National Library of Canada

Acquisitions and Bibliographic Services Branch

395 Wellington Street
Ottawa, Ontario
K1A 0N4

Bibliothèque nationale du Canada

Direction des acquisitions et des services bibliographiques

395, rue Wellington
Ottawa (Ontario)
K1A 0N4

Your file Votre référence

Our file Notre référence

NOTICE

The quality of this microform is heavily dependent upon the quality of the original thesis submitted for microfilming. Every effort has been made to ensure the highest quality of reproduction possible.

If pages are missing, contact the university which granted the degree.

Some pages may have indistinct print especially if the original pages were typed with a poor typewriter ribbon or if the university sent us an inferior photocopy.

AVIS

La qualité de cette microforme dépend grandement de la qualité de la thèse soumise au microfilmage. Nous avons tout fait pour assurer une qualité supérieure de reproduction.

S'il manque des pages, veuillez communiquer avec l'université qui a conféré le grade.

La qualité d'impression de certaines pages peut laisser à désirer, surtout si les pages originales ont été dactylographiées à l'aide d'un ruban usé ou si l'université nous a fait parvenir une photocopie de qualité inférieure.

Canada

ERRONEOUS ARTICULATORY ROUTINES:

A PERFORMANCE-BASED MODEL OF SPEECH PRODUCTION

by

Kathleen Brannen

A thesis submitted to the Department of Linguistics
and the Graduate School of the University of Ottawa
in partial fulfilment of the requirements
for the degree of

MASTER OF ARTS

in

LINGUISTICS

ISBN 0-612-07880-9

Canada

UNIVERSITÉ D'OTTAWA
UNIVERSITY OF OTTAWA

ABSTRACT

Young children who learn a second language (L2) are able to attain native pronunciation norms. However, L2 learners beyond childhood rarely rid themselves of foreign accent. Various hypotheses and models have been offered to explain such age-related differences. Few of these explanations have addressed the issue of perception/production asymmetries.

Neufeld's research has demonstrated that some older learners evidence native-like knowledge of phonological distinctions at the perceptual level, while unable to reproduce these distinctions in output. This asymmetry led him to propose his performance-based Pre- and Post-articulatory Verification model. This model assumes that, although native-like phonological representations may exist in the learner's L2 system, last-second morphophonological and phonetic adjustment may not take place because of a developmentally induced shift in focus from low- to high-level linguistic processing, i.e. to content and form.

This thesis elaborates upon Neufeld's ideas by centering on articulatory realization of phonetic specifications derived in the ultimate stage of sentence planning. It is suggested that, in order to meet real-time constraints, frequent and well-practiced articulatory sequences are eventually encoded as rapidly accessible routines. These routines are packaged instructions which translate phonetic representations into articulatory goals. This extension of Neufeld's model seeks to explain much of foreign accent in adolescent and adult L2 learners as the result of entrenched erroneous motor routines.

ACKNOWLEDGEMENTS

I would like to thank all my professors at the University of Ottawa for their part in transforming my initial interest in linguistics into a passion. In particular, I am grateful to my thesis advisor, Gerald Neufeld, for his willingness to share his time and knowledge. Discussions with him were both thought-provoking and enjoyable.

J'aimerais aussi remercier le Fonds FCAR pour le support financier alloué pendant la rédaction de ce mémoire.

Above all, I owe special thanks to my family -- Edward and Mary Brannen, Céline and Diets Habets, and Daniel and Julien Habets. Without their continued support and encouragement, none of this would have been possible. Merci beaucoup!

TABLE OF CONTENTS

CHAPTER ONE

1.1. Introduction

The persistence of foreign accent in second language speech is a phenomenon that has challenged researchers and educators for some time. Normal children always achieve community standards in their first language (L1). Likewise, children who learn a second language (L2) at a very early age are able to attain native norms at all levels including pronunciation; however, those who have begun learning an L2 as adults rarely achieve native-like status, especially with respect to pronunciation skills.

Anecdotal reports as well as empirical evidence suggest that although learners may gain mastery of other aspects of L2 grammar, such as syntax and morphology, accent-free speech, even for advanced learners, appears to be exceptional (Makkai, 1976; Ioup, 1984; Neufeld, forthcoming). Some researchers claim that native-like pronunciation is in fact impossible for older L2 learners (Scovel, 1988; Patkowski, 1990). Scovel (1981) has labelled this the "Joseph Conrad" phenomenon, after the Polish-born author who wrote so eloquently in English, his third language, and yet apparently retained a strong accent from his L1 throughout his life.

Some studies have shown that young children are more likely to ultimately attain native-like pronunciation than are older children and adults when length of study/exposure and other factors are controlled (Asher & Garcia, 1969/1982; Fathman, 1975;

Seliger, Krashen, & Ladefoged, 1975/1982; Oyama, 1976/1982; Patkowski, 1980; Tahta, Wood, & Loewenthal, 1981). These studies point to an age advantage for L2 pronunciation abilities: the younger the better.

Various explanations attempt to account for age-related differences in level of L2 attainment. As we shall see in detail in Chapter 2, the best known explanation which addresses these findings is the Critical Period hypothesis (Penfield & Roberts, 1959; Penfield, 1965; Lenneberg, 1967; Scovel, 1969; 1981; 1988; Lamendella, 1977; Patkowski, 1990). The Critical Period hypothesis (CPH) predicts that native-like pronunciation should be impossible for older L2 learners due to age-related structural changes in the brain.

The CPH developed mainly from neurological evidence which showed that young children seem to recover from aphasia; whereas, the prognosis for adults with comparable injuries is pessimistic (Penfield & Roberts, 1959; White, 1961; Basser, 1962; Smith, 1966; Kinsbourne, 1971). It was hypothesized that children's brains retain a certain "plasticity," which disappears after puberty. It is this plasticity which allows the child to reach a high level of pronunciation accuracy in his/her L2.

Another explanation for age-related differences in L2 ability -- with primary focus on syntax, morphology, and semantics -- involves factors attributed to cognitive maturation (Rosansky, 1975; Krashen, 1982; Felix, 1981; 1985). As we shall see in Chapter 2, such accounts attribute the inability to

acquire native-like linguistic abilities to the language-specific acquisition system either having to compete with (Felix, 1981; 1985) or being supplanted by (Rosansky, 1975) a developing non-language-specific cognitive system. This change in the acquisition process is attributed to cognitive changes associated with Piaget's "formal operations stage" which coincides with the onset of puberty. Proponents of this view postulate that the increasingly powerful deductive and analytic skills of the adolescent interfere with the language learning process in that, instead of being acquired strictly via the language acquisition device (Chomsky, 1959), the second language is analyzed by a more general problem-solving system. Since this more general cognitive system is not fully equipped to deal with language, the older L2 learner will find it very difficult to attain native-like mastery of the target language (TL).

In addition to these hypotheses, other explanations have been put forth to account for the phenomenon of foreign accent. One obvious difference between younger and older L2 learners which most likely contributes to accented speech is the existence in older learners of an already well-established L1 system. This entrenched system may induce the older learner to analyze the L2 via the structure of their L1. Such a strategy would lead to the superimposition of L1 phonological patterns upon L2 sounds, thus leading to accented speech. This phenomenon is usually called negative transfer, and was the basis of the Contrastive Analysis approach to foreign accent (Weinreich, 1953; Lado, 1957). As we

shall see in Chapter 2, although there have been several other accounts put forth to explain the etiology of foreign accent, negative transfer or interference from the first language is the major source (Brière, 1966; Nemser, 1971; Johansson, 1973; Dickerson, 1977; Tarone, 1972; 1987a; 1980/1987b).

Yet other factors which have been implicated as contributing to foreign accent are psychological, social, and emotional variables (Guiora, Brannon, & Dull, 1972; Taylor, 1974; Vigil & Oller, 1976; Guiora, Acton, Erard, & Strickland, 1980). It has been variously proposed, for example, that older learners are more inhibited than children when speaking the L2 (Guiora, Acton, Erard, & Strickland, 1980) and/or may be less motivated to become fluent in their L2 (Gardner & Lambert, 1972).

It has been 30 years since the idea of a critical period for language acquisition was first introduced. In that time, we have not advanced very far in our understanding of age-related differences in L2 speech. There are several possible reasons for this.

One important reason for lack of progress in research regarding the effect of maturational changes upon L2 proficiency is the presence of many complex, interacting factors. During the maturational process, so many changes take place that it is difficult to isolate the contribution of one particular factor, be it biological or cognitive. For example, in order to isolate possible neurophysiological influences, it is necessary to control for cognitive, psychological, social, and motivational

changes which co-occur with maturation. It is extremely difficult, if not impossible, to control for all these factors in experimental paradigms. This obstacle has impeded second language researchers from rigorously testing the CPH, thus leaving it as an a priori (but nevertheless intuitively plausible) assumption.

A second and obvious reason for lack of progress in research concerning the neurologically-based CPH is the inability to directly test it. Knowledge of visual processing in human beings has greatly progressed, thanks to the virtual identity of visual processing systems in genetically close primates. The same does not apply, however, to articulatory production. Even if we had a theory of the neuroanatomy of the speech production process, we would be unable to physically test it on normally functioning human brains.

A more important problem with maturational accounts of age-related differences in second language proficiency lies in their failure to specify which grammatical features in acquisition are affected, and more importantly, why.

Proponents of the critical period have not been able to elaborate on the hypothesis much more than did Lenneberg (1967) and Scovel (1969). The CPH has remained vague. One problem lies in Scovel's (1969; 1988) refinement of the hypothesis, wherein he claims that neurophysiological changes only affect the phonological/phonetic component of the grammar. Why it is that we would observe deficiencies at the level of phonology, without

similar consequences at other levels of the grammar such as syntax and semantics? If failure to attain native-like pronunciation is the result of learnability constraints, why would these constraints be limited to phonology? The phonological component is as much a part of the language-specific system as these other subsystems; it has been shown to be subject to systematic constraints or rules, as have the syntactic, morphological, and semantic components. Why then would the phonological component be singled out as unacquirable in later life? Any theory or hypothesis of second language acquisition (SLA) must address this issue.

Another area in which traditional maturational accounts lack precision is in the elaboration of the exact cause of foreign accent. In other words, just what aspect of the linguistic system is involved in the phenomenon of foreign accent. Are there performance deficiencies at the perceptual level (Flege, 1980; 1981; 1985; 1986; 1987; 1990)? Is the older learner unable to perceive phonological and/or phonetic contrasts in the L2, while at the same time retaining articulatory skills? Or does the problem lie in the inability to internalize a second phonological code, with perceptive and productive skills remaining intact? Or could it be that the problem does not lie at the level of perception, nor in the inability to acquire a new phonological code, but instead involves difficulties in translating native-like phonological representations into native-like articulation?

Most discussion on age-related differences in SLA fails to make such distinctions between competence and performance. Output is assumed to represent the state of the internalized grammatical knowledge of the L2 speaker. While this assumption may, in large part, be valid for performance in one's first language, extrapolation to L2 performance may not be warranted. Pronunciation of one's first language remains relatively steady under differing conditions, whereas, L2 productive performance is subject to more variability. For instance, L1 pronunciation tends to remain stable in stressful situations and/or during the production of complex utterances. However, under similar circumstances, L2 pronunciation tends to be somewhat more variable. Empirical evidence has indeed shown that the older L2 learner's performance is not necessarily an accurate reflection of his/her competence. Neufeld (1988) showed that perceptual capabilities can far exceed productive performance in older L2 learners. Guiora, Brannon, & Dull (1972) have shown that small amounts of alcohol can have a positive effect on articulatory performance in L2 learners, thus suggesting that learners' true competence does not necessarily surface in all situations. We do not observe the same degree of fluctuation in the production of first language speech. Therefore, the assumption that performance in the L2 speech of the older learner reflects his/her competence is premature.

This failure to be sufficiently explicit may actually inhibit the development of testable hypotheses in the field of

adult SLA. If we define proficiency in L2 as encompassing both internalization of the code as well as the capacity to use that code in a native-like manner, then researchers must be careful to focus on the precise nature of any proposed deficiency.

It is of considerable theoretical importance whether an enduring foreign accent involves incomplete acquisition of the TL phonological code or whether it is the result of an inability to access or otherwise use native-like representations in real-time communicative situations. If foreign accent is the result of learnability constraints on the older L2 learner, then theories which predict age-related differences in the ability to acquire higher-level grammatical subsystems of a new linguistic code would receive indirect support.

On the other hand, if it can be shown that L2 learners in fact are not compromised in their ability to acquire the phonological code of the TL grammar, then we may seriously question the status of theories such as the CPH and traditional accounts of cognitive maturation. Both the CPH and cognitive maturation hypothesis state that the older learner will be somehow compromised in his/her ability to acquire a new linguistic code, be it due to biological or cognitive constraints. The Critical Period hypothesis, as elaborated by Scovel (1969), applies only to pronunciation abilities of L2 learners. However, if learnability problems impede the L2 learner from acquiring native-like phonology, one would expect this to apply to other linguistic levels as well. Therefore,

this line of reasoning leads to an a priori rejection of this revised version of the CPH. Evidence of native-like phonological representations in older L2 learners (Neufeld, 1988) further weakens the CPH. If accent is due to performance problems at the level of production rather than competence lacunae, then it would be reasonable to assume that the L2 learner can, in fact, attain native-like mastery of higher linguistic levels such as morphology and syntax as well.

Traditionally, the study of language acquisition has focused on acquisition of the code (competence). This is only natural since most of the work on acquisition has focused on the first language, and as mentioned earlier, productive performance in one's native language is generally a reliable indication of the state of one's acquired competence. However, in light of the discussion in the previous section, it might be worthwhile including performance phenomena within the scope of acquisition, especially in the field of second language research.

There are at least two researchers in the field of SLA whose work focusses on the role of performance phenomena in foreign accent. Flege (1980, 1981, 1985, 1986, 1987, 1990) has put forth a hypothesis which relegates the problem of accent to perceptual strategies. He states that older L2 learners tend to classify L2 sounds with L1 sounds that are phonetically close. Flege's hypothesis predicts that L2 sounds without a counterpart in the L1, e.g., French /ü/ for English speakers, will be correctly articulated because they will not be perceived as belonging to an

L1 phonological category. We will examine Flege's work in further detail in Chapter 2.

Whereas Flege attributes foreign accent to perceptual strategies, Neufeld (1980, 1988) postulates that accented speech may be due to constraints on production. His (1988) work which demonstrated perception/production asymmetries has led him to seek answers to the persistence of accented speech in older L2 learners in the area of productive performance.

While Neufeld believes that cognitive maturation plays a central role in adults' inability to rid themselves of foreign accent, his hypothesis differs in one crucial aspect from traditional explanations based on cognitive maturation. The latter claim that the increasingly powerful deductive and analytic powers that accompany maturation interfere with the L2 learner's ability to acquire the code. Neufeld, however, believes that these reasoning powers do not interfere with the acquisition of competence as such, but rather with the adult's ability to use that competence in real-time speech production.

As Neufeld's data has shown, phonological competence and perceptual acuity in L2 can both be native-like, and yet accent still persists. This seems to indicate that there is something interfering with the translation of representations into output. He hypothesizes that increased abstract reasoning powers cause older L2 learners to become preoccupied with grammatical structure and semantic content of the message, at the expense of articulatory precision. As we shall see in detail later, foreign

accent may result from the bypassing of pre-articulatory verification and dependence instead on erroneous motor routines formulated during L2 learning.

The more well-known models of speech production (Fromkin, 1971; Garrett, 1975; 1984) have little to say about what processes take place between the phonological specification of utterances and their actual articulation. For instance, Fromkin's 1971 Utterance Generator incorporates a level where phonological rules apply, producing fully specified phonetic units which are mapped onto motor commands to the articulators. There is little detail specified beyond this. Some more recent models incorporate pre- and post-articulatory editors (Baars, Motley, & MacKay, 1975; Levelt, 1989), but do not elaborate on the possibility of articulatory routines.

1.2. Objectives

The goal of this thesis is to elaborate upon existing models of speech production in order to provide a partial explanation for why it is that adults seem to have so much difficulty in ridding themselves of their accented speech. It is hoped that the contribution made here will shed some light on how it is that some older L2 learners demonstrate native-like phonological competence, while at the same time producing non-native-like pronunciation.

1.3. Outline

In Chapter 2, we will begin with a critical review of the literature which addresses foreign accent, assessing the merits and shortcomings of different proposals. Chapter 3 will look at some current models of speech production, and examine the theoretical and empirical motivation for each, with particular emphasis on the later stages in the production process. In Chapter 4, we will elaborate upon Neufeld's Pre- and Post-articulation Verification Model, attempting to incorporate it into existing production models. This extension is intended to provide a partial explanation for the persistence of foreign accent in older L2 learners. We will provide a detailed examination of the hypothesis which holds that once an adequate level of articulatory proficiency is reached, erroneous articulatory patterns fossilize. It is claimed that, through continual use, these patterns become unitized in the form of motor routines. Motor routines are packaged procedures and instructions which determine vocal tract configurations. Once encapsulated within a motor routine, these instructions become entrenched. Reliance upon these erroneous routines is deemed to result in the production of accented speech.

CHAPTER TWO

EXPLANATIONS FOR FOREIGN ACCENT: A REVIEW OF THE LITERATURE

2.1. Introduction

Most people who have embarked upon the task of learning a second language (L2) after the age of 10 or 11 will attest to the immense difficulty in ridding themselves of their foreign accent. Even after many years of naturalistic and/or classroom exposure and practice in L2, these learners seem unable to achieve native-like articulatory status, despite the fact that they may well have native-like abilities at other linguistic levels such as syntax and vocabulary.

The causes of such age-related difficulties at the level of pronunciation have yet to be adequately explained. Even after many years of research, there are fundamental questions which remain unanswered. Is articulatory deviance the result of different perceptual strategies employed by the adult learner? Are adults compromised in their ability to learn new phonological or phonetic representations and/or modify existing ones? Does the problem lie in the inability to implement native-like phonological rules and representations in real-time communicative situations? Finally, what is special about the phonological/phonetic component that makes it so difficult for older L2 learners to achieve native-like proficiency as compared to higher linguistic subsystems? These are questions which require answers if we are to advance our knowledge of the second language acquisition process.

In this chapter we shall critically review the various hypotheses, models, and empirical evidence which have been offered in an effort to explain the causes of foreign accent as well as its perseverance in the speech of the L2 learner who is past 10 years of age. Explanations for the etiology of adult-child asymmetries fall into four general categories: neurophysiological, cognitive, social/sociopsychological, and psycholinguistic. In the following sections, we will look at each of these in turn and discuss what we view as the merits and shortcomings of each.

2.2. Neurophysiological Explanations

2.2.1. The Critical Period Hypothesis

During his work at the Montréal Neurological Institute, Dr. Wilder Penfield, in collaboration with several colleagues, developed a method of "mapping" the brain in order to delimit the cortical speech areas. This method was used in order to avoid excising these areas during surgery to correct focal epilepsy. As well as helping those patients in his care, this cortical mapping procedure and related study led Penfield and his colleagues to formulate hypotheses about the neurophysiology of language and speech mechanisms. Through his work, he observed that young children who had sustained massive lesions to or had undergone hemispherectomies of the language-dominant left hemisphere were more likely to recover their language abilities than were adults with corresponding insults. This led him to

suggest that children retain the capacity to relearn language in the non-dominant right hemisphere if injury occurs early enough in life. According to Penfield, adults seem to lose such "plasticity," therefore recovery of language in adults would involve re-engaging the dominant left hemisphere, rather than relearning in the right.

In 1967, Eric Lenneberg proposed a biologically-based "critical period" for language learning. This hypothesis was based on various findings. One source of evidence for the CPH was from the work on aphasia by researchers such as Penfield (1965) and Basser (1962), who found that children are able to recover from lesions to or hemispherectomies of the left hemisphere, whereas after puberty, such recovery seems no longer possible. In cases where Wada tests (anaesthesia of one hemisphere) were performed on these young patients, it was shown that the right hemisphere seemed to have taken over the function for language. This was not so for the post-pubertal patients. Further evidence came from studies on children with Down's Syndrome (Lenneberg, Nichols, & Rosenberger, 1964) which demonstrated that language development steadily progressed -- albeit at a slower rate than in the normal population -- until puberty, when progress reached a standstill. Still further evidence came from studies on pronunciation abilities of patients with acquired versus congenital deafness (Fry, 1966).

Based on these various findings, Lenneberg suggested that the age span from two years until puberty represents an optimal

period whereby human beings retain an

> innate flexibility for the organization of brain functions to carry out the complex integration of subprocesses necessary for the smooth elaboration of speech and language. After puberty, the ability for self-organization and adjustment to the physiological demands of verbal behavior quickly declines. (Lenneberg, 1967:158).

Lenneberg concluded that the infant's brain is equipotential, i.e. neither hemisphere is functionally specialized, and that with cognitive maturation the brain becomes increasingly specialized through neuronal changes, with speech eventually becoming fully and permanently functionally lateralized to the left hemisphere by the time of puberty. Termination of organizational plasticity at the age of 12 or 13 years was deemed to represent the end of a critical period for optimal language acquisition.

Scovel (1969; 1981; 1988) introduced modifications to the Critical Period hypothesis by restricting the effects of lateralization to foreign accent. He claims that native-like pronunciation is impossible for second language learners past puberty, the upper limit of the critical period. Scovel proposes that older L2 speakers may aspire to native-like status at higher linguistic levels such as syntax and semantics, but not at the level of articulatory proficiency. He has labelled this the "Joseph Conrad" phenomenon, after the Polish-born author who wrote so eloquently in English, his third language, and yet apparently retained a strong accent from his first language throughout his life. Scovel suggests that the reason that pronunciation is the only aspect of the linguistic system to be

compromised after the CP is because it "is the only part of language which is directly 'physical' and which demands neuromuscular programming....All other aspects of language are entirely 'cognitive' or 'perceptual' in that they have no physical reality...." (Scovel, 1988:62). He suggests that perhaps there is a selectional advantage (in the Darwinian sense) for the inability to acquire native-like sound patterns after puberty. Based on work by Hill (1972), Scovel (1981; 1988) speculates that foreign accent may have been important in our evolutionary history, from a reproductive point of view, in order to identify us as members of a particular demographic group.

The equation of the CPH with completion of lateralization came under criticism when it was discovered that lateralization is in fact complete much younger than puberty (Kimura, 1963; Geschwind, 1970; Knox & Kimura, 1970; Geffner & Hochberg, 1971; Krashen, 1973). For instance, Krashen (1973) reanalyzed some of the data which Lenneberg (1967) relied upon in formulating his hypothesis. In particular, re-examination of data from Basser (1962) indicated that functional specialization for language in the left hemisphere is evident as early as five years of age. Krashen found that all cases of right hemisphere damage resulting in aphasia occurred prior to five years old. Therefore, if the brain is "plastic" with respect to language function until puberty, Krashen showed that plasticity is not correlated with lateralization.

Recent work has in fact demonstrated that cerebral

asymmetries may be present at birth and even pre-natally (Entus, 1977; Wada & Davis, 1977; Molfese, 1977; Best, 1988; see Springer & Deutsch, 1988 for discussion). If correct, these findings compromise the position which links decline in pronunciation abilities after puberty with functional lateralization. It should be noted, however, that there is increasing evidence for the possibility of persistent foreign accent in speakers over six years old (Flege, 1991). If this is the case, then the link between earlier lateralization and foreign accent may be salvaged.

Other researchers have suggested that cerebral plasticity may not be due to lateralization at all. Whereas Lenneberg (1967) and Scovel (1969) associate loss of plasticity with lateralization of linguistic function to the left hemisphere, some believe it is due to other aspects of cerebral maturation (Seliger, 1978). For instance, Seliger has proposed the Multiple Critical Periods hypothesis based on findings from neurological research relating to myelination of axonal fibres and thickening of the corpus callosum (which joins the two hemispheres). Because of the differing timetables involved in the completion of biological development for areas of brain purported to subserve different linguistic levels -- with those areas subserving articulation being completed first -- Seliger suggests that each component of the linguistic system has its own "critical period."

Myelination of axonal fibres in particular has received considerable attention in recent literature on the CPH.

Myelination refers to the formation of lipid matter around neuronal axons (Abuhamdia, 1987), which creates a sheath which functions as insulation for conduction, much as insulation on an electric cable. Lecours (1975) states that

> the development of myelin in the sheaths of a fiber system has become space-committed in an invariable path...the fiber system that has completed its myelogenetic cycle may be assumed to have reached functional maturity (Lecours, 1975:122).

The chronicity of the myelination process has led certain researchers (Maxwell, 1984; Abuhamdia, 1987) to propose that foreign accent may be due to early myelination of the Golgi type I neuronal cells present in the motor area for speech.

2.2.2. Empirical Evidence for the Critical Period Hypothesis

Since Lenneberg's and Scovel's initial elaborations of the CPH, many studies have investigated the role of age as a determinant of degree of foreign accent. Asher & Garcia (1969/1982), Seliger, Krashen, & Ladefoged (1975), and Oyama (1976) found a negative correlation between the degree of foreign accent and age of arrival in the United States for groups of immigrants who varied in age from six to 19+ years of age. Fathman (1975) had similar results for children ranging in age from six to 15 years of age who were learning English in a naturalistic setting. Naturalistic exposure is an important variable in these types of tests since it is assumed that only the language-specific acquisition system is activated by naturalistic stimuli whereas classroom learning may implicate other more general cognitive systems. Cochrane (1980) found

children outperformed adults in both production and perceptual abilities. Cochrane & Sachs (1979) discovered that children were better than adults in an imitation task, but showed no such superiority in their ability to learn a Spanish phonological stress rule. This may indicate that children are better imitators, but not necessarily better in acquiring phonological rules.

These studies are interesting in that they confirm anecdotal reports of the superiority children have in approximating native norms in L2 pronunciation as opposed to those learners who have embarked upon L2 learning after puberty. However, they are purely of descriptive value and shed little light on the possible causes of such age-related differences.

2.2.3. Critique of the Critical Period Hypothesis

The CPH, as outlined above, is one of the most widely held and enduring positions accounting for the tenacity of foreign accent with respect to the older L2 learner. The reasons for this are evident. It makes good intuitive sense. Beginning with Chomsky's 1959 critique of B.F. Skinner's Verbal Behavior, linguists and those from other disciplines as well have convincingly shown that the capacity for language is innately determined. For example, evidence has been amassed which has shown first language development to follow a biologically determined schedule, one that is independent of that of other cognitive functions. This, along with the fact that all normal children who are exposed to language eventually speak that

language in a way that makes them indistinguishable from their ambient linguistic community, strengthens the concept of a biologically-determined first language acquisition schedule. With regard to second language learning, however, the situation is less clear.

Lenneberg's 1967 description of a critical period for language was intended to apply to first language acquisition. One might therefore question whether the CPH as elaborated by Lenneberg and Scovel is applicable to L2 acquisition. Since the neural systems subserving language functions have already been activated in L1 learning, it is possible that the linguistic capacity remains available for the learning of subsequent languages. This has been termed the "Exercise hypothesis" (see Johnson & Newport, 1989 for discussion). In fact, Lenneberg himself briefly addressed this issue. Although he felt that acquisition of a foreign language is compromised after puberty, particularly with respect to foreign accent, he did feel there is some validity to what was later termed the Exercise hypothesis. In addressing the fact that many older learners become quite proficient in their L2, he states:

> ...[W]e may assume that the cerebral organization for language learning as such has taken place during childhood, and since natural languages tend to resemble one another in many fundamental aspects...the matrix for language skills is present. (Lenneberg, 1967:176)

The fact that foreign accent is a wide-spread and persistent characteristic of the L2 speech of older learners certainly is strongly suggestive of some neurophysiological implication in L2

learning. The strong version of the CPH (Scovel, 1988) predicts in fact that no one can hope to achieve native-like status in pronunciation when learning commences after puberty. However, there is evidence that this may not be so. Hill (1970) has claimed that native-like accent is possible after puberty if cultural factors are favourable. Salisbury (1962) provided evidence of native-like articulatory proficiency in second language speakers of New Guinea, where multilingualism is necessary and desirable. Other studies have also shown that adults are capable of achieving native-like articulatory status. Neufeld (1977, 1978, 1979, 1980, 1988) has demonstrated that in laboratory-controlled conditions, learners are capable of passing as native speakers in many cases. Furthermore, the strong version of the CPH fails to account for the variability in L2 proficiency found in older learners; instead it implies a uniform application.

Despite the intuitive appeal of the CPH, little progress has been made in this area during the 30 years since this hypothesis was first proposed. There are several reasons for this. First, as mentioned earlier, the CPH has remained a largely speculative proposal. Since the CPH is not explicit regarding the nature and effects of age-related differences in L2 proficiency, those studies which have found evidence of such disparities can only be of descriptive value. For example, the correlations made between "degree of accent" and "age of arrival" in the host country are not indicative of a causal relationship

between the two variables. It is quite possible, for instance, that older immigrants may be disinclined to rid themselves of their accented speech because of a desire to remain within their own ethnic community.

Other evidence which has been taken as support for a CP is from pathology. Extrapolation from studies on brain damaged patients to the normal population is risky due to individual differences in neuropathological history as well as the omnipresent possibility that the damaged brain operates in a fundamentally different way than does the normal brain. The functional relevance of such processes as myelination are still poorly understood, and evidence for neurological changes corresponding to the proposed cut-off ages for articulatory proficiency is largely lacking at this time (Whitaker, Bub, & Leventer, 1981).

Second, some theorists propose a relatively sudden loss of ability (whether it be at age six or at puberty), but neurological development seems to follow a much more gradual course. For example, Lecours has shown that myelination is a progressive process, and suggests that the perfection of linguistic abilities may likewise follow a progressive course (1975:129). Also, it is still unclear whether proposed neurological changes are (a) the cause of foreign accent, or (b) coincidental with other maturational changes which are themselves the cause of foreign accent, or (c) correlated with consolidation of the first language system. This point is important because

effects attributed to neurobiological factors are in fact confounded with many other changes which occur in ontological development, as we shall see in the following sections of this chapter.

Finally, the CPH has been very vague in not specifying exactly what aspect of the linguistic system and/or language processing is compromised when we speak of the phenomenon of foreign accent. There has been virtually no discussion of whether foreign accent belongs in the domain of competence, i.e. an inability to internalize new phonological or phonetic rules and representations, or whether it belongs in the domain of performance, i.e. an inability to access and implement NL rules and representations. It remains unclear as to why certain linguistic subsystems should be compromised in later learning, while others are not, or why, for instance, particular phonological rules and representations should be difficult to acquire while others are acquired with ease. It is encouraging, however, to see that some researchers have begun to address these problems. As was discussed earlier, myelination timetables put completion of development of the motor areas for language at around the age of six years (Yakovlev, 1962; Lecours, 1975), the age at which foreign accent becomes difficult to overcome. Abuhamdia (1987) addresses Neufeld's 1980 findings of asymmetry between native-like perceptual versus non-native-like productive abilities in older second language learners by suggesting that the early maturation and myelination of the Golgi type I neuronal

cells in the language motor area may hinder productive performance while not affecting perception or competence.

Another obvious reason for lack of progress in research regarding the CPH is the inability to physically alter neurological structures that have been cited as contributing to a critical period. Given that speech is limited to human beings, manipulation of variables such as degree of myelination is virtually impossible. Knowledge of visual processing in human beings has greatly progressed, thanks to the virtual identity of visual processing systems in genetically close primates. The same does not apply however to articulatory production. Although we will eventually know more about the relationship between neurophysiological maturation and language learning, the present state-of-the-art does not allow for in-depth scrutiny of hypotheses such as the CPH.

2.2.4. Other Neurophysiological Explanations

Besides the Critical Period hypothesis, other neurophysiological explanations have been put forth to explain the persistence of foreign accent in the older learner. A popular notion among second language learners themselves is that as one gets older, neuromuscular flexibility declines due to years of practising the same "phonological habits" (see Tarone, 1987a, for discussion). This hypothesis is doubtful. For instance, as will be explained later, Neufeld (1977) trained adults with a pronunciation technique in laboratory conditions and found that adults were quite capable of articulating new and

exotic sounds. Furthermore, there has been no evidence showing that the tongue and vocal apparatus lose muscle tone or flexibility with age (Walsh & Diller, 1978; 1981).

2.3. Cognitive Processing and Foreign Language Accent

2.3.1. Contrastive Analysis and Transfer

During the 1950s and early 1960s, accounts for foreign accent were based on the theory of Structuralist Phonology. Using the phoneme as a basic unit, the Contrastive Analysis hypothesis attempted to explain accented speech by comparing structural differences between the L1 and L2 sound systems. All learner errors were attributed to "negative transfer" or "interference": pronunciation patterns from L1 being used in the articulation of the L2 (Weinreich, 1953; Lado, 1957).

In keeping with the behaviourist tradition popular at that time, it was assumed that pronunciation of L1 sounds was established through "articulatory habits," and that these same habits were called upon or transferred when the learner attempted to produce L2 sounds. Learning an L2 sound system was deemed to require the establishment of new stimulus-response pairs. Transfer was recognized as a general cognitive strategy rather than a language-specific cognitive activity (Selinker, 1972; Tarone, 1978; James, 1986; 1988; Hammarberg, 1988).

Within the Contrastive Analysis approach, various other units have been proposed to constitute the basis of interlingual identification. Weinreich (1953) claimed that accented speech

was due to interference at phonemic, phonotactic, and suprasegmental levels. He proposed that negative transfer at the phonemic level could occur due to:

(a) substitution (e.g. English /r/ for the Spanish trill); or

(b) underdifferentiation, where L1 allophones have phonologically distinct counterparts in L2 (e.g. Japanese L1 /r/~/l/ versus English L2 distinctive /r/ and /l/); or

(c) overdifferentiation, where L1 distinctive phonemes have allophonic counterparts in L2 (e.g. Thai L1 distinctive /t/ and /t^h/ versus English L2 /t/~/t^h/); or

(d) reinterpretation of distinctions, where "a bilingual distinguishes phonemes of the secondary system by features which in that system are merely concomitant or redundant, but which are relevant to the primary system" (Weinreich, 1953:18). For example, English L1 speakers may misinterpret the German L2 vowel distinction as being one of vowel quality rather than quantity.

Phonemic similarity was essentially determined by proximity on the phonemic chart. Unfortunately, in many cases, two or more L2 phonemes are in equal proximity to the L1 phoneme, and there was no theoretically motivated way of choosing between them.

Weinreich (1957) proposed that instead of phonemic units, distinctive features were in fact the units relied upon in interlingual identification. This represented an attempt to specify more clearly the precise features which constitute phonemic similarity. Again, however, two L2 sounds can be equidistant from a feature perspective.

Ritchie (1968) suggested that some distinctive features are more important in a particular language's sound system, and used these "feature hierarchies" to explain "differential substitution" of L2 English interdental fricatives. Differential substitution (Weinberger, 1990) refers to the fact that a particular L2 sound can sometimes take more than one substitution cross-linguistically, e.g. in the L2 English of L1 French Canadian speech /θ/ is realized as /t/; whereas, L1 Continental French speakers realize it as /s/.

More recently, Hancin-Bhatt (1994) has developed the Feature Competition Model of segmental transfer whereby she attempts to account for differential substitution with an algorithm that calculates feature prominence based on the principles of phonological underspecification (Archangeli, 1988). Hancin-Bhatt's model presupposes that foreign accent is due to learners' misperceptions of L2 sounds.

Perceptual strategies are also the basis for Flege's 1987 Equivalence Classification model. Flege's work addresses the issue of foreign accent from a phonetic perspective. In particular, he uses acoustic analyses to measure differences between native and non-native speakers' pronunciations. Flege (1985, 1987, 1990) proposes that L2 learners develop a phonetic representation of a phoneme which is shared by both L1 and L2 based on the already established L1 target as well as instances of the L2 sound. He postulates that this occurs via a cognitive mechanism termed "equivalence classification." For example, the

phonological repertoire of English includes the phonemes /p,b,t,d.../. French also has these phonemes in its repertoire; therefore, both French and English happen to share these particular phonological representations. However, the phonetic representation of these same phonemes in English is different from that of French. For example, the voice onset time (VOT) for /p,t/ in English is significantly longer than it is in French. Therefore, English speakers learning French would base their phonetic representation of these "similar" sounds upon the acoustic target from each language. However, for an L2 sound which has no equivalent in the L1, as is the case of the vowel /ü/ for English speakers of L2 French, the learner should have no difficulty in eventually achieving accurate pronunciation. Flege suggests that because the phonetic representation is determined by the acoustic target of both the L1 and L2 sound, in the case of "similar" sounds, the most the L2 learner can achieve is a perceptual target midway between the L1 and L2 targets. To explain a fossilized form which can be attributed to non-native VOT for stop consonants, Flege states:

> Assuming that adult L2 learners eventually achieve their perceptual target for L2 stops in production, they will at best produce L2 stops with VOT values that are intermediate to the VOT values in stops produced by monolingual speakers of L1 and L2 (1987:16).

As with Hancin-Bhatt's account for transfer, Flege's work is based on perception. His work is intimately related to the research done since the 1960s on categorical perception (Abramson & Lisker, 1970; Lisker & Abramson, 1970). Flege's model runs

into the same type of difficulty alluded to earlier whereby it is difficult to objectively determine which sounds are "similar" and which are "new."

Many researchers feel that the central unit for interlingual identification is not the phoneme, phone, or the distinctive feature, but instead the syllable (Tarone, 1972; 1976; 1980; Greenberg, 1983; Sato, 1984; Broselow, 1983; 1984/1987). For example, Broselow (1984/1987) found that L1 English speakers of L2 Egyptian Arabic have a strong tendency to perceive and pronounce Arabic word-initial consonant clusters such as in the phrase ?ildursi gdiid 'the chair is new' as *?ildursig diid, disallowing consonant clusters which are not permissible in English. Based on her findings, she formulated the Syllable Structure Transfer hypothesis:

> When the target language permits syllable structures that are not permitted in the native language, learners will make errors which involve altering these structures to those which would be permitted in the native language (Broselow, 1987:272).

Similarly, transfer effects have also been documented as the level of prosody (Studdert-Kennedy & Hadding, 1973; Pürschel, 1975; Esser, 1978; Anan, 1981; Scuffil, 1982).

Vago (1980), Rubach (1980; 1984), and Altenberg & Vago (1983/1987) have suggested that transfer effects are restricted to low-level, or post-cyclic, phonological rules. These rules occur late in the phonological derivation, are context-sensitive, apply automatically with no exceptions, and purportedly simplify pronunciation. Altenberg & Vago (1983/1987) cite Hungarian

Regressive Voicing Assimilation as a low-level or post-cyclic rule which is transferred to L1 Hungarian speakers' L2 English. This rule assimilates an obstruent in voicing to a following obstruent, e.g. <u>according to</u> rendered in L2 English as [ɛkordiŋk tu] and <u>about the</u> as [aboud dö].

In addition to these various accounts of the phenomenon of linguistic transfer in L2 acquisition, there have been numerous other studies which have been based upon interference effects in L2 speech (Stockwell, Bowen, & Martin, 1965; Brière, 1966; Nemser, 1971; Redard, 1973; Suter, 1976; Paik, 1977; Soudak, 1976; 1977; Tomaszczyk, 1980; Wode, 1976; 1977; 1978; 1981; 1983).

Although these studies were quite informative as to the types of transfer that occurs when learners speak in their second language, perhaps a more interesting finding from many of these investigations was that transfer could not account for all of L2 speakers' errors. Sometimes speakers produce sounds that are neither part of the L1 system nor the L2 system. And in some cases where the Contrastive Analysis hypothesis predicted interference, none occurred. It was unable to account for inter- as well as intra-speaker variability, due to experimental task or otherwise. Thus, in its strong form, Contrastive Analysis was an oversimplified hypothesis, inadequate for predicting many errors in L2 speech.

Aside from this important revelation provided by the "transfer" studies, there is one problem that has failed to be

addressed by these accounts of foreign accent. Many of these studies fail to specify whether transfer effects are perceptual or productive in origin, whereas others tend to attribute transfer effects to misperception of aural cues (Flege, 1987; Broselow, 1984/1987; Altenberg & Vago, 1983/1987; Hancin-Bhatt, 1994). Virtually none of the aforementioned researchers addresses perceptual/production asymmetries whereby L2 speakers can be shown to have native-like rules and representations on perceptual tasks, but nevertheless produce non-native-like speech (Major, 1987; Neufeld, 1988). For instance, Major (1987) recounts cases where students of phonetics can identify pharyngeal fricatives but are nonetheless unable to produce them. Likewise, many L2 speakers are well aware of their foreign accent, yet are unable to rid themselves of it.

2.3.2 Other Cognitive Strategies

Besides transfer, other cognitive strategies have been implicated in attempts to explain the origins of foreign accent. Well known is the work by Selinker (1972), in which he cites five central processes which are engaged when the older second language learner embarks upon the task of learning L2. Selinker believes that the majority of older learners rely on general cognition in learning L2; whereas, young learners rely on a language-specific acquisition device. The five processes include:

1. Transfer, as discussed in Section 2.3.1;
2. Transfer-of-training, whereby focus on specific structures in

classroom instruction is deemed to influence L2 speech. Selinker gives this example: although Serbo-Croatian has the he/she gender distinction, some Serbo-Croatian speakers of L2 English overuse he because classroom drills were presented exclusively with the pronoun he;

3. Strategies of second-language learning, for example, the tendency to simplify L2 structures (e.g. consonant cluster reduction);

4. Strategies of second-language communication, for example, where an L2 speaker might realize that concentrating too much on correct liaison in connected L2 French speech leads to unnatural sounding pronunciation and therefore, s/he decides to ignore the training s/he has received on liaison;

5. Overgeneralization of target language (TL) linguistic material; an example from phonology might be the production of the trilled /r/ in all linguistic environments which call for allophonic variants of the /r/ in the L2 Spanish produced by L1 English speakers.

More recently Selinker and Lakshmanan (1992) have put forth the Multiple Effects principle, which states that when one or more of these strategies acts in tandem with linguistic transfer with respect to a particular structure, we can expect persistence of accented speech or fossilization.

The majority of the work attributing alternate cognitive strategies to older speakers' abilities to generate utterances in their L2 assumes that these strategies are used to circumvent

deficient linguistic knowledge. Some researchers who have investigated age-related differences in language learning ability at the level of morphology, syntax, and semantics (Rosansky, 1975; Krashen, 1982; Felix, 1981; 1985; Bley-Vroman, 1988) have proposed that the ability to speak L2 with native-like proficiency is compromised by developing non-language-specific cognitive system. These researchers adopt a Piagetian approach to maturation whereby increasingly powerful deductive and analytic skills begin to develop at approximately seven years of age, and level out at Piaget's "formal operations stage" which coincides with the onset of puberty. Proponents of the dual access hypothesis postulate that the increasingly powerful deductive and analytic skills of the adolescent interfere with or completely supplant the language-specific learning process. In other words, they believe that these general skills prevent the L2 learner from acquiring a native-like mastery of another language.

However, all L2 speakers' errors may not be due to competence lacunae. Neufeld (1977) conducted an experiment in which monolingual English subjects received intensive training on Japanese and Chinese pronunciation to the exclusion of any instruction on syntax or semantics. Three out of 20 subjects received native-like status ratings by native speaker judges, while six others received near-native-like ratings. Since half of the group received native-like or near-native-like ratings, Neufeld proposes that older L2 learners are indeed capable of

attaining native-like pronunciation.

In a subsequent study, Neufeld (1988) replaced a nasal vowel in a French sentence with an allophone of that vowel. These replacements were judged as unacceptable by native French speakers. Subjects were to identify an anomaly by articulating the offending segment; they were told that articulatory accuracy was not required. The results from this task showed that proficient bilingual speakers performed at near-native-like levels compared with beginning bilinguals. The proficient and beginner bilingual groups performed at similar levels on production tasks as compared with the French controls. Neufeld interpreted these data as suggesting that the proficient bilingual subjects demonstrated native-like knowledge of their L2 phonological rules and representations, but that in real time performance, somehow these native-like rules failed to manifest themselves on the surface. Furthermore, other tasks within this experiment revealed that the proficient bilinguals' productive performance was most native-like in imitation tasks, only to progressively decline with increasingly complex tasks, from phrase repetition to story telling. Together, the results from Neufeld's work (1977, 1978, 1979, 1988) led him to propose his Pre- and Post-Articulatory Verification Model (PAVM) of speech production. Neufeld's PAVM holds that older L2 learners' speech production is constrained by changes which occur with cognitive maturation. But in contrast to traditional cognitive maturational accounts, Neufeld proposes that cognitive maturation

does not interfere with acquisition per se, but instead with the ability to use native-like rules and representations in real-time productive performance. He suggests that these general cognitive skills lead to an increasing preoccupation with form which interferes with the sentence production process.

Neufeld further suggests that reliance upon metalinguistic knowledge can likewise be disruptive during sentence planning. Some older L2 speakers have more of a tendency to be concerned with "correct" form at the level of morphology and syntax than other L2 speakers. Translation of metalinguistic knowledge into information that can be used by the linguistic output processor takes additional time. Therefore, in order to produce speech in real-time communication, pre-articulatory verification of pronunciation is bypassed, resulting in reliance on previously established, erroneous articulatory routines. We shall elaborate upon Neufeld's PAVM in Chapter 4.

2.3.3. The Role of Affect

Aside from general cognitive development and second language learner strategies, other psychological factors which likewise reside outside the language faculty have been suggested to account for foreign accent phenomena. These factors are usually subsumed under the rubric of "affect." In the field of psychology, affect refers to emotivity, anxiety, stress and the like which, by definition, are highly variable. However, in the field of L2 acquisition, affect is a term which encompasses emotions as well as more stable factors such as attitudes and

personality traits.

One of these psychological variables that has been positively correlated with pronunciation abilities is that of "empathy." In a series of studies, researchers tested the hypothesis that the degree to which one can empathize with the thoughts and feelings of others would have a positive effect on one's ability to authentically articulate in a second language (Guiora, 1967; 1970; 1972; Guiora, Lane, & Bosworth, 1968; Taylor, Catford, Guiora, & Lane, 1971; Guiora, Brannon, & Dull, 1972; Guiora, Acton, Erard, & Strickland, 1980; Schumann, Holroyd, Campbell, & Ward, 1978; Guiora & Schonberger, 1990). Empathy is considered to be part of the concept of language ego. Language ego is viewed as self-representation or identity through one's native language, and it is assumed that pronunciation is the most salient expression of that linguistic identity. In general, the results from these experiments did demonstrate a positive correlation between empathy and pronunciation proficiency, as variously measured through purportedly reliable tests of degree of empathy (Guiora, Brannon, & Dull, 1972), administration of alcohol or valium (Guiora, Beit-Hallahmi, Brannon, Dull, & Scovel, 1972; Guiora, Acton, Erard, & Strickland, 1980), and through the use of hypnosis (Schumann, Holroyd, Campbell, & Ward, 1978).

Degree of motivation has also been implicated in the ability to achieve native-like accent. Learners' attitudes towards the L2 society and culture -- analogous to "language ego

permeability" -- have been found to influence the degree to which pronunciation approximates L2 norms (Spolsky, 1969; Brown, 1980). Similarly, Suter (1976) and Purcell & Suter (1980) found that concern for "good" pronunciation was a important predictor of native-like articulation in L2.

The results from these investigations into the role of affective factors in L2 pronunciation skills are important in a number of ways. First of all, they allow for movement towards better pronunciation, given optimal affective conditions. Perhaps more importantly, these studies show that affective factors can either impede or promote native-like pronunciation. These results help to explain the variable productive performance so often observed in the older second language speaker. The implication is that articulatory output does not always reveal the state of the L2 learner's phonological and/or phonetic knowledge; affective factors can inhibit the older L2 speaker from fully performing his/her competence.

Although affective factors undoubtedly play a role in L2 pronunciation, this approach has some of the same problems we saw earlier with the neurophysiological approach. It is difficult, if not impossible to separate out the possible confounding factors involved with maturation. Are affective factors the cause of or correlated with other age-related differences? Also, none of the hypotheses we have seen specify the ways in which affective factors impinge upon the acquisition or use of specific linguistic features.

2.4. Social/Sociopsychological Explanations

Much work regarding L2 acquisition has focussed on the contribution of social and sociopsychological factors in determining degree of ultimate attainment.

Seminal work by Gardner & Lambert (1972) led to the formulation of some hypotheses which relate social-psychological factors with L2 learning. These researchers carried out large scale studies which investigated various factors that come into play when the L2 learning situation involves the interaction of minority and majority languages. This interaction was found to influence the degree of motivation that a person takes with him/her to the task of L2 learning. Cultural attitudes, values, stereotypes, and degree of ethnocentrism were all found to influence the extent to which the learner would achieve native-like proficiency in the L2.

It is obvious that one's accent is a powerful symbol of one's ethnic background. Depending upon cultural attitudes, a particular accent may be regarded favourably or negatively. For example, Ensz (1982) conducted a study whereby native continental French speakers rated L1 American English speakers of L2 French as to their intelligence, appearance, financial status, and social skills. Although not as influential as syntactic errors, pronunciation errors led native French speakers to give poor ratings to the L2 speakers on these points.

Similarly, Brennan & Brennan (1981) and Giles (1978) found that in multilingual communities, near-native-like L2 speech was

regarded with favour. However in other communities, L2 speech which closely approximated TL norms elicited negative responses from native listeners. Clyne (1981) explained this latter finding by suggesting that pronunciation is often expected to reflect the L2 speaker's status as an "outsider."

Another socially determined influence on the degree to which the L2 learner approximates the target language pronunciation norms is that of input. The nature and amount of input received by the L2 learner has been related to the presence of foreign accent (Larsen-Freeman, 1983). In many classroom learning situations, the teacher is a non-native speaker of the language being taught. Therefore, the model provided for the learner is that of non-native-like speech. If the learner only interacts with his/her teacher and/or peers in the classroom, accented speech is the only type of input s/he will receive. Obviously, if one has no access to native-like models, one cannot hope to achieve native-like pronunciation. However, even in situations where the teacher is a native speaker of L2, sociocultural attitudes may keep the learner from identifying with the teacher, instead conforming to the non-native-like models provided by peers (Plann, 1977).

Related to the role of input in L2 learning is the Interactive Feedback hypothesis. Vigil & Oller (1976) have proposed a model of L2 learning which depends upon the type of feedback the speaker receives from his/her audience. This feedback comes through both a cognitive and an affective channel.

The audience can either be the interlocutor or self-monitored speech. Cognitive feedback involves whether the message is understood or not, and affective feedback involves whether the expected response, positive or negative, is elicited. It is hypothesized that the speaker will tend to fossilize in his/her L2 development if positive cognitive and expected affective feedback are received. For instance, even if the L2 speaker's speech in heavily accented, if s/he succeeds in being understood and elicits the appropriate response, s/he will tend to be satisfied with the state of his/her pronunciation proficiency and not attempt further improvement. For an in-depth critique of this model, see Selinker & Lamendella (1979).

Sociolinguistic variation is another factor which influences L2 speech. Work by Labov (1966, 1969, 1972) has shown that L1 speakers' pronunciation exhibits stylistic variation. Speech styles fluctuate from carefully monitored to the vernacular. There have been several investigations of such sociolinguistic variation in L2 acquisition (Nemser, 1971; Schmidt, 1977; Beebe, 1980; Tarone, 1982; 1983; James, 1983; Dickerson, 1987).

For example, Schmidt (1977) investigated the pronunciation of adolescent speakers of Egyptian Arabic on reading tasks aimed at capturing formal versus less formal styles. The subjects were also divided into two groups according to socioeconomic status. The phonemes of relevance involved in the study were interdental fricatives /θ,ð/ and alveolar fricatives /s,z/.

Most L1 Arabic speakers of L2 English will substitute /θ,ð/

with /s,z/. This is usually attributed to interference from L1, since colloquial Arabic has no interdental fricatives. However, Classical Arabic does. Classical Arabic is a literary language, no longer considered a "living" language. When being attentive to style, literate Egyptian Arabic speakers will pronounce the interdental fricatives of Classical Arabic. However, any Classical Arabic word with /θ,ð/ may be colloquialized with /s,z/.

In general, the results of this study showed that in less formal speech tasks, Arabic speakers tended to pronounce both Arabic and English interdental fricatives as /s,z/, whereas in more formal speech tasks, these speakers pronounced them correctly as interdental fricatives. In addition, it was found that performance was dependent upon socioeconomic class, with the higher, more educated socioeconomic group producing more interdental fricatives. This investigation by Schmidt shows how interlanguage (IL) phonology is subject to transfer of stylistic variants from L1 to L2.

Beebe (1980) conducted a similar study of stylistic variation in the speech of L1 Thai speakers of L2 English. She found that not only did stylistic interference occur from L1, but also that these speakers demonstrated use of their knowledge of English stylistic variants in their L2 speech.

2.4.1 Critique of Social/Sociopsychological Explanations

Obviously, social and sociopsychological factors play a major part in determining the degree of L2 proficiency. But

methodological problems plague social factors studies. These investigations of L2 performance often use broad-based standardized tests. Many tests are of a self-report type which are intended to measure "attitudes." These tests are notoriously unreliable for a number of reasons. Subjects are often unable to assess their own attitudes and/or tend to give answers which they feel to be socially acceptable. Also the test construction may not give enough options or may offer inappropriate choices. Needed are more in-depth case studies in which more fine-grained, objective measures are used.

2.5. Psycholinguistically-Based Explanations

In Section 2.3.1, we looked at several studies which were based upon the Contrastive Analysis hypothesis (CAH). As was pointed out, a major finding to come out of many of these studies was the fact that CA was unable to account for all of L2 learners' errors. Also, in some cases where CAH predicted problems, none occurred. Analysis of these errors has led researchers to propose more psycholinguistically-based processes which come into play in determining what factors give rise to foreign accent (Johansson, 1973; Mulford & Hecht, 1980; Flege, 1980; Macken & Ferguson, 1981; Altenberg & Vago, 1983/1987; Flege & Davidian, 1985; Wode, 1976; 1977; 1978; 1981; 1983; Major, 1986; 1987).

Although most articulatory errors undoubtedly are due to transfer (Tarone, 1978; Hecht & Mulford, 1982/1987), some errors found to occur in L2 speakers' articulations have been attributed

to developmental substitutions, i.e. errors not due to the phonology of the native language, but which are found to occur in children's development of their L1. These types of errors are assumed to be governed by universal factors influencing the production and perception of speech. They include such processes as word-final consonant devoicing, consonant cluster simplification (through epenthesis or deletion), hardening (i.e. continuant -> stop), and overgeneralization.[1]

For example, Major (1986) found that L1 English speakers learning L2 Spanish tended to substitute the trilled /r/ for the flapped (allo)phone /D/. He considers this to be a case of the L1 developmental process of overgeneralization because the English phonological system does not include the trilled /r/ (but see Tarone, 1978).

Research has found that developmental processes may interact with transfer processes. Hecht & Mulford (1982/1987), in their study of Steinar, a six-year-old L1 Icelandic speaker, found that both developmental and transfer processes could work in tandem on a single phoneme. Icelandic has /s/ in its phonemic inventory, but not its voiced counterpart, /z/. In addition, a common process in L1 development is that of word-final consonant devoicing (Macken & Ferguson, 1981). Steinar consistently

---

[1] Note that these processes are not always developmental. Many languages use rules such as these as part of the adult phonological system. Clearly, it is crucial to provide an adequate description of both L1 and L2 phonological systems before we can classify an error as transfer or developmental.

pronounced word-final /z/ in his L2 English as /s/ throughout the 14 weeks of the study. This led Hecht & Mulford to propose that the cumulative effect of transfer and developmental processes on a single segment could lead to persistent articulatory errors in L2 pronunciation.

Tarone (1980) investigated the relative contribution of transfer at the syllabic level in L2 speech. She found that transfer is by far the greatest source of non-native-like pronunciation in L2 speech. However, she also discovered that in some cases where transfer would in fact have resulted in a correct form, learners resorted instead to developmental processes, which resulted in error. For example, Korean has closed syllables which terminate in /l/ such as [kuel] 'ninth month.' Despite the similarity, she found a case of an L1 Korean speaker of L2 English pronouncing school as an open syllable, [sku:]. Tarone proposes that this type of error occurs because of the universal tendency towards CV syllable structure. It has been suggested that such retreat to the basic CV syllable may occur under stress due to the experimental task or due to the demands involved in communicating in one's L2 (Hodne, 1985; Benson, 1988).

2.5.1. Language Universals

It is assumed that units and processes which are typologically common throughout languages of the world also represent units and processes which are basic (or unmarked) to the way language is represented and processed in the human mind.

Although some typologically common features are due to inter-language contact, phenomena such as implicational hierarchies (where the presence of one feature always implies the presence of another) are thought to be attributable to the universal properties of language.

Jakobson (1941/1968) proposed a universal hierarchy of structural laws which determines the phonemic inventory of languages of the world. For example, he claimed that the order of L1 acquisition of consonants is the following: stops >> nasals >> fricatives >> liquids. As for vowels, he claimed that back rounded vowels are acquired before front rounded vowels. Johansson (1973) found evidence for this in that L2 speakers of Swedish tended to substitute the back rounded vowel [U] for the front rounded [ø] in cases where the L1 had neither. Johansson suggested that

> the same vowels which appear as phonemes in children's speech and which are the most basic in the languages of the world, are also reproduced with fewest phonetic deviations. (Johannson, 1973:159)

Yet another type of process which may operate independently of transfer and be related to general phonological properties is the pressure to fill the cardinal or basic peripheral points on the vowel trapezium (Puppel, 1990).

Similarly, Tropf (1983) found that the order in which phonemes are acquired by L1 Spanish speakers of L2 German was related to their saliency on the "sonority hierarchy" (cf. Selkirk, 1984). Thus, the most sonorous part of the syllable, the nucleus, is acquired before onsets or codas. Likewise, the

most sonorous nuclei would be acquired before those of lesser sonority. These influences were also found to interact with the syllable structure of the L1, only applying in cases where the L1 was lacking similar syllable structures.

Perhaps one of the more well-known hypotheses to relate L2 phonological acquisition to markedness conditions is the Markedness Differential hypothesis (Eckman, 1977/1987; 1981). The MDH is stated as follows:

> The areas of difficulty that a language learner will have can be predicted on the basis of a systematic comparison of the grammars of the [native language (NL)], the [target language (TL)] and the markedness relations stated in universal grammar, such that (a) Those areas of the TL which differ from the NL and are more marked than the NL will be difficult; (b) The relative degree of difficulty of the areas of the target language which are more marked than the NL will correspond to the relative degree of markedness; (c) Those areas of the TL which are different from the NL, but not more marked than the NL will not be difficult (Eckman, 1987:61).

Markedness is defined according to implicational relations:

> A phenomenon A in some language is more marked than B if the presence of A in a language implies the presence of B, but the presence of B does <u>not</u> imply the presence of A (Eckman, 1987:60).

Eckman gives as an example of MDH effects evidence from Moulton (1962) which showed that L1 German speakers of L2 English seem to have more difficulty establishing word-final voicing contrasts than do L1 English speakers of L2 German in suppressing such contrasts (German only has voiceless word-final consonants). Eckman proposed a voicing contrast hierarchy whereby word-initial voicing contrasts are least marked, followed by medial contrasts, and with word-final contrast most marked.

The MDH has been subject to some criticism, however. For instance, Altenberg & Vago (1983/1987) and Hammarberg (1988) point out that some interlanguage phenomena are difficult to directly compare and, therefore, not amenable to markedness considerations.

Some more recent work in L2 phonology has delved into the relation of L2 phonology and universal grammar (UG). Most of this work has been done within the general theoretical framework of Chomsky's 1981 Government and Binding Theory, and addresses the nature of IL representations and principles of learning theory which L2 learners are purported to rely upon. Young-Scholten (1994), via her Asymmetry hypothesis, argues that IL phonology obeys the phonological principles of UG. Young-Scholten adopts the view espoused by White (1989) and others that UG is directly accessible to the L2 learner, but that learnability factors may interfere with complete acquisition.

Wexler & Manzini (1987), in reference to L1 acquisition, developed their Subset Principle based on the claim that the child can only set parameters based on positive evidence. Positive evidence constitutes those structures encountered in the input. The child is assumed to make absolutely no use of negative evidence. Negative evidence can be either direct or indirect. Direct negative evidence is where, for example, the adult overtly corrects the child. Indirect negative evidence refers simply to the failure to encounter a particular form in the input.

Young-Scholten assumes that if second language learners have direct access to the principles and parameters of UG, then SLA must also be guided solely by positive evidence. Thus she formulated her Asymmetry hypothesis:

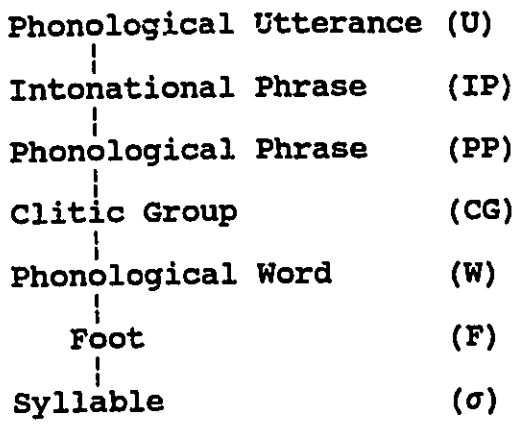
> a. If the L1-L2 situation is such that positive evidence can effect acquisition, then acquisition will ultimately take place.
> b. If the L1-L2 situation is such that negative evidence is required, acquisition will not take place. (Young-Scholten, 1994:201).

Young-Scholten tests her hypothesis by examining the acquisition of certain phonological processes. To verify the first part of the hypothesis, she looks at the acquisition of flapping in L2 English by German speakers. To test the second part of the hypothesis, she investigates the acquisition of weak pronouns in L2 German by English speakers.

Flapping in English applies to intervocalic or ambisyllabic /t,d/. She attributes the process of flapping to resyllabification. Nespor & Vogel (1982; 1986) propose a Prosodic Hierarchy which contains seven nested prosodic domains:[2]

---

[2] The Prosodic Hierarchy can be regarded as a multi-valued parameter.



This hierarchy is implicational in that a process which applies at a higher domain in the hierarchy must also apply at all lower domains. We can describe flapping in English as occurring at the Intonational Phrase level (IP).

Young-Scholten compares English flapping with German final devoicing processes. German obstruents are devoiced in word final position; however, intervocalically they remain voiced. Young-Scholten describes cases where German obstruents are not devoiced, i.e. not word final, as instances of resyllabification. However, unlike English resyllabification, the highest domain in which German resyllabification can apply is the Clitic Group (CG). Because resyllabification can occur at a higher domain in the Prosodic Hierarchy in English than it can in German, German resyllabification constitutes a subset of the English case. Therefore, L1 German speakers of L2 English have positive evidence in the L2 input as to the hierarchical level at which resyllabification applies in English. Thus, according to the Asymmetry hypothesis, German speakers of L2 English should easily acquire the appropriate application. In a pilot study, Young-

Scholten (1992) reported results which generally support this hypothesis.

To test the second part of her hypothesis, she investigated the acquisition of weak pronouns by English speakers of L2 German (1993). In English, rules of vowel reduction and deletion apply to unstressed syllables. These rules can apply to pronominal forms to yield, for example, alternations such as you versus ya. In German, however, there are apparently no such rules which apply to pronominals; instead, weak pronominal forms are clitic allomorphs which can appear solely in a post-COMP position. These clitic allomorphs are du versus de 'you'; ihn versus n 'him - accusative'; and, ihm versus m 'him - dative'. Young-Scholten classifies German clitics as a subset of English weak pronouns. Because L1 English speakers of L2 German would require negative evidence to inform them of the more restricted use of clitics in German, it is predicted that English speakers of L2 German should have trouble with and fossilize on this aspect of the grammar, i.e. they should freely reduce German clitics even in positions where they do not follow COMP. The results of this study supported the second part of the Asymmetry hypothesis. The English speakers showed a clear tendency to repeat ungrammatical reduced clitics more frequently than the native speakers. While interesting, it is important to remember that these investigations are only in the preliminary stages. Also, it is not clear that processes such as flapping and devoicing are directly comparable.

In a similar vein to Young-Scholten, Archibald (1992, 1993, 1994) investigated prosodic phonology from a principles and parameters perspective. However, his studies have led him to propose that not only positive evidence is available to both L1 and L2 learners, but indirect negative evidence is available as well. His claims are based on work by Saleemi (1992) who proposed that indirect evidence can be of use to the language learner depending on whether occurrences in the input reach a certain frequency threshold within a certain time period. Archibald (1994) suggested that this may account for L2 learners' variable performance: until the frequency threshold is reached, second language learners may oscillate between two or more possible parametric settings in their ILs. This implies that once that threshold is reached, if the L2 learner is still producing incorrect forms and no evidence for the correct form has become available, the learner will fossilize on the incorrect form.

2.5.2 Other Psycholinguistic Explanations

Another type of psycholinguistic explanation to account for the persistence of foreign accent in older L2 speakers in offered by Bever's 1981 formulation of a "psychogrammar." Bever assumes that the perception and production systems involved in language performance are distinct and develop separately. In L1 acquisition, linguistic competence develops and is represented in what he terms a "psychogrammar." The function of the psychogrammar is to mediate asymmetries between perception and

production via grammatical representations. In other words, discrepancies between the input the child receives and the output s/he produces are reconciled via the psychogrammar. Bever proposes that once both production systems attain a match, the psychogrammar falls into disuse. Because the phonological and phonetic levels of the grammar are more restricted than higher levels such as syntax or semantics, they are reconciled early on in the acquisition process. It is assumed that for the phonological component of the grammar, the psychogrammar falls into disuse early on. Therefore, older L2 speakers no longer have access to this innate mechanism to drive them to reconcile input with output. They must instead rely on other sources of motivation.

Bever further suggests that the psychogrammar can be kept functional if it continues to be used for second language acquisition before L1 acquisition is complete. He proposes that this may explain why languages learned consecutively after L2 seem to be progressively easier to learn. This proposal has much in common with the Exercise hypothesis, discussed in Section 2.2.3 of this chapter.

2.5.3 Critique of Psycholinguistic Explanations

These various psycholinguistic explanations for L2 learning after childhood lend strong support to the idea that some of the same processes that function during L1 acquisition are still

available to the older learner. Furthermore, many recent hypotheses and models are attempting to explain why it is that certain L1 units are transferred to the L2, while others are not. Some researchers have also offered some possible reasons as to why certain units tend to fossilize in the pronunciation of older L2 speakers.

As with other explanations, however, with the exception of Bever's 1981 "psychogrammar" account, most of these accounts based on psycholinguistic processes fail to address perception/production asymmetries, and attribute any production deficiencies to learnability considerations. Another shortcoming of the majority of these explanations is that they predict that no older L2 speaker can achieve native-like proficiency with respect to certain structures; they do not account for those older L2 learners who do manage to achieve native-like pronunciation skills. Some models also fail to address the observed variability in L2 learners' speech, due to linguistic or sociolinguistic context.

2.6. Summary

This chapter has presented a review of the literature relating to foreign accent in second language speech. We have looked at this phenomenon from four perspectives:
1. Neurophysiological, 2. Cognitive/Psychological,
3. Social/Sociopsychological, and 4. Psycholinguistic.

The most prevalent neurophysiological explanation for foreign accent is the Critical Period hypothesis. This hypothesis

attributes age-related differences in articulatory abilities to development and changes in neurological structures which occur throughout the course of maturation in the human organism. In general, it is thought that the brain loses "plasticity" throughout maturation, leading to a loss in the ability to articulate L2 according to native norms.

Section 2.3 looked at cognitive explanations for accent. Rather than attributing older learners' difficulties in achieving native-like articulatory proficiency to age-related neurolinguistic changes, it is proposed that maturation imposes different ways of processing language input or output. Cognitive strategies such as transfer and/or use of general problem solving skills are deemed to interfere with the older learner's ability to authentically produce L2 speech. For example, the Contrastive Analysis hypothesis held that the reliance on the use of articulatory units from the L1 for L2 production results in either positive or negative transfer; negative transfer results in accented speech. Also, affective factors such as degree empathy and motivation are supposed to determine the extent to which one's L2 speech will be native-like.

In the third part of the chapter, we saw how social and sociopsychological considerations come into play during the L2 acquisition process of older learners. The interaction of minority and majority languages has been shown to have an effect on learners' motivation to learn the second language.

In Section 2.5, we looked at psycholinguistic explanations of SLA. We have seen how developmental processes may surface in the older learner's L2 phonology. We reviewed the Markedness Differential hypothesis which predicts that those aspects of the L2 which are less marked (or more basic) than the L1 will be easily learned; whereas, those which are more marked will be acquired with difficulty or not at all. Other psycholinguistic explanations are based upon universal grammar and learnability constraints. For example, the relation of two languages with respect to the Subset Principle may have an influence the acquisition of L2 phonology. Finally, we reviewed Bever's "psychogrammar" construct.

This review of various investigations and explanations into the speech of L2 learners has shown the multivariate nature and complexity of the second language acquisition process.

CHAPTER THREE

MODELS OF SPEECH PRODUCTION

3.1. Introduction

Before we proceed to the elaboration of a model of articulatory production which addresses foreign accent, it is first necessary to examine various speech production models that have been proposed in the literature to date. This will give us an idea of the basic and generally accepted architecture of the speech production system, including its levels or subsystems as well as temporal ordering. Although not all researchers agree on the details of the speech production process, we will see that there appears to be some consensus as to its general functioning. The models outlined in this chapter will provide us with a general framework within which to situate the proposals to be put forth in Chapter 4.

Speech production research lags behind other psycholinguistic endeavours, such as work on perception or comprehension, principally due to the fact that the production process is, for the most part, covert. Consequently, we are faced with difficulty in the construction and interpretation of tests intended to investigate the nature of such internal processes. While perception research can rely on experimental methods such as the use of synthetic speech and auditory masking to reveal such effects as categorical perception and phoneme restoration, production research is much more limited. For instance, delayed response times in speech production tests are open to some degree

of speculation as to exactly at which point in the system the delay occurs. Most insight into the production process has been gleaned from examination of speech errors and pausal phenomena (e.g., Boomer & Laver, 1968; MacKay, 1970; Fromkin, 1971; Butterworth, 1980). More recently, promising insights have come from computational models of speech production (Stemberger, 1985; Dell, 1986; 1989; Guenther, 1994; 1995).

Some pertinent questions for researchers in language production include: How is the non-linguistic message translated into linguistic form, and how is this linguistic form translated into articulation? What are the psychologically-real units employed at the articulatory level? How are these units temporally controlled? How is it that the speech production process proceeds so quickly, given the complexity involved in arranging the message into syntactic and phonological form? Related to the latter is the question of how we manage to make relatively few errors in our productions? Each of the models reviewed in this chapter attempts to answer one or more of these questions.

As stated earlier, the main purpose here is to theoretically situate the model to be proposed in Chapter 4. One important underlying assumption of this is that speech production in the second language proceeds in much the same manner as it does in the first. This position is supported by many researchers in the field of L2 production (Dechert & Raupach, 1980; 1987; Wiese, 1984; Dechert, 1984; Bialystok & Sharwood Smith, 1985; Hulstijn,

1989; Crookes, 1991). For example, Wiese (1984) investigated pausal phenomena in L2 speech production. He found that while L2 speech demonstrates a greater incidence of pauses and hesitations than does L1 speech, this difference is manifest in quantity and not in quality. In other words, the location of pauses in the string is suggestive of similar planning units for both L1 and L2. Even though there were more pauses in L2 speech, Wiese found no evidence that L2 speakers use a different speech production mechanism than that used in L1. This makes intuitive sense: a single production system for both L1 and L2 is economical.

It will be recalled from Chapters 1 and 2 that Neufeld's Pre- and Post-articulatory Verification Model (PAVM) holds that increased abstract reasoning powers cause some older L2 learners to become preoccupied with form and content of the message, at the expense of articulatory precision. It is proposed that foreign accent results from the bypassing of pre-articulatory verification and dependence instead on erroneous motor routines formulated during L2 learning. These motor routines are packaged sequences of commands to the articulators which are built up after practice, stored as units, and triggered under the appropriate circumstances.

To establish the feasibility of the PAVM, this chapter will mainly focus on: 1. The temporal demands of the speech production process; 2. The nature of articulatory monitoring; and, 3. The practability and nature of articulatory routines. Section 3.2 begins with a look at the classic models of speech production.

In Section 3.3, we will review models which incorporate editors and monitors. We will examine physiological models of production whose main focus is on motor control in Section 3.4. Section 3.5 will provide an overview of some current information-processing models which include articulatory routines. A conclusion and summary is presented in Section 3.6.

3.2. Classical Models of Speech Production

3.2.1. Fromkin's 1971 Utterance Generator

Based on an extensive corpus of speech error data -- primarily phonological slips -- Fromkin (1971) developed one of the first models of speech production. Fromkin's analysis of these speech errors led her to postulate the psychological reality of such theoretical concepts as phonological features, the segment, the syllable, as well as different levels of representation. For instance, the following example involves an error involving the feature of [voice] (Fromkin's (15a)):

(1) What does the course consist of --> what does the gorse consist of

Segment metathesis is exemplified in (2) (Fromkin's (3a)):

(2) keep a tape --> teep a cape

Syllabic reversal is shown in (3) (Fromkin's (19c)):

(3) phi-lo-so-phy --> phi-so-lo-phy

Evidence for independent levels in the speech production process came from such observations as that when speech errors such as those involving sound exchanges occur, the resulting string is

always phonologically acceptable according to the specific rules of the language in question. For example, (4) shows that morphophonemic rules which determine the form of the plural morpheme in English apply after segmental metathesis (Fromkin's (22b):

(4) tab stops [staps] --> tap stobs [stabz]

This suggests that segmental transpositions occur at a level previous to the application of phonological constraints.

The Utterance Generator, as it was termed, divided the production process into six stages or levels. Each level is divided into a representation (declarative knowledge) and a process (procedural knowledge) which translates the representation of that level into that of the next lower level. Thus, this model is essentially linear and top-down, proceeding from message to articulation without any feedback loops from lower to higher levels. The general outline of the Utterance Generator is as follows:

Stage I:	"Meaning" to be conveyed. Syntactic and semantic structure generator.
Stage II:	Syntactic-semantic structures. Intonation contour generator.
Stage III:	Structures with primary stress and intonation specified.
Stage IV:	Lexical look-up. Phonologically underspecified lexical items.
Stage V:	Phonological specification.
Stage VI:	Generation of motor commands for speech. Phonetic feature bundles mapped onto motor commands to muscles.

It is at Stage IV where Fromkin proposes that phonological segments are put into a buffer. Input to the buffer may become mis-ordered, resulting in the transposition of one segment for another or of one syllable for another. Stage V is where language-specific morphophonemic (accommodation) processes occur. Stage VI is where "automatic" phonetic and phonological (i.e. post-cyclic and/or post-lexical) rules apply.

3.2.2. Garrett's Model

Garrett's Model of speech production resembles Fromkin's Utterance Generator in many respects. It too is based on speech error data, but its main focus is on syntactic and lexical rather than phonological errors.

Perhaps the major contribution made by Garrett is the distinction between a "functional" and a "positional" level of representation. He was led to this distinction by the observation that word exchange errors involving two words of the same grammatical category can span several phrases; whereas, sound errors occuring between words of differing grammatical category tend to occur within the same phrase. Furthermore, sound errors are sensitive to similarity of phonetic shape and location, such that initial segments or clusters tend to interact with other initial units, medial with medial, and final with final. Lexical transpositions do not depend on such phonetic similarity, but rather involve semantic relations. Therefore, Garrett (1975) proposed a functional level at which semantic and grammatical relations are established and a positional level

where phonemically specified lexical formatives are inserted into ordered frames. Garrett (1984) further provided for "double lexical look-up" whereby the first lexical selection is based upon functional relations and the second look-up retrieves word forms. At a more peripheral level of the production process, the sound level of representation, full specification of phonetic detail is filled in. This is where the language-specific, "automatic" morphophonemic and phonological rules apply. This phonetic specification is then somehow translated into motor articulation. It is interesting to note that Garrett (1975:147,Fn.13) entertains the possibility that accommodations may not be associated with the sound level of representation, but rather "can be taken as an 'editing' explanation...as opposed to a view that [sound errors] are somehow antecedently prevented."

Both Fromkin's and Garrett's models depict speech production as a more or less serially ordered process, proceeding from a conceptual to a syntactic to a motor level of articulation. They say little, however, about the nature of editing mechanisms in speech production; so it is to that issue that we turn in the next section.

3.3. Editing and Monitoring in Speech Production

Even though the extensive corpora of speech errors collected by Fromkin and Garrett may lead one to think otherwise, the incidence of erroneous articulations is actually exceedingly rare relative to the volume of speech produced by most people. To account for the scarcity of speech errors in output, many

researchers have included "editors" or "monitors" in their elaborations of production models (Laver, 1980; Shattuck-Hufnagel, 1980; 1983; Baars, Motley, & Mackay, 1975; Motley, Baars, & Camben, 1983; Levelt, 1989). This section will elaborate on two types of editing: A connectionist model (Motley, Baars, & Camben, 1983) and a perceptual loop model (Levelt, 1983; 1989). As we shall see in the following sections, connectionist models inherently incorporate editors within the production system; whereas, the perceptual loop model places the editing mechanism as separate and external to the speech production system per se.

3.3.1. Motley, Baars, and Camden's 1983 Editing Model

Work by Baars, Motley, & MacKay (1975) has given strong evidence for covert editing in the process of speech production. For instance, in one experimental condition, subjects were primed with a series of word pairs intended to elicit socially inappropriate Spoonerisms[3] (e.g. tool kits --> cool tits). Even though in many cases, these subjects did not overtly commit such errors, increases in Galvanic Skin Response showed that these speakers must have covertly constructed such Spoonerisms that were presumably edited before articulation.

---

[3] The term "Spoonerism" is coined after the Reverend William Spooner, the Warden of New College in Oxford from 1903 to 1924. He was (in)famous for the frequent transpositions of words and segments in his speech. Some believe he may have suffered from a mild form of aphasia.

Motley, Baars, and Camben (1983) outline issues which must be addressed by an editing model for speech production. Some questions to be asked are: 1. How does an error formulation occur? 2. Where is editing located; when and how is it put into operation? 3. Does the edit function to veto inappropriate plans or to promote appropriate ones? 4. How can output errors occur despite prearticulatory editing? 5. What happens after a formulated message is vetoed?

In their effort to answer these questions, Motley et al. formulated an editing model which centres upon a spreading activation lexicon. Based upon experimentally induced speech errors such as those exemplified above, Motley et al. proposed that the semantic intent of the message as well as extralinguistic factors such as context are simultaneously fed into the lexicon and syntactic component of the grammar, thereby generating competing plans on both a lexical and syntactic level (cf. The Competing Plans hypothesis; Baars, 1980). Each of these competing plans (e.g. two synonymous words and/or clauses) respectively pass through a lexical and a syntactic "options filter." This "options filter" chooses the most appropriate of the competing plans and sends it to a "message formulation" component. This syntactically and lexically specified message is phonologically and then neuromotorically coded. Prearticulatory editing takes place after neuromotor coding, and prior to overt articulation.

Prearticulatory editing in this model (and others as well) requires that linguistic formulations be covertly articulated prior to overt output (similar to the popular notion of "silent speech"). In Motley et al.'s model, this impending output plan is checked, not against the same rule system that was used to generate it, but against residual activation levels of nodes in the lexicon.

This version of a spreading activation lexicon holds that activation spreads bidirectionally through a multitude of interconnections with semantic, phonological, syntactic, and even extralinguistic associates of a particular lexical node. For example, the lexical node for house could activate or be activated by its semantic associate, home as well as phonologically similar words such as hearse. In turn, each of these associates spreads its activation to its associates, and so on. In such a network, activation weakens the farther it spreads; but also, the converging influence from many sources results in a higher activation level for a particular node.

In the formulation of the message, the lexical node receiving the highest activation "fires." After firing there is decay in the activation level. So prearticulatory verification entails checking the impending output against the residual level of activation of lexical nodes, the editor accepting only those plans which fall within a particular range of activation. If the activation level of a node corresponding to the impending output plan is unacceptably low, the editor will veto that plan.

Similarly, if the relevant node is too highly activated, it will also be vetoed since it probably represents a subsequent unit in the linguistic message.

Errors would occur when, for example, two lexical nodes were equally activated as in cases of lexical blends. Another source of error could be extraneous factors, such as context or subconscious influences associated with Freudian slips. Although not specifically mentioned by Motley et al., it is also possible that noise in the system could serve to augment the level of activation of a particular node.

Motley, Baars, and Camden's model of speech production is one of the first to elaborate upon the feasibility of editing mechanisms in linguistic encoding processes. It is a general model, however, and by allotting all editing criteria to the lexicon fails to address post-lexical phonotactic constraints on articulation.

3.3.2. Levelt's (1989) Perceptual Loop Model

While the focus of Motley et al.'s research was on covert editing, Levelt has directed his studies more to overt editing and correction of speech errors. In his 1983 paper, Levelt reports on research which analyzes the nature of self-repair of speech errors, based on such criteria as where the utterance is interrupted and the use of editing expressions such as "...er..." and "...that is...." Self-repair is evidence of both covert and overt monitoring. For instance, (5) (Levelt's (1989) (29)) indicates covert editing processes.

(5) I go f-, all the way straight.

Because the entire word has not been articulated before correction, the editing mechanism must be relying upon an internal phonetic plan rather than auditory feedback. Other errors seem to involve post-articulatory editing such as that in (6) (Levelt's (1989) (21)):

(6) Straight on to green -- to red.

To account for such errors and self-repairs, Levelt (1983; 1989) espouses a perceptual loop model of self-monitoring. This model incorporates both an internal as well as an external feedback loop. The internal loop operates upon the internal phonetic plan; the external loop relies on auditory information from overt speech. Both sources of information feed into the speech comprehension system. By only allowing for last-second prearticulatory verification (as opposed to separate editors for semantics, syntax, etc.), and by feeding back into the comprehension system, this model avoids unparsimonious duplication of processing during the editing phase.

As noted earlier, various researchers incorporate editors and monitors into their models of speech production. Those familiar with the field of second language research will no doubt have heard of another type of editor, that which forms the basis of Krashen's Monitor model. At this point, we would like to briefly outline the fundamentals of Krashen's hypothesis. The purpose is to avoid confusion between his model and the editing mechanisms we have surveyed in the previous sections of this

chapter. Krashen's Monitor is of a different nature than the editors proposed by Motley et al., Levelt, and others.

Krashen (1985) makes the distinction between "acquired" and "learned" knowledge. Acquired knowledge results from the internalization of "comprehensible input" (i.e. "intake" in Krashen's terms). Learned or metalinguistic knowledge results from the overt memorization of the rules of L2 grammar. This conscious knowledge is what comprises the Monitor. Monitoring can occur either prior or subsequent to articulation. Prearticulatory Monitoring will engender slow and awkward speech, filled with false starts and dysfluent pauses. Postarticulatory Monitoring will manifest itself in frequent self-corrections. Krashen proposes that L2 speakers vary along a continuum as to how much they rely on the Monitor in their L2 productions. Those who are overly concerned with form and "correctness" are classified as "over-users." The L2 productions of the over-user are punctuated with dysfluencies. The "under-user," however, is little concerned with form and correct usage, being more concerned with the message. The under-user will have little or no recourse to the Monitor; therefore, his/her L2 speech will be more fluent (though not necessarily error-free). The basic premise behind the Monitor is that conscious consultation with such non-linguistic-specific metalinguistic knowledge, especially prior to articulation, slows down the production process.

Krashen's Monitor might be best classified as a strategy of L2 production. It differs from the production models surveyed in

this chapter in that it is an ad hoc mechanism for L2 production. It is solely comprised of consciously formulated grammatical rules. In the L1 production models covered here, editors and monitors are intrinsic to the speech production process. In Krashen's terms, these editors operate upon "acquired" knowledge, and are usually below the level of conscious awareness.

In principle, Krashen's Monitor might operate in L1 production as well as in L2 production. For example, conscious consultation of rules as to the appropriate use of "who" versus "whom" might lead to hesitation or false starts even in L1 speech production. But this type of Monitoring is of a different nature than monitors which edit internal speech for semantic, syntactic, phonological, and phonetic incongruencies. These monitors are intrinsic to the language production system. They check on grammatical well-formedness constraints which, in some cases, have yet to be adequately described and explained by linguists.

3.4. Models of Articulatory Production

Fromkin's and especially Garrett's models of speech production do not detail the specific mechanisms involved in the articulatory component of the production process. In this section, we will look at some models whose aim is precisely to provide such detail.

3.4.1. Lashley's 1951 Problem of Serial Ordering

In his classic 1951 paper, Lashley proposed a hierarchical or preplanning model for the temporal sequencing of motor activity, including articulatory production. He objected to the

previously postulated Associative Chain Theory (Washburn, 1916; Watson, 1920). This latter theory holds that motor behaviour operates as a type of servomechanism in that it is a consequence of a chain of events, whereby the feedback received by the accomplishment of one movement is required to elicit the next movement. Lashley pointed out some serious drawbacks to associative chain models. First of all, he believed that feedback is too slow to provide information to inform the following motor movement. Secondly, chain models seem to require that the following speech unit be deterministically dependent upon the previous unit; but of course, speech units are highly permutable. Finally, he noted that evidence from speech errors, such as anticipatory Spoonerisms, seem to require a central and preplanned representation of articulatory strings.

3.4.2. Closed- vs. Open-loop Models

Associative chain models are closely related to the concept of closed-loop control, and preprogrammed or hierarchical models are related to the concept of open-loop control.[4] In closed-loop systems, feedback from articulatory performance is matched with the intention or program. Any discrepancies require

---

[4] The difference between chains and closed-loop control is that the former functions using correct or intended feedback; whereas, closed-loop systems make use of feedback from an erroneous articulation and adjustments are made in order that the intended program matches performance. Preprogramming "applies to nonsequential dependencies among the elements in a pattern or series; open-loop control usually does not carry this implication" (Kent, 1976:80).

adjustments in the execution of the motor units. In an open-loop system, centrally programmed commands are issued independent of feedback.

Much of the research and discussion in the area of the motor production of speech over the last four decades has focussed on the role of feedback in articulation. In their 1984 book, Borden & Harris distinguish four types of feedback that a speaker may rely upon during speech production: auditory, tactile, proprioceptive, and central.

Auditory feedback includes air- and bone-conducted sounds which inform the speaker of the result of his/her articulations. Tactile feedback would come from receptors on the surface of articulators which would provide information on the degree and location of pressure from the tongue and lips during speech production. If auditory and/or tactile feedback is used to monitor speech, it would only be useful after-the-fact, since it is relatively slow. Therefore, this type of external feedback could only serve to overtly correct speech or to modify articulatory programs for subsequent productions.

Proprioceptive feedback is a result of motor activity in the muscles. Specialized muscle fibres called spindles provide information on the length and tenseness of that muscle. This type of feedback is quicker than external feedback, therefore it is possible it could be used in time to make prearticulatory modifications to the speech control units.

Internal or central feedback may also be used by the speech

production system. It is hypothesized that this type of feedback would rely upon information from the motor commands themselves, prior to actual motor response. Borden & Harris (1984) note that evidence has shown activity in the cerebellum and thalamus approximately 100 msec prior to movement, but they are quick to point out that, due to methodological restrictions, this cannot be directly linked to a feedback loop at this time.

There have been numerous studies which have attempted to determine the role of feedback during normal speech production. For example, bite blocks and other prostheses have been introduced into the vocal tract in order to determine if and how the speaker readjusts his/her speech to accommodate such modifications. The role of acoustic monitoring has been studied through the use of delayed auditory feedback (DAF), whereby the speaker listens to his/her own speech presented with a slight time lag. Another method related to proprioceptive and tactile feedback involves the use of anaesthesia as a nerve block to observe how the speaker compensates.

Although speakers do initially have difficulty when confronted with vocal tract alterations, most quickly adapt their speech accordingly. With regards to DAF, some speakers are greatly compromised in their ability to speak under such conditions, while others seem able to ignore the aberrant auditory signal. Similarly, under nerve block conditions, some speakers experience deviations in their speech patterns; whereas, others function well (Bordon, Harris, & Oliver, 1973). Because

of individual variation in performance, Borden & Harris (1984) suggest that attentional factors may be involved, especially with regard to delayed auditory feedback effects. And the fact that speakers in general demonstrate a remarkable ability to compensate for feedback interruption seems to indicate that the feedback system is highly redundant. If one feedback link is blocked, others will compensate for this lacuna.

Although researchers do not agree as to whether motor speech production involves closed-loop (Wickelgren, 1969) or open-loop control (Kozhevnikov & Chistovich, 1965/1966; Kent, Carney, & Severeid, 1974), it is quite possible that both mechanisms may in fact be involved (Easton, 1972; Borden, 1980). One particularly interesting model of this type is that by Borden (1980) which takes into consideration developmental factors in speech production.

3.4.3. Borden's 1980 Developmental Feedback Model

Borden (1980) proposes that less skilled speakers may depend more upon external feedback than would more skilled speakers. She states that:

> Young children developing speech, and speakers of any age attempting to learn a new language, must use all available feedback channels in their efforts to match the sound patterns of the new language with the sensations produced by their own imitations (Borden, 1980:224).

She goes on to suggest that the ability to use feedback appropriately may be dependent upon age factors, young children being particularly adept at matching their own speech with that of the model. Older L2 learners, on the other hand, may rely

instead upon stored auditory, tactile, and proprioceptive images from their first language.

Some study on feedback interruption has focussed on age-related differences. For instance, very young children were shown to compensate to a different degree than adults in auditory masking as well as amplification conditions (Siegel, Pick, Olsen, & Sawin, 1976). However, by four years of age, children compensated in much the same way as adults. Differences in the effect of altered feedback have also been investigated with L2 learners. MacKay (1970) tested English-German bilinguals using the delayed auditory feedback technique and found differences that may indicate that less feedback control is required for native speakers than for non-native speakers (see Borden, 1980 for discussion).

Borden & Harris's 1984 model of speech production resembles some of the models we have seen in previous sections; however, it provides somewhat more detail at the level of articulation than do these others. There are four basic levels in the model:

1. Perceptual Target: An abstract auditory representation that relates to an abstract spatial representation of the speech mechanism.

2. Internal Feedback: Interactions among the cerebrum, basal ganglia, and cerebellum to prepare the system to produce a phrase in the form of a motor schema leading to activation of muscle groups.

3. Motor Schema: A rough (underspecified) plan of speech production based upon an abstract representation. Instructions are fed forward in syllable-sized chunks. These instructions are fed to muscle groups cooperatives such as laryngeal position adjusters, fundamental frequency adjusters, mouth position adjusters, etc.

4.a. Articulator Movements and Cavity Changes: Abstract representations such as the phoneme and syllable disappear into quasi-continuous movements. Coarticulatory variation is accounted for by self-regulation within muscle groups.
b. Air Pressure and Acoustic Output: Air pressure variations within the vocal tract set up audible pressure waves.

In addition to internal feedback on level 2, this model incorporates feedback mechanisms from the muscle group cooperatives (proprioception) and from level 4 (taction and audition). Proprioception feeds back into the Motor Schema centre in order to provide for self-regulation by the appropriate muscle groups, and also to obtain information on upcoming units from the feedforward mechanism in order to adjust general motor instructions accordingly. External stimuli from taction and audition feeds back into both the Motor Schema level and the Perceptual Target level to provide the speaker with post-articulatory information in order that s/he may subsequently correct his/her own speech.

Borden & Harris's 1984 model of speech production proposed that instructions to the articulators are sent in syllabic-sized units. Many researchers concur with this idea, while others suggest different units of production. It is to this topic that we turn in the next section.

3.4.4. Units of articulatory production

3.4.4.1. *Distinctive features*

Several researchers have proposed models in which instructions to the articulators are based upon bundles of binary features (Henke, 1966; Moll & Daniloff, 1971; Benguerel & Cowan,

1974). For example, Henke (1966) developed a computational model which incorporates a look-ahead mechanism. Coarticulation effects occur across segmental units until a contradictory feature occurs. For example, lip rounding from one segment will influence all prior and subsequent segments that either agree in rounding or are unspecified for that feature.

3.4.4.2. *The phoneme*

In her 1971 article, Fromkin suggested that the because of such speech errors as metathesis and the breaking up of consonant clusters, the phonetic segment seems a likely candidate as a discrete performance unit. Other research has also found evidence for the psychological reality of the phoneme. For example, in their study of fluent backward talkers, Cowan, Braine, & Leavitt (1985) found that these speakers had precise representations of phonemic and phonetic units around which they planned and structured their backward translations. However, whether psychological reality translates to psychomotor reality is less clear.

One model that attempts to give psychomotor reality to the segment is that by Wickelgren (1969). His Extrinsic Allophone model proposes that the input unit to the articulators is in the form of elementary motor responses from a detailed allophone. The phoneme receives its allophonic status by virtue of coarticulatory influences from the immediately preceding and immediately following phonemes. To demonstrate the way in which coarticulation functions in his model, Wickelgren gives the

example of the phonemic anagrams, /strʌk/ and /krʌst/. Even though these two representations contain the same phonemes when instructions are sent to the articulators, the preceding and following context are encoded with them: $/_{\#}s_{t,s}t_{r,t}r_{\Lambda,r}\Lambda_{k,\Lambda}k_{\#}/$ versus $/_{\#}k_{r,k}r_{\Lambda,r}\Lambda_{s,\Lambda}s_{t,s}t_{\#}/$. This model has been criticized on a number of grounds, one of which being that coarticulation effects often extend well beyond contiguous elements.

3.4.4.3. *The syllable*

The syllable seems to hold special status in many areas of linguistic theory as well as in models of speech production. Several researchers maintain that the syllable constitutes the basic unit of articulatory production (Crompton, 1981; Kent & Rosenbek, 1982; Laubstein, 1985). Many models based on coproduction (Kozhevnikov & Chistovich, 1965/1966; Perkell, 1969; Fowler, 1980) consider the vowel (the nucleus of the syllable) to be the basic substrate in coarticulatory phenomena.

Crompton's 1981 model of speech production considers the syllable to form the basis of articulatory routines. He proposes that phonetically underspecified lexical items are input in parallel into the "articulatory programmer." The address of each syllabic routine is located based on the activation of the onset, nucleus, and coda of the syllable. To use Crompton's example (1981:682), the lexical item spank contains the onset sp, the nucleus æ, and the coda ŋk. The onset would prime or activate all syllables beginning with sp, the nucleus would activate all syllables with æ, and the coda would activate all syllables

ending with ŋk. Therefore, the most highly activated syllable would correspond to spank. These syllabic routines are then processed by the "incorporator," which puts them into their correct serial order and applies intersyllabic coarticulatory phonetic modifications.

Crompton proposes that certain speech errors can be explained by a "malfunctioning at the addressing stage of retrieval" (1981:682). For instance, in the case of the speech error, its a meal mystery, he suggests that "contamination" can occur from one onset to another during the address search. Thus the onset of /ri:l/ in contaminated by the onset from /mIs/, causing the syllabic routine /mi:l/ to be activated instead.

Although he is able to account for several types of speech errors, Crompton's model has been criticized on several points (see Laubstein, 1985 for discussion). For example, Laubstein notes that this model fails to account for the fact that speech error data find no interaction between closed and open class items. Crompton's model treats all syllables on an equal par.

One interesting aspect of Crompton's work is his incorporation of articulatory routines. Other models of speech production have also proposed such routines, and it is to these models that we turn in the next section.

3.5. Models Incorporating Articulatory Routines

3.5.1. Kennedy's 1988 Information-processing Model

In her 1988 paper, Kennedy applies Gagné's 1983 general cognitive model to language -- specifically to second language acquisition. Kennedy's expansion upon Gagné's work centres upon unitization of procedural knowledge into automatic routines. According to this model, learning, including language acquisition, consists in the unitization of progressively larger productions. Once unitized, these packaged routines will be automatically triggered by the appropriate environmental stimulus. These routines have the advantage of speeding up the production process, but they also have the disadvantage of being encapsulated, rigid, and impermutable. Bypassing these unitizations would require a conscious effort.

Kennedy speculates that the young child's language may consist of non-unitized procedural knowledge which gradually gets packaged into routines as the child matures. She proposes that persistent foreign accent in the speech of older L2 learners may be due to the difficulty in bypassing the unitized L1 phonological system. To do so would require conscious effort, hence the use of working memory. If working memory is also being used to manipulate declarative knowledge in the formulation of syntactic structures (i.e. metalinguistic knowledge), it may be impossible to focus on bypassing unitized L1 phonological routines.

This model is rather general. Kennedy does not specify, for

example, the precise environmental stimulus required to trigger these unitizations. In the following section we look at more detailed models of a different nature, but which also incorporate the concept of articulatory routines.

3.5.2. Spreading Activation Models of Speech Production

In recent years, several researchers, principally in the field of cognitive psychology, have been developing models of speech production which emphasize the connectedness and interaction between linguistic levels, as opposed to the modularity of such levels emphasized in linguistic theory. These models are generally classed as "spreading activation," (Dell, 1986; 1989) including "interactive activation" (McClelland & Rumelhart, 1981; Rumelhart & McClelland, 1982; Stemberger, 1985), and "connectionist" (Grossberg & Stone, 1986).

In his 1985 article, Stemberger outlines the basic elements and processes of an interactive activation model. Such computer models are often intended to represent neural functioning in the brain. They consist of a complex network of "units" (neurons) and "links" (synapses) which join these units. What drives the system is "activation," whose level varies and is in constant flux due to multiple influences. Each unit has its own "resting level." Activation spreads throughout the network from unit to unit.

There are several levels within such a system, usually representing such linguistic concepts as semantic, syntactic, and phonological. Dell (1985) further specifies a syllabic component

level (onset and rime) and a phonological feature level. Links connect both units on the same level as well as units between levels. However, links between levels are usually excitatory whereas links on the same level are usually inhibitory. Activation of a particular syllable on one level, for example, would activate its onset and rime on a lower level, but would inhibit other syllables on the same tier. At a certain threshold of activation, a particular unit "fires," after which its activation level quickly decays.

In a spreading activation model, speech errors arise through noise in the system. This noise may be random in nature, due to frequency effects, or activation from several sources, due to the high degree of interconnectedness.

As described in Section 3.3.1 of this chapter, editors are implicitly incorporated into such a model through bidirectional activation between levels. Similarly, articulatory and other types of routines are "built in" to the system. Frequently used units and links, such as commonly used words in the lexicon and recurrent syllable onsets, are more easily activated. The threshold level for the activation of frequently used units is lower than it is for less common units, and frequency effects are encoded upon the links between levels and units through different "weightings."

Spreading activation models such as those by Stemberger (1985) and Dell (1985; 1989) provide a different way of looking at the speech production process, compared with the more

traditional linguistic models such as that of Garrett (1975; 1984). In many instances, they adequately account for the same types of speech errors as traditional linguistic models do. However, extensive empirical testing of both types of speech production models is required before any conclusions can be drawn as to the superiority of one model over another.

3.6. Conclusion

In this chapter we have reviewed various conceptions of the speech production process ranging from the classic models of Fromkin and Garrett to those focussing on motor articulation to computational models such as the spreading activation model by Stemberger. We have been interested in discovering how these models have addressed various issues such as: How the non-linguistic message is translated into articulation? What are the psychologically-real units employed in articulation? How are these units temporally controlled? How is it that the speech production process proceeds so quickly, given its complexity and the resulting propensity for errors? We have seen that answers to these questions are primarily based upon speech error data, since these data provide one of the only ways we can get a "window onto the mind."

The purpose of this chapter has been to gain a general idea of how speech production may function, in order that we may situate the articulatory production model we will elaborate in Chapter 4. This model critically depends upon certain hypotheses which we have encountered in some of the research reviewed in

this chapter. These hypotheses are: 1. There are severe time constraints involved in the production of utterances; 2. Production involves some type of monitoring or editing mechanism to ensure appropriate output on various linguistic levels; 3. Production incorporates the use of packaged "routines" for frequent, well-practiced procedures, in order to leave more time for "creative" processing.

CHAPTER FOUR

A Performance-Based Model of Speech Production

4.1. Introduction

If the study of speech production in L1 is complex, sentence planning and neuromotor functioning in L2 is even more so. As we have seen in Chapter 2, it is possible to attribute foreign accent to a variety of factors, the interaction between which presents numerous problems for researchers. The majority of explanations for the persistence of accented speech in older L2 learners are competence-based. In other words, they attribute non-native-like articulation to difficulties in acquiring the L2 code. However, while it is reasonable to assume that learnability problems are responsible for some aspects of accent, especially in early and intermediate stages of the acquisition process, the persistence of deviant articulation in advanced L2 speakers may be partly attributable to performance constraints. Evidence which demonstrates native-like competence in perceptual tests while at the same time showing non-native-like articulation (Neufeld, 1980; 1988) demands attention.

There are several possibilities which could account for such asymmetries. The first would be to propose a "dual competence" model for phonological representations (Troike, 1970). Such a model could account for disparity in performance by postulating that the perceptual system uses a competence base which is separate from the one used in production. According to this view, asymmetry occurs when native-like representations are

available for decoding and non-normative, fossilized representations are used for sentence production. Although this hypothesis might account for perception-production asymmetries, it is less than economical in that many, perhaps most, representations would be duplicated.

Another possibility pertains to the inability of the articulators to produce new sounds after a certain "critical age." This explanation is improbable. Second language speakers vary along a continuum as to the quality of their pronunciation in their L2 (Naiman, Fröhlich, Stern, & Todesco, 1978). In fact, some advanced learners achieve native-like quality at the articulatory level, retaining an accent only with respect to suprasegmentals such as intonation and cadence (Neufeld, forthcoming). Also, empirical evidence has demonstrated that adults are indeed able to produce new and exotic sounds (Neufeld, 1977).

A third explanation for perception-production asymmetries, the one adopted in this thesis, is based upon performance constraints. Here, only a single competence base is presumed to exist for perception and production. The model outlined in this chapter further assumes that the L2 learner may demonstrate native-like knowledge of morphophonological rules and representations while at the same time continuing to speak with an accent.

4.2. Articulatory Routines

Central to this model is the notion of articulatory or motor routines. Underlying this concept is the assumption in information-processing theory that many types of learning involve the unitization of complex procedures through repeated use (Gagné, 1983; Peters, 1983; Kennedy, 1988). In other words, during initial stages of learning, a given procedure must be performed step by step. In contrast, during later stages of learning, these steps become automatic due to their being grouped together into one unit or program. Instead of reconstructing the procedure from initial building blocks, a single routine in which the entire procedure is encoded is executed.

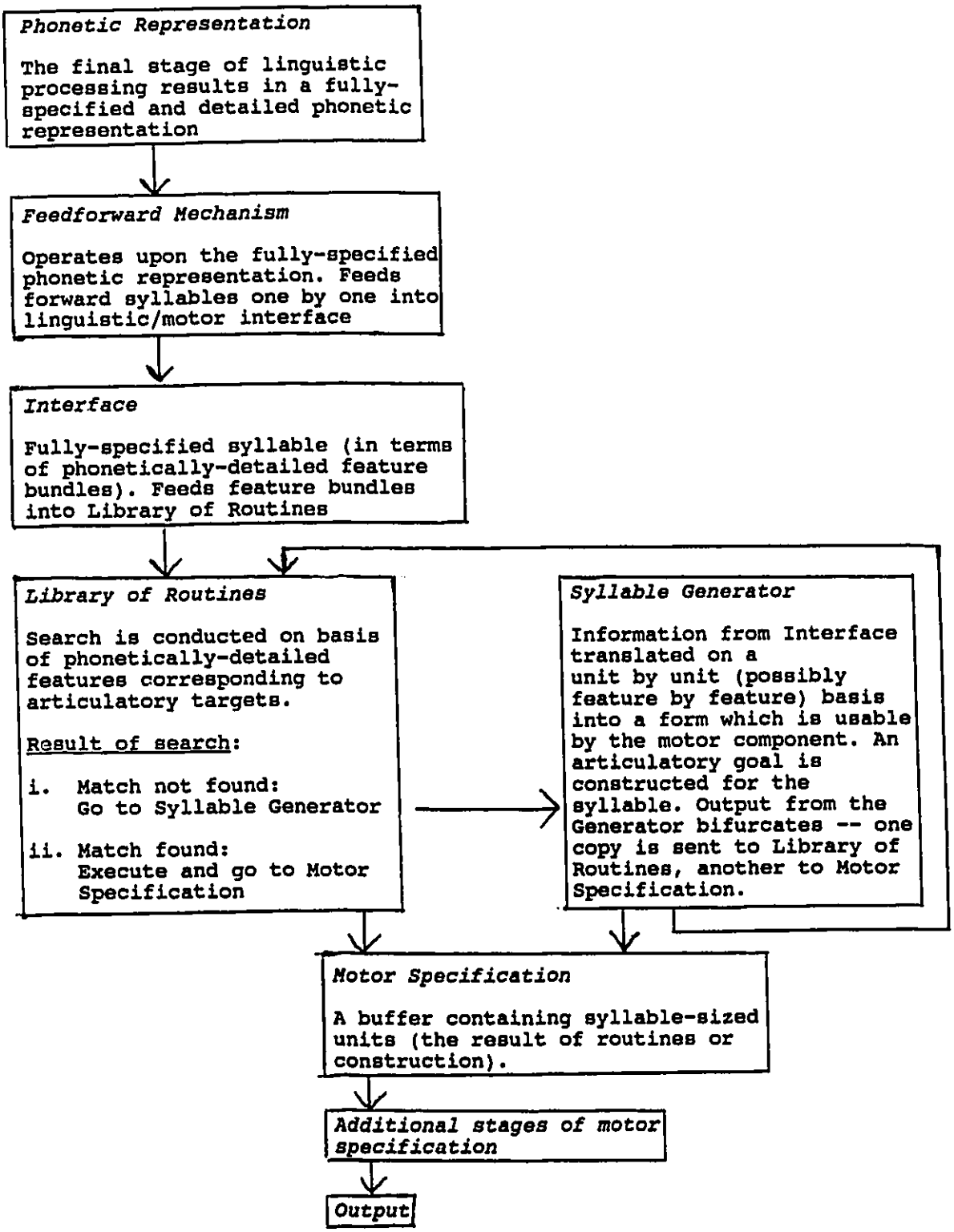
A simple analogy should suffice to illustrate this concept. At the morphosyntactic level, there exists such formulaic expressions as "Your guess is as good as mine." Although the initial prearticulatory construction of such an expression in early learning might constitute the application of syntactic rules such as agreement, through repeated use, this phrase presumably becomes unitized.

In a similar fashion, this model proposes that many complex instructions, used to determine the configuration of the vocal tract, are eventually unitized into a single articulatory routine.

In the following section, we will outline the general schema for the model of articulatory production proposed here. We will then elaborate upon the concepts that underlie this schema.

Finally, we will discuss how this model might function during sentence planning and vocalization in L1, then L2.

4.3. Schema of the Model



4.4. How the Model Works

4.4.1. Phonetic representation

After the application of all morphophonological and phonological rules, this final stage in the linguistic production process consists of a fully-specified, finely detailed phonetic representation.[5]

4.4.2. Feedforward mechanism

The fully-specified phonetic representation is fed into the phonetic-motor interface, one syllable at a time. The syllable is chosen as the primary unit in this model because of its importance at both the linguistic and articulatory/perceptual levels. At the linguistic level, it forms the basis of several phonological processes, most importantly those which determine rhythmic patterns. At the articulatory/perceptual level, there is an inextricable link between consonant and vowel, e.g. it is the formant frequencies of the vowel that allow us to decode the preceding and following consonants.

4.4.3. Interface

It is here that the linguistic system is linked with the motor system. Each segment of the syllable is specified in terms of phonetic feature bundles (Chomsky & Halle, 1968), along with fine phonetic detail. For example, the syllable /pa/ might

---

[5] The terminology used here does not imply espousal of any particular theory of phonology.

contain the following features:[6]

/p/ = -son -syl -cont -voice -constr -spread -nas +lab +ant -low	/a/ = -cons +syl +cont +voice -constr -spread -nas -lat -lab -cor +back +low

These binary features are composed of subcomponents that specify phonetic detail such as duration, subtle differences in place of articulation (e.g. more front or back), or degree of height.

Each syllable is scanned for its features and phonetic detail. This information is sent to a parser which segments the information in order to determine the basis upon which a search in the Library of Routines will proceed. The result of this parse is fed into the Library. As explained in the next section, the parse may organize features hierarchically.

4.4.4. Library of Routines

The search for matching routines is performed using a type of gating process. The onset of the syllable is analyzed, creating a cohort (cf. Marslen-Wilson, 1987 on lexical access) of possibilities in the Library. It is possible that features are hierarchically organized and that the search for routines begins

---

[6] It is possible that the input to the motor system includes all feature specifications, including those which are redundant from a phonological point of view.

with those features highest in the hierarchy. For example, given a syllable /pa/, we might propose that Place of Articulation (= [+labial]) is highest in the hierarchy. A search of the Library based on [+labial] would result in a cohort of all bilabials. The next highest feature in the hierarchy, possibly Voicing (= [-voice]), would serve to narrow the cohort to all voiceless bilabials, and so on. Routines are weighted according to recency/frequency effects. This weighting has the effect of making routines relatively more or less salient for selection in a search.

Routines contain information concerning the articulatory goal or target. The target has a range of permissible variation. For example, if the articulatory goal is for the blade of the tongue to make contact with the alveolar ridge, a certain amount of latitude (perhaps in terms of millimetres) around the target would be allowed. In effect, the goal is a prototype which permits variation to a certain periphery beyond which the target is no longer considered as belonging to that category.

Temporal constraints on the production process may force the selection of a close match from the Library of Routines. Close matches might be selected from a cohort of ten candidates, for instance. In other words, the search will not proceed beyond this point. In the event that within the cohort of ten, there exists an acceptably close match, then that match will be selected. If no acceptably close match is located, then the search will be aborted and the phonetic specification sent to the

Syllable Generator.

4.4.5. What Constitutes a "Close" Match?

As stated above, articulatory routines specify articulatory goals or targets. That is, they do not contain information about which muscle groups need to be activated in order to produce a particular sound; instead, they specify the final outcome in terms of physical parameters. For example, the articulatory routine which corresponds to a syllable containing the vowel specified with the features [+high, -back, +round], /ü/, contains the target specified in terms of lip rounding and high tongue blade. With respect to the articulatory goal of lip rounding, there is a certain amount of latitude permitted with respect to exact degree of roundedness. In other words, a phonetic representation in the interface that is specified as high and very rounded may trigger the same articulatory routine as a high and less rounded specification. However, a specification which is altogether out of the target range of that routine will either trigger another routine, or if none corresponds to that specification, construction of the syllable will necessarily take place. Syllable generation, however, is a time-consuming process since the articulatory configuration must be built without the benefit of any unitized information. Therefore, as we will see later, syllable construction is carried out as a last resort, especially under the temporal constraints imposed by processing

overload.

Recency/frequency effects also have an effect in determining which routine will be selected as a close match. Conceivably, two routines may overlap in their range of permissible distance from each one's prototypical goal. In a case where the phonetic representation could select two or more routines as close matches, that routine which had the highest activation level due to its frequent use would be selected over the other, less salient routines.

4.4.6. How Routines are Lost

As noted above, routines are weighted according to recency/frequency effects. Each time a routine is called up based upon the phonetic specifications in the interface (or through generation), it is reinforced and becomes more salient. The activation level of those routines that fail to be called upon soon starts to decay. This decay continues until the point where, eventually, the activation level falls below a minimum threshold. Any routine below this minimum threshold will be unavailable to a search of the Routine Library. This is how articulatory routines are "lost."

4.4.7. Syllable Generator

Input to this stage is the syllable-sized, fully-specified phonetic representation. Bundles of phonetically-detailed features are scanned and generation takes place. The output of the Syllable Generator is equal to that of articulatory routines.

Construction (generation) may involve some type of pre-articulatory verification. The syllable-building process may be continually monitored as to its conformity with the phonetic representation. This could be achieved by backtracking, effectively undoing the translation/construction process and checking the result of this reversal against the phonetic representation.[7] Such pre-articulatory verification would be temporally costly. The use of articulatory routines would preclude the use of such time-consuming monitoring mechanisms.

The output from the Syllable Generator bifurcates, with one copy being sent into the Library of Routines and the other to Motor Specification. A new routine entering the Library from the Syllable Generator is the least activated of all. It will not be included in a search cohort due to its being below minimal threshold level.

As envisioned in this model, the bifurcated output from the Generator allows for parallel processing. Since one copy has been sent on for further motor processing, the copy sent to the Library has time to search through all the routines (those above and below minimal threshold) in order to locate a previously constructed counterpart, if indeed one exists. If found, this routine is "overwritten" or its salience increased by one degree. Only when the same syllable is generated repeatedly will its

---

[7] This type of monitoring would be nicely handled in a connectionist type of model whereby the activated nodes in the Syllable Generator would stimulate their higher level nodes in the phonetic representation, and vice versa.

corresponding routine in the Library surpass minimal threshold. At this point, its (close) match with the phonetic representation will trigger its execution.

4.4.8. Motor Specification

The input to this component of the motor system comes from either the Library of Routines or the Syllable Generator. Instructions are given regarding particular muscular activity -- which muscles, their tension, length, and temporal ordering of movement.

In this motor subsystem, syllables are held in a buffer. Coarticulatory adjustments are made based on upcoming information contained in this buffer. For instance, segments early in the string are often nasalized in anticipation of an upcoming nasal segment. Since the lowering of the velum is a relatively slow movement, the motor instructions which invoke its lowering must be sent early in the string in order that the target be reached in time for the relevant nasal segment. Such foresight requires some way of looking ahead, hence the buffer.[8]

---

[8] Given the complexity of motor planning required for articulation of a syllable, it may prove necessary to include additional stages.

4.4.9. Output

4.5. How the Model Functions in L1

4.5.1. Developmental Considerations

In the development of L1 phonology, the young child begins with non-adult-like (NAL) representations. Thus, the final stage in the production process results in a NAL phonetic representation. The feedforward mechanism feeds this deviant representation into the linguistic-motor interface. At this point, a search of the Routine Library is conducted. At this early stage in development, we may assume that no routines exist; therefore, no match is found. Since no match is found, the phonetic representation is sent to the Syllable Generator.

The Syllable Generator builds the articulatory goal based upon phonetic features and sends one copy to the Library and another to Motor Specification for further processing. Inasmuch as the input to the Generator is NAL, both the copy to the Library and output will be NAL.

Phonological development in L1 proceeds in a series of stages, with infants and young children progressing towards the adult state through a series of plateaus. Consequently, we may assume that for a time, this NAL representation continues to serve as the input to the phonetic-motor interface. Continued construction of the same NAL syllable results in a reinforcement of its corresponding routine in the Library until the point where this routine surpasses the minimal threshold level. Once the

routine surpasses minimal threshold, it becomes available for a search. So the next time the young child articulates that same (NAL) syllable, a search of the Routine Library will locate a match and execute it.

However, soon the child updates his/her phonological representations. For the purposes of exposition, let us assume that this updating results in an adult-like (AL) representation.[9] At this point, the input to the phonetic-motor interface is normative. However, a search of the Library of Routines may nevertheless select the NAL routine, if the input falls within the acceptable margin of error for that routine. The result may be a NAL pronunciation in the face of an AL representation.

This situation will not persist for long, however. The young child is attentive to pronunciation and most likely relies heavily on auditory, tactile, and proprioceptive feedback (cf. Borden, 1980). Noting incompatibility with his/her output and the phonetic representation, the young child will focus on his/her subsequent articulation of the syllable in question. In effect, this attention to articulation translates into more time being dedicated to this aspect of production. Time allows the speaker to "bypass" stored routines and to construct the AL syllable. This attentional factor may well be the crucial difference between the child and the adult. The latter is less

---

[9] Usually the child proceeds through a series of varying non-adult-like representations before finally adopting the adult form.

likely to dedicate extra time to constructing a syllable, relying instead on routines where possible, as we shall see in greater detail later.

Construction of the AL syllable places a copy in the Library of Routines; its subsequent reinforcement through further generation leads to its surpassing the minimal threshold. At this point it becomes available in a search of the Library, and succeeding input from the feedforward mechanism of the now AL representation will call upon the corresponding AL routine.

After a certain time, the young child's phonological and phonetic representation of this particular syllable stabilizes. The previous NAL form never surfaces at the final stage of linguistic production. Therefore, the NAL routine is never called up, causing its activation level to continually drop to the point of falling below minimal threshold, effectively being lost.

4.5.2. How the Model Functions for Adult L1

Once the speaker reaches approximately 10 years of age, s/he has reached a steady state in his/her phonological development. We can assume that phonological rules and representations are AL. This means that the final stage in the production process results in an AL phonetic representation, thereby invoking the corresponding AL articulatory routines.

Under normal circumstances, speech production in L1 operates relatively smoothly and automatically. But what happens, for example, when the speaker becomes overly concerned with syntactic

rules?

As sociolinguistic research has shown, speakers vary along a continuum in their speech styles -- from vernacular to formal. The vernacular is the most systematic of all speech styles. However, in formal situations, the speaker may monitor and edit his/her speech, carefully selecting the appropriate vocabulary and perhaps using more exotic syntactic constructions. In fact, the L1 adult speaker may appeal to prescriptively taught rules of grammar in the formulation of his/her productions. For example, s/he may consult such metalinguistic knowledge as when to use "who" versus "whom," or "I" versus "me."

The integration of such explicit knowledge into the language-specific processor would presumably require some sort of translation mechanism.[10] This translation process must surely be disruptive and time-consuming from the standpoint of sentence planning.

Given the temporal restrictions imposed upon the entire

---

[10] Proponents of linguistic modularity may express some concern as to how such non-linguistic material may be used at all in speech production. However, while supporting the notion of modularity in principle, it appears that we must somehow incorporate mechanisms which allow for interface between linguistic and non-linguistic information at some point in the derivation. It may be that the individual sub-components of the linguistic processor, e.g. syntactic and semantic, are informationally encapsulated while the link between one level and the next may allow for extra-linguistic information to be incorporated. Despite such difficulties, it is evident that we must allow for some type of interface since L1 speakers do make use of metalinguistic knowledge in real time production. And as we shall see later, many L2 speakers may be quite reliant on this type of knowledge.

speech production process in real-time communication, it is probable that translation of explicit knowledge into data compatible with the input constraints of the sentence output processor leaves significantly less time for later, low-level processes such as phonological and phonetic fine-tuning.[11] This disruption at lower levels may result in less-than-optimal phonetic representations at the last stage of linguistic processing. Why then do we not observe more deviation in L1 articulation in correlation with degree of formality in style?

It is proposed here that the relative stability in pronunciation across styles in L1 speech is due to the use of articulatory routines. In L1, any deviation in phonetic representation due to a lack of processing time at lower levels would presumably be quite minor. When a cohort of possible routines is constructed, the correct adult/native-like routine is selected. This is because the deviation in the phonetic representation is slight enough to fall within the range of the correct adult/native-like routine. Therefore, what we observe, in essence, is a correction of the deviant representation by the use of a well-established articulatory routine.

---

[11] Note that in certain cases, metalinguistic knowledge concerns pronunciation. For instance, in Labov's (1966) study of New York English, he found that in formal situations, speakers pronounced the standard /θ/ in words such as "think;" however, in the vernacular, the /t/ variant was more likely to be realized. This demonstrates that focus on metalinguistic matters may in fact direct attention to articulation.

4.6. How the Model Functions in L2

As stated earlier, this model of articulatory production is applicable to both L1 and L2. Therefore, the process described for L1 in Section 4.5 is the same as that which occurs in L2. How then do we account for the presence of foreign accent in the speech of older L2 learners, and why is foreign accent so persistent? The answer to this question may be attributed, in part, to the existence of a subset of erroneous routines in the set available to the older L2 speaker.

4.6.1. Why are Some Articulatory Routines in L2 Speech Erroneous?

It is proposed here that in the initial and intermediate stages of learning, older L2 speakers do dedicate some of their attentional resources to the level of articulation. This is necessary, of course, since extremely deviant pronunciation will preclude any further linguistic decoding on the part of the interlocutor. Preliminary evidence (Neufeld, forthcoming) has shown that at early and intermediate stages, L2 learners steadily and linearly improve at all linguistic levels. However, at more advanced stages, most speakers tend to plateau at a point where they still retain non-native-like articulation, despite continued improvement at higher linguistic levels such as syntax and morphology. Why do we observe such plateauing at the articulatory level?

A possible explanation for this plateauing may involve a shift in focus on the part of the older L2 learner. Once the learner perceives that s/he has attained a level of articulatory

precision that permits adequate comprehension on the part of the interlocutor, s/he may shift attentional resources away from articulation and toward other linguistic levels that affect form and meaning. In particular, s/he may tend to focus more on the content and form of the message, in some cases accessing formally learned metalinguistic knowledge during the production process in order to ensure the morphosyntactic well-formedness of the utterance. This shift in focus results in less attention being dedicated to low-level and less meaning-encoding processes such as morphophonemic adjustment.

4.6.2. The Effects of Processing Overload

It is proposed that in L2 production, speakers are subjected to processing overload. They are required to draw upon many stores of information during the speech production process. When the older L2 speaker directs his/her focus to content and form of the message, and/or to metalinguistic rules in order to help formulate utterances, this causes temporal disruptions in the production process.

The older L2 speaker's focus on meaning, form, and metalinguistic knowledge, along with the fact the s/he must somehow compensate for lack of competence in one or several linguistic areas, results in a slowing down of the entire speech production process. In order to produce speech in accordance with real-time constraints, any available shortcuts in the process must be exploited. Since the final stages of linguistic processing encode the least amount of meaning, the speaker may

adopt the (unconscious) strategy of diverting attention from these levels in order to direct maximal attentional resources to those linguistic levels which carry the most meaning, i.e. lexico- and morpho-syntax. The result from this change in focus may manifest itself in less attention being paid to morphophonological refinement and to matching final phonetic representations with output.

There are four ways in which erroneous articulatory routines could contribute to non-native-like pronunciation:

1. The older L2 learner may fail to develop native-like morphophonemic rules and representations. In this case, the input to the interface may be close enough in range to an already existing articulatory routine from L1. The L1 routine, in this event, would be executed, and we would observe what looks like (and in fact is) L1 interference.

2. The L2 speaker might not take the time to construct a syllable and rely, instead, on a close match in the Library of Routines. As will be recalled from earlier discussion, strong evidence exists (Neufeld, 1980; 1988) for the existence of native-like phonological competence in advanced L2 learners. Thus, presuming a native-like phonetic representation as input to the interface, this assumes that there exists no native-like routine in the Library for this particular input; instead, a close match is selected from among the cohort of routines.

Recall from earlier discussion that it was noted that young children are heavily dependent on feedback to ensure consistency

between the phonetic representation and output. It is hypothesized that many older L2 speakers may be less concerned with matching the phonetic representation with actual output. Therefore, when an erroneous routine is used in the articulation of an otherwise native-like representation, little attention to directed to the discrepancy between output and phonetic representation: no attempt will be made to bypass erroneous routines in order to construct the "correct" syllable. In other words, the older L2 speaker may be choosing "the path of least resistance," the consequence of which is a failure to create an updated routine to accord with the native-like phonetic representation.

It is also conceivable, however, that failure to bypass erroneous routines in order to construct "correct" syllables may be the result of time constraints imposed by disruptions at the sentence planning level. In other words, the "path of least resistance" may be forced due to a lack of time, rather than the disinclination to match articulatory output with the intention.

3. Assuming native-like competence at the phonological level, such competence may not be realized due to the older L2 speaker having insufficient time to apply the appropriate morphophonemic adjustments. The result of this would be non-native-like input to the interface and therefore the calling up of non-native-like routines. This could be caused either by disruption at the sentence planning level or by a simple (unconscious) decision not to focus on low-level processing.

Whatever the cause, the result is a non-native-like phonetic representation at the last stage of production. In contrast to the minor deviations we would find in L1, the deviations in L2 would be more serious. For example, in L1 we might find minor deviations such as reduced VOT on an aspirated consonant-vowel sequence. We might expect that the resulting less-than-optimal phonetic representation to nonetheless fall within the acceptable range for the routine corresponding to the fully aspirated consonant-vowel sequence. However, in the case of L2, disruptions at higher linguistic levels might cause greater deviation at the level of phonetic fine-tuning in that discrepancies may occur along several parameters. With respect to the above example, it may not only be that degree of VOT is maladjusted, but also the precise height of the vowel and its degree of fronting, for instance. Thus, the resulting non-native-like phonetic representation in L2 speech could be so discrepant from the corresponding (correct) routine, that it would not be selected from among the cohort. However, this non-native-like phonetic representation might fall within the range of acceptability of another (incorrect) routine, in which case that erroneous routine would be selected and executed.

4. Even for those forms where the native-like rules and representations have stabilized, we may observe "backsliding" to a previous stage of development. Backsliding occurs when the learner reverts to a non-native-like rule or representation after the native-like rule has been acquired.

Backsliding at the morphophonemic level results in occasional non-native-like phonetic input to the interface. At early and intermediate stages in the development of L1 and late-learned L2, both a non-native-like and a native-like routine exist in tandem in the Library. In the case of the advanced older L2 learner, however, the non-native-like routine receives reinforcement from occasional backsliding to a non-native-like phonetic representation in the interface. It is never permitted to fall below minimal threshold level, and thus is never lost.

In contrast, the young L1 learner, by allotting more attentional resources to low-level processes, ensures that the phonetic input to the interface is always AL. After stabilization of the phonological system, backsliding does not occur in L1; thus NAL routines do not receive reinforcement and are eventually lost by virtue of falling below the minimal threshold of activation.

4.6.3. An Example of an Erroneous Articulatory Routine in L2

In early learning, French speakers of L2 English may have a non-native-like phonetic representation for a word-initial syllable. For instance, due to the existence of non-native-like phonological rules, English /p^he/ may initially be represented as equivalent to French /pe/. Therefore, the input to the interface would be specified according to phonetic features such as: /p/ = [+lab, -voi, -cont] and /e/ = [-hi, -lo, -bk]. A look-up in the repertoire of articulatory routines selects the corresponding (French) routine.

Later in the acquisition process, the learner updates his/her phonetic representation to the native-like English /p^he/. The (French) routine, however, will continue to be selected in a search of the Library of Routines. Otherwise expressed, the erroneous routine is selected based on the fact that the phonetic input, /p^h/, falls within an acceptable range of the target for /p/: both involve lip closure and differ only in the voice onset time following release of the closure. At this point in learning, construction using pre-articulatory verification is no longer used to establish a match between the phonetic representation and the impending output. This may be due either to the speaker choosing the path of least resistance, or it may be forced by temporal constraints imposed by disruption at higher linguistic levels. In the interests of economy, a search is made in the Library of Routines for the nearest acceptable match to the phonetic representation; unfortunately, this close match is erroneous.

4.7. Summary

In this thesis, we have elaborated a performance-based model for speech production which attempts to offer a partial explanation for the persistence of foreign accent in the speech of older L2 learners.

In Chapter 2, we have examined various proposals that have been advanced to explain child-adult differences in the quality of pronunciation in L2 speech. In general, young children are better able to achieve native-like articulatory proficiency than

those who begin learning L2 at a later stage. We have examined accounts which attribute this difference to neurophysiological, cognitive, social/sociopsychological, and psycholinguistic factors. We have seen that many of these explanations attribute differences to the older learner's inability to acquire native-like competence in L2. We noted that some models fail to make competence/performance distinctions, or are otherwise too imprecise in their formulation to permit adequate empirical testing. Others, however, are well-developed and offer great insight into the phenomenon of foreign accent.

In Chapter 3, we briefly reviewed some models of speech production. Many of the concepts in that chapter have been included, in one form or another, in the model detailed in this thesis.

In Chapter 4, we have discussed at some length the preliminaries of an articulatory production model that we believe applicable to both first and second language acquisition and performance. We propose that cognitive maturation brings with it a shift in focus away from low-level processes such as articulation towards higher-level processes that are more related to language structure and content. It is our contention that it is this shift in focus which inhibits many older learners from ridding themselves of their accented speech. Unless the L2 speaker is predisposed to focus on pronunciation, extra time taken in the planning of the sentence -- due to syntactic, lexico-semantic, and/or morphological complexity, and possibly

the integration of metalinguistic knowledge as well -- results in less time being available for lower-level, non-meaning-related processing.

We have claimed that erroneous motor routines become entrenched at a point in learning where the older speaker judges the development of his/her L2 pronunciation to have reached an adequate level of comprehensibility. Nevertheless, the learner's phonological (and other linguistic) competence may continue to develop independently.

Consistent with our model, lack of time, due to processing overload in the sentence planning process, may have some of the following consequences:

1. The older L2 learner fails to develop native-like morphophonemic rules and representations. In this case, the learner may be relying upon routines from his/her L1, which are close matches with the phonetic input, or s/he may develop erroneous routines based on non-native-like, pre-interface, phonetic representations.

2. Even if the older L2 learner updates certain rules in his/her phonological competence such that the resulting phonetic input to the neuromotor interface is native-like, s/he may nevertheless rely upon erroneous routines that are sufficiently close matches to the input.

3. In the presence of certain native-like rules in phonological competence, the older L2 learner may not have the time to apply these rules, resulting in a non-native-like

phonetic representation. These variable and possibly non-systematic errors would be systematized through the use of articulatory routines.

4. Even when certain native-like phonological rules and representations have been acquired, backsliding may reinforce erroneous routines which would have otherwise been lost.

4.8. Conclusion

It must be pointed out that the model proposed here is a preliminary version. In many ways it is incomplete and no doubt oversimplified. It is evident that many questions remain to be answered. Empirical testing is required.

In particular, the basis upon which a search is conducted may need further refinement. Also, laboratory tests would need to tease out whether a particular erroneous routine is due to the failure to apply morphophonological and phonetic fine-tuning, or to the failure to bypass erroneous routines in favour of syllable generation.

The model developed in this thesis delineates some possible reasons for the inability of many adolescent and adult L2 learners to rid themselves of foreign accent in their speech. We have seen that most models of second language acquisition attribute the existence and persistence of foreign accent to learnability problems resulting in the non-acquisition of certain aspects of phonological competence. Certainly some of these

models are cogent, but not necessarily to the exclusion of performance considerations. To communicate with native-like proficiency in one's L2 requires not only the internalization of the rules and representations applicable to that language, but also access and use of those rules and representations. Therefore, models of performance also have their place in the field of L2 acquisition.

REFERENCES

Abramson, A.S. & Lisker, L. (1970) "Discriminability along the voicing continuum: Cross-language tests." Proceedings of the Sixth International Congress of Phonetic Sciences, 569-573.

Abuhamdia, Z. (1987) "Neurobiological foundations for foreign language." IRAL, Vol.XXV/3, Aug.1987, 203-211.

Altenberg, E.P. & Vago, R.M. (1987) "Theoretical implications of an error analysis of second language phonology production." pp. 148-164 in G. Ioup & S.H. Weinberger Interlanguage Phonology: The Acquisition of a Second Language Sound System. Cambridge, MA: Newbury House. (Originally published in 1983 in Language Learning, 33, 427-448)

Anan, F. (1981) "A study of intonation interference." The Bulletin, The Phonetic Society of Japan, 167, 9-13.

Archangeli, D. (1988) "Aspects of underspecification theory." Phonology Yearbook, 5, 183-207.

Archibald, J. (1992) "Transfer of L1 parameter settings: Some empirical evidence from Polish metrics." Canadian Journal of Linguistics, 37, 301-339.

Archibald, J. (1993) Language Learnability and L2 Phonology: The Acquisition of Metrical Parameters. Dordrecht: Kluwer.

Archibald, J. (1994) "A formal model of learning L2 prosodic phonology." Second Language Research, 10, 3, 215-240.

Asher, J.J. & Garcia, R. (1982) "The optimal age to learn a foreign language." pp.3-12 in S.D. Krashen, R.C. Scarcella, & M.H. Long (eds.) Child-Adult Differences in Second Language Acquisition. Rowley, MA: Newbury House. (Originally published in 1969 in Modern Language Journal, 53, 334-341.)

Baars, B.J. (1980) "The competing plans hypothesis: An heuristic viewpoint on the causes of errors in speech." in H.W. Dechert & M. Raupach (eds.) Temporal Variables in Speech, pp.39-49. The Hague: Mouton.

Baars, B.J.; Motley, M.T.; & MacKay, D.G. (1975) "Output editing for lexical status in artificially elicited slips of the tongue." Journal of Verbal Learning & Verbal Behavior, 14, 382-391.

Basser, L. (1962) "Hemiplegia of early onset and the faculty of speech with special reference to the effects of hemispherectomy." Brain, 85, 427-460.

Beebe, L. (1980) "Sociolinguistic variation and style-shifting in second language acquisition." Language Learning, 30, 433-447.

Benguerel, A.-P. & Cowan, H.A. (1974) "Coarticulation of upper lip protrusion in French." Phonetica, 30, 41-55.

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

Best, C.T. (1988) "The emergence of cerebral asymmetries in early human development: A literature review & a neuroembryological model." pp.5-34 in D.L. Molfese & S.J. Segalowitz (eds.) Brain Lateralization in Children: Developmental Implications. New York: The Guiford Press.

Bever, T.G. (1981) "Normal acquisition processes explain the critical period for language learning" pp.176-198 in K.C. Diller (ed.) Individual Differences and Universals in Language Learning Aptitude. Rowley, MA: Newbury House.

Bialystok, E. & Sharwood Smith, M. (1985) "Interlanguage is not a state of mind." Applied Linguistics, 5, 101-117.

Bley-Vroman, R. (1988) "The fundamental character of foreign language learning." in W. Rutherford & M. Sharwood Smith (eds.) Grammar and Second Language Teaching: A Book of Readings, Rowley, MA: Newbury House.

Boomer, D.S. & Laver, J.D.M. (1968) "Slips of the tongue." British Journal of Disorders of Communication, 3, 2-12.

Borden, G.J. (1980) "Use of feedback in established and developing speech." pp.223-242 in N. Lass (ed.) Speech and Language, Vol.3.

Borden, G.J.; Harris, K.; & Oliver (1973) "Oral feedback I. Variability of the effect of nerve-block anesthesia upon speech." Journal of Phonetics, 1, 289-295.

Borden, G.J. & Harris, K. (1984) Speech Science Primer: Physiology, Acoustics, and Perception of Speech. Baltimore, MD: Williams & Wilkins.

Brennan, E.M. & Brennan, J.S. (1981) "Accent scaling and language attitudes: Reactions to Mexican American English speech." Language and Speech, 24, 207-222.

Brière, E. (1966) "An investigation of phonological interference." Language, 42(4), 768-796.

Broselow, E. (1983) "Non-obvious transfer: On predicting epenthesis errors." in S. Gass & L. Selinker (eds.) Language Transfer in Language Learning, pp.269-280. Rowley, MA: Newbury House.

Broselow, E. (1987) "An investigation of transfer in second language phonology." pp.261-278 in G. Ioup & S.H. Weinberger (eds.) Interlanguage Phonology: The Acquisition of a Second Language Sound System. Cambridge, MA: Newbury House. (Originally published in 1984 in IRAL, 22, 253-269)

Brown, H.D. (1980) "The optimal distance model of second language acquisition." TESOL Quarterly, 14, 157-164.

Butterworth, B. (1980) "Some constraints on models of language production." in B. Butterworth (ed.) Language Production (Vol.1), pp.423-459. London: Academic.

Chomsky, N. (1959) "Review of Verbal Behavior by B.F. Skinner." Language, 35, 26-58.

Chomsky, N. (1981) Lectures on Government and Binding. Dordrecht: Foris.

Chomsky, N. & Halle, M. (1968) The Sound Pattern of English. New York: Harper & Row.

Clyne, M. (1981) (ed.) Foreigner Talk. The Hague: Mouton.

Cochrane, R.M. (1980) "The acquisition of /r/ and /l/ by Japanese children and adults learning English as a second language." Journal of Multilingual and Multicultural Development, 1, 4, 331-360.

Cochrane, R.M. & Sachs, J. (1979) "Phonological learning in a laboratory setting." Language & Speech, Vol.22, Part 2.

Cowan, N.; Braine, M.D.S.; & Leavitt, L.A. (1985) "The phonological and metaphonological representation of speech: Evidence from fluent backward talkers." Journal of Memory and Language, 24, 679-698.

Crompton, A. (1981) "Syllables and segments in speech production." Linguistics, 19, 663-716.

Crookes, G. (1991) "Second language speech production research: A methodologically oriented review." Studies in Second Language Acquisition, 13, 113-132.

Dechert, H.W. (1984) "Second language production: Six hypotheses." pp.211-230 in H.W. Dechert; D. Möhole; & M. Raupach (eds.) Second Language Productions. Tübingen: Gunter Narr Verlag.

Dechert, H.W. & Raupach, M. (1980) (eds.) Towards a cross-linguistic assessment of speech production. Frankfurt: Lang.

Dechert, H.W. & Raupach, M. (1987) Psycholinguistic Models of Production. Norwood, NJ: Ablex.

Dell, G.S. (1985) "Positive feedback in hierarchical connectionist models: Applications to language production." Cognitive Science, 9, 3-23.

Dell, G.S. (1986) "A spreading-activation theory of retrieval in sentence production." Psychological Review, 93, 283-321.

Dell, G.S. (1989) "The retrieval of phonological forms in production: Tests of predictions from a connectionist model." in W. Marslen-Wilson (ed.) Lexical Representation and Process, pp.136-165. Cambridge, MA: MIT Press.

Dickerson, W. (1977) "Language variation in applied linguistics." ITL Review of Applied Linguistics, 35, 43-66.

Dickerson, W. (1987) "Explicit rules and the developing interlanguage phonology." in A. James & J. Leather (eds.) Sound Patterns in Second Language Acquisition, pp.121-140. Dordrecht: Foris.

Easton, T.A. (1972) "On the normal use of reflexes." American Scientist, 60, 591-599.

Eckman, F. (1981) "On predicting phonological difficulty in second language acquisition." Studies in Second Language Acquisition, 4, 18-30.

Eckman, F. (1987) "Markedness & the contrastive analysis hypothesis" pp. 55-69 in G. Ioup & S.H. Weinberger (eds.) Interlanguage Phonology: The Acquisition of a Second Language Sound System. Cambridge, MA: Newbury House. (Originally published in 1977 in Language Learning, 27, 315-330)

Ensz, K.Y. (1982) "French attitudes toward typical speech errors of American speakers of French." Modern Language Journal, 66, Summer, 133-139.

Entus, A.K. (1977) "Hemispheric asymmetry in processing of dichotically presented speech and nonspeech sounds by infants." in S. Segalowitz & F.A. Gruber (eds.) Language Development and Neurological Theory, pp.63-73. New York: Academic Press.

Esser, J. (1978) "Contrastive intonation of German and English: Problems and some results." Phonetica, 35, 41-55.

Fathman, A. (1975) "The relationship between age & second language productive ability." Language Learning, 25, 2, 245-253.

Felix, S.W. (1981) "On the (in)applicability of Piagetian thought to language learning." Studies in Second Language Acquisition, 3, 201-220.

Felix, S.W. (1985) "More evidence of competing cognitive systems." Second Language Research, 1, 47-72.

Flege, J.E. (1980) "Phonetic approximation in second language acquisition." Language Learning, 30(1), 117-134.

Flege, J.E. (1981) "The phonological basis of foreign accent: A hypothesis." TESOL Quarterly, 15(4), 443-455.

Flege, J.E. (1984) "The detection of French accent by American listeners." Journal of the Acoustical Society of America, 76(3), 692-707.

Flege, J.E. (1985) "The production and perception of foreign language speech sounds." Biocommunication Research Reports, Birmingham, AL: University of Alabama at Birmingham.

Flege, J.E. (1986) "Effects of equivalence classification on the production of foreign language speech sounds." in A. James & J. Leather (eds.) Sound Patterns in Second Language Acquisition.pp.9-39. Foris: Dordrecht.

Flege, J.E. (1987) "The production of "new" and "similar" phones in a foreign language: Evidence for the effect of equivalence classification." Journal of Phonetics, 15, 47-65.

Flege, J.E. (1990) "English vowel production by Dutch talkers: More evidence for the 'similar' vs. 'new' distinction." in J. Leather & A. James (eds.) New Sounds 90: Proceedings of the Amsterdam Symposium on the Acquisition of Second-Language Speech, pp.255-293. Amsterdam: University of Amsterdam.

Flege, J.E. (1991) "Age of learning affects the authenticity of voice-onset time (VOT) in stop consonants produced in a second language." Journal of the Acoustical Society of America, 89, 395-411.

Flege, J.E. & Davidian, R. (1985) "Transfer and speech production." Applied Psycholinguistics, 5, 323-347.

Flege, J.E. & Eefting, W. (1987) "The production and perception of English stops by Spanish speakers of English." Journal of Phonetics, 15, 67-83.

Fowler, C. (1980) "Coarticulation and theories of extrinsic timing control." Journal of Phonetics, 8, 113-133.

Fromkin, V.A. (1971) "The non-anomalous nature of anomalous utterances." Language, 47, 1, 27-52.

Fry, D.B. (1966) "The control of speech and voice." in H. Kalmus (ed.) Regulation and Control in Living Systems. New York: Wiley.

Gagné, E. (1983) The Cognitive Psychology of School Learning. Vol.1. Unpublished manuscript.

Gardner, R.C. & Lambert, W.E. (1972) Attitudes and Motivation in Second-Language Learning. Rowley, MA: Newbury House.

Garrett, M.F. (1975) "The analysis of sentence production." pp.133-177 in G.H. Bower (ed.) The Psychology of Learning & Motivation. New York: Academic Press.

Garrett, M.F. (1984) "The organization of processing structures." in D. Caplan, A. Lecours, & A. Smith (eds.) Biological Perspectives on Language, Cambridge, MA: MIT Press.

Geffner, D. & Hochberg, I. (1971) "Ear laterality performance of children from low and middle socioeconomic levels in a verbal dichotic listening task." Cortex, 7, 193-203.

Giles, H. (1978) "Linguistic differentiation in ethnic groups." in H. Tajfel (ed.) Differentiation between Social Groups, pp.50-73. London: Academic.

Greenberg, C. (1983) "Syllable structure in second language acquisition." CUNY Forum, 9, 47-64.

Grossberg, S. & Stone, G. (1986) "Neural dynamics of word recognition and recall: Attentional priming, learning, and resonance." Psychological Review, 93, 46-74.

Guenther, F.H. (1994) "A neural network model of speech acquisition and motor equivalent speech production." Biological Cybernetics, 72, 43-53.

Guenther, F.H. (1995) "Speech sound acquisition, coarticulation, and rate effects in a neural network model of speech production." Psychological Review, 102, 3, 594-621.

Guiora, A.Z. (1967) "Toward a systematic study of empathy." Comprehensive Psychiatry, 11, 531-538.

Guiora, A.Z. (1970) "Transpositional research in the clinical process." Comprehensive Psychiatry, 11, 531-538.

Guiora, A.Z.; Acton, W.R.; Erard, R.; & Strickland, F.W. (1980) "The effects of benzodiazepine (valium) on permeability of language ego boundaries." Language Learning, 30, 2, 351-363.

Guiora, A.Z.; Beit-Hallahmi, B.; Brannon, R.C.L.; Dull, C.Y.; & Scovel, T. (1972) "The effect of experimentally induced changes in ego states on pronunciation ability in second language: An exploratory study." Language Learning, 30, 2, 351-363.

Guiora, A.; Brannon, R.C.L.; & Dull, C.Y. (1972) "Empathy and second language learning." Language Learning, 22, 1, 111-130.

Guiora, A.; Lane, H.; & Bosworth, L. (1968) "An explanation of some personality variables in authentic pronunciation in a second language." in H. Lane & E. Zale (eds.) Studies in Language and Language Behaviour, 4, 463-474.

Guiora, A.Z. & Schonberger, R. (1990) "Native pronunciation of bilinguals." in J. Leather & A. James (eds) New Sounds 90: Proceedings of the Amsterdam Symposium on the Acquisition of Second-Language Speech, pp. 26-36. Amsterdam: University of Amsterdam.

Hammarberg, B. (1988) Studien zur Phonologie des Zweitspracherwerbs. Stockholm: Almqvist & Wiksell International.

Hancin-Bhatt, B. (1994) "Segment transfer: A consequence of a dynamic system." Second Language Research, 10, 3, 241-269.

Hecht, B.F. & Mulford, R. (1987) "The acquisition of a second language phonology: Interaction of transfer & developmental factors." pp.213-228 in G. Ioup & S.H. Weinberger (eds.) Interlanguage Phonology: The Acquisition of a Second Language Sound System. Cambridge, MA: Newbury House. (Originally published in 1982 in Applied Psycholinguistics, 3, 313-328.)

Henke, W.L. (1966) "Modeling of articulatory activity during speech production." Speech Communication Research Final Report. Research Laboratory of Electronics, MIT.

Hill, J. (1970) "Foreign accents, language acquisition, and cerebral dominance revisited." Language Learning, 20, 237-248.

Hill, J. (1972) "On the evolutionary foundations of language." American Anthropologist, 74, 308-317.

Hodne, B. (1985) "Yet another look at interlanguage phonology: The modification of English syllable structure by native speakers of Polish." Language Learning, 35, 405-422.

Hulstijn, J.H. (1989) "A cognitive view of interlanguage variability." pp.17-31 in M.R. Eisenstein (ed.) The Dynamic Interlanguage. New York: Plenum.

Ioup, G. (1984) "Is there a structural foreign accent? A comparison of syntactic & phonological errors in second language acquisition." Language Learning, 34, 2, 1-17.

Jakobson, R. (1968) Child Language, Aphasia, and Phonological Universals. The Hague: Mouton. (Originally published in 1941 as Kindersprache, Aphasie, und Allgemeine Lautgesetze)

James, A. (1983) "Transferability and dialect phonology: Swabian-English." in A. James & B. Kettemann (eds.) Dialect Phonology and Foreign Language Acquisition, pp.162-188. Tübingen: Gunter Narr.

James, A. (1986) "Phonic transfer and phonological explanation: Some theoretical and methodological issues." in E. Kellerman & M. Sharwood Smith (eds.) Crosslinguistic Influence in Second Language Acquisition, pp.134-149. Oxford: Pergamon.

James, A. (1988) The Acquisition of a Second Language Phonology. Tübingen: Narr.

Johansson, F.A. (1973) Immigrant Swedish Phonology: A Study of Multiple Contact Analysis. Lund: CWK Gleerup.

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

Kennedy, B.L. (1988) "Adult versus child L2 acquisition: An information-processing approach." Language Learning, 38, 4, 477-496.

Kent, R.D. (1976) "Models of speech production." pp.79-104 in N.J. Lass (ed.) Contemporary Issues in Experimental Phonetics. New York: Academic Press.

Kent, R.D.; Carney, P.; & Severeid, L. (1974) "Velar movement and timing: Evaluation of a model for binary control." Journal of Speech and Hearing Research, 17, 470-488.

Kent, R.D. & Rosenbek, J.C. (1982) "Prosodic disturbance and neurologic lesion." Brain and Language, 15, 259-291.

Kimura, D. (1963) "Cerebral dominance and the perception of verbal stimuli." Canadian Journal of Psychology, 15, 166-171.

Kinsbourne, M. (1971) "The minor cerebral hemisphere as a source of aphasic speech." Archives of Neurology, 25, 302-306.

Kozhevnikov, L. & Chistovich, L. (1965) Rech: Artikulyatisiya i Vospriyatiye. Moscow-Leningrad. (Translated in 1966 as Speech: Articulation and Perception. Springfield, VA: United States Department of Commerce, Joint Publications Research Service, Vol.30)

Knox, C. & Kimura, D. (1970) "Cerebral processing of nonverbal sounds in boys and girls." Neuropsychologia, 8, 227-237.

Krashen, S.D. (1973) "Lateralization, language learning, & the critical period: Some new evidence." Language Learning, 23, 1, 63-74.

Krashen, S.D. (1982) "Accounting for child-adult differences in second language rate and attainment." pp.202-226 in S.D. Krashen, R.C. Scarcella, & M.H. Long (eds.) Child-adult Differences in Second Language Acquisition. Rowley, MA: Newbury House.

Krashen, S.D. (1985) The Input Hypothesis: Issues and Implications. London: Longman.

Krashen, S.D.; Long, M.A.; & Scarcella, R.C. (1979) "Age, rate and eventual attainment in second language acquisition." TESOL Quarterly, 13, 4, 573-582.

Labov, W. (1966) The Social Stratification of English in New York City. Washington, DC: Center for Applied Linguistics.

Labov, W. (1969) "The study of language in its social context." Studium Generale, 23, 30-87.

Labov, W. (1972) Sociolinguistic Patterns. Philadelphia, PA: University of Pennsylvania Press.

Lado, R. (1957) Linguistics across Cultures. Ann Arbor: University of Michigan Press.

Lamendella, J. (1977) "General principles of neurofunctional organization and their manifestation in primary and non-primary acquisition." Language Learning, 27, 155-196.

Larsen-Freeman, D. (1983) "The importance of input in second language acquisition." in R. Anderson (ed.) Pidginization and Creolization as Language Acquisition. Rowley, MA: Newbury House.

Lashley, K.S. (1951) "The problem of serial order in behavior." in L.A. Jeffress (ed.) Cerebral Mechanisms in Behavior, pp.112-136. New York: Wiley.

Laubstein, A.S. (1985) The Nature of the 'Production Grammar' Syllable. Ph.D. Dissertation: University of Ottawa.

Laver, J.D.M. (1980) "Monitoring systems in the neurolinguistc control of speech production." in V.A. Fromkin (ed.) Errors in Linguistic Performance, pp.287-305. New York: Academic.

Leather, J. & James, A. (1991) "The acquisition of second language speech." Studies in Second Language Acquisition, 13, 305-341.

Lecours, A.R. (1975) "Myelogenetic correlates of the development of speech and language." pp.121-135 in E.H. Lenneberg & E. Lenneberg (eds.) Foundations of Language Development: A Multi-disciplinary Approach. Vol.1. New York: Academic Press.

Lenneberg, E.H. (1967) Biological Foundations of Language. New York: John Wiley & Sons.

Lenneberg, E.H.; Nichols, J.A.; & Rosenberger, E.F. (1964) "Primitive stages of language development in monogolism." Disorders of Communication XLII: Research Publications, A.R.N.M.D. Baltimore, MA: Williams & Wilkins.

Levelt, W.J.M. (1983) "Monitoring and self-repair in speech." Cognition, 14, 41-104.

Levelt, W.J.M. (1989) Speaking. Cambridge, MA: The MIT Press.

Lisker, L. & Abramson, A.S. (1970) "The voicing dimension: Some experiments in comparative phonetics." Proceedings of the Sixth International Congress of Phonetic Sciences, 563-567.

Long, M.H. (1990) "Maturational constraints on language development." Studies in Second Language Acquisition, 12, 251-285.

Lukach, M. (1993) Speech Production Processing in the Second Language. Unpublished MA Thesis: University of Ottawa.

MacKay, D.G. (1970) "Spoonerisms: The structure on errors in the serial order of speech." Neuropsychologia, 8, 323-350.

Macken, M.A. & Ferguson, C.A. (1987) "Phonological universals in language acquisition." pp.3-22 in G. Ioup & S.H. Weinberger (eds.) Interlanguage Phonology: The Acquisition of a Second Language Sound System. Cambridge, MA: Newbury House. (Originally published in 1981 in H. Winitz (ed.) Native Language and Foreign Language Acquisition, pp.110-129. New York: New York Academy of Sciences.)

Major, R.C. (1986) "The ontogeny model: Evidence from L2 acquisition of Spanish r." Language Learning, 36, 4, 453-503.

Major, R.C. (1987) "Foreign accent: Recent research and theory." IRAL, XXV, 3, 185-201.

Makkai, V.B. (1976) "The competence-performance dichotomy as manifested in the phonology of bilinguals." Studies in Language Learning, 1, 2, 219-234.

Marslen-Wilson, W.D. (1987) "Functional parallelism in spoken word recognition." Cognition, 25, 71-102.

Maxwell, D.L. (1984) "The neurology of learning & language disabilities: Developmental considerations." pp.35-59 in G.P. Wallach & K.G. Butler (eds.) Language Learning Disabilities in School-Age Children. Baltimore: Williams & Williams.

McClelland, J.L. & Rumelhart, D.E. (1981) "An interactive activation model of context effects in letter perception: Part 1. An account of basic findings." Psychological Review, 88, 375-407.

Molfese, D.L. (1977) "Infant cerebral asymmetry." in S.J. Segalowitz & F.A. Gruber (eds.) Language Development and Neurological Theory. New York: Academic Press.

Moll, K.L. & Daniloff, R.G. (1971) "Investigation of the timing of velar movements during speech." Journal of the Acoustical Society of America, 45, 1217-1233.

Moulton, W. (1962) The Sounds of English and German. Chicago: University of Chicago Press.

Motley, M.T.; Baars, B.J.; & Camden, C.T. (1983) "Experimental verbal slip studies: A review and editing model of language encoding." Communication Monographs, 50, 79-101.

Mulford, R. & Hecht, B. (1980) "Learning to speak without an accent: Acquisition of a second-language phonology." Papers and Reports on Child Language Development, 18, 61-74.

Naiman, N.; Fröhlich, M.; Stern, H.; & Todesco, A. (1978) The Good Language Learner: Research in Education Series (No.7) Toronto: The Ontario Institute for Studies in Education.

Nemser, W. (1971) An Experimental Study of Phonological Interference in the English of Hungarians. Bloomington, IN: Indiana University.

Nespor, M. & Vogel, I. (1982) "Prosodic domains of external sandhi rules." in H. van der Hulst & N. Smith (eds.) The Structure of Phonological Representations, Part I, pp.225-255. Dordrecht: Foris.

Nespor, M. & Vogel, I. (1986) Prosodic Phonology. Dordrecht: Foris.

Neufeld, G. (1977) "Language learning ability in adults: A study on the acquisition of prosodic and articulatory features." Working Papers on Bilingualism, 12, 45-60.

Neufeld, G.G. (1978) "On the acquisition of prosodic and articulatory features in adult language learning." The Canadian Modern Language Review, 34, 163-174. (Also appears in G. Ioup & S. Weinberger (eds.) Interlanguage Phonology: The Acquisition of a Second Language Sound System, pp.321-332. Cambridge, MA: Newbury House.)

Neufeld, G.G. (1979) "Towards a theory of language learning ability." Language Learning, 29, 2, 227-241.

Neufeld, G.G. (1980) "On the adult's ability to acquire phonology." TESOL Quarterly, XIV, 3, 285-298.

Neufeld, G.G. (1988) "Phonological asymmetry in second language learning & performance." Language Learning, 38, 4, 531-560.

Neufeld, G.G. (forthcoming) "Foreign accents in the speech of adult second language learners." University of Ottawa.

Oyama, S. (1982) "A sensitive period for the acquisition of a nonnative phonological system." pp.20-38 in S.D. Krashen, R.C. Scarcella, & M.H. Long (eds.) Child-Adult Differences in Second Language Acquisition. Rowley, MA: Newbury House. (Originally published in 1976 in Journal of Psycholinguistic Research, 5, 261-285.)

Paik, Y. (1977) "Pronunciation difficulties of Korean students learning English as a second language." Dhak Yonku, 13(2), 177-189.

Patkowski, M.S. (1980) "The sensitive period for the acquisition of syntax in a second language." Language Learning, 30(2), 449-472.

Patkowski, M.S. (1990) "Age & accent in a second language: A reply to James Emil Flege." Applied Linguistics, 11, 1, 73-89.

Penfield, W. & Roberts, L. (1959) Speech & Brain Mechanisms. Princeton: Princeton University Press.

Penfield, W. (1965) "Conditioning the uncommitted cortex for language learning." Brain, 88, 787-798.

Perkell, J.S. (1969) Physiology of Speech Production: Results and Implications of a Quantitative Cineradiographic Study. Cambridge, MA: MIT Press.

Peters, A. (1983) The Units of Language Acquisition. New York: Cambridge University Press.

Plann, S. (1977) "Acquiring a second language in an immersion situation." in H.D. Brown, C. Yorio, & R. Crymes (es.) On TESOL '77, pp.213-223. TESOL, Washington, DC.

Puppel, S. (1990) "Some preliminary observations of Polish and English vowel spaces in contact." in J. Fisiak (ed.) Further Insights into Contrastive Linguistics, pp.241-253. Amsterdam: Benjamins.

Purcell, E.T. & Suter, R.W. (1980) "Predictors of pronunciation accuracy: A re-examination." Language Learning, 39, 271-288.

Pürschel, H. (1975) Pauze und Kadenz: Interferenzerscheinungen bei der englischen Intonation deutscher Sprecher. Tübingen: Niemeyer.

Redard, F. (1973) Contrastive Phonemics: Notes and Exercises. Neuchâtel, Switzerland: Centre de linguistique, U Neuchâtel.

Ritchie, W. (1968) "On the explanation of phonic interference." Language Learning, 18, 183-197.

Rosansky, E. (1975) "The critical period for the acquisition of language: Some cognitive developmental considerations." Working Papers on Bilingualism, 6, 10-23.

Rubach, J. (1984) "Rule typology and phonological interference." in S. Eliasson (ed.) Theoretical Issues in Contrastive Phonology, pp.37-50. Heidelberg: Groos.

Rumelhart, D.E. & McClelland, J.L. (1982) "An interactive activation model of context effects in letter perception, Part 2: The contextual enhancement effect and some tests and extensions of the model." Psychological Review, 89, 60-94.

Saleemi, A. (1992) Universal Grammar and Language Learnability. Cambridge: Cambridge University Press.

Salisbury, R.F. (1962) "Notes on bilingual and language change in New Guinea." Anthropological Linguistics, 4(7), 1-13.

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

Schmidt, R. (1977) "Sociolinguistic variation and language transfer in phonology." Working Papers on Bilingualism, 12, 79-95.

Schneiderman, E.I. & Desmarais, C. (1988) "The talented language learner: Some preliminary findings." Second Language Research, 4, 2, 91-109.

Schumann, H.H.; Holroyd, J.; Campbell, R.N.; & Ward, F.A. (1978) "Improvement of foreign language pronunciation under hypnosis: A preliminary study." Language Learning, 28, 143-148.

Scovel, T. (1969) "Foreign accents, language acquisition, and cerebral dominance." Language Learning, Vol.XIX, 3-4, 245-253.

Scovel, T. (1981) "The recognition of foreign accents in English & its implications for psycholinguistic theories of language acquisition." pp.389-401 in J.-G. Savard & L. Laforge (eds.) Proceedings of the 5th Congress of L'association internationale de linguistique appliquée. Québec: Les presses de l'université Laval.

Scovel, T. (1988) A Time to Speak. Cambridge, MA: Newbury House.

Scuffil, M. (1982) Experiments in Comparative Intonation: A Case Study of English and German. Tübingen: Niemeyer.

Seliger, H.W. (1978) "Implications of a multiple critical periods hypothesis for second language learning." in W.C. Ritchie (ed.) Second Language Acquisition Research: Issues & Implications. New York: Academic Press.

Seliger, H.W.; Krashen, S.D.; & Ladefoged, P. (1982) "Maturational constraints in the acquisition of second languages." pp.13-19 in S.D. Krashen, R.C. Scarcella, & M.H. Long (eds.) Child-Adult Differences in Second Language Acquisition. Rowley, MA: Newbury House. (Originally published in 1975 in Language Sciences, 38, 20-22)

Selinker, L. (1972) "Interlanguage." IRAL, 10, 209-231.

Selinker, L. & Lakshmanan, U. (1992) "Language transfer and fossilization: The multiple effects principle." in S.M. Gass & L. Selinker (eds.) Language Transfer in Language Learning, pp.197-216. Amsterdam: John Benjamins.

Selinker, L. & Lamendella, J.T. (1979) "The role of extrinsic feedback in interlanguage fossilization: A discussion of "Rule fossilization: A tentative model."" Language Learning, 29, 2, 363-375.

Selkirk, E. (1984) "On the major class features and syllable theory." in M. Aronoff & R. Oehrle (eds.) Language Sounds Structure, pp.107-136. Cambridge, MA: MIT Press.

Shattuck-Hufnagel, S. (1983) "Sublexical units and suprasegmental structure in speech production planning." in P.F. MacNeilage (ed.) The Production of Speech, pp.109-136. New York: Springer-Verlag.

Siegel, G.M.; Pick, H.L.; Olson, M.G.; & Sawin, L. (1976) "Auditory feedback in the regulation of vocal intensity of preschool children." Developmental Psychology, 12, 255-261.

Skinner, B.F. (1957) Verbal Behavior. New York: Appleton-Century-Crofts.

Smith, A. (1966) "Speech and other functions after left (dominant) hemispherectomy." Journal of Neurology, Neurosurgery and Psychiatry, 29, 467-471.

Snow, C.E. & Hoefnagel-Höhle, M. (1977) "Age differences in the pronunciation of foreign sounds." Language & Speech, 20, 4, 357-365.

Soudak, L.I. (1977) "Error analysis and the system of English consonants." ELT-Journal, 31(2), 125-130.

Spolsky, B. (1969) "Attitudinal aspects of second language learning." Language Learning, 20, 271-287.

Springer, S. & Deutsch, G. (1989) Left Brain, Right Brain. New York: W.H. Freeman.

Stemberger, J.P. (1985) "An interactive model of language production." in A.W. Ellis (ed.) Progress in the Psychology of Language (Vol.1), pp.143-186. Hillsdale, NJ: Erlbaum.

Stockwell, R.; Bowen, J.; & Martin, J. (1965) The Grammatical Structures of English and Spanish. Chicago: Chicago University Press.

Studdert-Kennedy, M. & Hadding, K. (1973) "Auditory and linguistic processes in the perception of intonation contours." Language and Speech, 16, 293-313.

Suter, R.W. (1976) "Predictors of pronunciation accuracy in second language." Language Learning, 30(2), 271-287.

Tahta, S.; Wood, M.; & Loewenthal, K. (1981) "Age changes in the ability to replicate foreign pronunciation & intonation." Language & Speech, 24, 4, 363-372.

Tarone, E. (1972) "A suggested unit for interlingual identification in pronunciation." TESOL Quarterly, 6, 325-331.

Tarone, E. (1976) "Some influences on interlanguage phonology." Working Papers on Bilingualism, 8, 87-111.

Tarone, E. (1982) "Systematicity and attention in interlanguage." Language Learning, 32, 69-84.

Tarone, E. (1983) "On the variability of interlanguage systems." Applied Linguistics, 4, 142-163.

Tarone, E.E. (1987a) "The phonology of interlanguage." pp.70-85 in G. Ioup & S.H. Weinberger (eds.) Interlanguage Phonology: The Acquisition of a Second Language Sound System. Cambridge, MA: Newbury House. (Originally published in 1978 in J. Richards (ed.) Understanding Second and Foreign Language Learning, pp.15-33. Rowley, MA: Newbury House)

Tarone, E.E. (1987b) "Some influences on the syllable structure of interlanguage phonology." pp.232-247 in G. Ioup & S.H. Weinberger (eds.) Interlanguage Phonology: The Acquisition of a Second Language Sound System. Cambridge, MA: Newbury House. (Originally published in 1980 in International Review of Applied Linguistics, 4, 143-163)

Taylor, L.L.; Catford, J.C.; Guiora, A.Z.; & Lane, H.L. (1971) "Psychological variables and the ability to pronounce a second language." Language and Speech, 14, 146-157.

Taylor, B. (1974) "Toward a theory of language acquisition." Language Learning, 24, 23-36.

Tomaszczyk, J. (1980) "On accented speech: The Polish of Polish Americans." Studia Anglica Posnaniensia, 12, 121-137.

Troike, R. (1970) "Receptive competence, productive competence, and performance." in J. Alatis (ed.) Report of the Twentieth Annual Round Table, pp.63-73. Washington, DC: Georgetown University Press.

Tropf, H. (1983) Variation in der Phonologie des ungesteuerten Zweitspracherwerbs: Bd. 1, Bd. 2. Ph.D. Dissertation: Universität Heidelberg.

Vago, R.M. (1980) The Sound Pattern of Hungarian. Washington, DC: Georgetown University Press.

Vigil, F. & Oller, J. (1976) "Rule fossilization: A tentative model." Language Learning, 26, 281-295.

Wada, J.A. & Davis, A. (1977) "Fundamental nature of human infants' brain asymmetry." Canadian Journal of Neurological Sciences, 4, 203-207.

Walsh, T.M. & Diller, K.C. (1978) "Neurolinguistic foundations to methods of teaching a second language." IRAL, 16(1), 1-14.

Walsh, T.M. & Diller, K.C. (1981) "Neurolinguistic considerations on the optimum age for second language learning." in K.C. Diller (ed.) Individual Differences & Universals in Language Learning Aptitude. Rowley, MA: Newbury House.

Washburn, M.F. (1916) Movement and Mental Imagery. Boston: Houghton Mifflin.

Watson, J.B. (1920) "Is thinking merely the action of the language mechanisms?" British Journal of Psychology, 11, 86-104.

Weinberger, S. (1990) "Minimal segments in L2 phonology." in J. Leather & A. James (eds.) New Sounds 90: Proceedings of the Amsterdam Symposium on the Acquisition of Second-Language Speech, pp. 137-179. Amsterdam: University of Amsterdam.

Weinreich, U. (1953) Languages in Contact. The Hague: Mouton.

Weinreich, U. (1957) "On the description of phonic interference." Word, 13, 1-11.

Wexler, K. & Manzini, R. (1987) "Parameters and learnability in binding theory." in T. Roeper & E. Williams (eds.) Parameter Setting. Dordrecht: Reidel.

Whitaker, H.; Bub, D.; & Leventer, S. (1981) "Neurolinguistic aspects of language acquisition and bilingualism." Annals of the New York Academy of Sciences, 379, 59-74.

White, H. (1961) "Cerebral hemispherectomy in the treatment of infantile hemiplegia." Confinia Neurologica, 21, 1-50.

White, L. (1989) Universal Grammar and Second Language Acquisition. Amsterdam: John Benjamins.

Wiese, R. (1984) "Language production in foreign & native languages: Same or different?" pp.11-25 in H.W. Dechert; D. Möhle; & M. Raupach (eds.) Second Language Productions. Tübingen: Gunter Narr Verlag.

Wickelgren, W.A. (1969) "Context-sensitive coding, associative memory, and serial order in (speech) behavior." Psychological Review, 76, 1-15.

Wode, H. (1976) "Developmental sequences in naturalistic acquisition." Working Papers in Bilingualism, 11, 1-31.

Wode, H. (1977) "On the systematicity of L1 transfer in L2 acquisition." in C. Henning (ed.) Proceedings of the Los Angeles Second Language Research Forum, pp.160-169. Los Angeles: Department of English, UCLA.

Wode, H. (1978) "The beginnings of non-schoolroom L2 phonological acquisition." IRAL, 16, 109-125.

Wode, H. (1981) Learning a Second Language, I: An Integrated View of Language Acquisition. Tübingen: Gunter Narr Verlag.

Yakovlev, P.I. (1965) "Morphological criteria of growth and maturation of the nervous system in man." Research Publication of the Association for Nervous and Mental Disease, 39, 3-46.

Young-Scholten, M. (1992) "The subset principle in interlanguage phonology: A preliminary investigation." in J. Leather & A. James (eds.) New Sounds 90, pp.200-217. Amsterdam: University of Amsterdam.

Young-Scholten, M. (1993) The Acquisition of Prosodic Structure in a Second Language. Tübingen: Niemeyer.

Young-Scholten, M. (1994) "On positive evidence and ultimate attainment in L2 phonology." Second Language Research, 10, 3, 193-214.