The acquisition of a new phonological contrast: The case of stop consonants in French–English bilinguals

A. Caramazza

Department of Psychology, The Johns Hopkins University, Baltimore, Maryland 21218

G. H. Yeni-Komshian

Division of Laryngology and Otology, The Johns Hopkins University School of Medicine, Baltimore, Maryland 21205

E. B. Zurif

Aphasia Research Center, Boston University School of Medicine, and Boston V. A. Hospital, Boston, Massachusetts

E. Carbone

Department of Psychology, Sir George Williams University, Montreal, Quebec, Canada

(Received 13 February 1973; 28 March 1973)

Cross-language studies have shown that Voice Onset Time (VOT) is a sufficient cue to separate initial stop consonants into phonemic categories. The present study used VOT as a linguistic cue in examining the perception and production of stop consonants in three groups of subjects: unilingual Canadian French, unilingual Canadian English, and bilingual French–English speakers. Perception was studied by having subjects label synthetically produced stop-vowel syllables while production was assessed through spectrographic measurements of VOT in word-initial stops. Six stop consonants, common to both languages, were used for these tasks. On the perception task, the two groups of unilingual subjects showed different perceptual crossovers with those of the bilinguals occupying an intermediate position. The production data indicate that VOT measures can separate voicing contrasts for speakers of Canadian English, but not for speakers of Canadian French. The data also show that language switching in bilinguals is well controlled for production but poorly controlled for perception at the phonological level.

Subject Classification: 9.7, 9.2, 9.5.

INTRODUCTION

Bilingual speakers appear to have little difficulty in keeping their two languages distinct. This observation, backed by the results of experimental studies at the lexical, syntactic, and semantic levels,[1–2] implies that bilinguals have developed separate strategies for independently processing linguistic material in each language. Yet, little is known about how bilinguals process language at the phonological level. The experiment reported here was designed to study this question; our specific intention was to investigate how bilinguals perceive and produce the voiced and voiceless forms of the stop consonants /b–p/, /d–t/, and /g–k/.

Phoneticians have invoked various phonetic dimensions in order to capture the voiced–voiceless distinction prevalent in most languages. In the particular case of English stop consonants, for example, distinctive features such as voicing, aspiration, and articulatory force have all been implicated, either individually or in combination, as features sufficient to generate the phonemic categories /p,t,k/ and /b,d,g/.[3–4] However, the apparent independence of these features has been questioned. Lisker and Abramson[5–6] have sought to demonstrate that these features can be completely derived from the single articulatory variable of voice onset time (VOT). VOT stands for the temporal relation existing between changes in the glottal aperture and the supraglottal gestures; and acoustically, it is realized as the timing difference between the release of the stop occlusion and the onset of quasi-periodical laryngeal vibrations.[5]

The importance of this temporal cue has now been well documented. Cross-language studies of speech production have shown that variations in VOT distinguish voicing contrasts not only in English, but in many other languages.[5] Moreover, these same studies have found that the different languages use somewhat similar locations along the VOT continuum to produce voicing distinctions. In addition, experimental observations have indicated a complementary use of VOT in perception—variations along this dimension being a sufficient cue for perceptually categorizing stop consonants into phonemic categories.[7–12]

Given this evidence, we felt it would be instructive to determine how individuals who have acquired two languages deal with VOT as a phonological cue. What was done experimentally, then, was to test bilingual subjects under two separate conditions; when they were set to speak and be spoken to in one language, and then

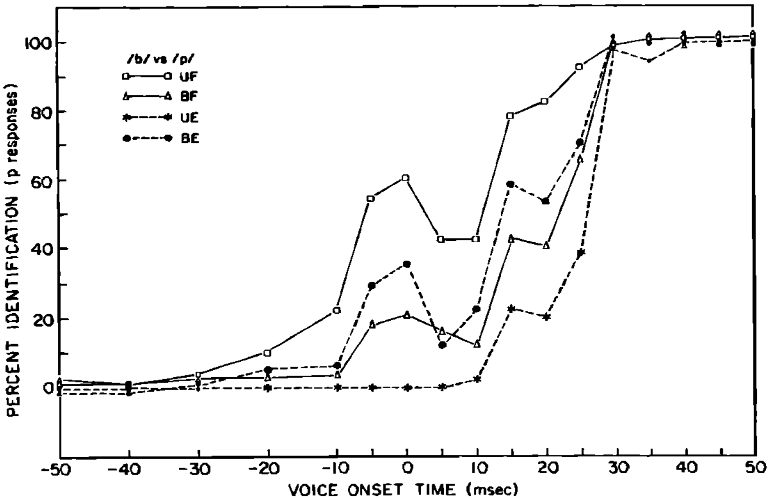

FIG. 1. Percentage of /p/ responses as a function of VOT. Each data point in the UE and UF functions is based on 50 observations. The data points for the functions of the bilinguals in the French set (BF) and the bilinguals in the English set (BE) are based on 100 observations each.

again, when they were in a set for the other language. Further, and in order to establish baselines against which to measure the effects of acquiring two languages on the phonological system, we also tested unilingual speakers of the languages involved. In each condition, perception was assessed by having subjects label synthetic speech sounds that differed in VOT, while spectrographic analyses of spoken stop-initial words were used to assess production. Our subjects were either unilingual or bilingual with respect to Canadian English and Canadian French.

I. METHOD

A. Materials

The experimental stimuli in the perception part of the study were three different continua of stop+vowel syllables synthesized at the Haskins Laboratories. The basic pattern for each stimulus item consisted of three steady-state formants for the vowel [a] to which was added the appropriate release burst and formant transitions to produce either the bilabial, alveolar, or velar stops. Each of these three sets contained 37 syllables and varied only on VOT. The duration of each syllable was 350 msec. The VOT values ranged from 150 msec preceding (−150) to 150 msec following the release burst in steps of 10 msec, except for the range of −10 to 50 msec where steps of 5 msec were taken. Five random sequences of each of the three basic continua were produced by splicing. These 15 sequences were employed in the perception test.

The words used to assess production were common stop-initial English and French words, typed on 3×5 white cards. With the exception of one English word, none of the words used in the experiment were minimal pairs. There were nine words for each of the six stop consonants for each language, thus making a total of 54 English and 54 French words. Only three words, those with a stop+[a] initial, for each consonant, were analyzed. Thus the number of words analyzed were: 180 for each unilingual group and 360 for each of the two language conditions of the bilingual group.

B. Subjects

Forty subjects were paid to participate in this experiment: 10 unilingual Canadian English speakers (UE), 10 unilingual French Canadian speakers (UF), and 20 Canadian French–English bilinguals (BF and BE). The subjects were either high school or university undergraduate students with ages ranging from 17 to 25 years. Of these subjects, 19 were female and 21 were male, and all had normal hearing as reported subjectively.

The unilingual subjects were all native speakers of their respective languages, either English or French. However, they all knew some words in the other language, which is unavoidable in a bilingual country. The bilingual subjects were all native speakers of French and had begun to acquire English at no later than their seventh birthday. Actually, 10 of these subjects were classified as compound bilinguals and 10 as coordinate bilinguals, the former category referring to those subjects who had learned both languages in the same social context, the latter to those who had learned their languages in different contexts.[13] We had felt initially that there might be some differences between these two groups. However, since no major differences arose, either in the perception or production part of the experiment, we have treated them as one group.

Bilingual proficiency was determined in two ways. Subjects were initially screened by having them produce self-ratings of their knowledge of English on a 7-point scale, with values ranging from *no knowledge* (1) to *excellent knowledge* (7). Only those subjects who achieved a score of at least 5 were admitted for further assessment. The final selection was then made by having subjects read aloud a passage from Jane Austin's *Sense*

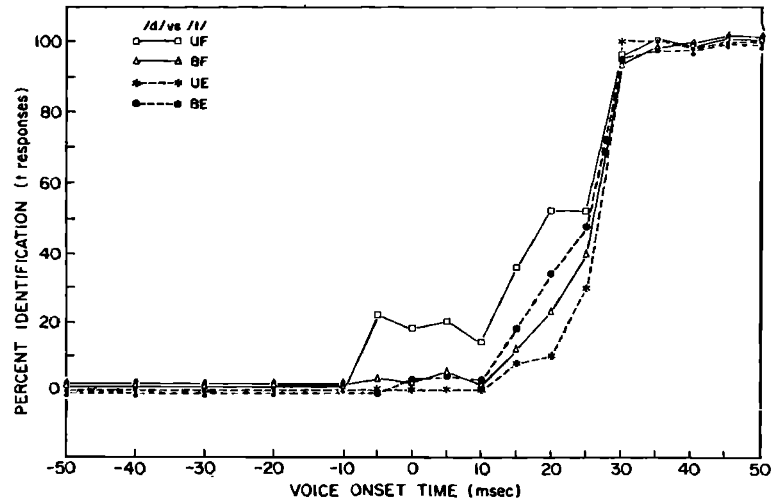

FIG. 2. Percentage of /t/ responses as a function of VOT. Each data point in the UE and UF functions is based on 50 observations. The data points for the functions of the bilinguals in the French set (BF) and the bilinguals in the English set (BE) are based on 100 observations each.

and Sensibility. Reading speed has been shown to be an effective measure of bilingualism[14] and so the first 20 subjects that read aloud at a rate of at least 180 words/min. were tested in the present experiment.

C. Procedure

Subjects were tested individually in acoustically quiet rooms. The unilingual speakers were tested in a single session either at an English university or at a French high school, depending on the language group they belonged to. Two different experimenters were employed: one, a native speaker of Canadian English who tested the English subjects, the other, a native speaker of Canadian French who tested the French subjects. The bilingual group was tested twice, once by the English experimenter in the English university and once by the French experimenter in the French high school. The two testing sessions for the bilinguals were between two and three weeks apart, and were counterbalanced in terms of which language was tested first. In addition, precautions were taken both to maintain uniformity between the two testing sessions and to create a psychological set for one or the other language. In the English testing situation, then, materials, instructions, and the atmosphere, in general, were maximally accentuated as being English, while in the French condition these variables were emphasized as being French.

Each testing session began by having the subject read aloud a set of English or French stop-initial words containing either of two homorganic consonants, e.g., papillon–ballade, and by recording his responses on tape. The subject was then asked to label the VOT variants for the same class of stops that he had just read. The response mode in this task was to have the subjects mark on a printed form their choice of either the voiceless or voiced form of the homorganic pair being tested. The stimuli for this part of the experiment were delivered through binaural headphones, and consisted of the five different random orders of the continuum. This procedure, of assessing production first and then perception, was repeated for each of the three classes of stops, bilabial, alveolar, and velar. The unilingual subjects thus read three sets of words and labelled each of the three stop continua. In contrast, the bilingual subjects, who participated both in the English and French conditions, read six sets of words, three sets in English and three sets in French; also, they labelled each of the three stop continua twice. The order of presenting the three types of stop consonant pairs, i.e., bilabial, alveolar or velar, was random.

Wide-band (and whenever necessary narrow-band) spectrograms were made of the recorded words and analyzed on a voiceprint sound spectrograph. VOT values were obtained directly from these spectrograms by measuring the distance between the onset of energy in the formant frequency range representing the release of air pressure and the first vertical striations representing glottal pulsation.

II. RESULTS

A. Perception

The average identification functions for each of the three groups of subjects are presented separately for the bilabial, alveolar, and velar stops (Figs. 1, 2, and 3). In each of these three figures, the percentage of "voiceless" responses (p, t, or k) is plotted as a function of the VOT continuum. The 50% crossover points for the two unilingual groups are clearly different from each other. In all cases, these perceptual crossovers are at lower VOT values for the UF subjects than for the UE subjects. This is especially so for the bilabial and velar stops. In addition, the identification functions for the two groups are noticeably different in terms of their shape and their rate of change.

If rate of change from one phoneme category to the other is taken as an indication of noise in the decision

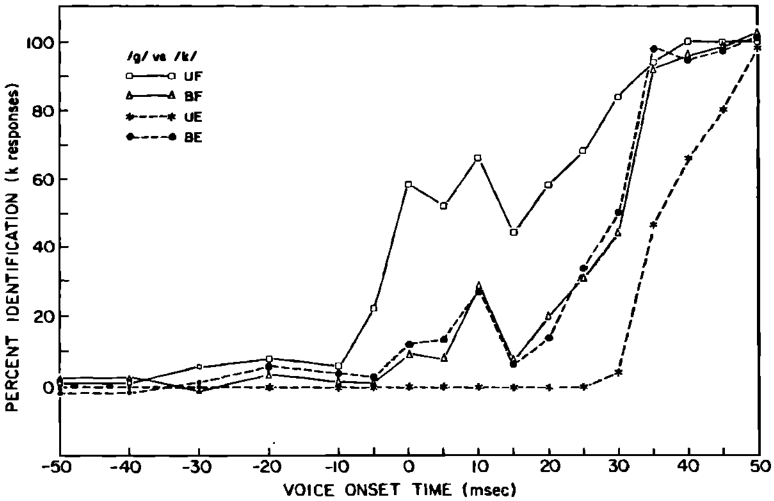

FIG. 3. Percentage of /k/ responses as a function of VOT. Each data point in the UE and UF functions is based on 50 observations. The data points for the functions of the bilinguals in the French set (BF) and the bilinguals in the English set (BE) are based on 100 observations each.

process, then the rather steep curves for the UE group suggest that VOT is a strong perceptual cue in Canadian English. However, this does not appear to be the case for Canadian French; on the contrary, speakers of Canadian French seem relatively insensitive to VOT as a categorical phonological cue. This is suggested by noting that their identification functions show a slower rate of change and are less monotonic than those for the UE speakers. Actually, the UF curves are slightly ambiguous with respect to how they divide the continuum, but it should also be pointed out that the staggered shapes of the UF group's functions did not result from the spurious averaging of individual curves. Inspection of individual identification functions revealed that all the UF subjects had nonmonotonic functions. Many of the "dips" in the individual curves matched those present in the average functions.

The bilingual subjects' 50% crossover values, both in the English and French modes, occupy intermediate positions relative to those of the two unilingual groups. However, their identification functions have certain characteristics in common with the UF as well as the UE functions. On the one hand, the bilinguals, like the UF speakers, generated curves that are not especially monotonic. On the other hand, the rates of change shown by the bilingual curves approach those generated by the UE speakers. This suggests that, while bilinguals are perhaps less sensitive to VOT variations than

TABLE I. Means and standard deviations (in milliseconds) of the perceptual functions as estimated by Probit Analysis. The means are estimates of the crossover points, and the standard deviations are estimates of the slope of the perceptual functions.

	/b-p/		/d-t/		/g-k/	
	Mean	SD	Mean	SD	Mean	SD
UF	8	17	21	15	14	23
UE	24	7	25	5	38	7
BF	19	8	24	6	28	8
BE	17	10	23	7	27	8

UE speakers, they utilize this acoustic cue more than UF speakers do.

Another point of interest in the bilingual data is the similarity of the curves in the two language sets. In neither language mode was there any switching of the bilingual functions to match the functions of the unilingual subjects. Rather, bilinguals appear to have based their perceptual decisions on the same criteria in both the French and English sets.

In our description of the functions presented in Figs. 1–3, we have emphasized three measures. One is the crossover point marking the VOT value at which 50% of the responses are for one phoneme category and 50% for the other. This value can be taken as an estimate of the category boundary for the two phonemes. The other two measures are rate of change (slope) from one category to the next and the shape of the function (e.g., monotonicity). While rate of change captures the degree of dispersion, or variability of response best, this characteristic can be further defined by the shape of the function. Thus far, however, we have been estimating these three measures directly from the graphs; and although differences and similarities among the group functions are readily apparent from the graphs, they do not permit descriptive statistical analyses.

Therefore, to measure the degree of dispersion of the various perceptual functions we have adopted a curve-fitting procedure termed Probit Analysis.[15] This analysis makes use only of the data lying between the asymptotic regions of each curve and yields quantitative estimates of both the 50% crossover points (means) and the slopes of the curves, the latter being inversely proportional to the standard deviations of the distribution of data points. Parenthetically, it should be noted that if identification functions are to be used as evidence for positing that speech perception is categorical, then these functions should be monotonic in the crossover range. Gross violations of monotonicity

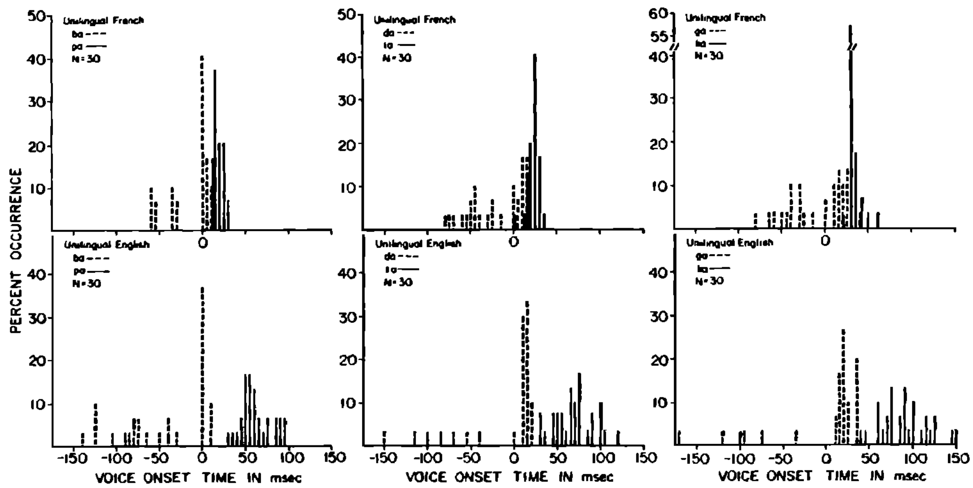

FIG. 4. VOT distributions for the production of stop initial words by French and English unilingual speakers. The distributions for each member of the pair of homorganic stops is based on 30 observations.

imply that the independent variable (i.e., VOT) is only weakly correlated with some variable which is influencing the subject's decision.

Table I presents the outcome of the Probit Analysis: means and standard deviations for the three groups of subjects are shown separately for the three stop-consonant pairs. In all cases the quantitative results are well aligned with the estimates taken from the graphs. The variability of response is lowest for the UE group, next lowest for the bilingual group (in both language modes), and highest for the UF group. The large amount of variability in the UF group supports the suggestion that they do not use VOT as a major cue in discriminating voiced from voiceless consonants. The bilingual group, however, does appear to utilize this acoustic cue: the standard deviations for this group, while slightly greater than those for the UE group, are much smaller than those obtained for the UF group. In addition, the consistency of the means and standard deviations in the two language modes suggests that bilinguals use the same phonetic criteria when perceiving voicing distinctions in French as they do when perceiving these distinctions in English.

B. Production

Histograms of VOT distributions for the two unilingual groups are presented in Fig. 4. As can be seen from the lower panels of this figure, the distributions of VOT values for the UE subjects do not overlap on any of the three phonemic contrasts. For the UF group, however, the separation between phonemic categories is not so marked; there is, in fact, a substantial degree of overlap for each phonemic contrast (Fig. 4, upper panels). These results complement the findings on the perceptual task: VOT appears to be an important variable for voicing distinctions in Canadian English but not in Canadian French.

Figure 5 presents the bilingual production data separately for the French and English modes. As shown, the bilingual subjects produced voicing distinctions which were clearly different for the two languages; and this disparity stands in marked contrast to the similarity of their perceptual functions in the two language modes. When speaking French, they produced stops with overlapped VOT values similar to those of the UF group, whereas when speaking English, their VOT values shifted toward the UE subjects' distribution range and showed a clear separation for each phonemic contrast. However, as is apparent from the mean values of VOT for the voiceless consonants (Table II), the bilingual subjects were more closely aligned with the UF group, when in the French mode, than they were with the UE subjects, when in the English mode. This may reflect the fact that, while our subjects were bilingual, they had acquired English as their second language.

Parametric statistical tests could not be performed on all the production data because of the clearly bimodal, in fact discontinuous, distributions of the voiced stops. A repeated measures analysis of variance compared the performance of the bilingual speakers on the three voiceless stop consonants in the two language modes. Performance in these two modes was significantly different [$F(1,19)=81.08$, $P<0.001$], with bilingual subjects producing longer voicing lags when in

TABLE II. Means of VOT values (in milliseconds) for the voiceless consonants in the production test.

	/p/	/t/	/k/
UF	18	23	32
UE	62	70	90
BF	20	28	35
BE	39	48	67

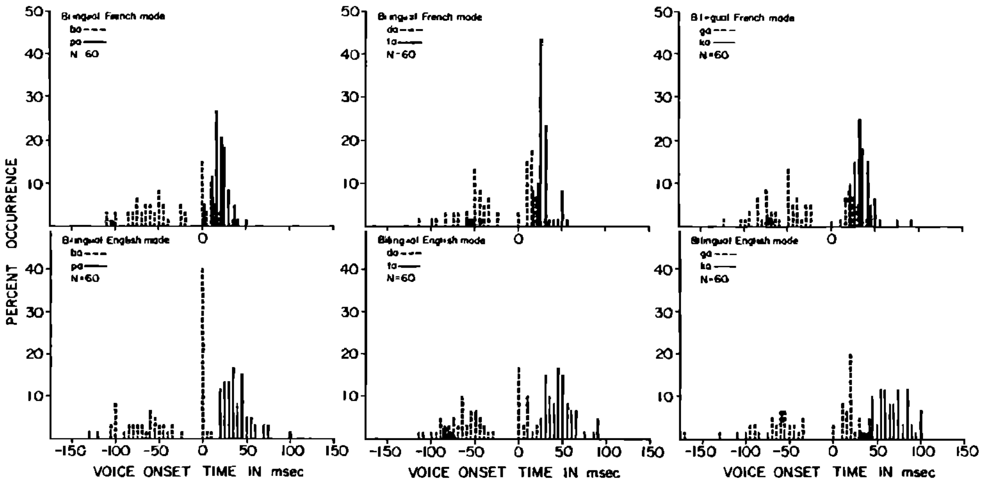

FIG. 5. VOT distributions for the production of stop initial words in French and in English by the bilingual speakers. The distributions for each member of the pair of homorganic stops is based on 60 observations.

the English mode than in the French mode. In addition, the three stop consonants differed significantly from one another [$F(2,38)=108.55$, $P<0.001$], with with voicing lag being progressively longer for /p/, /t/, and /k/. A significant effect was obtained for the interaction of language mode by type of consonant [$F(2,38)=15.04$, $P<0.001$]. This latter result indicates that the bilingual subjects were producing relatively longer voicing lags for /k/ in English, as compared to French, than the language differences seen for /p/ and /t/.

Two other analyses of variance were carried out on the production of the voiceless stops. These compared bilingual productions in the French mode with UF productions and bilingual productions in the English mode with UE productions. The voicing lags produced by the bilinguals in the French mode were not significantly different from those produced by the UF speakers [$F(1,84)=3.56$, $P>0.05$], but in the English mode, voicing lags for the bilinguals were significantly shorter than the lags for the UE subjects [$F(1,84)=44.10$, $P<0.001$]. Both analyses also revealed significant ($P<0.001$) consonant differences, but no significant language by consonant interactions.

III. DISCUSSION

A. Unilingual Speakers

The findings we have reported for the Canadian UE group are entirely consistent with Lisker and Abramson's data on American English speakers.[5,7–8] Both their American subjects and our Canadian UE subjects generated perceptual functions with sharp monotonic slopes; and both produced similar perceptual crossovers at each place of articulation when labelling the synthetic VOT variants. Further, the American and Canadian subjects produced similar and, in each case, clearly nonoverlapping VOT distributions when uttering the phonemic contrasts. So it appears that VOT is phonemic in English, whether American or Canadian. Of course, this inference is based on the assumption that steep monotonic functions in perception and clearly separated VOT distributions in production are sufficient criteria for assigning phonemic status to physical dimensions.

No comparisons can be drawn for data obtained from the UF subjects. However, their grossly nonmonotonic identification functions, evincing a wide range of perceptual uncertainty, strongly suggest that VOT is not a sufficient cue for the perception of voicing distinctions in Canadian French. Had we only investigated speech perception, then perhaps the noise in the UF perception curves could have been attributed to the influence of the vowel quality in the stimuli; but this possibility seems ruled out by the UF production data. In fact, since the UF speakers showed a substantial amount of VOT overlap in their production of the homorganic stops, it seems reasonable to suggest that voicing and aspiration, themselves, are only minimally useful as perceptual cues in Canadian French. It may be, then, that other phonetic dimensions such as articulatory force (fortis–lenis)[4] or perhaps rate of formant transition[16] are the relevant phonetic dimensions for the UF speakers. In any event, the data obtained from the UF group cast doubt on any theory assigning VOT a universal status in the total determination of the phonetic dimensions of voicing, aspiration, and articulatory force.

B. Bilingual Speakers

While there are a number of fairly evident conclusions to be drawn from the bilingual data in this study, the generalization of these conclusions to other bilingual populations must be limited. Specifically, having suggested that VOT is phonemic in Canadian English but not in Canadian French, our results cover only those bilinguals who have acquired a second language in which phonemic distinctions are based on an articulatory variable (e.g., VOT) not present in the first-learned language. Such bilinguals are to be distinguished from any who have acquired two languages, both of which base phonemic distinctions on the same articulatory variable.

In this context, consider first the production data. When speaking in French, the bilinguals showed a marked overlap in their VOT distributions for each phonemic contrast. These distributions very closely resembled those shown by the UF subjects, and, in fact, no statistical differences emerged between the two groups on this measure. It seems, therefore, that the bilingual subjects had retained the Canadian French mechanisms of encoding speech. In other words, there is no evidence of phonological interference from their second language (English).

Yet the phonological system of the bilingual is not completely free from interlanguage interference. Rather the interference appears to be unidirectional: from the first, perhaps stronger language to the second, perhaps weaker language. The bilingual subjects were capable of switching encoding mechanisms at the phonological level, but they did so imperfectly. Thus, although they showed both a shift in VOT to the UE distribution range and a clear VOT separation for each phonemic contrast when speaking in English, they did not totally align themselves with the UE group on these measures. Analyses of variance performed on the distributions of VOT values for the voiceless consonants did yield significant differences between these two groups.

Statistical analyses could only be carried out on VOT distributions for the voiceless stops, but the VOT distributions produced by the bilingual subjects for the voiced stops also warrants consideration. Specifically, it should be noted that they showed no appreciable differences in the two language modes for the voicing lead and short voicing lag regions. Thus, the difference in their productions of French and English words was in the amount of voicing lag produced in uttering the voiceless words. This suggests that in acquiring English the bilingual subjects learned to control VOT in their productions of the voiceless consonants and did not modify their productions of the voiced consonants. These results suggest that VOT control is important only at phonemic boundary regions and relatively unimportant at other points in the productive range, where the information carried by VOT is phonemically irrelevant.

Unlike the production results, the perceptual functions in the two language sets were not very different from each other: both curves had similar shapes, steep yet nonomonotonic, and both showed perceptual crossover points at positions intermediate to the UF and UE functions. The fact that the identification functions are steep suggests that the bilinguals were making greater use of VOT as a phonemic cue than were the UF subjects. The results suggest that perhaps the bilingual subjects had to deal with the test stimuli as if they were exemplars of English speech sounds in order to use this VOT information. This is supported by the fact that the identification functions of the bilingual subjects closely match predictions which can be made from their productions of English words but not French words. The lack of monotonicity in their identification functions, however, suggests that the effects of interference from their first-learned language are seen in perception as well as production.

In general, it appears reasonable to suggest that the phonological processors the bilingual acquires for his second language are contaminated by properties accruing to his first language. Further, unlike the learning of a second vocabulary, the acquisition of a second phonological system does not appear to be quantal. Rather, the process seems to consist of a gradual and continuous progression toward a target which may never be attained: and this appears to hold for perception and production.

However, when the similarity of the perceptual functions in the two language modes is contrasted with the difference shown for the production distributions in these language modes, the bilinguals appear better able to adapt their production mechanisms than their perceptual mechanisms to the second language. This ability to switch mechanisms from one language to another has been reported in detail elsewhere,[17] but briefly stated, it seems that language switching is easier for production than for perception. In perception, the stimulus itself seems to determine the type of analysis to be performed.

ACKNOWLEDGMENTS

We would like to express our thanks to Dr. A. S. Abramson and Dr. L. Lisker of the Haskins Laboratories for their helpful comments on this research and for their loan of their synthesized stop continua. We would also like to thank Dr. B. Green for suggesting the use of Probit Analysis and Mr. F. Sonsini for writing part of the program for the analysis of the perceptual data. The assistance of Mrs. Bignell in data collection is appreciated.

This research was supported in part by the National Research Council of Canada, Grant number A0291, NINDS Research Grant number 09994, and NINDS Research Grant number 06209.

[1]W. E. Lambert, "Psychological Studies of the Interdependencies of the Bilingual's Two Languages," in *Substance and Structure of Language*, edited by Jaan Puhvel (U. of California Press, Berkeley and Los Angeles, 1969).

[2]J. Macnamara, "The Bilingual's Linguistic Performance: a Psychological Overview," in *Problems of Bilingualism*, edited by J. Macnamara, J. Social Issues **23**, 58–77 (1967).
[3]R-M. S. Heffner, *General Phonetics* (U. of Wisconsin Press, Madison, Wisc., 1949).
[4]R. Jakobson, G. G. M. Fant, and M. Halle. "Preliminaries to Speech Analysis," Acoust. Lab., MIT, Cambridge, Mass., Rep. No. 13 (1952) (Reprinted by MIT, Cambridge, Mass., 1963).
[5]L. Lisker and A. S. Abramson, "A Cross Language Study of Voicing in Initial Stops: Acoustical Measurements," Word **20**, 384–422 (1964).
[6]L. Lisker and A. S. Abramson, "Distinctive Features and Laryngeal Control," Language **47**, 767–785 (1971).
[7]A. S. Abramson and L. Lisker, "Voice Onset Time in Stop Consonants: Acoustic Analysis and Synthesis," 5th Intn. Congr. Acoust., Liège, 1–4, 1965.
[8]A. S. Abramson and L. Lisker, "Discriminability Along the Voicing Continuum: Cross Language Tests," Proc. 6th Intn. Congr. Phon. Sci., Prague, 569–573 (1970).
[9]A. S. Abramson and L. Lisker, "Voice Timing in Korean Stops," Paper presented at the 7th Intn. Congr. Phon. Sci., Montreal (1971).
[10]L. Lisker and A. S. Abramson, "The Voicing Dimension: Some Experiments in Comparative Phonetics," Proc. 6th Lang. Intn. Congr. Phon. Sci., Prague 563–567 (1970).
[11]A. M. Liberman, P. C. Delattre, and F. S. Cooper, "Some Cues for the Distinction between Voiced and Voiceless Stops in Initial Position," Language and Speech **1**, 153–167 (1958).
[12]A. M. Liberman, K. S. Harris, J. A. Kinney, and H. Lane, "The Discrimination of Relative Onset-Time of the Components of Certain Speech and Non Speech Patterns," J. Exp. Psychol. **61**, 379–388 (1961).
[13]S. M. Ervin and C. E. Osgood, "Second Language Learning and Bilingualism," J. Abnormal Social Psychol. (Suppl.) **49**, 139–146 (1954).
[14]J. Macnamara, "How Can We Measure the Extent of a Person's Bilingual Proficiency?" in *Description and Measurement of Bilingualism*, edited by L. G. Kelly (Toronto U. P., Toronto, 1969).
[15]D. J. Finney, *Probit Analysis* (Cambridge U. P., Cambridge, England, 1952).
[16]C. Summerfield and M. P. Haggard, "Articulatory Rate Versus Acoustic Invariants in Speech Perception," J. Acoust. Soc. Am. **52**, 113(A) (1972).
[17]A. Caramazza, G. Yeni-Komshian, E. Zurif, and E. Carbone, "Language Switching in Bilinguals: the Phonological Level," (in preparation).