Journal of Phonetics (1997) **25,** 169–186

Amount of native-language (L1) use affects the pronunciation of an L2

James Emil Flege* and Elaina M. Frieda

University of Alabama at Birmingham, Birmingham, AL 35294-0019, U.S.A.

Takeshi Nozawa

Akashi College of Technology, Akashi-shi Hyogo 674, Japan

Received 25th July 1996, and in revised form 16th December 1996

The purpose of this study was to determine if variation in amount of native language (L1) use influences second language (L2) production accuracy. Native English-speaking listeners auditorily evaluated short English sentences that had been spoken by a group of native English monolinguals and by the subjects in two native Italian (NI) groups. The subjects in the NI groups were matched according to their age of immigration to Canada from Italy (5.9 *vs.* 5.6 years), but differed according to self-reported use of Italian (36% *vs.* 3%). The subjects in both NI groups were found to speak English with detectable foreign accents even though they began learning English as children and had spoken English for 34 years on average. The NI subjects who spoke Italian relatively often had significantly stronger foreign accents than those who seldom spoke Italian. These findings challenge the view that ultimate success in pronouncing an L2 is determined solely by an individual's state of neurological development at the time of first exposure to the L2. It appears that the degree of activation of the L1 or the strength of its representations may also influence L2 production accuracy.

© 1997 Academic Press Limited

1. Introduction

The earlier in life that one begins to learn a second language (L2), the better one is apt to pronounce it (e.g., Suter, 1976; Asher & Garcia, 1969; Oyama, 1979; Purcell & Suter, 1980; Tahta, Wood & Lowenthal, 1981; Thompson, 1991). Robust age-related effects on the pronunciation of an L2 have led some investigators (e.g., Scovel, 1988) to conclude that L2 speech learning must occur during a critical period in order to be fully effective (see Singleton, 1989, for a review). Patkowski (1990) presented data suggesting that the strength of foreign accents increases greatly if L2 learning begins after the age of 15 years. However, based on a review of the findings then available, Long (1990) concluded that an L2 is usually spoken without accent if learning begins by the age of 6 years, *with* a foreign accent if learning begins after

* Author to whom all correspondence should be addressed at: Division of Speech and Hearing, School of Health Related Professions, University of Alabama at Birmingham, VH 503, Birmingham, AL 35294-0019, U.S.A.

0095-4470/97/020169 + 18 $25.00/0/jp960040 © 1997 Academic Press Limited

the age of 12 years, and with *variable success* between the ages of 6 and 12 years. Long's summary, which suggests that the critical period for speech does not end abruptly, was supported by the results of Flege, Munro & MacKay (1995), who found that a linear relation exists between non-natives' age of learning English as an L2 and their degree of perceived foreign accent in English.

Two important questions pertaining to the relation between age and L2 pronunciation accuracy remain unresolved. It is unclear whether especially talented adults or adolescents might learn to speak an L2 without foreign accent in adulthood (compare the results of Bongaerts, Planken & Schils, 1995 to those of Flege *et al.,* 1995). Uncertainty also exists as to *when* in life foreign accents first emerge. Flege (1988) showed that native English-speaking listeners could detect foreign accent in English sentences spoken by Chinese adults who had arrived in the US at an average age of 8 years. Using the same scaling technique and English speech materials, Flege & Fletcher (1992) showed that native English listeners were unable to detect foreign accent in sentences spoken by native Spanish speakers who had all arrived in the US by the age of 6 years. Listeners in the Flege *et al.* (1995) study were able to detect foreign accent in English sentences spoken by Italian adults who had immigrated to Canada prior to the age of 10 years. Interestingly, one of the 10 native English-speaking listeners managed to detect foreign accent in English sentences spoken by a subgroup of native Italian (NI) subjects who had arrived in Canada at an average age of just 3 years.

The most important aim of this study was to test a hypothesis developed as an alternative to the well known Critical Period Hypothesis. (This ''single system'' hypothesis will be presented below.) Another aim of the study was to test further the conclusion that individuals who begin learning their L2 as young children may speak it with a detectable foreign accent. The final aim was to determine if native speakers of American and Canadian English would be equally able to detect foreign accent in English sentences spoken by the non-native subjects, who had learned to speak English in Ottawa, Canada.

English sentences spoken by 40 of the 240 NI subjects from the Flege *et al.* (1995) study were re-examined. The aim of the earlier study was to examine the effect of the age of learning an L2 by comparing 10 subgroups of NI subjects who differed in age of immigration from Italy to Canada. The aim of present study was to assess the role of variations in L1 use. The subjects making up the two groups compared in this study were matched according to their age of immigration to Canada, but differed according to their self-reported use of Italian.

The so-called Critical Period Hypothesis (CPH) is widely viewed as providing an explanation for why many individuals speak their L2 with a foreign accent. The end of a critical period for speech is usually associated with some sort of neurological change (e.g., lost plasticity, hemispheric specialization, or neurofunctional reorganization) thought to arise as the result of normal maturation. Such a change(s) might be expected to occur at roughly the same chronological age in many individuals (e.g., Penfield & Roberts, 1959; Lenneberg, 1967; Scovel, 1969; Lamendella, 1977). The change(s) could conceivably affect the processing and/or storage in long-term memory of information pertinent to the L2 (e.g., Genesee, Hamers, Lambert, Mononen, Seitz & Starck, 1978). The CPH seems to imply that some aspect(s) of the capacity that permits children to learn to pronounce their L1 accurately is reduced or lost beyond the critical period.

There are two problems with the CPH. One problem is that the CPH represents the labeling of a phenomenon (*viz.,* age-related effects on performance in an L2) rather than a true explanation of it. The actual mechanism(s) that deteriorate (or are lost) as the result of maturation are left unspecified. For example, a neurological change(s) might conceivably reduce the ability to add or modify the sensorimotor programs used for producing the vowels and consonants of an L2 (McLaughlin, 1977). Or, it might reduce ability to establish perceptual representations for new vowels and consonants (Flege, 1995; Rochet, 1995).

The other problem is that the CPH is not testable, and so does not actually constitute a hypothesis. As noted by Flege (1987), a great many factors that might conceivably influence speech learning are inevitably confounded with chronological age (the usual surrogate for the underlying neuro-maturational factor(s) thought to precipitate a lost/slowed ability to learn speech). For example, subjects' age of first exposure to an L2 in a predominantly L2-speaking environment may be related to their strength of emotional attachment to the L1 speaking community and/or to their willingness to sound just like members of the L2-speaking culture. To take another example, either length of residence in an L2-speaking environment or chronological age must be confounded in a research design meant to compare groups of subjects differing in their age of arrival in an L2-speaking environment.

Investigators have attempted to develop more readily testable hypotheses. One such attempt might be called the ''exercise hypothesis''. According to this hypothesis, the ability to learn to produce and perceive speech remains intact across the life span, but only if one continues learning speech uninterruptedly (see Bever, 1981; Hurford, 1991). However interesting it might be, this hypothesis may be difficult or impossible to test. It might not be possible to recruit matched groups of subjects who have begun to learn some language, X, at the same age and under similar circumstances but who differ according to whether other languages were learned between L1 acquisition and the time of first exposure to language X.

According to an ''unfolding hypothesis'', foreign accents are the indirect consequence of previous phonetic development, not the result of lost or attenuated speech learning abilities (Oyama, 1979; see also Elman, 1993). For example, the phonetic categories established for vowels and consonants in the L1 may become better defined with age (Flege, 1992*a, b*) and so become ever more likely to ''assimilate'' phonetically different vowels and consonants in an L2 (Best, 1995).[1] The unfolding hypothesis predicts that the more fully developed the L1 phonetic system is at the time L2 learning begins, the more foreign-accented the pronunciation of the L2 will be. A problem exists for the unfolding hypothesis, however. The state of development of the L1 phonetic system is apt to co-vary with maturation and development (and, of course, chronological age). This means that differentiating the unfolding hypothesis from the CPH may be impossible.

The ''single system'' hypothesis described below is testable, however, and will be examined in the present study. The single system hypothesis makes a prediction not made by the CPH (or any other hypothesis we know of). It predicts that the loss of the L1, or its attenuation through disuse (Grosjean, 1982; Romaine, 1995; Paradis,

[1] When this happens, an L2 vowel or consonant may be replaced in production by its perceived ''counterpart'' from the L1, at least in initial stages of L2 learning. Also, the prior existence of phonetic categories in the L1 may inhibit development of categories for the vowels and consonants of the L2.

in press), may reduce the degree of perceived foreign accent in an L2. Put another way, the "less" L1 there is, the smaller will be its influence on the L2 (Dunkel, 1948).

Weinreich (1953) was apparently the first to suggest that the mutual influence of a bilingual's two languages on one another is inevitable. If so, it may be impossible for a bilingual to control two languages in exactly the same way as two separate monolinguals. Indeed, a number of investigators have suggested that it is not appropriate to assess bilinguals in the same way that one assesses monolinguals (Grosjean, 1982). For example, Cook (1995) observed that divergences from monolingual-defined norms for the L1 or the L2 should not be viewed as a failure, as suggested by Selinker (1972), but as the necessary consequence of "multi-competences" in two languages. Cook suggested that, in the aggregate, the multicompetences of a bilingual normally exceed the competence of any one monolingual. Mack (1986, p. 464) noted that although early bilinguals may be quite fluent in both of their languages, the way they process language may differ from that of monolinguals because of a "pattern of linguistic organization that is unlike that of a monolingual" (see also Weber-Fox & Neville, 1992; Neville, Mills & Lawson, 1992).

According to the single system hypothesis, bilinguals are unable to fully isolate the L1 and L2 phonetic systems, which necessarily interact with one another. The L1 and L2 systems may, of course, form constrained subsystems that can be activated and deactivated to varying degrees (Paradis, 1993). This is what permits different modes of pronunciation in the L1 and L2. However, according to the single system hypothesis, the phonic elements of the L1 subsystem necessarily influence phonic elements in the L2 system, and vice versa. The nature, strength, and directionality of the influence may vary as a function of factors such as the number and nature of categories established for phonic elements of the L1 and L2, the amount and circumstances of L1 and L2 use, language dominance, and so on (see, e.g., Anisfeld, Anisfeld & Semogas, 1969; Macnamara, 1973; Ho, 1986; Cutler, Mehler, Norris & Segui, 1989; Flege, 1995).

As mentioned earlier, the primary aim of this study was to determine if degree of perceived foreign accent in an L2 depends on the amount of L1 use. The two groups of NI subjects whose pronunciation of English sentences were compared began learning English at the same ages but differed significantly in how much they continued to speak Italian. The single system hypothesis would receive support if the "HiUse" subjects (who spoke Italian frequently) but not the "LoUse" subjects (who spoke Italian seldom) were found to have detectable foreign accents in English. It would also be supported if English sentences spoken by the HiUse subjects were found to have stronger foreign accents than sentences spoken by the LoUse subjects. Either (or both) findings would indicate that some factor other than, or in addition to, neurological maturation at the time L2 learning begins has an influence on non-natives' ultimate degree of success in pronouncing their L2.

2. Method

2.1. *Speech materials*

Flege *et al.* (1995) found that the foreign accent ratings of native English listeners accorded five short English sentences were equally revealing of foreign accent.

Therefore, in order to reduce the size of the foreign accent rating task, just three of the five original sentences (*viz., Paul ate carrots and peas, I can read this for you, The good shoe fit Sue*) were examined in the present study.

2.2. *Talkers*

All 60 of the subjects examined here were drawn from the Flege *et al.* (1995) study, which compared sentences spoken by 24 native English (NE) subjects to sentences spoken by 10 groups of NI subjects defined on the basis of age upon arrival in Canada. All 264 (240 NI + 24 NE) subjects were recorded in a quiet room in a Roman Catholic church in Ottawa. The use of a directional head-mounted microphone (Shure Model SM10A) provided recordings suitable for auditory evaluation and acoustic analyses.

Three groups of subjects, each with 10 males and 10 females, were formed for the present study. The subjects in one group were native English (NE) speakers from Ontario. The 40 subjects in two NI groups had all been born in Italy and immigrated to Canada between the ages of 2.6 and 9.6 years. NI subjects from the previous study were re-assigned to new groups in such a way that the subjects in the two new NI groups were matched for age of arrival in Canada but differed to the greatest extent possible (while maintaining gender balance) according to self-reported percentage use of Italian.

Characteristics of the three groups are summarized in Table I. The HiUse NI subjects reported using Italian significantly more often than did the LoUse subjects (36% *vs.* 3%) [$F(1,38) = 120.8,\ p < 0.001$],[2] but subjects in these groups did not differ significantly in chronological age [$F(1,38) = 3.34,\ p > 0.05$] or their age upon arrival in Canada [$F(1,38) = 0.301,\ p > 0.10$]. It is likely that English was the dominant language of many of the 40 NI subjects. Thirty-eight reported using English 50% of the time or more. Most of the subjects (17 HiUse subjects, all 20 LoUse subjects) indicated that English was the better of their two languages. When asked which of their two languages they would retain if only one language could be spared, 13 HiUse subjects and 16 LoUse subjects chose English.

Table I also reports the mean foreign accent ratings that were obtained by Flege *et al.* (1995) for the 60 subjects examined here. In the previous study, native English-speaking listeners used a continuous scale that ranged from ''strongest foreign accent'' to ''Native English—no foreign accent'' to rate English sentences spoken by a total of 264 subjects (those re-examined here plus 204 others). The listeners indicated their judgments by moving the lever on a response box to an appropriate position. Based on the lever's position, a value ranging from 0 to 255 was stored on the PC used for testing. (The listeners were unaware of the actual numerical values.)

A post-hoc ANOVA was carried out to examine the mean ratings obtained for the 60 subjects making up the three groups newly formed for the present study. It yielded a significant effect of Group [$F(2, 57) = 10.49,\ p < 0.001$]. A Tukey's test

[2] The HiUse subjects had lived for a shorter period of time in Canada than had the LoUse subjects [32.4 *vs.* 35.9 years, $F(1, 38) = 120.8,\ p < 0.001$]. However, there was no correlation between the subjects' length of residence (LOR) in Canada and the foreign accent scores obtained previously for them ($r = 0.12,\ \mathrm{df} = 38,\ p = 0.943$) nor, as will be shown below, between variations in LOR and the results obtained in the present study.

TABLE I. Characteristics of the native English (NE) subjects and the two native Italian groups (LoUse, HiUse) who participated. There were 10 male and 10 female subjects in each group. All time intervals are expressed in years

		% Use of Italian	Chronological age	Age of arrival	Age of exposure	Length of residence	Foreign accent[a]
NE	*M*	—	39	—	—	—	225
	SD	—	(8)	—	—	—	(13)
	range	—	27–55	—	—	—	196–241
LoUse	*M*	3%	42	5.6	5.9	36	203
	SD	(2)	(5)	(2.0)	(1.8)	(5)	(27)
	range	0–5%	32–53	2.6–9.6	3.2–9.6	26–44	135–234
HiUse	*M*	36%	38	5.9	6.2	32	191
	SD	(13)	(6)	(2.3)	(2.1)	(6)	(29)
	range	15–60%	25–45	2.6–9.5	2.6–9.5	18–41	125–244

[a] Foreign Accent, mean ratings obtained using a continuous scale by Flege *et al.* (1995). See text for explanation.

revealed that the LoUse and HiUse subjects' sentences received significantly lower ratings ($M = 203, 191$) than did the NE subjects' sentences ($M = 225$) ($p < 0.01$). Sentences spoken by the LoUse and HiUse subjects did not differ significantly ($p > 0.10$), but this does not necessarily mean that they produced the English sentences with equal accuracy. Foreign accent ratings are subject to range effects (Flege & Fletcher, 1992). The listeners may have overlooked detectable between-group differences because sentences spoken by the HiUse and LoUse subjects were presented along with sentences spoken by NI subjects having much stronger foreign accents.

All 240 NI subjects in the original study, including the 40 re-examined here, responded to a language background questionnaire (LBQ). The LBQ consisted mainly of seven-point equal appearing interval (EAI) scale items. The HiUse and LoUse subjects' responses to four items pertaining to language use are summarized in Table II. The HiUse subjects reported using Italian more, and English less, than did the LoUse subjects. Not surprisingly, the subjects' responses to questions pertaining to how often they used Italian in the home, at work, and in social situations were inversely correlated with their responses to the same questions asked with respect to the use of English ($r = -0.580$, $\mathrm{df} = 38$, $p < 0.01$).

The HiUse and LoUse subjects' use of Italian in the home differed. Fewer HiUse than LoUse subjects (4 *vs.* 13) reported sharing a household with one or more native speakers of English. The HiUse and LoUse subjects' reported use of Italian with relatives their own age or older (5.1 *vs.* 4.4 on a scale ranging from "never" to "often") did not differ significantly ($p > 0.10$), but the HiUse subjects reported using Italian less with their younger relatives than did the LoUse subjects (3.5 *vs.* 1.8; $p < 0.01$).[3] Also, the HiUse subjects reported using Italian significantly more with their closest friend(s) than did the LoUse subjects (3.0 *vs.* 1.5; $p < 0.01$), and had spent somewhat more time in Italy subsequent to their immigration to Canada than had the LoUse subjects (13 *vs.* 3 months; $p < 0.10$).

[3] The statistical results reported here and below for tests of differences between the HiUse and LoUse subjects were obtained in one-way ANOVAs with 1 and 38 degrees of freedom.

TABLE II. The mean responses obtained from two groups of native Italian (NI) subjects in response to seven-point rating scale items. "Prob." indicates the significance of *F*-tests carried out to examine differences between NI subjects who used Italian seldom (LoUse) or relatively often (HiUse)

	In English			In Italian		
LBQ Item	LoUse	HiUse	Prob.	LoUse	HiUse	Prob.
Language use						
At home	6.5	4.1	0.001*	2.1	5.1	0.001*
At work/school	6.8	5.9	0.017*	1.2	2.3	0.005*
In social situations	5.8	5.3	0.133	2.7	4.0	0.003*
In past 5 years	6.3	5.7	0.015*	3.0	4.8	0.001*
Mean	6.4	5.3		2.3	4.1	
Language ability						
Pronunciation ability-Q1	6.0	5.5	0.819	2.7	4.7	0.001*
Pronunciation ability-Q2	6.6	6.4	0.515	3.2	5.6	0.001*
Perceptual recall ability	6.6	6.0	0.089	3.5	5.0	0.005*
Ability to speak on telephone	6.7	6.6	0.818	4.4	5.1	0.255
Mean	6.5	6.1		3.5	5.1	

Note: Some items were reversed so that larger numbers always correspond to greater use or ability.

The HiUse and LoUse subjects' control of Italian was not evaluated. However, the LBQ items summarized in Table II suggest that the HiUse subjects pronounced Italian better than did the LoUse subjects. The subjects were asked in two differently worded items (Q1 and Q2) to assess their own ability to pronounce English and Italian. The HiUse subjects rated their Italian pronunciation ability more highly than did the LoUse subjects, but the two groups' self-ratings for English did not differ significantly ($p > 0.10$). The subjects were also asked to evaluate their ability to remember how words are prounced in English and Italian (designated "perceptual recall ability"). The HiUse subjects gave themselves significantly higher ratings than did the LoUse subjects for Italian but not English. (The two groups' self-estimated ability to speak Italian over the telephone did not differ significantly.)

The two groups of NI subjects seem to have had similar experiences learning English. Only one of the 40 subjects—a member of the HiUse group—reported having received special instruction in English beyond the regular classes in English language provided to all students in school. The HiUse and LoUse subjects did not differ significantly in the time that elapsed between the time of their arrival in Canada and the time they began hearing and trying to use English (0.24 *vs.* 0.35 years). Nor were there differences in how long the HiUse and LoUse subjects estimated it had taken them to reach the point of being able to speak English "comfortably" (1.5 *vs.* 1.4 years), how often they sought out special opportunities to practice English (2.7 *vs.* 2.6), or how much they wanted to sound "just like" native speakers of English (3.5 *vs.* 2.7) ($p > 0.10$).

In summary, the HiUse and LoUse subjects were drawn from the same community of Italian immigrants living in Ottawa, Canada. The subjects in these two groups seem to have had similar experiences learning English as an L2. English was used frequently, and was clearly of great importance for all of the NI subjects. The

primary differences between the HiUse and LoUse subjects appears to have been how often, and probably how well, they spoke Italian.

2.3. *Listeners*

The 10 native speakers of Canadian English who rated sentences in the study by Flege *et al.* (1995) differed in their sensitivity to the presence of foreign accent. Some—but not all—of them detected foreign accent in English sentences spoken by NI subjects who arrived in Canada as young children. According to Long (1990), a heterogeneous speech community exists in Ottawa because of immigration, creating ''tolerance for . . . within-language variation'' which may make Ottawans reluctant to judge English sentences to be foreign accented. This observation raises the question of whether the results obtained for one group of listeners will generalize to another group of native English-speaking listeners.

Two techniques were used to assess the generalizability of the results obtained here. First, we carried out ''listener analyses'' that were analogous to the ''item analyses'' common to psycholinguistic research. In these analyses, a mean value for all of the subjects within a group was obtained for each listener. Second, data were obtained from two groups of native English-speaking listeners who spoke different dialects of English. All but one of the 12 individuals in the ''American'' listener group had been born and raised in Alabama. All 12 ''Canadian'' listeners came from Ontario, the province in which the speech samples under evaluation were obtained.[4]

All 24 listeners were living in Birmingham, Alabama, when they were asked to auditorily evaluate sentences spoken by the three groups of talkers. The American and Canadian listeners were matched for age [30.1 *vs.* 29.6 years; $F(1, 22) = 0.101$, $p > 0.10$] and gender (there were 3 males and 9 females in each group). Each listener passed a pure-tone hearing screening at octave intervals between 500 and 4000 (ref: 25 dB HL) before participating.

The hearing acuity of the two groups of listeners was assessed more thoroughly several days after the foreign accent experiment. The Test of Basic Auditory Capabilities (Christopherson & Humes, 1992), which consists of eight 72-item subtests (six examining tonal or temporal discrimination, and two examining speech sounds) was administered to each listener. The scores were submitted to a (2) Listener Group $\times$ (8) Subtest ANOVA. The percent correct scores obtained for the American and Canadian listeners (80.4%, 81.9%) did not differ significantly [$F(1, 22) = 0.46$, $p > 0.10$]. Thus, if a difference between the two groups of listeners were found to exist, it probably could not be attributed to differences in auditory acuity.

The two groups of listeners did differ in other ways, however, as indicated by one-way ANOVAs[5] examining their responses to seven-point EAI scale items on a questionnaire. The Canadian listeners reported being more familiar with the English spoken in Ottawa than did the American listeners ($p < 0.01$). The population of Alabama is more homogenous than that of Ottawa. Not surprisingly, the Canadians reported having been exposed to a wider variety of foreign accents than did the Americans ($p < 0.01$). They also reported having heard Italian-accented English

[4] Just one of the Canadians was from Ottawa, however.

[5] The one-way ANOVAs testing for differences between the two groups of listeners had 1 and 22 degrees of freedom.

more often than the Americans (4.5 *vs.* 2.3; $p < 0.01$).[6] The Canadian and American listeners did not differ, however, in self-reported musical ability (3.6 *vs.* 3.9), ability to mimic accents (3.1 *vs.* 3.3), or ability to learn new forms of pronunciation (4.6 *vs.* 4.2) ($p > 0.10$).

2.4. *Procedure*

The listeners were tested one at a time in a sound booth, where they heard sentences binaurally over headphones at a comfortable level. The three English sentences being evaluated were presented in separate blocks, the order of which was counterbalanced across the listeners in the American and Canadian groups. The listeners were told that some of the English sentences had been spoken by native speakers of Italian, and that their job was to judge the language background of each talker. The listeners were told to push one of four buttons marked ''definitely Italian'', ''probably Italian'', ''probably English'', and ''definitely English'' after hearing each sentence. The interval between each response and the presentation of the next sentence was 1.5 s.

All analyses focused on the listeners' responses to the final three presentations of each sentence. (The listeners' responses to the first random presentation of the 60 sentences in each block were just for practice.) Two types of analyses were undertaken. In one type, the four buttons were assigned values 1, 2, 3, and 4 so as to form a scale ranging from least English-like to most English-like. In the other type, the experiment was treated as a foreign accent detection task. Here, use of buttons 1 and 2 (''definitely Italian'' and ''probably Italian'') for sentences spoken by NI subjects was counted as hits, and the use of the same two buttons for sentences spoken by NE subjects was counted as false alarms.

3. Results

3.1. *Foreign accent ratings*

In this section, the listeners' responses are treated as ratings of degree of foreign accent along a scale that ranged from ''definitely Italian'' (1) to ''definitely English'' (4). Separate ''talker'' and ''listener'' analyses were undertaken. Two scores were calculated for each talker for the talker analysis, each based on the judgments of 12 listeners in a group (Americans or Canadians). Each talker-based mean was based on 108 judgments (12 listeners $\times$ 3 sentences $\times$ 3 replicate judgments). As shown in Fig. 1, similar differences for the three groups of talkers were obtained from the American and Canadian listeners. For both groups of listeners, the ratings were highest for the NE subjects, somewhat lower (less English-like) for the LoUse subjects, and lower still for the HiUse subjects.

The talker-based ratings were submitted to a (2) Listener Group $\times$ (3) Talker Group ANOVA. Neither the main effect of Listener Group [$F(1, 114) = 1.63$, $\mathrm{MSE} = 0.466$, $p > 0.10$] nor the two-way interaction reached significance

[6] The Canadians reported being more aware of difference in the speech characteristics of several pairs of North American cities than did the American listeners ($p < 0.01$), and being somewhat better able to recognize differences between various kinds of foreign accents in English such as French- *vs.* German-accented English ($p = 0.091$).

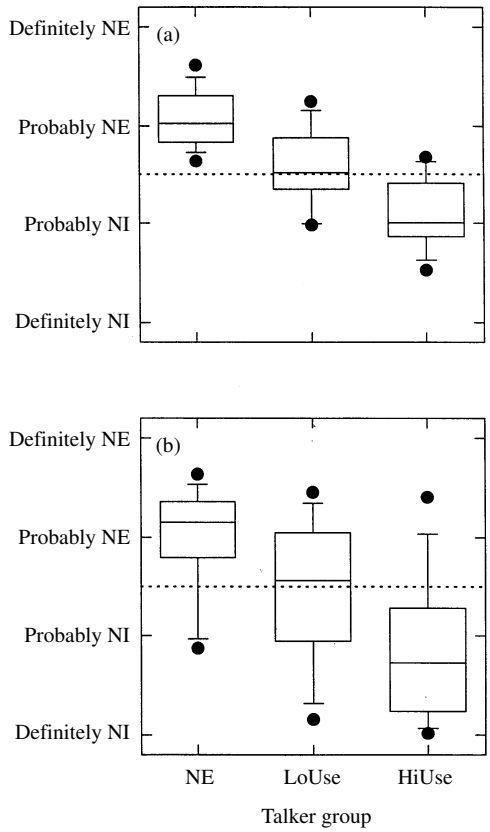


Figure 1. The mean ratings (a) by American listeners and (b) by Canadian listeners of English sentences spoken by native English (NE) subjects or by native Italian (NI) speakers who spoke Italian seldom ("LoUse") or relatively often ("HiUse"). The listeners indicated whether English sentences had "definitely" or "probably" been spoken by a NE or NI speaker. The vertical lines indicate the 50th percentile (median) of the ratings for each group (upper and lower edges = 25th and 75th percentiles, bars = 10th and 90th percentiles, filled circles = 5th and 95th percentiles).

$[F(2, 114) = 0.10,\ \text{MSE} = 0.466,\ p > 0.10]$, suggesting that the Canadian listeners were no better at scaling foreign accent than were the American listeners. However, the Talker Group factor did reach significance $[F(2, 114) = 24.02,\ \text{MSE} = 0.466,\ p < 0.001]$ because, as revealed by a Tukey's test, all pairwise differences between the three groups of talkers (NE = 3.03, LoUse = 2.49, HiUse = 1.97) were significant ($p < 0.01$).

The listener-based ratings were obtained by averaging over the 20 talkers in a group, once for each of the 24 listeners. The three mean ratings obtained for each listener (one each for the NE, HiUse, and LoUse groups) were each based on 180 judgments (20 talkers per group $\times$ 3 sentences $\times$ 3 replicate judgments). When the listener-based mean ratings were examined in a (2) Listener Group $\times$ (3) Talker Group ANOVA, the results were similar to those obtained for the talker-based ratings. The effect of Listener Group was marginally significant $[F(1, 66) = 3.38,\ \text{MSE} = 0.134,\ p = 0.071]$ and the two-way interaction was nonsignificant $[F(2, 66) =$

0.21, MSE = 0.134, $p > 0.10$]. However, the Talker Group factor was again significant [$F(2, 66) = 49.98$, MSE = 0.134, $p < 0.001$] because all pairwise differences between the three groups of talkers (NE = 3.03, LoUse = 2.49, HiUse = 1.97) were significant ($p < 0.01$).

3.2. *Foreign accent detection*

The foregoing analyses suggested that, contrary to expectation, the Canadian listeners were no more able than were the American listeners to scale foreign accent in sentences spoken by the NI subjects. However, inspection of Fig. 1 reveals that a few Canadian listeners, but no American listener, incorrectly identified sentences spoken by NE subjects as having been spoken by a NI subject. Thus, although the Canadian and American listeners received identical instructions, they may have shown different response biases, which may have obscured a difference between them.

Additional analyses were therefore undertaken in which the experiment was treated as a foreign accent detection task. A′ scores were computed for both talkers and listeners (see above) based on the proportion of hits and false alarms. A′ is an analog of d′ from the Theory of Signal Detection that does not require a large number of responses. Its use as a dependent variable was preferred over percent correct scores or mean ratings because it provides an *unbiased* measure of perceptual sensitivity. The formula of Snodgrass, Levy-Berger & Haydon (1985) was used to compute the A′ scores. Sentences produced by native Italian speakers that were labeled ''definitely'' or ''probably Italian'' were counted as hits. Sentences spoken by native English speakers that were incorrectly labeled ''Italian'' were counted as false alarms.

In the talker analysis, six A′ scores (3 sentences × 2 listener groups) were computed for each talker. The maximum number of both hits and false alarms was 36 (12 listeners × 3 replicate judgments). The A′ scores obtained for the American and Canadian listeners are shown in Fig. 2. For all three sentences (and both listener groups), the A′ scores are higher for the HiUse than for the LoUse subjects. This means that the listeners were more sensitive to non-native characteristics in the HiUse subjects' sentences than in the LoUse NI subjects' sentences. The A′ scores were also somewhat higher for sentence 3 (*The good shoe fit Sue*) than for the other two sentences that were examined.

The 240 talker-based A′ scores were examined in a (2) talker Group × (2) Listener Group × (3) Sentence ANOVA with repeated measures on the Sentence factor. The difference in A′ scores obtained for the HiUse and LoUse subjects (0.749 *vs.* 0.622) was significant [$F(1,76) = 9.38$, MSE = 0.104, $p < 0.01$]. This finding indicates that the listeners were more sensitive perceptually to non-native characteristics in sentences spoken by the HiUse than by the LoUse subjects. The difference between the American and Canadian listeners (0.672 *vs.* 0.699) was non-significant [$F(1, 76) = 0.42$, MSE = 0.104, $p > 0.10$]. The Sentence factor was significant [$F(2, 152) = 7.64$, MSE = 0.012, $p < 0.01$] because, as revealed by a Tukey's post-hoc test, the A′ scores for *The good shoe fit Sue*[7] were signficantly higher than those for the other two English sentences ($p < 0.01$). No significant two- or three-way interaction was obtained in the analysis of the talker-based A′ scores.

[7] The close proximity of /ʃ/ and /s/, both of which occur in Italian, may have constituted a kind of tongue twister in this sentence.

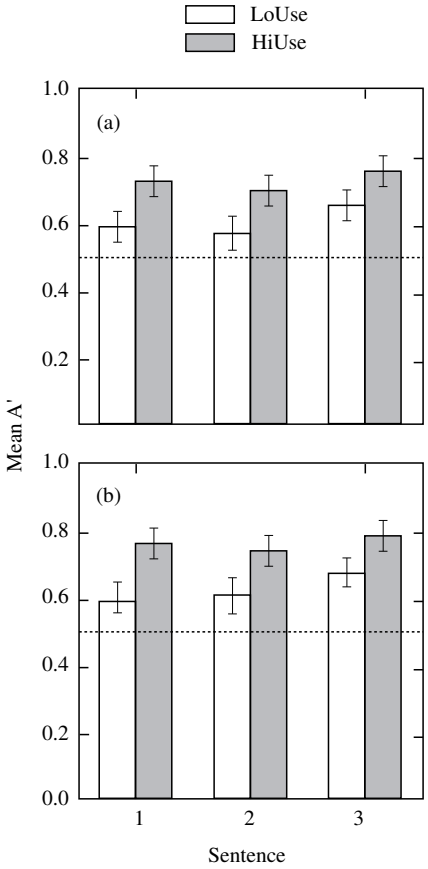


Figure 2. The mean A′ scores calculated from the judgments by (a) American and (b) Canadian listeners of sentences spoken by native Italian speakers who used Italian either seldom (“LoUse”) or relatively often (“HiUse”). An A′ value of 0.5 or lower indicates that listeners were unable to detect non-native characteristics in the English sentences they were hearing (see text). The brackets enclose +/−1.0 standard error.

The lack of a significant Listener Group effect does not necessarily mean that the Canadian and American listeners performed the accent detection task equivalently, for the talker-based A′ scores were not optimally suited for identifying a difference. It was necessary to use the responses for *all 20* native English talkers to establish a false alarm rate when computing the talker-based A′ scores. The hit rate, however, was based on the responses obtained from each individual native Italian talker.[8] In computing listener-based A′ scores, on the other hand, the hit and false alarm rates were balanced.[9]

[8] It would have been inappropriate to use the false alarm rate of, say, NE talker 3 when calculating the A′ score for LoUse talker 3 because the talkers in the various groups were not matched in any rational fashion.

[9] In computing listener-based scores, the false alarm rate was based on how many times (maximum = 60) a *particular listener* incorrectly judged sentences that were spoken by the 20 NE subjects to have been spoken by a native speaker of Italian. The hit rate was based on the number of times (maximum = 60) that the same listener correctly judged sentences that had been spoken by the 20 talkers in one of the NI groups to have been produced by a native speaker of Italian.

The six listener-based A′ scores that were obtained for each listener (2 talker groups × 3 sentences) were submitted to a (2) Talker Group × (2) Listener Group × (3) Sentence ANOVA. This analysis yielded a significant main effect of Talker Group [$F(1, 44) = 59.4$, MSE = 0.008, $p < 0.01$] because the A′ scores were higher for the HiUse than the LoUse talkers (0.784 *vs.* 0.673). As before, the Sentence factor reached significance [$F(2, 88) = 21.3$, MSE = 0.003, $p < 0.01$] but not any two-way or three-way interaction ($p > 0.05$). In the listener analysis, however, the difference between the Canadian and American listeners (0.744 *vs.* 0.713) did reach significance [$F(1, 44) = 4.45$, MSE = 0.008, $p < 0.05$]. This indicates that the Canadian listeners were perceptually more sensitive to non-native characteristics in sentences spoken by the NI subjects living in Ottawa than were the American listeners.

The A′ analyses presented earlier indicated that the HiUse and LoUse subjects differed significantly, but these analyses did not demonstrate directly that either group had a foreign accent. It was not possible, as in the analyses of ratings (see above) to directly compare the HiUse and LoUse subjects to the NE subjects. This is because the judgments of the NE subjects' sentences were needed to establish the false alarm rates needed to compute the A′ scores. A series of *t*-tests was therefore carried out.

An A′ score of 0.5 is obtained when hit and false alarm rates are equal. Such a score can be interpreted as showing a lack of perceptual sensitivity by listeners to the presence of non-native characteristics. A total of eight *t*-tests were carried out to test the significance of differences in mean A′ scores from 0.5, one each for listener-based and talker-based A′ scores obtained for all possible combinations of the two talker and the two listener groups. The results of these tests are summarized in Table III. The mean A′ scores differed significantly from 0.5 in all eight instances. This means that the sentences spoken by both the LoUse and the HiUse subjects had detectable foreign accents.

TABLE III. Summary of *t*-tests comparing the difference of mean A′ scores from 0.5, a value indicating a lack of perceptual sensitivity to the presence of foreign accent

Talker-based

Talkers	Listeners	Mean A′	N	*t*	Prob.
LoUse	Americans	0.611	20	2.71	0.014
LoUse	Canadians	0.632	20	3.00	0.007
HiUse	Americans	0.733	20	5.79	0.001
HiUse	Canadians	0.766	20	6.46	0.001

Listener-based

Talkers	Listeners	Mean A′	N	*t*	Prob.
LoUse	Americans	0.661	12	9.67	0.001
LoUse	Canadians	0.685	12	14.23	0.001
HiUse	Americans	0.766	12	15.65	0.001
HiUse	Canadians	0.802	12	30.30	0.001

Four additional analyses were carried out to provide additional insight into the question of when in life foreign accents first appear (see Introduction). Listener-based A′ scores were computed based on the judgments of all 24 listeners. The purpose of the first *t*-test was to determine if the A′ scores obtained for all 40 NI subjects differed significantly from 0.5. The second test examined the A′ scores obtained for the 30 NI subjects who arrived earliest in Canada. These subjects had an average age of arrival (AOA) of 4.8 years (range = 2.6 to 7.4 years). The next test examined the 20 earliest-arriving NI subjects (mean AOA = 4.0 years, range = 2.6 to 5.5 years), and the final *t*-test examined the 10 earliest arriving NI subjects (mean AOA = 3.2 years, range = 2.6 to 3.9 years). In *all* four analyses, the mean A′ scores differed significantly from 0.5 (*t*-values ranging from 3.21 to 5.74, $p < 0.005$). This suggests that bilinguals may speak their L2 with a slight but detectable accent no matter how early in life they began to learn the L2.

3.4. *Regression analyses*

Regression analyses were carried out in an attempt to account for variance in the native English-speaking listeners' perceptual evaluations of sentences spoken by the 40 NI subjects. Two multiple regression analyses examined talker-based ratings obtained from the American and Canadian listeners; two others examined talker-based A′ scores obtained for the two listener groups. Although little variance was accounted for, one finding supported the view that the NI subjects' ability in Italian was related to how accurately they produced the English sentences.

The predictor variables in the regression analyses were percent use of Italian, age of arrival and length of residence in Canada, and self-reported ability in English and Italian. The analyses examining A′ scores did not succeed in predicting a significant amount of variance ($p > 0.10$). Analyses examining the ratings were slightly more successful. The analysis of the Americans' ratings accounted for a significant 13% of variance ($p < 0.01$). AOA was the single variable entered into the model. The analysis of the Canadians' ratings was somewhat more successful. AOA was entered as the first variable, accounting for 13% of the variance. Self-reported ability in Italian was entered at Step 2, accounting for a significant 9% of additional variance ($p < 0.01$).

4. Discussion

This study yielded three findings. First, and most importantly, the native Italian subjects who continued to speak their L1 relatively often (the ''HiUse'' NI subjects) had significantly stronger foreign accents in English than did the subjects who seldom spoke Italian (the ''LoUse'' NI subjects). Second, although both NI groups were comprised of individuals who began learning English in childhood, the subjects in both groups were found to have detectable foreign accents.

These findings challenge the Critical Period Hypothesis (CPH). It is often said that the critical period for speech ends at the age of 12 or 15 years (e.g., Scovel, 1988; Patkowski, 1990). Subjects in the two NI groups were first exposed to English

at an average age of 5.8 years. At this age, certain aspects of the Italian phonological/phonetic system may not have been fully acquired (see Kuijpers, 1996). However, the subjects in both NI groups were found to have detectable Italian accents in their productions of three short English sentences. Further, a post-hoc analysis indicated that subjects who had arrived in Canada at an average age of 3.2 years had a detectable foreign accent. It must be acknowledged, however, that the foreign accents noted here were very mild, and might not be readily evident in non-laboratory conditions. Perhaps the view that a critical period for speech ends at the age of 12 or 15 years would receive support if just foreign accents that were sufficiently strong to reduce comprehensibility (Munro & Derwing, 1995) or intelligibility were considered.

Our results agree with the results obtained by Mack (1986) in the semantic and syntactic domains. They suggest that early bilinguals—no matter how fluent in the L2—may be observed to differ from monolinguals if their performance is scrutinized closely. The results obtained here are reminiscent of those obtained by Altenberg & Cairns (1983). Their analysis of bilinguals' judgments of phonotactic acceptability suggested that two sets of phonotactic constraints may be ''activated'' even when one of those sets is ''unnecessary and inappropriate'' (p. 185). Based on results obtained using different experimental procedures, Grosjean (e.g., 1982, in press) concluded that a bilingual's two language systems are always activated to some degree (see also Mägiste, 1979).

According to the CPH, an individual's state of neurological maturation at the time of first exposure to the L2 determines how accurately the L2 will be pronounced. All 40 of the NI subjects examined in the present study had lived in Canada for at least 18 years ($M = 34$ years). The ''HiUse'' and ''LoUse'' subjects differed primarily according to how often they spoke Italian (36% *vs.* 3%). The subjects in the HiUse and LoUse groups had arrived in Canada at the same ages (all before the age of 10 years), so it would be reasonable to assume that they had reached the same state of neurological maturation at the time of their first exposure to English. However, the HiUse subjects had significantly stronger foreign accents than did the LoUse subjects. This strongly suggests that an individual's state of neurological development is not the only—or necessarily the most important—determinant of how accurately an L2 will ultimately be pronounced.

This is the first study, to our knowledge, to have assessed the effect of amount of L1 use on performance in an L2. The findings of this study must be confirmed by additional research if the conclusion that amount of L1 use influences non-natives' L2 pronunciation is to be fully accepted. We can suggest several improvements that might be introduced to the design of future studies. First, this was a retrospective study. English sentences from the Flege *et al.* (1995) study were re-examined, so there was no opportunity to evaluate objectively the NI subjects' control of Italian. The HiUse subjects' self-reports on a questionnaire suggested that they spoke Italian better than the LoUse subjects. Between-group differences in L1 ability should be assessed formally in future studies. Responses to several other questionnaire items suggested that the HiUse and LoUse subjects did not differ significantly according to additional factors that might influence L2 pronunciation accuracy (e.g., motivation to sound native-like in English, mimicry ability, and so on). These variables should also be assessed more formally and precisely.

Related questions pertain to how best to assess bilinguals' amount of L1 use. Should *listening* to the L1 be evaluated as well as the amount of time spent *speaking* the L1? Should recent use of the L1 be weighted more heavily than earlier use of the L1? Finally, is the aggregate amount of L1 use over a bilingual's entire life more important than use of the L2 in the period immediately preceding a test and, if so, how should it be quantified?[10] One way to assess the relative importance of various L1 use variables would be to assess each for a large population of bilinguals, then determine which of the variables accounts for the largest amount of variance in L2 performance scores.

The questions just raised are of more than just methodological interest. Indeed, answers to these questions might lend insight into the underlying basis of the L1 use effect reported here. If the L1 and L2 necessarily interact (e.g., Weinreich, 1953; Grosjean, 1982; Cook, 1995), then the amount of recent L1 use may be less important than is bilinguals' overall competence in the L1 or their aggregate lifetime use of the L1. If the timing of L2 acquisition determines how a bilingual's linguistic systems will be organized (Mack, 1986), then the amount of early L1 use may be more important than is recent L1 use. However, if one conceives of the L1 and L2 as subsystems that can be selectively activated and deactivated (Paradis, 1993), then recent L1 use may be more important than the aggregate lifetime use of the L1 (or the amount of L1 use at the time the L2 was first being learned).

The third finding of interest pertained to listeners' ability to detect and scale foreign accent. Native English-speaking listeners from Ontario were found to be better able to detect foreign accent in sentences spoken by the NI subjects than were native English-speaking listeners from Alabama. However, although the difference between the two groups of listeners was significant in the most sensitive (and appropriate) of the four analyses carried out, the difference was small, perhaps because of countervailing factors. The Canadians' greater familiarity with the target L2 may have given them an advantage over the Alabamians. However, if Long (1990) is correct in saying that ''tolerance'' induced by exposure to many speech varieties lessens listeners' ability to detect foreign accent, then the Canadians' familiarity with a wider range of dialects and foreign accents than the listeners from Alabama may have worked to their disadvantage.

In summary, the results obtained here corroborate Mack's (1986) view that early bilingualism does not ensure ''monolingual-like linguistic performance''. While the results do not disprove the existence of a critical period, they indicate that the passing of a critical period is not sufficient in itself to explain all aspects of non-nativeness in the speech of individuals who have learned English as an L2. The most important difference between the native Italian and English subjects in this study may not have been the ages at which they were first exposed to English, but rather the presence of another language subsystem for the native Italian subjects.

This research was supported by a grant (DC00257) from the National Institute for Deafness and Other Communicative Disorders. The authors thank Ian MacKay and Murray Munro for help obtaining the recordings used here, and Grace Yeni-Komshian for discussion.

[10] Kempe & MacWhinney (1996) suggest that the results of a lexical decision task may provide a better estimate of the overall amount of experience in an L2 than a measure such as length of residence in a predominantly L2-speaking environment.

References

Altenberg, E. & Cairns, H. (1983) The effects of phonotactic constraints on lexical processing in bilingual and monolingual subjects, *Journal of Verbal Learning and Verbal Behavior,* **22**, 174–188

Anisfeld, M., Anisfeld, E. & Semogas, R. (1969) Cross-influences between the phonological systems of Lithuanian-English bilinguals, *Journal of Verbal Learning and Verbal Behavior,* **8**, 257–261

Asher, J. & Garcia, R. (1969) The optimal age to learn a foreign language, *The Modern Language Journal,* **53**, 334–341

Best, C. (1995) A direct realist view of cross-language speech perception. In *Speech perception and linguistic experience: theoretical and methodological issues* (W. Strange, editor), pp. 171–206. Timonium, MD: York Press

Bever, T. (1981) Normal acquisition processes explain the critical period for language learning. In *Individual differences and universal in language learning aptitude* (K. Diller, editor), pp. 176–198. Rowley, MA: Newbury House

Bongaerts, T., Planken, B. & Schils, E. (1995) Can late learners attain a native accent in a foreign language? A test of the Critical Period Hypothesis. In *The age factor in second language acquisition* (D. Singleton & Z. Lengyel, editors), pp. 30–50. Clevedon: Multilingual Matters

Christopherson, L. & Humes, L. (1992) Some psychometric properties of the Test of Basic Auditory Capabilities (TBAC), *Journal of Speech and Hearing Research,* **35**, 929–935

Cook, V. (1995) Multicompetence and effects of age. In *The age factor in second language acquisition* (D. Singleton & Z. Lengyel, editors), pp. 51–66. Clevedon: Multilingual Matters

Cutler, A., Mehler, J., Norris, D. & Segui, J. (1989) Limits on bilingualism, *Nature,* **340**, 229–230

Dunkel, H. (1948) *Second language learning.* Boston: Ginn & Company

Elman, J. (1993) Learning and development in neural networks: the importance of starting small, *Cognition,* **48**, 71–99

Flege, J. E. (1987) A critical period for learning to pronounce foreign languages? *Applied Linguistics,* **8**, 162–177

Flege, J. E. (1988) Factors affecting degree of perceived foreign accent in English sentences, *Journal of the Acoustical Society of America,* **84**, 70–79

Flege, J. E. (1992*a*) The intelligibility of English vowels spoken by British and Dutch talkers. In *Intelligibility in speech disorders: theory, measurement, and management* (R. Kent, editor), pp. 157–232. Amsterdam: John Benjamins

Flege, J. E. (1992*b*) Speech learning in a second language. In *Phonological development, models, research, and applications* (C. Ferguson, L. Menn & C. Stoel-Gammon, editors), pp. 565–604. Parkton, MD: York Press

Flege, J. E. (1995) Second-language speech learning: findings, and problems. In *Speech perception and linguistic experience: theoretical and methodological issues* (W. Strange, editor), pp. 233–273. Timonium, MD: York Press

Flege, J. E. & Fletcher, K. (1992) Talker and listener effects on the perception of degree of foreign accent, *Journal of the Acoustical Society of America,* **91**, 370–389

Flege, J. E., Munro, M. J. & MacKay, I. (1995) Factors affecting degree of perceived foreign accent in a second language, *Journal of the Acoustical Society of America,* **97**, 3125–3134

Genesee, F., Hamers, J., Lambert, W., Mononen, L., Seitz, M. & Starck, R. (1978) Language processing in bilinguals, *Brain and Language,* **5**, 1–12

Grosjean, F. (1982) *Life with two languages, an introduction to bilingualism.* Cambridge: Harvard University Press

Grosjean, F. (in press) Processing mixed language: issues, findings and models. In *Tutorials in bilingualism: psycholinguistic perspectives* (A. de Groot & J. Kroll, editors). Hillsdale, NJ: Lawrence Erlbaum Assoc.

Ho, D. (1986) Two contrasting positions on second-language acquisition: a proposed solution, *International Review of Applied Linguistics,* **24**, 35–47

Hurford, J. (1991) The evolution of the critical period for language acquisition, *Cognition,* **40**, 159–201

Kempe, V. & MacWhinney, B. (1996) The cross-language assessment of foreign language vocabulary learning, *Applied Psycholinguistics,* **17**, 149–184

Kuijpers, C. T. L. (1996) Perception of the voicing contrast by Dutch children and adults, *Journal of Phonetics,* **24**, 367–382

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

Lenneberg, E. (1967) *Biological foundations of language.* New York: Wiley

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

Mack, M. (1986) A study of semantic and syntactic processing in monolinguals and fluent early bilinguals, *Journal of Psycholinguistic Research,* **15**, 463–488

Macnamara, J. (1973) Nurseries, streets, and classrooms, *The Modern Language Journal,* **57**, 250–254
Mägiste, E. (1979) The competing language systems of the multilingual: a developmental study of decoding and encoding processes, *Journal of Verbal Learning and Verbal Behavior,* **18**, 79–89
McLaughlin, B. (1977) Second-language learning in children, *Psychological Bulletin,* **84**, 438–459
Munro, M. & Derwing, T. (1995) Processing time, accent, and comprehensibility in the perception of native and foreign-accented speech, *Language and Speech,* **38**, 289–306
Neville, H., Mills, D. & Lawson, D. (1992) Fractionating language: different neural subsystems with different sensitive periods, *Cerebral Cortex,* **2**, 244–258
Oyama, S. (1979) The concept of the critical period in developmental studies, *Merrill-Palmer Quarterly,* **25**, 83–103
Paradis, M. (1993) Linguistic, psycholinguistic, and neurolinguistic aspects of the ''interface'' in bilingual speakers: the Activation Threshold Hypothesis, *International Journal of Psycholinguistics,* **9**, 133–145
Paradis, M. (in press) Neurolinguistic aspects of 'native speaker'. In *The native speaker* (R. Singh, editor), Beverley Hills, CA: Sage Publications
Patkowski, M. (1990) Age and accent in a second language: a reply to James Emil Flege, *Applied Linguistics,* **11**, 73–89
Penfield, W. & Roberts, L. (1959) *Speech and brain mechanisms.* Princeton, NJ: Princeton University Press
Purcell, E. & Suter, R. (1980) Predictors of pronunciation accuracy: a reexamination, *Language Learning,* **30**, 271–287
Rochet, B. (1995) Perception and production of L2 speech sounds. In *Perception and linguistic experience: theoretical and methodological issues* (W. Strange, editor), pp. 379–410. Timonium, MD: York Press
Romaine, S. (1995) *Bilingualism.* Oxford: Blackwell Publishers Ltd
Scovel, T. (1969) Foreign accents, language acquisition, and cerebral dominance, *Language Learning,* **19**, 245–253
Scovel, T. (1988) *A Time to Speak: a psycholinguistic inquiry into the critical period for human speech.* New York: House/Harper & Row
Selinker, L. (1972) Interlanguage, *International Review of Applied Linguistics,* **10**, 209–231
Singleton, D. (1989) *Language acquisition: the age factor.* Clevedon, England: Multilingual Matters
Snodgrass, J., Levy-Berger, G. & Haydon, M. (1985) *Human experimental psychology.* Oxford: Oxford University Press
Suter, R. (1976) Predictors of pronunciation accuracy in second language learning, *Language Learning,* **26**, 233–253
Tahta, S., Wood, M. & Lowenthal, K. (1981) Foregin accents: factors relating to transfer of accent from the first language to the second language, *Language & Speech,* **24**, 265–272
Thompson, I. (1991) Foreign accents revisited: the English pronunciation of Russian immigrants, *Language Learning,* **4**, 177–204
Weber-Fox, C. & Neville, H. (1992) Maturational constraints on cerebral specialization for language processing: ERP and behavioural evidence in bilingual speakers, *Neuroscience Abstracts,* **18**, 335
Weinreich, U. (1953) *Languages in Contact.* New York: Linguistic Circle of New York