.

The concepts of interference and approximation as used in the literature on second language learning do not appear

to be a factor here. The problem is one of apparent deterioration in performance in the acquired second language, and not one of initial acquisition. This is interference after the fact, so to speak.

4.5.3 Hypothesis 3 - Results

The results (see Figure 4.5.3) indicate that native listeners do not decide that their interlocutor is a non-native speaker by attending to his continuative intonation. Neither the French nor the English control subjects discriminated non-native from native sentences at levels much different from chance. Nor were there any main effects for age or language, sentence type or sex. This means that French groups did not even excel the immersion students, who had much less exposure to French than the native French speakers.

The one statistically significant trend in this data was that the older immersion students identified native continuative intonation more successfully than did the younger immersion students. On the perception test, the 10 year old, 14 year old and 16 year old immersion students all chose the sentences with the French continuative intonation significantly more often than did the 6 year old immersion students. (For the 10 year olds, $Q\ (2,52) = -3.133$; for the 14 year olds, $Q\ (2,52) = -3.878$; and for

the 16 year olds, Q (2,52) =-3.665.) This trend is plotted in Figure 4.5.3. It is hardly surprising that at age 6 the immersion students did worse on the perception test than did the members of any other group, because of their lack of familiarity with French. They appear to have chosen the non-native (more English) versions of the French sentences as preferable. The older immersion students preferred the native French sentences more strongly, reflecting a greater familiarity with French.

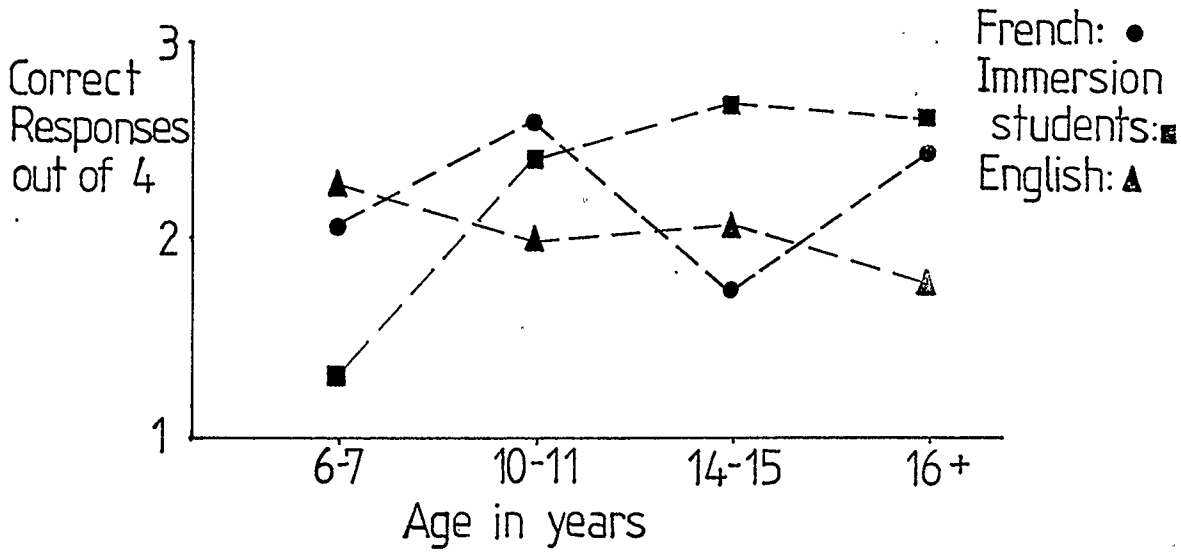


Figure 4.5.3 Graph of the English, the French and immersion students' results on the perception test. Answers are scored out of four, and each subject contributed two scores out of four to these results.

4.5.4 Hypothesis 4 - Results

The critical period hypothesis could not be explicitly tested (see section 4.0.3). However, the results obtained from the experiments described here do reflect upon the question of the influence of age on learning a second language. The conclusions of this chapter and chapter five deal with this matter.

4.5.5 Correlation Results

The correlation between performance on the production and the perception tests varied in strength and direction. Correlation values were calculated for the age groups within each language (see Figure 4.5.5). A positive correlation coefficient value (r value) for the French subjects means that a subject who chooses the sentences with unchanged French intonation on the perception test produces the rising continuative slopes characteristic of French. The r value for the 10 year old French would be interpreted this way. A negative r value for the immersion subjects means that a subject who chooses the sentences with unchanged French intonation on the perception test produces the falling continuative slopes characteristic of English. The 14 year old immersion students' r value provides an example of this occurrence.

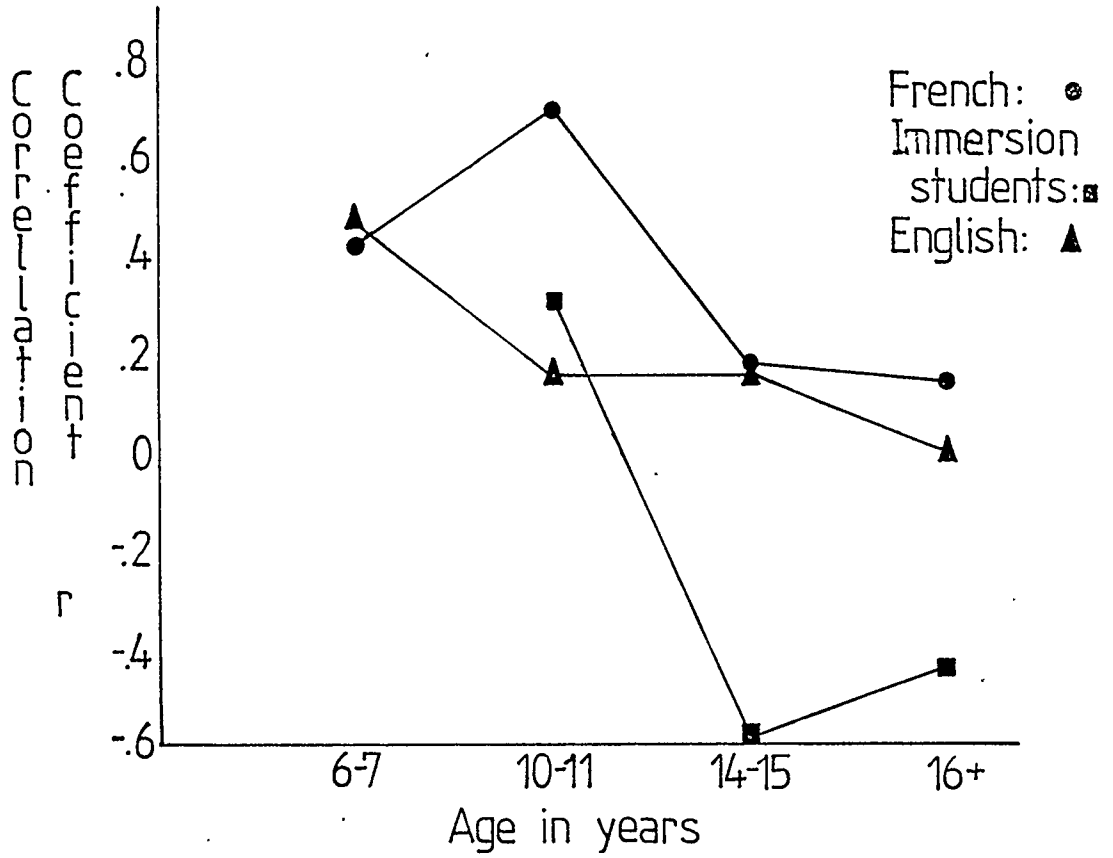


Figure 4.5.5 The Correlation Coefficients for the English, the French and the immersion students' performance on the perception and production tests. For lack of production data, no correlation was possible for the 6 year old immersion students.

The fairly strong negative value for the 14-15 year old immersion students (-.58) and the positive value for the French 10 year olds (.69) approach significance at the .01 level (two tailed t test). The positive value for the French control subjects suggests that the comprehension of native French intonation patterns is not yet complete in the French 10 year olds. This result compares favorably

with Cruttenden's claims that native English speakers at age 10 have an incomplete understanding of the English intonation system. It is possible that the French children who produce the most positive continuative slopes are attending closely to intonational differences, but are not sufficiently familiar with the range and functions of French intonation patterns to be confused by the number of contexts an adult might conjure up for both members of a pair of sentences on the perception test. This would explain good performance on the perception test being connected with the production of rising slope on the production test. Weaker correlation coefficients were obtained for older native speakers. It is likely that the younger subjects attend more closely to intonation, as Tahta, Wood and Loewenthal (1981) suggest, as they are trying to master the intonation systems of their native language. In addition, the older subjects may find it easier to imagine contexts for both members of a sentence pair on the perception test. They find a wider range of intonation patterns acceptable as native. This is due to their better knowledge of the intonation system of their language.

The negative value for the immersion students suggests that the more English a bilingual's produced slope in French is, the more reliably he will discriminate native

French from non-native French continuative intonation patterns. This counter-intuitive result could be interpreted as a consequence of the older students' growing familiarity with the wealth of French intonation patterns. Immersion students who find it difficult to nominate one member of a sentence pair as the more natural French (because they are able to imagine a context for either sentence) score lower on the perception test, but produce more positive slopes in their spoken French. This very odd trend needs to be backed up by further research to establish its importance.

4.6 The Status of Slope

To see whether it was the slope or the change in F0 over the continuative patterns of their second language intonation system that the children were acquiring, an analysis of variance was run on the change in F0. The change in F0 over the continuative intonation is significantly more strongly positive for the French and the immersion students than it is for the English students ($F(2,312)=13.903$, $p<.01$). This was true for slope as well (see section 4.5.2). There was no main effect of age associated with the change in F0 over the continuative intonation, whereas there was such a major effect associated with the slope. It is then possible that slope

is significant, independently of the change in F0 on which it depends. A test which uses a consistent change in F0 over the continuative pattern , but varying slopes, could more firmly establish slope's independence as an intonational component.

4.7 Conclusions

In this chapter I have shown that English and French native speakers produce significantly different intonational slopes for the continuative function. In this respect, I have provided evidence in support of Delattre's claim that the slope of continuative intonation may distinguish speakers of some languages.

Interference from English is not a problem when French intonation is initially acquired by immersion students. However, interference does occur once continuative intonation has been learnt and it effects a drift back toward the production of typically English continuative slope values. By the age of 16, immersion students produce French slopes similar to those of the English speakers.

The perception results are not as clear-cut as the production results. Scores were generally close to random, with only the immersion students showing a clear developmental trend. The randomness in these results and

also in those from the correlation tests is in itself worthy of comment.

It is possible that the older immersion students, precisely because of their exposure to two of the three languages represented in the perception test, are more proficient at distinguishing native from less native-like French. This trend requires further data for support, as the immersion students are on the borderline of statistical significance (two-tail test at the .01 level).

There may be a good reason for the poorer performance of the native speakers on the perception test. A native speaker is familiar with the intonation patterns of his own language and he is possibly more aware of all the subtle variations in intonation in his language than is a bilingual. He is too much in the know, so to speak, while the bilingual profits by his own grosser knowledge of non-native intonation. The native speaker can more easily imagine a context in which a given intonation would be appropriate. Because of his greater exposure to his own language and his lack of awareness of formally different, but functionally similar, intonation patterns of the second and third languages used in the synthetic sentences, he has trouble discriminating native from non-native patterns.

This implies that it may be misleading to speak of a single continuative intonation, as does Delattre. At best,

one can talk of a `basic' continuative intonation, which is what speakers generally produce. However, this `basic' intonation may be replaced or modified by other intonation patterns which signal continuation in addition to some other function. Section 1.1.3 would lead one to expect the concept of `basic' intonation to be a problem in practice.

This conclusion is consolidated by the remarks of the adult controls. Seven out of the eight French speakers spontaneously declared after hearing the first two sentences on the perception test that the differences were entirely due to intonation. However, they said it was extremely hard to prefer one version of a sentence to another, for they could imagine acceptable contexts for both. The English adults who pointed out that stress, intonation, tone or emphasis differences between the sentences accounted for their choices also said that the different stress placement on words in the sentence pairs was a matter of personal taste in some cases.

It is then wrong to conclude that native listeners cannot decide that their interlocutor is a non-native speaker by attending to his intonation. Multiple ambiguity due to convergence within the native intonation system has likely confounded the results of at least the older native speakers. The extent to which this conclusion is correct can only be discovered by further research with a better

perception test. I have therefore not eliminated the possibility that intonation may serve as a cue to non-native speaker identification.

Perception tests such as the one used in the present thesis are unable to deal with the convergence of function within a language. It is also impossible to neglect the confounding effect of convergence. A larger context for the sentences on the perception test might help to solve these problems. Such a context would consist of several consecutive sentences which set the emotional, social and regional register of the conversation.

CHAPTER FIVE

CONCLUSIONS

This thesis has attempted to provide data pertaining to five hypotheses on the role of the perception and production of terminal and continuative intonation in English and French. The conclusions presented in this thesis are based upon physical measurements and a statistical analysis of pitch movement, rather than solely on the judgments of native speakers. While native speaker judgments are useful in that they are based on a multitude of factors, too numerous to take into account in a computer analysis, in the field of foreign accent study this complexity is a problem. Native judges are known to be influenced by the speaker's pronunciation when judging intonation (James, 1976). The present thesis is, to my knowledge, the first which has controlled segmental cues in, and conducted a statistical analysis on, intonational data across languages.

First, it has been shown that the slope of the pitch is a significant component of a continuative intonation across English, French and German. This encourages the view that an intonation pattern may be analysed in an

atomistic fashion, since these cross-linguistic differences were revealed using an atomistic treatment. Whether slope is a significant intonational component in its own right, or whether slope's significance is only an artefact of its dependence on a change in F0 remains to be established by research addressed specifically to this question.

Slope seems to be a salient characteristic of a continuative intonation, for young French immersion students acquire French continuative slopes without interference from their native English by the age of 10. However, continuative slopes are produced with increasingly English values by the older immersion students. This interference after acquisition may be one of the symptoms of a developing interlanguage.

Interlanguage (Selinker, 1972 and 1975) may be called an interim linguistic system. It is characterized by mutual intelligibility among its speakers, systematicity, stability of errors, backsliding or reappearance of errors presumed eradicated, and fossilization. Plann (1977) suggests that native speakers of the culturally dominant language are prone to develop a classroom interlanguage when they become immersed in a less prestigious language, to which they are exposed only in school. She claims that the development and persistence of this interlanguage is

due to the large amount of incorrect peer input from classmates and to peer group pressure.

It is indeed possible that the immersion students feel certain ties to their mother tongue, which they feel the acquisition of native-like French would sever. As Lambert (1967) says:

> "the whole process of becoming bilingual can be expected to involve major conflicts of values and alliances." (p91)

An interlanguage may persist and then fossilize if speakers feel that functional competence in their second language is all that is required of them. This may well be true of the immersion students in this study. Further research with adult second language students might show whether strong motivation to speak French like a native would overcome this fossilization. Further research would also be necessary to show whether the older immersion students have lost the ability to produce French continuative slope, or whether their English slopes could be classified as errors in performance, rather than competence.

The data presented here are ambiguous with respect to the critical period hypothesis. Until it is clear that the apparent deterioration of the immersion students'

continuative slope values toward English values is or is not a matter of performance, the issue cannot be decided.

It is also unclear, given the perception results, whether intonation can serve as a cue to non-native speaker identification. The testing of that hypothesis must await further research.

A type of interference or interlanguage may occur after a certain linguistic feature, here continuative intonation, has been acquired. It has always been assumed that once a child had achieved native-like control of an aspect of his second language, he did not then regress with further exposure to the language. The fact that this can happen demands further research into what must be very powerful factors and causes.

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APPENDIX 1

STATISTICAL MEASURES

The statistical measures employed in this thesis will be described in order of appearance in the main body of the thesis.

The Chi Square test reveals whether or not it is likely that there is a dependency between two variables, such as language background and the maximum slope of F0. The greater the value of the Chi square statistic beyond a certain critical value, the more probable it is that this dependency exists. The degrees of freedom dictate the critical value adopted. The degrees of freedom may be defined as the number of the pieces of information in a sample that cannot be deduced from each other (Weinberg, Schumaker and Oltman, 1981).

An analysis of variance reveals whether there is a significant difference between the variances of at least two data samples in a given set of data samples. The concept of variance may be used to test for difference among means, such as the sample mean scores on the perception test for each language group. The

variances between means and within the data comprising each mean are compared to yield an F ratio. If the value of this ratio exceeds a certain critical value (determined by the degrees of freedom involved), then one may conclude that at least on mean is significantly different from one other mean.

The t test reveals whether one sample mean is significantly different from another sample mean. In this thesis t test have been put to two uses. First, the sample mean of one age group with a certain language background has been compared to the sample mean of the group with a different language background but sharing the same age. Second, t tests were used to compare the correlation coefficient `r' for some age groups with a certain language background to a preset correlation coefficient value of 0, which indicates no correlation between performance on two measures. One mean may be considered significantly different from the other if the t value yielded by the t test on the means surpasses a certain value determined by the degrees of freedom.

Newman-Keuls studentized range tests reveal whether there is a significant difference between two sample means which represent only a fraction of all the data gathered. The significant differences

between the scores of the bilinguals of various ages on the perception test were located by this method.

When an interaction between independent factors has yielded a significant F value in an analysis of variance, a Newman-Keuls test provides a way of locating this interaction. Because it retains the error term calculated for all the data gathered, and it takes into account the proportion of the whole that the data subsample being examined represents, it provides a conservative, and therefore more reliable measure of significance when multiple comparisons have to be done. The Q statistic results from the Newman-Keuls test between means and signals a significant difference between those means if it exceeds a certain critical value determined by the degrees of freedom.

The Pearson Product-Moment Correlation Coefficient, known simply as `r', indicates how two variables correlate. It shows the strength and the direction (positive or negative) of this correlation. In this thesis, every subject's score on the perception test was related to the mean slope he produced on the production test. A positive value for r means that, as one variable increases, so does the other. A negative value means that one increases as

the other decreases. The significance of r may be determined by running a t test against an r value of 0.

APPENDIX 2

The following English sentences were used in the first data collection. French and German sentences with similar semantic and syntactic content were used to collect French and German data.

1. He is playing with the cat and the dog.
2. The dog's playing with Jane or Anne.
3. She is visiting Anne or Robert.
4. I want the blue dress and the white skirt.
5. Paul reads some books and magazines.
6. I like the flute and the clarinette.
7. Anne goes to school and to church.
8. I like apples and bananas.
9. She likes pears and peaches.
10. Janice draws with pens and markers.
11. Mark draws with crayons and pencils.
12. He washes before going out.
13. Ray drew pictures after buying new pens.
14. Julie swims before eating dinner.
15. The kitten drinks milk before eating.
16. Joe ate lunch before going out.
17. Helen eats breakfast before going to school.
18. She reads before going to sleep.
19. At night he eats and plays his records.
20. She drinks tea and eats sandwiches.
21. Bob eats lunch and then goes for a walk.
22. Peter goes swimming and then goes home.
23. The kitten plays and then falls asleep.
24. Meg rides her bike and then comes in.
25. She plays and then she goes to sleep.
26. The kitten plays.
27. The kitten drinks milk.
28. The dog's playing with Jane.
29. She is visiting Anne.
30. I want the blue dress.
31. At night he eats.
32. Peter goes swimming.
33. I like apples.