Applied Psycholinguistics **21** (2000), pp. 205–228
Printed in the United States of America

Age of learning effects on the duration of sentences produced in a second language

SUSAN G. GUION
University of Oregon

JAMES E. FLEGE and SERENA H. LIU
University of Alabama, Birmingham

GRACE H. YENI-KOMSHIAN
University of Maryland, College Park

ADDRESS FOR CORRESPONDENCE
Susan G. Guion, Department of Linguistics, 1290 University of Oregon, Eugene, OR 97403-1290.
Email: guion@oregon.uoregon.edu

ABSTRACT
Research has shown that L2 utterances diverge increasingly from target language phonetic norms as the age of L2 learning increases. Other research has suggested that L2 speakers produce longer utterances than native speakers. The aim of this study was to determine whether L2 utterance durations increase as age of learning increases. Fluently produced English sentences spoken by 240 native speakers of both Italian and Korean (selected on the basis of age of arrival [AOA]) were examined. For both L1 groups, the duration of English sentences was positively correlated with AOA. The AOA effect was found to be significant even when confounding variables were partialed out. These results are taken as preliminary support for the proposal that the more established the L1 is at the time of first exposure to the L2, the more it will interfere with L2 production, thus requiring greater processing resources to suppress it.

A great deal of research has focused on the effect of variation in the age of L2 learning on the production of an L2 (Asher & García, 1969; Fathman, 1975; Long, 1990; Patkowski, 1980, 1990). The results of these investigations indicate that L2 pronunciation becomes less authentic or more foreign-accented as the age of onset of L2 learning increases. These results have generally been taken as support for the critical period hypothesis. The critical period hypothesis states that human beings are optimally suited to learn certain types of behavior (including language abilities) during a certain age span, and that after this period has passed learning the behavior becomes difficult or impossible (Lenneberg, 1967). This view is based on the assumption that the neural maturational state of the learner (as indexed by the age of onset of L2 learning) is of primary importance

to language learning. Experiential and motivational factors are seen as markedly less important. Thus, the critical period hypothesis would predict that L2 learners could attain proficiency comparable to L1 learners as long as the onset of L2 learning took place before the end of the critical period.[1] After this period, L2 learners would not be expected to attain nativelike proficiency in the L2. In fact, no relation between proficiency in the L2 and age of onset of L2 learning is predicted after the critical period has passed.

Counterevidence to the predictions made by the critical period hypothesis has been provided by several studies. First, Bongaerts, van Summeren, Planken, and Schils (1997) compared some highly successful and highly motivated native Dutch late learners of English to native English speakers. They found that pronunciation ratings of 5 of 11 late learners were indistinguishable from the native English speakers. The critical period hypothesis would predict that only early learners could attain such nativelike proficiency. Thus, the nativelike proficiency attained by the later learners in the Bongaerts et al. (1997) study disconfirms the predictions made by the critical period hypothesis.

Second, the amount of L1 use has been found to affect L2 production proficiency in groups of L2 learners matched for age of onset of L2 acquisition. Flege, Frieda, and Nozawa (1997) and Guion, Flege, and Loftin (in press) found that L1 use exerted a measurable effect on the L2 pronunciation of earlier learners matched for age of L2 acquisition. Piske and MacKay (1999) found that the L1 use effect also applied to late learners of an L2. The critical period hypothesis does not predict these results, as it only allows age of L2 acquisition as a predictor. The L1 use effect found in the studies just cited was interpreted by the authors as an interaction between the L1 and L2 systems. Flege et al. (1997) and Guion et al. (in press) proposed that the L1 and L2 phonetic systems reside in the same phonological space and can exert a mutual influence on each other. Although the two systems can be activated to varying degrees (Grosjean, 1999; Paradis, 1993), one phonetic subsystem cannot be fully deactivated while the other is in use (Soares & Grosjean, 1984). Because the L1 and L2 reside in a common phonological space and neither of the languages can be fully deactivated, the phonic elements of the L1 and L2 will influence one another in production. The strength of the influence could be affected by overall recent use of the L1 and L2, whether the conversation partners speak the L1 and/or the L2, the extent to which interlocutors codeswitch, and the topic of conversation (Grosjean, 1982, 1992, 1999).

A third set of studies has disconfirmed the predictions of the critical period hypothesis by demonstrating a linear relationship between age of L2 acquisition and L2 proficiency. The critical period hypothesis predicts no relationship between age of arrival (AOA) and L2 proficiency after the critical period has passed. Flege, Munro, and MacKay (1995b) examined an AOA-stratified population of 240 native speakers of Italian. These subjects had lived in Ottawa, Canada, for 32 years on average but differed according to AOA (2 to 23 years). A strong correlation between AOA and production proficiency was observed, such that the later subjects had arrived in Canada, the more strongly accented were their productions of English sentences. Yeni-Komshian, Flege, and Liu (1997, submitted) obtained similar findings in a study examining 240 native

Korean subjects who differed according to their AOA in the United States. Other work has focused on segmental production. For example, it was shown that the later native Italian speakers arrived in Canada, the less accurately they produced specific English vowels (Munro, Flege, & MacKay, 1996) and consonants (Flege, Munro, & MacKay, 1995a).

The linear relationship between AOA and L2 production proficiency can be analyzed as an effect of L1 and L2 interaction (Flege, 1995). One hypothesis states that the more established the L1 is at the time of L2 acquisition, the greater the influence it will have on the L2. This is because, as L1 phonetic categories are established and elaborated through childhood and into adolescence (Flege & Eftig, 1986; Hazan & Barrett, 1999; Parnell & Amerman, 1978), they become more likely to assimilate L2 vowels and consonants (Best & Strange, 1992; Ortega & Hazan, 1999). Such a hypothesis would depend on the interaction of the L1 and L2 linguistic systems. Recently, good evidence for the interaction of the L1 and L2 systems has been presented by Yeni-Komshian et al. (1997, submitted). The authors investigated the foreign accent ratings of 240 AOA-stratified native Korean learners of English. The degree of foreign accent in the L1 and L2 was found to be inversely correlated. That is, the subjects who had relatively good pronunciation of English (mostly early bilinguals) tended to have poor pronunciation of Korean, whereas those who had poor pronunciation of English (mostly late bilinguals) tended to have good pronunciation of Korean. These results indicate that the L1 and L2 can exert mutual influence on one another.

There is also evidence of the L1 slowing L2 response latencies (Fox, 1996; Meuter & Allport, 1999). In naming tasks, bilinguals showed longer response latencies when switching from the weaker L2 to the dominant L1 than when switching from the L1 to the L2. The authors interpreted this finding to mean that naming in the L2 requires active inhibition or suppression of the L1. In addition, event-related brain potential studies showed that late L2 learners had slower processing in the L2 for some language tasks than did earlier L2 learners and monolinguals (Weber-Fox & Neville, 1999).

Bilinguals who have slower reading rates in their L2 than their L1 also showed slower processing rates in the L2 in other tasks (Favreau & Segalowitz, 1982, 1984). Reading rate was assessed by computing the average words per minute in read-aloud texts. They found that bilinguals who read the L1 and L2 at the same rate comprehended the L2 at a significantly faster rate when allowed to vary the rate of presentation than bilinguals who read the L2 more slowly. The bilinguals who read the L1 and L2 at the same rate also showed faster reaction times on a lexical decision task in the L2 than bilinguals who read the L2 more slowly than the L1.

Taken together, the results from the Yeni-Komshian et al. (1997, submitted), Fox (1996), Meuter and Allport (1999), and Weber-Fox and Neville (1999) studies indicate that the L1 and L2 linguistic systems do indeed interact with each other. The interaction can produce reduced production proficiency, creating stronger foreign accents as well as slowing the processing in one of the languages. The hypothesis tested in the current study extends this observation. We propose that the interaction of the L1 and L2 affects production proficiency,

and that the more established the L1 system is at the time of L2 learning, the more effect it will have on the L2.

The aim of the current study was to determine whether a linear relationship exists between AOA and L2 processing rate. Given the close relationship of speech rate to other measures of processing rate (Favreau & Segalowitz, 1982, 1984), L2 processing rate was indexed here by the duration of repeated L2 sentences under controlled conditions. A correlation between AOA and sentence duration could indicate that the more established the L1 is at the time of first exposure to an L2, the more it interferes with L2 production and the greater the processing resources required to suppress it.

A number of previous studies have examined the duration of utterances spoken in an L2. Munro and Derwing (1995) had 10 adult Mandarin learners of English who had lived in Canada for 4 years on average read 40 English sentences. The Mandarin subjects' sentences were significantly longer than those of the native English subjects (2,290 vs. 1,770 ms – a 29% difference). Elsendoorn (1984) examined native Dutch speakers of English in the Netherlands ($n = 27$) and native English controls ($n = 9$). The subjects were given a list of 344 English sentences to study. They heard these sentences over headphones in blocks of 40. The subjects were told to copy the stress pattern and to pay no attention to the speaker's speech rate. The subjects were explicitly instructed to "use a tempo that was natural." The native Dutch speakers produced sentences that were significantly longer than the native English subjects (2,659 ms vs. 2,268 ms – a 17% difference). However, Flege (1979) tested two groups of 6 native Arabic speakers who had lived in the United States 8 and 39 months on average. The subjects read a list of words in an English carrier phrase. The native Arabic groups produced sentence durations that were comparable to those of the native English controls (1,336 ms and 1,387 ms vs. 1,376 ms).

Speech rate, defined as the number of syllables spoken per unit of time in a nonspeeded task (with or without pauses), has also been investigated. Speech rates were found to be greater for more advanced L2 students (Riggenbach, 1991; Sabin, Clemmer, O'Connell, & Kowal, 1979) and to increase for L2 students over a 6-month period (Lennon, 1990). In addition, speech rate was found to be correlated with "fluency" ratings (Pennington, 1992) and also with global accentedness ratings (Munro, 1999).

Taken together, the studies reviewed here suggest that nonnative speakers are apt to produce longer utterances in an L2 than are native speakers. In addition, the studies indicate that speech rate increases as proficiency in the L2 increases. However, this has not been shown conclusively. In fact, Flege (1979) found no difference between the native and nonnative speakers' sentence durations; however, this study included only a small number of participants.

The first task of this study was to determine whether sentence duration differences between native and nonnative subjects are reliable and whether a linear relationship between sentence duration and AOA exists. There are several reasons why one might question the conclusion that nonnative speakers produce L2 utterances with longer durations than native speakers.

The first reason is that some part, or all, of the effects reported previously may have been due to sampling error. There tends to be a great amount of

intersubject variability in utterance durations when speakers are recorded in a laboratory setting (e.g., Byrd, 1994; Crystal & House, 1988a, 1988b; Gaitenby, 1965). This may be due to variations in the general pattern of speaking rate, individual differences in how people respond to the presence of a microphone, or both. The previous studies have examined comparatively few individuals. It is possible that the nonnative speakers who were selected had slower characteristic speaking rates or reacted differently to the laboratory setting than the native controls.

Second, the previously reported effects may have been due, at least in part, to the presence of disfluencies. It is not unreasonable to assume that nonnative speakers would produce L2 utterances less fluently than native controls. The presence of pauses (perceptible or even subperceptible) might have contributed to the reported effects. For example, the relative unfamiliarity of particular words in an L2 utterance might have led the nonnative subjects to pause, thereby increasing the duration of their L2 utterances.

Third, good readers tend to produce shorter utterances while reading than poor readers. In studies that examined speech that was read (Favreau & Segalowitz, 1982, 1984; Munro & Derwing, 1995; Riggenbach, 1991; Sabin et al., 1979), the differences that were found may have been due to native versus nonnative differences in reading ability.

A fourth potential problem is experimenter bias. Talkers tend to accommodate to the speaking rate of their interlocutor (Giles & Smith, 1979). It is possible that experimenters in previously reported research spoke more slowly to nonnative than native subjects. If so, then some part of the effects reported previously may have been a result of speech accommodation. Also, specific instructions regarding rate (e.g., Elsendoorn, 1984) could have biased the subjects' speaking rate.

The present study controlled for all of these potential artifacts. Here, we examined the English sentences spoken by native Italian (NI) and native Korean (NK) speakers that were rated for degree of overall foreign accent in two previous studies. Flege et al. (1995b) found that the later the NI speakers first arrived in Canada from Italy, the stronger their foreign accents were in English. Similarly, Flege, Yeni-Komshian, and Liu (1999) found that the later the NK subjects first arrived in the United States, the more strongly foreign-accented their productions of English sentences were.

The potential problem of sampling error was obviated by the large number of nonnative subjects examined – 240 in each of the NI and NK groups. The potential problems of experimenter bias, differences in reading ability, and the presence of disfluencies were largely obviated by having the subjects repeat a standard set of recorded sentences that were presented auditorily. Nearly all of the sentences were produced fluently. The duration values for those few sentences that were not produced fluently (defined as having repetitions or pauses greater than 200 ms in duration) were replaced with group mean values. In addition, the subjects were given no instructions regarding speaking rate.

The second task of the study was to determine whether the AOA effect on sentence duration was a generalizable finding. We examined two populations of speakers (NI and NK) in unrelated experiments to replicate our findings.

Table 1. *The 11 subgroups of native English* (*NE*) *and native Italian* (*NI*) *subjects*

Group	AOA[a]	LOR[b]	Age[c]	L1 use[d]	Number[e]
NE	—	—	39	—	14f, 10m
NI-1	3	35	38	18%	17f, 7m
NI-2	5	34	39	15%	14f, 10m
NI-3	8	34	42	16%	17f, 7m
NI-4	10	32	42	19%	12f, 12m
NI-5	12	35	46	29%	15f, 9m
NI-6	14	31	45	27%	12f, 12m
NI-7	16	30	46	37%	10f, 14m
NI-8	17	29	47	35%	14f, 14m
NI-9	19	27	46	46%	12f, 12m
NI-10	22	28	49	38%	11f, 13m

[a]Age of arrival in Canada in years; [b]length of residence in Canada in years; [c]age at time of testing in years; [d]percentage of self-estimated use of Italian; [e]f = female, m = male.

The results will be presented in four sections. The sentence durations of the NI and NK subjects are presented in the first two sections. Sentence durations were found to correlate with AOA for both groups. The third section presents the results of temporal acoustic analyses that examined in greater detail the utterances spoken by two subsets of NK subjects who produced English sentences with relatively long and relatively short durations, as well as the utterances spoken by a set of native English controls. One aim of this section was to determine whether the sentence duration effects were due to the presence of short pauses ("micro-pauses"). Another aim was to determine whether the effect was due to the presence of a larger amount of utterance-final lengthening for NK subjects with longer sentences than for the NK subjects with shorter sentences or for the native English controls. The final aim was to identify the source of the sentence duration effects by examining the durations of three sound-segment types. The fourth section presents correlation analyses examining the relation between the NI and NK subjects' English sentence duration and a number of other variables (e.g., the subjects' age, length of residence in an English-speaking environment, and the overall use of the L1).

NATIVE ITALIAN SENTENCE DURATIONS

Method

Subjects. Of the 264 subjects, 24 were monolingual native speakers of Canadian English (NE) and 240 were native Italian (NI) speakers who had learned English as an L2 in Canada. Characteristics of the subjects are shown in Table 1. The mean chronological age of the NI subjects ranged from 38 to 49 years. The NI subjects were assigned to one of ten groups based on their AOA in

Table 2. *The duration of the model sentences presented to native English (NE) and native Italian (NI) subjects*

Stimulus sentence	Duration (ms)
Paul ate carrots and peas.	1,599
The good shoe fit Sue.	1,369
He turned to the right.	912
The red book was good.	1,034
I can read this for you.	1,150
M (*SD*)	1,212 (274)

Canada. The mean AOAs of the ten groups ranged from 3 to 22 in roughly 2-year increments. The later the NI subjects had arrived in Canada, the more they reported using Italian (L1 use). All of the NI subjects had a length of residence in Canada of at least 15 years at the time they were recorded ($M = 32$ years) (see Flege et al., 1995b, for additional details).

Procedure. The NE and NI subjects were recorded individually in a quiet room using a portable audiocassette tape recorder. They were tested by a native English speaker who interacted with the subjects in English only. All 264 subjects heard the same recorded stimuli in the same order and were recorded using the same equipment.

The elicitation procedure allowed for the collection of fluently produced sentences without the need for reading, while also minimizing the likelihood of mimicry. The five English sentences shown in Table 2 were presented to the subjects on a written list. They were also modeled aurally in short dialogues using prerecorded stimuli. For example, the test sentence "He turned to the right" was elicited using these materials:

Voice 1: In which direction did he turn? (pause)
Voice 2: He turned to the right. (pause)
Voice 1: In which direction did he turn? (longer pause)

After hearing a question (Voice 1) and a response (Voice 2), followed by the same question a second time (Voice 1), the subjects were asked to repeat the model sentence (i.e., what was said by Voice 2). The delay between the model and its repetition, as well as the intervening speech material, were expected to minimize direct mimicry of the model.

Most important, no instructions were given regarding speaking rate. We considered it likely, however, that the subjects would tend to produce the sentences at a speaking rate that was similar to that of the aurally presented models. A working assumption of this study was that both the NE and NI subjects would tend to accommodate to the speaking rate in the tape-recorded English stimulus sentences in a similar way. As previously pointed out, speakers accommodate

to their interlocutor in a variety of ways, including speaking rate (Giles & Smith, 1979). Accommodative adjustments in speech rate have been linked to a talker's desire to appear likable or not likable (Putman & Street, 1984).[2]

Measurements. The duration of all fluently produced sentences was measured. A sentence was considered to be fluent if it was free from any word, syllable, or segmental repetition and did not contain a pause longer than 200 ms. Given these criteria, we could be fairly confident that, if native versus nonnative differences in sentence durations were observed, such differences could not be attributed to the presence of readily detectable pauses or disfluencies.

The selected sentences were measured to the nearest millisecond from spectrographic displays on a personal computer. The durations were calculated as the difference in the location of cursors placed on the onset and offset of the sentences. The sentence onset was defined as the release burst or onset of frication (in sentences beginning with a stop or affricate), the onset of frication (in sentences beginning with a fricative), or the beginning of voiced formant structure (in sentences beginning with a vowel, liquid, or glide). The offset of sentences was defined as the end of the voice bar in the nasal murmur (in sentences ending in a nasal), the end of the voiced format structure (in sentences ending with a vowel), or the end of the stop closure (as determined by the offset of the formant transitions in sentences ending in a stop consonant).[3]

The first author measured all of the sentences. Measurement reliability was assessed by remeasuring 28 randomly selected tokens of one sentence. These same sentences were also measured by the second author. Intrameasurer error was quite small. The mean duration for the two sets of measurements by the first author differed by less than 1 ms, with a high correlation between the two sets of measurements ($r = .99$). Intermeasurer difference was also small – less than 5 ms ($r = .99$).

As mentioned earlier, sentences containing repetitions or pauses longer than 200 ms were not measured. Only 23 of the 1,320 sentences (2%) were omitted for this reason. To ensure that there would be five sentence duration values for each subject, the missing values were replaced by a subject's mean sentence duration, weighted by the mean duration of the sentence in question. For example, if a subject's sentence was excluded, the overall average (across speakers) for that particular sentence was multiplied by the average proportion of the speaker's sentences to the mean sentence durations.

Results and discussion

Late-arriving groups of NI subjects were found to have sentence durations longer than the early-arriving groups, who had sentence durations comparable to the NE group. The latest arriving group (NI-10) produced sentences with an average duration of 1,390 ms – 15% longer than the NE control group.

The mean duration of sentences spoken by the NE controls (1,204 ms) was almost exactly the duration of the model sentences that were presented over the loudspeaker (1,212 ms). It is possible that the characteristic speaking rate of the

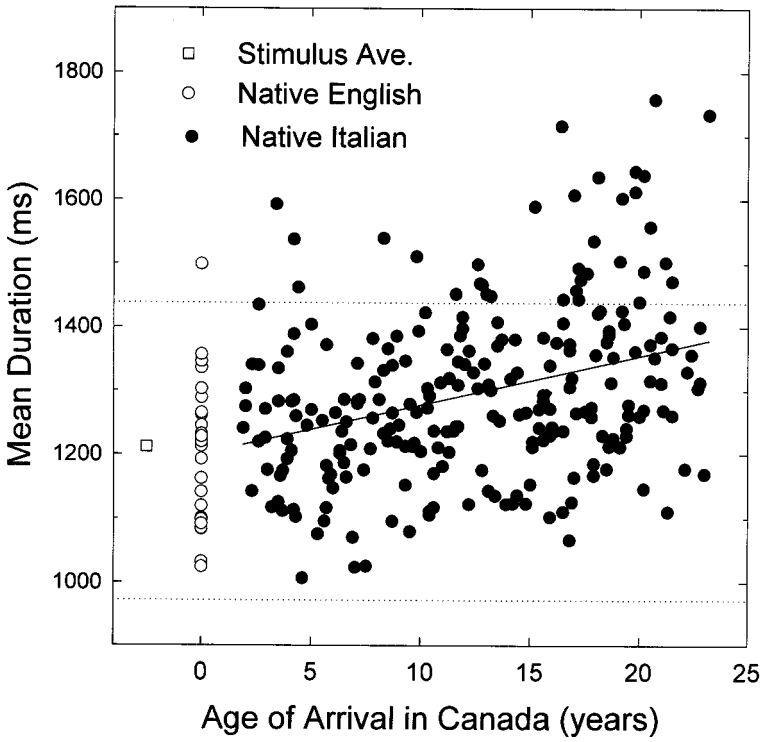

Figure 1. The mean duration of sentences spoken by 240 NI subjects and 24 NE control subjects. Also shown is the duration of the stimulus sentences that all subjects repeated. The dotted lines indicate ± two standard deviations around the native English mean.

24 NE controls matched that of the model utterances. More likely, they tended to accommodate to the speaking rate of the model utterances.

The mean duration of the five English sentences spoken by each of the 264 subjects was calculated. Figure 1 shows the NIs' mean sentence durations as a function of their AOA in Canada. (The 24 NE controls were assigned an AOA of 0 because they were born in Canada.) The later the NI subjects had arrived in Canada, the longer their sentences were. The correlation between the 240 NI subjects' AOA and their sentence duration was $r = .33$ ($df = 238$, $p < .01$).

The 264 mean sentence durations were submitted to a one-way ANOVA examining the effect of group (11 levels). The significant group effect, $F(10, 253) = 4.7$, $p < .01$, was explored by a Tukey's HSD test. The sentences spoken by groups NI-8, NI-9, and NI-10 (with mean AOAs of 17, 19, and 22 years) were significantly longer than those of the NE subjects, whereas the sentences spoken by NI groups with AOAs less than 17 years did not differ significantly from those of the NE control group. See Table 3 for group means, standard deviations, and results of Tukey's test.

Table 3. *The mean duration, standard deviation, and results of Tukey's test paired comparisons for the sentences repeated by native English* (*NE*) *and native Italian* (*NI*) *subjects*

Group	Mean duration	Standard deviation	Tukey's HSD ($p < .01$)
NE	1,204	115	NE < NI-8, NI-9, NI-10
NI-1	1,256	111	NI-1 < NI-10
NI-2	1,232	129	NI-2 < NI-10
NI-3	1,249	113	NI-3 < NI-10
NI-4	1,253	112	NI-3 < NI-10
NI-5	1,301	94	
NI-6	1,291	119	
NI-7	1,300	140	
NI-8	1,352	152	
NI-9	1,343	140	
NI-10	1,390	162	

NATIVE KOREAN SENTENCE DURATIONS

As just discussed, the NI subjects' English durations were positively correlated with their AOA. As far as we know, this is the first time such a relation has been reported. The question addressed here is whether this finding is generalizable. In this section, we report on an attempt to replicate the NI finding with a different population of speakers in an unrelated experiment. In this experiment, the duration of English sentences spoken by native Korean (NK) subjects who differed according to their AOA in the United States was measured. The English sentences spoken by the NK subjects were rated in a previous study for overall degree of perceived foreign accent (Flege et al., 1999) but were not measured acoustically.

Method

Subjects. Of the 264 subjects recorded in College Park, Maryland, 24 were monolingual NE speakers and 240 were native Korean (NK) speakers who had learned English as an L2. As shown in Table 4, the NK subjects were assigned to one of ten subgroups based on their AOA in the United States. The groups' mean AOAs ranged from 3 to 22 years. All of the NK subjects had a length of residence in the United States of at least 8 years at the time they were recorded. The mean chronological age of the NK subjects ranged from 23 to 34 years. Again, note that the older the subjects were when they arrived in the United States, the greater their L1 use was (for additional details, see Yeni-Komshian et al., 1997, submitted).

Procedure. The NE and NK subjects were recorded individually in a quiet room using a portable audiocassette tape recorder. They were tested by college-

Table 4. *The 11 subgroups of native English* (*NE*) *and native Korean* (*NK*) *speakers*

Group	AOA[a]	LOR[b]	Age[c]	L1 use[d]
NE	—	—	28	—
NK-1	3	20	23	2.3
NK-2	5	16	21	2.5
NK-3	7	17	24	2.6
NK-4	9	15	24	2.9
NK-5	11	14	24	3.2
NK-6	13	12	24	3.6
NK-7	15	13	27	3.5
NK-8	17	13	29	3.7
NK-9	19	14	32	3.7
NK-10	22	14	34	3.8

Note: There were 12 male and 12 female subjects in each group.
[a]Age of arrival in the United States in years; [b]length of residence in the United States in years; [c]age at time of testing in years; [d]mean self-estimated rating of Korean use on a 5-point scale.

Table 5. *The duration of the model sentences presented to native English* (*NE*) *and native Korean* (*NK*) *subjects*

Stimulus sentence		Duration (ms)
Ron set a thick rug in the sun.		2,192
Joe will feed the pup who sat by you.		2,099
You should thank Sam for the food.		1,739
Fit a ring to the water tap.		1,729
Get rid of the soot behind the seat.		2,363
Pat took the lead on the way to the ship.		2,119
Read the theme he wrote about the zoo.		2,247
It is fun to play chess with a rook.		1,811
Tom tried to shoot a rat near the shack.		2,007
The tip of the cane was made of teak.		1,845
	M (*SD*)	2,015 (224)

aged Korean/English bilinguals who interacted with the subjects in English and Korean.

The elicitation differed from the one used in testing the NI subjects. The subjects heard a recording of a male native English speaker's production of 10 sentences (listed in Table 5). The stimulus sentences were produced at a moderate to slow speaking rate and had an average duration of 2,015 ms. The subjects were also given a written list of the sentences to be repeated. The sentences were

presented over a high-quality loudspeaker (Acoustic Research) at a comfortable listening level. Each sentence was presented twice, followed by a short tone. The interval between the first presentation of the sentence and the tone was approximately 1 second; the interval following the second presentation of the sentence was approximately 4 seconds. The subjects were instructed to repeat the sentence after both presentations, waiting for the tone each time before speaking. The delay between the native-produced model and the subject's repetition of it was expected to minimize the possibility of veridical imitation from sensory memory. The subjects' second productions of the 10 sentences were measured because they were more distant temporally from the models and were more likely to have been produced fluently than the first productions. Again, no instructions regarding speaking rate were given.

Measurements. The sentence durations were measured using the same procedures as described for the NI subjects. Some 293 sentences (11%) were excluded because they contained a part or whole repetition or had a pause longer than 200 ms. In all analyses, the duration value for disfluent sentences was replaced by the weighted mean duration of that sentence for the group to which a subject belonged. (See the description in the NI section for more details.)

Results and discussion

The mean duration of the 10 sentences spoken by each subject was calculated. In Figure 2, the mean duration for the 240 NK subjects is plotted as a function of AOA. The mean duration of sentences spoken by the 24 NE controls, who were assigned an AOA of 0, is also plotted, as is the average duration of the 10 stimulus sentences the subjects were asked to repeat.

The latest arriving group (NK-10) had a mean sentence duration of 2,251 ms – 27% longer than the NE mean. The NE controls' sentences were somewhat shorter than the stimulus sentences (1,877 vs. 2,015 ms). This was also true for the sentences spoken by the early-arriving NK subjects.

As AOA increased, the NK subjects' sentence durations also increased. The simple correlation between the 240 NK subjects' AOA and sentence duration was .58 ($df = 238$, $p < .001$). That means that 34% of the variance in the NK subjects' sentence durations could be accounted for by knowing when they had immigrated to the United States.

The mean sentence duration scores were submitted to a one-way ANOVA examining the effect of group (11 levels). The ANOVA was significant, $F(10, 253) = 17.1$, $p < .001$. Pairwise differences between groups were examined using Tukey's HSD tests. The nonnative subjects in groups NK-5 through NK-10 (all of whom had arrived in the United States after the age of 10 years) were found to have produced significantly longer sentences than the NE subjects ($p < .01$). See Table 6 for group means, standard deviations, and results of Tukey's test.

Despite a number of differences between the NK and NI groups, the NI results were replicated with the NK group. The later in life the NK subjects began to learn English, the longer in duration their English sentences were. This suggests that the age effect on sentence durations is a robust and generalizable effect.

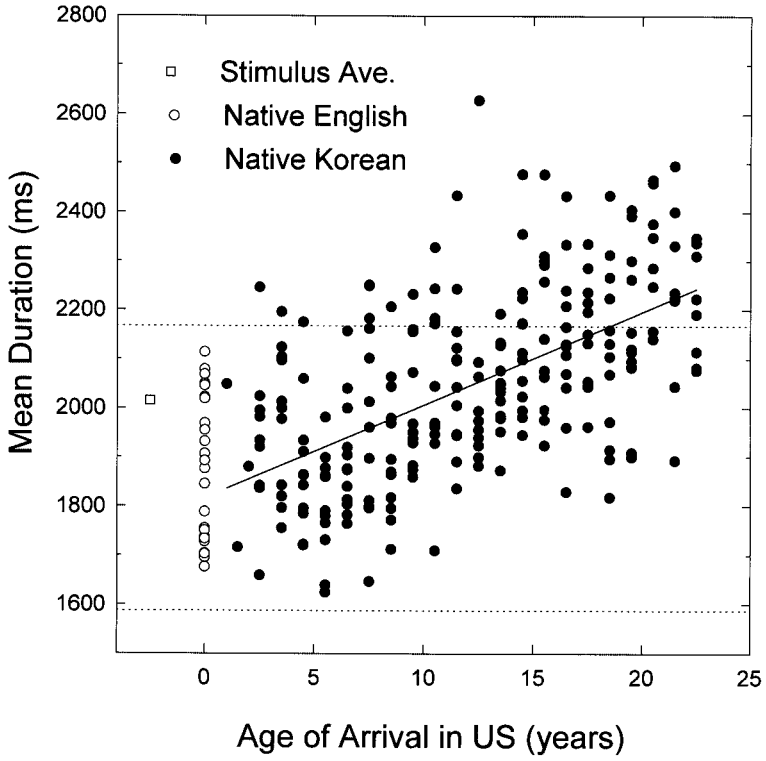

Figure 2. The mean duration of sentences spoken by 240 NK subjects and 24 NE control subjects. Also shown is the duration of the stimulus sentences that all subjects repeated. The dotted lines indicate ± two standard deviations around the native English mean.

There were, however, important differences in the results between the two studies. First, the correlation between AOA and sentence durations was smaller for the NI than for the NK subjects. The stronger correlation for the NK subjects is in part due to the greater difference in sentence duration between the early and late arrivers than that between the NI subjects. The difference between the NK-10 and NK-1 groups was 308 ms, whereas it was 187 ms for the NI-10 and NI-1 groups. In addition, the sentence durations for the NK subjects had a greater variance ($s^2 = 36{,}481$) than those of the NI subjects ($s^2 = 18{,}388$), $F(239, 239) = 1.98$, $p < .01$.

The second difference between the two studies was the age at which native versus nonnative differences first became apparent. NI subjects who began learning English after the age of 16 years produced sentences that were significantly longer than those of the NE controls, whereas NK subjects who began learning English after the age of 10 years produced significantly longer sentences than the NE controls.

The basis for the apparent difference between the NI and NK subjects is uncertain because the two studies differed in several ways. Perhaps the greater

Table 6. *The mean duration, standard deviation, and results of Tukey's test paired comparisons for the sentences repeated by native English (NE) and native Korean (NK) subjects*

Group	Mean duration	Standard deviation	Tukey's HSD ($p < .01$)
NE	1,877	145	NE < NK-5, NK-6, NK-7, NK-8, NK-9, NK-10
NK-1	1,943	151	NK-1 < NK-7, NK-8, NK-9, NK-10
NK-2	1,836	123	NK-2 < NK-5, NK-6, NK-7, NK-8, NK-9, NK-10
NK-3	1,944	168	NK-3 < NK-7, NK-8, NK-9, NK-10
NK-4	1,957	137	NK-4 < NK-7, NK-8, NK-9, NK-10
NK-5	2,061	162	NK-5 < NK-10
NK-6	2,033	151	NK-6 < NK-10
NK-7	2,153	161	
NK-8	2,142	135	
NK-9	2,130	172	
NK-10	2,251	148	

length of residence of the NI than the NK subjects in an English-speaking environment (32 vs. 15 years, on average) was an important factor. That is, the sentence duration effect may diminish as nonnative subjects gain experience in their L2. Another possible explanation is that the sentences repeated by the NI subjects were shorter, and arguably easier, than those repeated by the NK subjects. Another possibility is that the L1 of the NK subjects was more highly activated than that of the NI subjects because the NK, but not the NI, subjects produced sentences in both of their languages during testing.

ADDITIONAL TEMPORAL MEASUREMENTS

This section presents the results of temporal acoustic analyses that examined the utterances spoken by two subgroups of NK subjects and a group of NE controls in greater detail. The NK subjects were selected for the additional analyses because they showed a larger AOA effect than the NI subjects and were perhaps more likely to reveal the nature of the effect. One NK subgroup had relatively short sentence durations and early AOAs, and the other NK subgroup had relatively long sentence durations and late AOAs. These two subgroups thus reflected the larger set of data. Subgroups were analyzed because making fine-grained temporal measurements for all of the 264 subjects would have been too cumbersome. The acoustic data presented in this section, therefore, provides a representative sampling of the participants.

Subjects. Some 45 subjects without any missing data were selected from the original population of 264 subjects (see Table 3). The 15 NK subjects with the shortest mean sentence durations were assigned to the more proficient group (because their sentence durations resembled those of the NE controls). The 15 NK subjects with the longest durations were assigned to the less proficient group

Table 7. *Characteristics of the native English (NE), more proficient native Korean (MP), and less proficient native Korean (LP) subjects, reporting results of one-way ANOVAs conducted on each variable as well as the post hoc comparisons*

	Group means				
Variable	NE	MP	LP	$F(2, 42)$	Tukey's HSD ($p < .01$)
Sentence duration (ms)	1,853	1,772	2,228	84.4	NE, MP < LP
AOA	0.0	5.9	16.3	258.2	NE, MP < LP, NE < MP
% of observed segmental errors	0.0	.3	1.5	5.6	NE, MP < LP
Grammaticality judgment score (%)	98%	96%	79%	41.4	NE, MP > LP
Foreign accent (1 = strong accent, 9 = no accent)	8.3	7.3	3.8	95.0	NE, MP > LP, NE > MP
Korean use rating (1–5 scale)	—	2.6	3.6	16.0	MP < LP
Mean English use (1–5 scale)	—	4.3	3.7	5.0	MP > LP

(because their sentence durations diverged from those of the NE controls). The third group consisted of 15 randomly selected NE speakers. Of the 15 subjects in each group, either 7 or 8 were female.

As summarized in Table 7, the more proficient NK subjects made fewer segmental errors, had fewer errors on a grammaticality judgment test, and had a better overall pronunciation of English than did the less proficient NK subjects.

Aims of the analyses. The analyses of sentences spoken by the three subgroups had three aims. The first was to determine if the sentence duration effects reported earlier were due to the presence of micro-pauses. Recall that only sentences having pauses greater than 200 ms were excluded from analysis. The second aim was to determine if the relatively long duration of English sentences spoken by some NK subjects was due to an unusually large amount of utterance-final lengthening. Utterance-final lengthening may differ across languages (Oller, 1972). Perhaps utterance-final lengthening is greater in Korean than in English, and the NK subjects transferred this relatively larger effect into English. Different explanations would be required for the AOA effect if that effect were localized in the final few segments of an utterance, as opposed to an effect that was distributed over the entire sentence. The final aim of these analyses was to determine if the three groups differed equally in terms of the duration of three classes of segments: vowels, sonorant consonants, and obstruent consonants.

Procedure. The 5 of the original 10 sentences that had the least missing data for all subjects (sentences 1, 2, 3, 4, and 8 in Table 5) were selected for analysis. The durations of individual segments that could be measured from a spectrographic display were measured to the nearest millisecond. As already men-

tioned, none of the sentences had auditorily detectable pauses greater than 200 ms. The remaining micro-pauses were measured. Micro-pauses, defined as periods of no acoustic energy (other than stop gaps), occurred in only a few locations in the sentences. The durations of words were calculated by adding appropriate segment durations.

Results and discussion

Micro-pauses. The first finding was that the age effect on sentence durations was apparently not due to the presence of micro-pauses in sentences spoken by the less proficient NK subjects.

The total duration of micro-pauses in each sentence, if any, was calculated. Then the average duration of micro-pauses per sentence was calculated for each subject. Finally, the ratio of total average micro-pause length to mean overall sentence duration was calculated for each of the 45 subjects. The ratios for the three groups were similar (NE = .011, less proficient NK = .016, more proficient NK = .011). A one-way ANOVA examining the effect of group (three levels) was nonsignificant, $F(2, 42) = 2.22$, $p > .1$. Thus, the difference in overall sentence length found for the more and less proficient NK speakers can not be attributed to the presence of micro-pauses.

Sentence-final lengthening. The possibility existed that the relatively long sentences spoken by the late-arriving NK subjects were due to a greater amount of sentence-final lengthening[4] than that produced by the NE controls. Sentence-final lengthening, in English at least, is due primarily to the elongation of vowels (Gaitenby, 1965; Oller, 1972). An analysis was undertaken to determine if the vowel duration differences between the less proficient NK and NE subjects were restricted to the vowels found in sentence-final words and if the lengthening of sentence-final words vis-à-vis nonfinal words was greater for the less proficient NK subjects than for the NE subjects.

The ratio of the duration of words occurring at the end of sentences to the duration of the entire sentence in which the word was found was calculated for each subject. The ratios for each of the three groups differed little: NE = .21, less proficient NK = .20, more proficient NK = .21. The final word-to-sentence ratios were submitted to a mixed-design Group × Sentence ANOVA, which yielded a nonsignificant main effect of group, $F(2, 42) = .3$, $p > .10$, but a significant main effect of sentence, $F(4, 168) = 90.7$, $p < .01$. The significant effect for sentence was not surprising, as the sentences differed in number of syllables and words. The interaction was nonsignificant, $F(8, 168) = 1.7$, $p < .09$. This indicates that the less proficient NK subjects did not lengthen sentence-final words more than the NE subjects or the more proficient NK subjects.

Segment types. Most of the 102 vowel and consonant segments in the sentences could be reliably measured. However, 19 segments were not easily measured and so were excluded from the following analysis. (These segments include liquid/vowel and two-stop sequences.) The remaining segments were

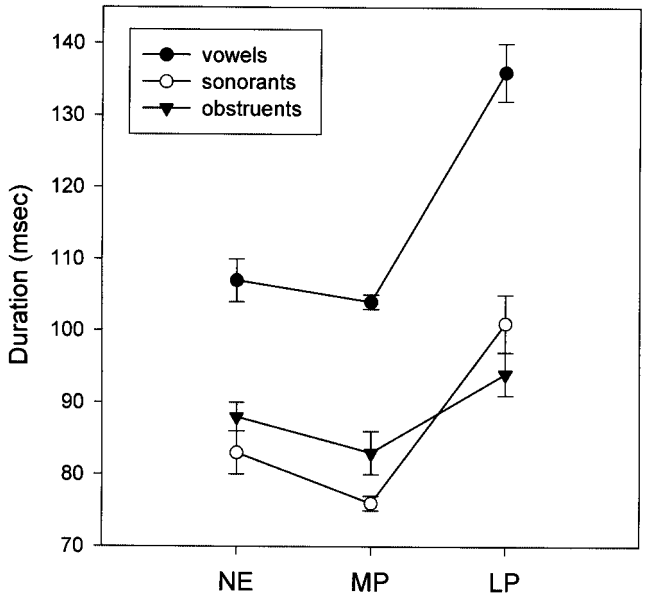

Figure 3. The mean durations (and standard errors) for the three segment types: vowels ($N = 33$), sonorants ($N = 11$), and obstruents ($N = 39$) for the three groups: native English (NE), more proficient native Korean (MP), and less proficient native Korean (LP).

classified as one of the following segment categories: vowels ($n = 33$ segments), sonorant consonants ($n = 11$), and obstruent consonants ($n = 39$).

Figure 3 shows the average duration of the three segment types for the three groups (NE, more proficient NK, and less proficient NK). The less proficient NK speakers produced longer segments than the NE and more proficient NK groups across all segment categories, but their vowels showed a greater difference from the other two groups than their sonorants and obstruents did.

The three category means for each speaker were submitted to a Group (NE, more proficient NK, and less proficient NK) × Segment Category (vowel, sonorant, obstruent) ANOVA. There was a significant finding for the main effects of group, $F(2, 42) = 43.9$, $p < .01$, and segment category, $F(2, 84) = 175.7$, $p < .01$, as well as a significant interaction, $F(4, 84) = 9.3$, $p < .01$. The significant interaction was explored with a series of one-way ANOVAs performed on each segment category. Vowels were found to differ in length by group, $F(2, 24) = 44.36$, $p < .01$. The less proficient NK speakers' vowels were about 29% longer than those of the NE and more proficient NK speakers (136 vs. 107 and 104 ms). The groups were also found to differ for the sonorant consonants, $F(2, 42) = 33.92$, $p < .01$. The sonorants of the less proficient NK subjects were about 27% longer on average than those of the NE and more proficient NK subjects (101 vs. 83 and 76 ms). The difference in the duration of the obstruent consonants was found to be marginally significant for the three groups, $F(2, 42) = 4.10$, $p < .05$. The less proficient NK subjects produced obstruents that were

about 10% longer than those of the NE and more proficient NK subjects (94 vs. 88 and 83 ms).

These results suggest that the difference in sentence durations produced by late-arriving NK subjects was largely due to their production of vowels and sonorants. The late-arriving NK subjects produced longer vowels in all (sentential) contexts, not just in vowels found in utterance-final position.

CORRELATION ANALYSES

In the previous sections, we have observed an effect of AOA on the duration of sentences spoken by the NK and NI subjects. The relation between AOA and sentence duration might seem to be obvious and straightforward, but it is not. This is because, as in previous research (Bachi, 1956; Bahrick, Hall, Goggin, Bahrick, & Berger, 1994), AOA was confounded with other factors that might have potentially influenced the sentence durations.

Chronological age and other subject variables were confounded with AOA in the two sets of data examined here. The first study examined 240 Italian/English bilinguals living in Ottawa, Canada. The second study examined 240 Korean/English bilinguals living in and around Washington, DC. The AOAs of the subjects in both studies ranged from 2 to 23 years. Even though most of the subjects who arrived in North America after the age of 12 years had studied English as an academic subject in school before immigrating, AOA represented the age of the subjects at the time of their first extensive exposure to, and use of, English.

The NK and NI groups were similar in that they consisted of individuals who had learned English in North America. However, the two groups differed in a number of respects. The NI subjects were older on average than the NK subjects (44 vs. 26 years) and had lived for a longer time in North America at the time of testing (32 vs. 15 years on average). A methodological difference is that the NI subjects were tested only in English by a monolingual speaker of English, whereas the NK subjects were tested in both English and Korean by bilingual Korean/English experimenters.

Similar confounds with AOA were observed for both groups. The fact that the same pattern of intervariable confounds emerged in both studies suggests that these confounds are an inherent characteristic of populations of immigrants in North America. First, chronological age was confounded with AOA. The later the subjects in both groups had arrived in North America, the older they were at the time of testing ($r = .52$ for the NI subjects and $r = .68$ for the NK subjects). The second confound involved length of residence in North America. The later the subjects arrived, the shorter their length of residence was ($r = -.44$ for the NI subjects and $r = -.42$ for the NK subjects).

Longer experience speaking English or relative youth might be associated with relatively short sentence durations. If so, then the late-arriving subjects were disadvantaged in two ways with respect to early-arriving subjects. One might argue that being older when tested would not be expected to lead to a greater divergence from the phonetic norms of an L2. However, having used the L2 less at the time of testing might reasonably be expected to have an effect.

Table 8. *NK subjects' simple and partial correlations with sentence duration*

	Simple correlation	Variable(s) partialed out				
		AOA[a]	Age[b]	LOR[c]	L1 use[d]	Three variables[e]
AOA	.58***	—	.42***	.58***	.43***	.14*
Age	.45***	.10	—	.56***	.34***	−.08
LOR	−.17*	.11	.41***	—	−.10	.09
L1 use	.44***	.09	.33***	.41***	—	.10

[a]Age of arrival in the United States; [b]chronological age at the time of testing; [c]length of residence in the United States; [d]average rating of Korean use on a 5-point scale for the following situations: with parents, with siblings, with two or three best friends, at home, at work, at social events, overall during the last 5 years; [e]amount of variance accounted for after the other three variables have been partialed out.
***$p < .001$; *$p < .05$.

(The importance of the confound between AOA and length of residence in the two studies being discussed was probably mitigated somewhat by the fact that subjects were required to have lived in North America for at least 8 years to be admitted to either study.)

A third confound with AOA, also evident for both nonnative groups, is probably of greater theoretical and practical importance. The subjects were asked to evaluate how often they used their L1 and L2 in a variety of contexts.[5] The later the nonnative subjects had arrived in North America, the less they reported using English ($r = -.47$ for the NI subjects and $r = -.56$ for the NK subjects). Conversely, the later the nonnative subjects had arrived in North America, the more often they reported using their native language ($r = .44$ for the NI subjects and $r = .66$ for the NK subjects).

To summarize, three variables that could potentially affect L2 sentence durations were correlated with the NI and NK subjects' AOAs (chronological age, length of residence, and amount of L1 use). Furthermore, these three variables were all correlated with one another and with AOA, both for the NI and NK subjects ($p < .01$).

The following technique was used to determine whether the sentence duration effects reported here were indeed due to variations in AOA as opposed to variables confounded with AOA. First, we computed the simple correlations between sentence durations, on the one hand, and AOA, age, length of residence, and L1 use, on the other hand. We then examined the relation between sentence duration and each of the other four variables in a series of partial correlations.

The results for the simple and partial correlations are summarized in Table 8 for the NK subjects and in Table 9 for the NI subjects. The AOA effect on sentence duration for the NK subjects appears to be a real effect. The AOA–duration correlation remained significant when the confounding variables were par-

Table 9. *NI subjects' simple and partial correlations with sentence duration*

	Simple correlation	Variable(s) partialed out				
		AOA[a]	Age[b]	LOR[c]	L1 use[d]	Three variables[e]
AOA	.33***	—	.15*	.43***	.27***	.02
Age	.42***	.30***	—	.43***	.39***	−.02
LOR	.11*	.30***	−.15*	—	−.17**	.02
L1 use	.22***	.08	.15*	.25***	—	.10

[a]Age of arrival in Canada; [b]chronological age at the time of testing; [c]length of residence in Canada; [d]average rating of Italian use on a 7-point scale for the following situations: with relatives the same age or older, with younger relatives, with best friends, at home, at work, at social events, overall during the last 5 years; [e]amount of variance accounted for once the other three variables have been partialed out.
***$p < .001$; **$p < .01$; *$p < .05$.

tialed out. Also, the effects of the other variables (age, length of residence, and L1 use) became nonsignificant when AOA was partialed out. However, for the NI subjects, whose results are shown in Table 9, AOA was not the only important variable. Both age and length of residence were independent predictors of sentence duration. Age and length of residence retained their significance when AOA was partialed out.

The differing effect of AOA in the two groups of speakers could be due to their different characteristics. In particular, the NI speakers were older and had been in North America for a longer time than the NK speakers. Perhaps the effect of chronological age on sentence duration is more prevalent in an older population.

In summary, we can conclude that AOA affected sentence durations of the NK subjects independently of confounded variables. AOA also influenced the sentence duration of the NI subjects, but it was not the only important variable.

GENERAL DISCUSSION AND CONCLUSION

Previous research (e.g., Elsendoorn, 1984; Munro & Derwing, 1995) has suggested that an L2 is produced more slowly (i.e., with longer utterance durations) than is the native language. However, no previous study has examined the relation between the age at which L2 learning commences and the duration of fluently produced English sentences. Here, in a nonspeeded sentence repetition task, we found that the duration of English sentences was correlated positively with the age of first exposure to English (indexed by the nonnative subjects' age of arrival in an English-speaking country). This correlation was first shown with the native Italian subjects and then replicated in an unrelated study using native Korean subjects.

More detailed acoustic analyses of sentences spoken by late-arriving NK subjects suggested that the native versus nonnative sentence duration differences may be largely due to differences in vowel and sonorant duration. The AOA effect remained significant when confounding variables were partialed out. For the Korean speakers, AOA was found to be the most important variable, and for the Italian speakers, AOA was one of several important variables.

The correlation between AOA and sentence duration for two independent samples of L2 learners is taken as preliminary support for the hypothesis that the more established the L1 is at the time of first exposure to an L2, the more it interferes with L2 production and the greater the processing resources required to suppress it. Previous studies (Fox, 1996; Meuter & Allport, 1999; Weber-Fox & Neville, 1999; Yeni-Komshian et al., 1997, submitted) indicate that the L1 and L2 linguistic systems interact with each other and that the interaction can produce reduced production proficiency, creating stronger foreign accents as well as slowing processing in one of the languages. We propose that the interaction of the L1 and L2 affects processing rate, here indexed as sentence duration, and that the more established the L1 system is at the time of L2 learning, the more effect it will have on the L2.

Further research into the relationship between sentence duration and other factors needs to be conducted, however, before any firm conclusions can be drawn. For example, it would be valuable to examine the effect the amount of experience speaking the L2 has on the duration of L2 sentences in a cross-sectional design. Both the number of years speaking the L2 and the amount of recent use might be varied. The questions of interest would be whether sentence durations decrease systematically as a function of length of residence in a predominantly L2-speaking country and how much the L2 was used in a certain period of time preceding the test. If either of these factors was found to influence sentence durations, it would still be necessary to ascertain whether the amount of practice using the L2 or the influence of the L1 system on the processing and production of the L2 was the source of the effect.

It would be valuable to examine the duration of the sentences spoken in the L1 as well as in the L2. Would it be the case that L1 sentence durations are inversely related to AOA in the predominantly L2 speaking environment? That is, would it be the case, for example, that the later Koreans arrived in the United States, the shorter (and the more like those of Korean monolinguals) their Korean sentences would be? If so, it would mean that the duration of the sentences bilinguals produced in their L1 and L2 would be inversely related. Such a finding, if obtained, would suggest the possibility that proficiency in the L1 and in the L2 is inversely related. It would not rule out the possibility, of course, that certain individuals are highly proficient in both the L1 and the L2.

Finally, the data presented here were based on sentences produced following an aural model, without instructions as to speaking rate. One wonders if the late-arriving subjects who produced English sentences with relatively long durations could have produced sentences with shorter durations resembling those of the English monolinguals had they attempted to do so. That is, would no AOA effect have been observed here had the subjects been asked to repeat the sentences as rapidly as possible? Or, would the sentences of all subjects have de-

creased by a constant percentage? The latter finding, if obtained, would suggest that the effects we observed represent fixed constraints on the production of the L2, perhaps due to competition between the L1 and L2 for processing resources.

ACKNOWLEDGMENTS

This research was supported by a grant from the National Institute of Deafness and Other Communicative Disorders (DC02892). The authors thank Murray Munro and Ian MacKay for their help in gathering the sentences spoken by the native Italian subjects and Jonathan Loftin, Thorsten Piske, and Ratree Wayland for comments on the manuscript. Thanks are also extended to Upali Lockridge for editorial assistance.

NOTES

1. There is not an agreed-upon age for the termination of the critical period. Estimates range from 6 years old (Long, 1990) to 15 years old (Patkowski, 1980).
2. Thakerar, Giles, and Cheshire (1982) found that dyadic conversation participants converged toward the speech rate believed to be characteristic of their partner when they desired the social approval of their partner. Speech accommodation effects have also been found for tape-recorded materials. In several studies, subjects either converged to, or diverged from, the tape-recorded speech (Bourhis & Giles, 1977; Bourhis, Giles, Leyens, & Tajfel, 1979).
3. The closure and release of sentence-final stops was not measured because the final stops were not released in all cases.
4. The domain of utterance-final lengthening is usually the syllable (Delattre, 1966; Lindblom, 1968). All the sentence-final words are monosyllabic in the five sentences investigated here. Therefore, the investigation was conducted on sentence-final words.
5. The Italian/English bilinguals used percentages as well as rating scales; the Korean/English bilinguals used rating scales only.

REFERENCES

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

Bachi, R. (1956). Statistical analysis of the revival of Hebrew in Israel. *Scripta Heirosolymitana, 3,* 179–247.

Bahrick, H., Hall, L., Goggin, J., Bahrick, L., & Berger, S. (1994). Fifty years of language maintenance and language dominance in bilingual Hispanic immigrants. *Journal of Experimental Psychology, General, 123,* 264–283.

Best, C., & Strange W. (1992). Effects of phonological and phonetic factors on cross-language perception of approximants. *Journal of Phonetics, 20,* 305–330.

Bongaerts, T., van Summeren, C., Planken, B., & Schils, E. (1997). Age and ultimate attainment in the pronunciation of a foreign language. *Studies in Second Language Acquisition, 19,* 447–465.

Bourhis, R., & Giles, H. (1977). The language of intergroup distinctiveness. In H. Giles (Ed.), *Language, ethnicity and intergroup relations* (pp. 119–135). New York: Academic.

Bourhis, R., Giles, H., Leyens, J., & Tajfel, H. (1979). Psycholinguistic distinctiveness: Language divergence in Belgium. In H. Giles & R. St. Clair (Eds.), *Language and social psychology* (pp. 158–185). Baltimore: University Park Press.

Byrd, D. (1994). Relations of sex and dialect to reduction. *Speech Communication, 15,* 39–54.

Crystal, T., & House, A. (1988a). The duration of American–English vowels: An overview. *Journal of Phonetics, 16,* 263–284.

(1988b). The duration of American-English stop consonants: An overview. *Journal of Phonetics, 16,* 285–294.

Delattre, P. (1966). A comparison of syllable length conditioning among languages. *International Review of Applied Linguistics, 4,* 183.

Elsendoorn, B. (1984). *Tolerances of durational properties in British English vowels.* Unpublished doctoral dissertation, Institute of Phonetics, University of Utrecht.

Fathman, A. (1975). The relationship between age and second language learning ability. *Language Learning, 25,* 245–253.

Favreau, M., & Segalowitz, N. (1982). Second language reading in fluent bilinguals. *Applied Psycholinguistics, 3,* 329–341.

(1984). Automatic and controlled processes in the first- and second-language reading of fluent bilinguals. *Memory and Cognition, 11,* 565–574.

Flege, J. (1979). *Phonetic interference in second language acquisition.* Unpublished doctoral dissertation, Department of Linguistics, Indiana University, Bloomington.

(1995). Second-language speech learning: Findings and problems. In W. Strange (Ed.), *Speech perception and linguistic experience: Theoretical and methodological issues* (pp. 233–273). Timonium, MD: York.

Flege, J., & Efting W. (1986). Linguistic and developmental effects on the production and perception of stop consonants. *Phonetica, 43,* 155–171.

Flege, J., Frieda, E., & Nozawa, T. (1997). Amount of native-language (L1) use affects the pronunciation of an L2. *Journal of Phonetics, 25,* 169–186.

Flege, J., Munro, M., & MacKay, I. (1995a). Effects of age of second-language learning on the production of English consonants. *Speech Communication, 16,* 1–26.

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

Flege, J., Yeni-Komshian, G., & Liu, S. (1999). Age constraints on second-language acquisition. *Journal of Memory and Language, 41,* 78–104.

Fox, E. (1996). Cross-language priming from ignored words: Evidence for a common representational system in bilinguals. *Journal of Memory and Language, 35,* 353–370.

Gaitenby, J. (1965). The elastic word. *Haskins Laboratories Status Report on Speech Research, 2,* 3.1–3.12.

Giles, H., & Smith, P. (1979). Accommodation theory: Optimal levels of convergence. In H. Giles & R. St. Clair (Eds.), *Language and social psychology* (pp. 45–65). Oxford: Blackwell.

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

(1992). Another view of bilingualism. In R. Harris (Ed.), *Cognitive processing in bilinguals* (pp. 51–63). Amsterdam: North Holland.

(1999). The bilinguals's language modes. In J. Nicol & T. Langendoen (Eds.), *Language processing in the bilingual.* Oxford: Blackwell.

Guion, S., Flege, J., & Lotfin, J. (in press). The effect of L1 use on pronunciation in Quichua–Spanish bilinguals. *Journal of Phonetics.*

Hazan, V., & Barrett, S. (1999). The development of phoneme categorization in children aged 6 to 12 years. *Proceedings of the 14th International Congress of Phonetic Sciences, San Francisco, 1–7 August 1999* (pp. 2493–2496).

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

Lennon, P. (1990. Investigating fluency in EFL: A quantitative approach. *Language Learning, 40,* 387–417.

Lindblom, B. (1968). Temporal organization of syllable production. *Speech Transmission Laboratory Quarterly Status Report, Stockholm, Sweden, Royal Institute of Technology, 4*(3).

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

Meuter, R., & Allport, A. (1999). Bilingual language switching in naming: Asymmetrical costs of language selection. *Journal of Memory and Language, 40,* 25–40.

Munro, M. (1999). The role of speaking rate in the perception of L2 speech. *Journal of the Acoustical Society of America, 105*(A), 1032.

Munro, M., & Derwing, T. (1995). Processing time, accent, and comprehensibility in the perception of native and foreign-accented speech. *Language and Speech, 38,* 389–406.

Munro, M., Flege, J., & MacKay, I. (1996). The effect of age of second-language learning on the production of English vowels. *Applied Psycholinguistics, 17,* 313–334.

Oller, D. (1972). The effect of position in utterance on speech segment duration in English. *Journal of the Acoustical Society of America, 54,* 1235–1246.

Ortega, M., & Hazan, V. (1999). Enhancing acoustic cues to aid L2 speech perception. *Proceedings of the 14th International Congress of Phonetic Sciences, San Francisco, 1–7 August 1999* (pp. 117–121).

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.

Parnell, M., & Amerman, J. (1978). Maturational influences on the perception of coarticulatory effects. *Journal of Speech and Hearing Research, 21,* 682–701.

Patkowski, M. (1980). The sensitive period for the acquisition of syntax in the second language. *Language Learning, 30,* 449–472.

(1990). Age and accent in a second language: A reply to James Emil Flege. *Applied Linguistics, 11,* 73–89.

Pennington, M. (1992). Discourse factors related to L2 phonological proficiency: An exploratory study. In J. Leather & A. James (Eds.), *Proceedings of the 1992 Amsterdam Symposium on the acquisition of second-language speech* (pp. 137–155).

Piske, T., & MacKay, I. (1999). Age and L1 use effects on degree of foreign accent in English. *Proceedings of the 14th International Congress of Phonetic Sciences, San Francisco, 1–7 August 1999* (pp. 1433–1436).

Putman, W., & Street, R. (1984). The conception and perception of noncontent speech performance: Implications for speech-accommodation theory. *International Journal of the Sociology of Language, 46,* 97–114.

Riggenbach, H. (1991). Toward an understanding of fluency: A microanalysis of nonnative speaker conversations. *Discourse Processes, 14,* 423–441.

Sabin, E., Clemmer, E., O'Connell, D., & Kowal, S. (1979). A pausological approach to speech development. In A. W. Seigman & S. Feldstein (Eds.), *Of speech and time: Temporal speech patterns and interpersonal contexts* (pp. 35–55). Hillsdale, NJ: Erlbaum.

Soares, C., & Grosjean, F. (1984). Bilinguals in a monolingual and bilingual speech mode: The effect on lexical access. *Memory and Cognition, 12,* 380–386.

Thakerar, J., Giles, H., & Cheshire, J. (1982). Psychological and linguistic parameters of speech accommodation theory. In C. Fraser & K. Scherer (Eds.), *Advances in the social psychology of language* (pp. 203–255). Cambridge: Cambridge University Press.

Weber-Fox, C., & Neville, H. (1999). Functional neural subsystems are differentially affected by delays in second language immersion: ERP and behavioral evidence in bilinguals. In D. Birdsong (Ed.), *Second language acquisition and the critical period hypothesis* (pp. 23–38). Mahwah, NJ: Erlbaum.

Yeni-Komshian, G., Flege, J., & Liu, H. (1997). Pronunciation proficiency in L1 and L2 among Korean–English bilinguals: The effect of age of arrival in the U.S. *Journal of the Acoustical Society of America, 102*(A), 3138.

Yeni-Komshian, G., Flege, J., & Liu, H. (submitted). *Pronunciation proficiency in the first and second languages of Korean–English bilinguals.*