

*Dialect Effects in Vowel Perception: The Role of Temporal Information in French**

JOANNE L. MILLER

Northeastern University, Boston

FRANÇOIS GROSJEAN

Université de Neuchâtel, Switzerland

KEY WORDS

dialect effects

language specificity

speech perception

vowel duration

vowel perception

ABSTRACT

The importance of vowel duration for specifying vowel contrasts differs across languages. In English, for example, a number of vowel pairs are acoustically differentiated by both temporal and spectral information, whereas in standard French temporal information plays a much more minor role. Gottfried and Beddor (1988) reported that the effectiveness of vowel duration in perception varies accordingly: For native speakers of English, but not native speakers of standard French, a change in vowel duration affected the perceptual identity of a vowel contrast. We tested the hypothesis that the relative prominence of vowel duration within different dialects of a given language also has perceptual consequences. Vowel duration plays a much more important role in the phonological system of Swiss French than standard French. Given this, we predicted that native speakers of Swiss French, unlike native speakers of standard French, would use temporal information when identifying vowels. Our prediction was confirmed. These findings indicate that just as there are cross-language differences in fundamental aspects of speech perception, so too are there cross-dialect differences, and they support the view that the perceptual mapping between acoustic signal and vowel category is sensitive to global aspects of the listener's phonological system.

* Acknowledgments: This research was supported by a grant to the first author from the National Institutes of Health (NIDCD DC 00130) and by grants to the second author from the Swiss National Science Foundation (32-37276.93 and 1213-045375.95). We extend our thanks to Terry Gottfried and Patrice Beddor for kindly sending us their stimulus materials, to Jean-Yves Dommergues for testing the French listeners in Paris (Experiment 1), to François Voillat of the Glossaire des patois de la Suisse romande for helping us collect information on Swiss French phonology, and to Michele Page and Michael Dickson for assistance in testing the English listeners.

Correspondence may be addressed to either Joanne L. Miller, Department of Psychology, Northeastern University, Boston, MA 02115 (e-mail: jlmiller@neu.edu) or François Grosjean, Laboratoire de traitement du langage et de la parole, Université de Neuchâtel, Avenue du Premier-Mars 26, 2000 Neuchâtel, Switzerland (e-mail: francois.grosjean@lettres.unine.ch).

INTRODUCTION

It is known that languages differ in the extent to which they use temporal information to distinguish vowels. A case in point is the difference between English and standard French.¹ In English, temporal information covaries with spectral information for many vowel pairs. For example, the vowels /i æ u/ are intrinsically longer than their spectrally similar counterparts /i ɛ o/ (Peterson & Lehiste, 1960). Moreover, numerous studies have shown that listeners are sensitive to these durational differences, and that under certain circumstances a change in vowel duration alone can alter the identity of a vowel (Ainsworth, 1972; Mermelstein, 1978; Strange, 1989; Whalen, 1989). For example, Mermelstein demonstrated that shortening a vowel that was spectrally ambiguous for /æ/ versus /ɛ/ shifted the predominant percept from the “long” vowel /æ/ to the “short” vowel /ɛ/.

The situation in standard French is quite different. Here, the evidence indicates that vowel duration plays only a minor role in the phonological system of the language (Carton, 1979; Delattre, 1959, 1965; Malmberg, 1964). In particular, there appears to be only one clear case in modern standard French in which temporal information covaries with spectral information to specify a common vowel contrast. This is the contrast between /o/ and /ɔ/ (as in *côte* vs. *cotte*), with /o/ being longer than /ɔ/ (see Gottfried & Beddor, 1988, for discussion of this point). As noted by Gottfried and Beddor (1988), temporal information also covaries with spectral information for the /ɑ/-/a/ contrast and the /ø/-/œ/ contrast; however the /ɑ/-/a/ distinction is rarely made in modern standard French (it is rapidly disappearing from the language) and the /ø/-/œ/ contrast appears in only two minimal pairs.

This raises the question of how listeners of standard French treat differences in vowel duration when trying to identify /o/ versus /ɔ/. Gottfried and Beddor (1988) discuss two major alternatives. One is that native French listeners are sensitive to the durational difference between /o/ and /ɔ/ and use it during identification. This leads to the prediction that spectrally ambiguous vowels between /o/ and /ɔ/ will be identified as /o/ if relatively long but as /ɔ/ if relatively short, analogous to the case of the /æ/-/ɛ/ contrast for English listeners noted above. The second alternative is that if, as in the case of standard French, vowel duration does not play a prominent role in the phonological system of a language, then listeners will virtually ignore it when identifying any particular vowel. If this is the case, then standard French listeners should use only spectral characteristics when identifying /o/ versus /ɔ/; changes in vowel duration should not affect vowel identification.

In order to test these two alternatives, Gottfried and Beddor (1988) employed a trading relation paradigm (Repp, 1982), which involves orthogonally varying the acoustic properties under investigation (in this case, spectral and temporal information), and measuring the effect on perception. Specifically, they synthesized three series of stimuli that ranged from *côte* to *cotte*. The /o/-/ɔ/ vowel change within each series was effected, in an identical manner, by systematically altering the formant frequency values of the vowels from those appropriate for /o/ to those appropriate for /ɔ/. Thus, within a series only spectral information varied. The three series differed from each other only in overall vowel duration. Two groups of subjects were asked to identify the stimuli, native speakers of standard French

¹ We use the term “standard French” to refer to the French spoken in and around Paris, as well as in many other parts of France (excluding the South).

and native speakers of English who did not know French.² Both groups of subjects produced orderly identification functions, with a monotonic decrease in /o/ (as opposed to /ɔ/) responses as the formant frequency values became more appropriate for /ɔ/. This indicates that both groups of listeners used the variation in spectral information within the series to identify the vowels.

However, the two groups differed markedly in the way in which the change in vowel duration across the three series affected performance. For the English listeners, variation in vowel duration had a very clear effect. It produced a perceptual trading relation with the spectral information, such that the identification function shifted toward the /ɔ/-end of the series as vowel duration increased. In other words, as the vowels became longer, they were more likely to be identified as the "long" vowel /o/ than the "short" vowel /ɔ/. This effect was most pronounced in the midregion of the series, where the spectral values were relatively ambiguous for the two vowels; identification of the endpoint stimuli, with appropriate spectral values for /o/ and /ɔ/, was virtually unaffected by the duration difference. Thus, consistent with the importance of vowel duration within the English phonological system, English listeners used duration along with spectral information when identifying the /o/-/ɔ/ contrast. For the native French listeners, however, vowel duration had no effect on performance. Although, as noted above, the three *côte-cotte* identification functions were very orderly for these listeners, indicating the consistent use of spectral information to identify the vowels, the functions were not displaced relative to one another along the stimulus continuum as a function of the change in vowel duration. Thus the standard French listeners relied solely on the spectral properties of the vowels to differentiate *côte* from *cotte*; there was no trading relation with vowel duration. On the basis of these results, Gottfried and Beddor (1988) concluded that the perceptual role of vowel duration for vowel identification depends not only on whether there is covariation of vowel duration with spectral information during speech production for a particular vowel contrast, but also on the overall prominence of vowel duration differences in the phonological system of the language.³

The purpose of the present investigation was to determine whether phonological differences related to vowel duration that exist for dialects within a given language also have perceptual consequences. Our test case is the contrast between standard French and Swiss French. Although detailed acoustic comparisons of these two dialects of French do not appear to exist, the phonological systems of the two dialects are generally considered to be very similar (Walter, 1982). Nonetheless, they do differ in one respect that is critical to our concern, the role of vowel duration. In Swiss French, unlike standard French, duration does appear to play a prominent role in the phonological system (Métral, 1977; Tranel, 1987). There are two vowel contrasts that regularly covary in spectral and temporal information. These are the /o/-/ɔ/ contrast (as in *côte* and *cotte*) that also appears in standard

² The study also included a group of native speakers of English who were learning French. Overall, the performance of the French learners was similar to that of the native English speakers who did not know French, although the size of the vowel duration effect was smaller for those learners who had more advanced competency in French.

³ Footnote 3: see overleaf.

French and the /ɑ/-/a/ contrast (as in *tâche* and *tache*); as we noted in the introduction, this contrast is rapidly disappearing from standard French. Moreover, there are also vowel pairs in Swiss French that are distinguished only by temporal information, for example, /i:/ versus /i/ (as in *vie* and *vit*) and /a:/ versus /a/ (as in *voie* and *voix*). It should be noted that these latter pairs are actually homophones in standard French, where there is no durational difference. Interestingly, the differential role of vowel duration in the two French dialects is reflected in self reports of the relative extent to which spectral information (timbre) and duration differentiate vowel pairs. On the basis of a large survey of speakers from many regions of France, including speakers of standard French, Martinet (1971) concluded that for the majority of French speakers, vowels are thought to be differentiated primarily by spectral differences, with durational differences playing a more minor role. In contrast, when Métral (1977) used the same questionnaire with speakers in the French part of Switzerland, he found that durational differences and spectral differences were both thought to play a major role in differentiating vowels within the language.

Taken together, these findings suggest that vowel duration plays a much more important role in the phonological system of Swiss French than it does in standard French. In the current study, we tested the consequences of this dialect difference for vowel perception. More specifically, we tested the hypothesis that given the importance of vowel duration in their dialect, native speakers of Swiss French, unlike native speakers of standard French, would use durational differences in addition to spectral differences when identifying the *côte-cotte* contrast.

EXPERIMENT 1: ENGLISH AND STANDARD FRENCH

The main purpose of the first experiment was to replicate Gottfried and Beddor's (1988) finding that native speakers of standard French use only spectral properties to differentiate

³ According to this account, the English listeners' sensitivity to vowel duration in this task derives directly from the importance of vowel duration in the phonological system of English. On a more specific level, the English listeners may have performed the task by implicitly pairing French words with English words. As we note in the procedure section of Experiment 1, Gottfried and Beddor (1988) point out that many of their English listeners (like our English listeners) reported that *côte* sounded like the English word *coat* (with the "long" English vowel /o"/), and that *cotte* sounded like the English word *cut* (with the "short" English vowel /ʌ/. This suggests that the English listeners were using temporal information as they would when identifying spectrally similar English vowel pairs. We should point out that Bohn (1995) has offered a quite different explanation for the English listeners' sensitivity to vowel duration in Gottfried and Beddor's study (as well as in other cross-language vowel perception studies). He suggests that perhaps the listeners were using vowel duration not because it plays a prominent role in English, but rather because the non-native /o/- /ɔ/ contrast was not well differentiated spectrally for the English listeners, and they therefore used a general perceptual strategy of relying on salient durational differences between the vowels. One problem with this alternative explanation is that the English listeners in Gottfried and Beddor's study (as in our replication, see Experiment 1) identified the endpoint stimuli of the series as /o/ and /ɔ/ with high accuracy; thus, there is no evidence that they found the spectral differentiation of the stimuli difficult. Moreover, as noted above, the English listeners reported hearing the French words as approximations of English words. This makes it likely that they were applying an English processing strategy (which involves the use of duration) when identifying the vowels.

côte and *cotte*. In order to demonstrate that our procedures were indeed sufficiently sensitive to yield a vowel duration effect if one exists, we also tested a group of native English speakers on this contrast. Based on Gottfried and Beddor's paper, we expected that these listeners would use both temporal and spectral properties when identifying the two vowels.

Method

Participants. Two groups of listeners participated in the experiment, a standard French group and an English group. The standard French group consisted of ten monolingual students at the University of Paris VII whose native language was standard French, whereas the English group consisted of ten monolingual students and staff at Northeastern University whose native language was English. The participants reported no history of a speech or hearing disorder.⁴

Stimuli. The test stimuli were identical to those used by Gottfried and Beddor (1988), who kindly provided us with a tape-recording of the stimulus sequences they used in their experiments. We used this tape in the two experiments reported in the present paper. The stimuli are described in detail by Gottfried and Beddor and can be briefly characterized as follows. The basic stimulus set consisted of three 10-step /kot/-/kɔt/ (*côte-cotte*) series, for a total of 30 stimuli. These series consisted of five-formant stimuli generated on a serial software formant synthesizer at Haskins Laboratories, using parameter values based on acoustic analyses of a male native speaker of standard French producing the words *côte* and *cotte*. The three series differed from each other only in the duration of the steady-state vowel portion of the word, which was kept constant within a series. Total vowel duration (including formant transitions) was 140, 180, and 220 ms for the short, medium, and long series, respectively. Within each series, the change in vowel from /o/ to /ɔ/ was effected (in an identical manner) by systematically altering the first (F1) and second (F2) formant frequencies of the vowel from values appropriate for /o/ to values appropriate for /ɔ/.

Two stimulus sequences comprised of these stimuli were used in the current experiments. The first was a familiarization sequence that consisted of 15 randomly selected members from the 30-member stimulus set. The second was a test sequence that contained 10 instances of each of the 30 stimuli, for a total of 300 stimuli. The 300 stimuli were arranged in random order, in blocks of 20. The interstimulus interval was 1.5 s and the interblock interval was 5 s.

Procedure. The procedure was closely patterned after that used by Gottfried and Beddor (1988). The French subjects were tested at the University of Paris VII and the English subjects were tested at Northeastern University in Boston. Instructions were given in the subject's native language. All subjects listened to the stimuli over headphones at a comfortable listening level that was kept constant across subject groups (approximately 77 dB SPL). The procedures were kept as similar as possible across the two language groups, given differences in laboratories and native language.

⁴ Two additional French listeners were tested but replaced because, unlike the other participants, for none of the three vowel duration series did they produce identification functions that followed a generally decreasing pattern of percentage of /o/ responses as the spectral characteristics changed across the stimulus continuum from those appropriate for *côte* to those appropriate for *cotte*.

The sequence of events for the French listeners was as follows. First, the subjects were played the familiarization sequence twice. During the first presentation, listeners were asked to listen to each of the 15 items, without responding, in order to become familiar with the synthetic speech. During the second presentation, they were asked to identify each item as *côte* or *cotte*. Next, the 300-member test sequence was presented twice, so that across the two presentations of the test sequence subjects identified each of the 30 stimulus items 20 times. Once again, subjects were asked to identify each item as *côte* or *cotte*. Subjects indicated their response by circling *côte* or *cotte* on a prepared answer sheet.

The sequence of events for the English listeners was the same as that for the French listeners, with two exceptions. First, prior to hearing the familiarization sequence with the synthetic stimuli, the subjects were played a brief tape consisting of natural productions of *côte* and *cotte* produced by a male native speaker of standard French (this tape was also provided to us by Gottfried and Beddor). The purpose of this tape was to introduce the English subjects to the French vowel distinction they would be identifying. Second, instead of circling *côte* or *cotte* on an answer sheet, the English subjects responded by pointing to the appropriate word, *côte* or *cotte*, printed on a card in front of them; an experimenter recorded each response on a prepared answer sheet. Furthermore, pilot testing with extensive debriefing had revealed that nearly all English subjects asked to perform the task did so by implicitly pairing the French word *côte* with the English word *coat* and the French word *cotte* with the English word *cut* (see Footnote 3). In order to make this implicit strategy available to all subjects, we printed these English words, in smaller letters and in parentheses, just under the printed French words. We note that Gottfried and Beddor (1988) report that many of the English-speaking listeners in their experiment also heard the two French vowels as these English counterparts.

Results and discussion

The group identification functions for the standard French listeners and the English listeners are presented in Figures 1 and 2, respectively. As the figures show, we were successful in replicating Gottfried and Beddor's (1988) main findings. From Figure 1, it is apparent that all three functions for the French listeners show an orderly monotonic decrease in percent /o/ responses as the spectral characteristics vary across the series from those appropriate for /o/ to those appropriate for /ɔ/; however, the three identification functions are not displaced relative to one another. This indicates that these listeners based their vowel decision solely on the spectral variation within each series, ignoring the durational differences across the series. In contrast, Figure 2 shows that the English listeners used both temporal and spectral properties when identifying the vowels. Not only were the functions orderly but, in addition, they were displaced relative to one another: as vowel duration increased across the three series, the identification function moved toward the /ɔ/- end of the continuum, yielding an increase in /o/ responses.

This difference between language groups was confirmed by statistical analyses. For each subject, for each series, we computed the overall percentage of /o/ responses, averaged across the ten stimuli within the series. This served as the dependent measure for all analyses. For the standard French listeners, the mean percentage of /o/ responses was 54.7, 55.2, and 56.1 for the short, medium, and long series, respectively. For the English listeners, these values were 50.9, 57.0, and 60.6, respectively. We first performed a two-way ANOVA on

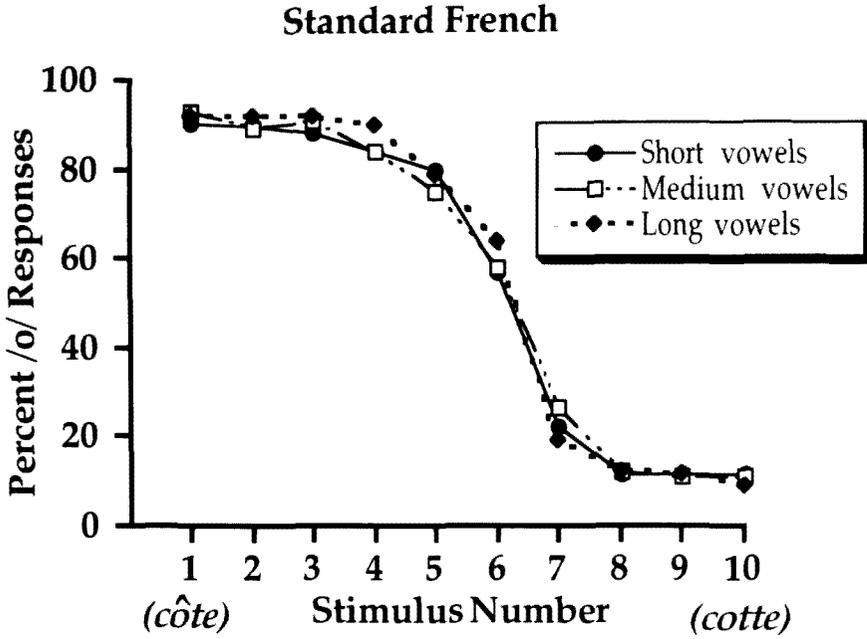


Figure 1

Group identification functions from native speakers of standard French for three *côte-cotte* (/o/-/ɔ/) series that differ in vowel duration. Experiment 1.

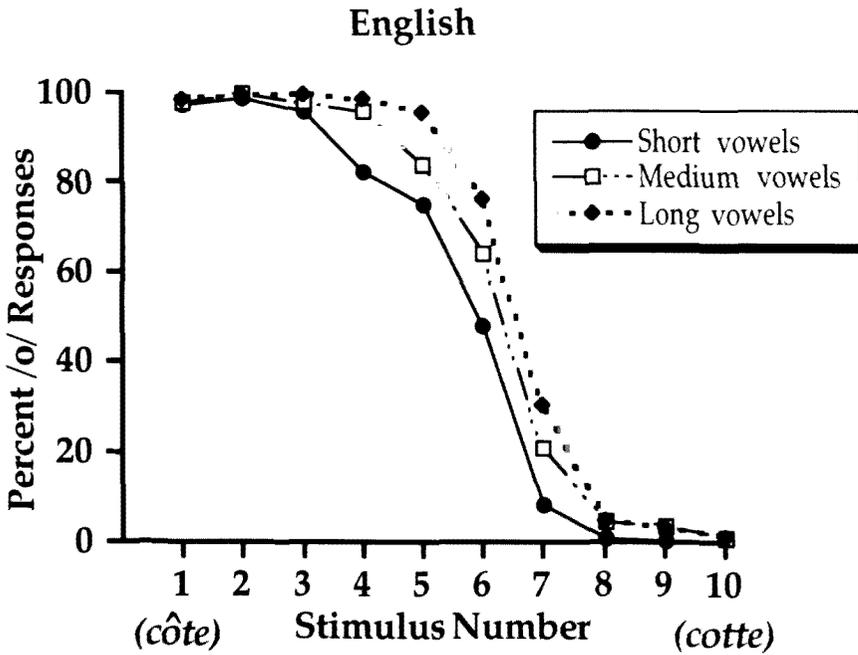


Figure 2

Group identification functions from native speakers of English for three *côte-cotte* (/o/-/ɔ/) series that differ in vowel duration. Experiment 1.

the data, with language group as a between-subjects factor and vowel duration as a within-subjects factor. Most importantly, the ANOVA revealed the expected interaction between language group and duration, $F(2,36) = 7.34$, $p < .008$. (There was also a main effect of vowel duration, $F(2,36) = 12.59$, $p < .001$; there was no main effect of language group, $F(1,18) < 1$.) To determine the source of the interaction, we next conducted separate one-way repeated measures ANOVAs for the two language groups. There was a highly significant effect of vowel duration on the percentage of /o/ responses for the English group, $F(2,18) = 15.28$, $p < .003$, but no vowel duration effect for the French group, $F(2,18) < 1$.

The results of this study clearly replicate those of Gottfried and Beddor (1988) in showing that native speakers of standard French base their decision solely on spectral properties when identifying the *côte-cotte* contrast, even though this particular contrast is acoustically differentiated not only by spectral properties but also by duration in the production of standard French. The fact that we did obtain a vowel duration effect for the English listeners indicates that our procedures were sufficiently sensitive to yield a measurable effect. This pattern of results sets the stage for the next experiment, which focused on native speakers of Swiss French.

EXPERIMENT 2: SWISS FRENCH

As we discussed in the introduction, /o/ and /ɔ/ are differentiated in production by temporal and spectral information in both Swiss French and standard French, but the dialects differ in that vowel duration plays a much more prominent role in the overall phonological system of Swiss French. Given this, we predicted that native speakers of Swiss French, unlike those of standard French, would use temporal information in addition to spectral information when making the *côte-cotte* distinction.

In conjunction with Experiment 2, we conducted a small acoustic measurement study in order to confirm that /o/ and /ɔ/ are differentiated by both spectral and temporal information in Swiss French in the specific context of *côte* and *cotte*. We asked four native female speakers of Swiss French to produce tokens of each of these words in citation form and, for each vowel (two tokens from each speaker), we measured F1, F2, and vowel duration. The results confirmed that the two vowels are well differentiated both spectrally and temporally in Swiss French. Moreover, the values we obtained are reasonably close to the values reported for these words in Gottfried and Beddor (1988) for five native female speakers of standard French (with the formant values being somewhat lower in our corpus, possibly due to differences in specific task and measurement procedures across the studies). Specifically, Gottfried and Beddor report mean F1/F2 values (in Hz) of 438/1160 and 541/1512 for /o/ and /ɔ/, respectively; the values from our corpus are 385/1090 and 455/1435, respectively. This yields /o/-to-/ɔ/ F1 formant ratios of .81 and .85 for standard and Swiss French, respectively, and F2 formant ratios of .77 and .76 for standard and Swiss French, respectively. The mean vowel durations in Gottfried and Beddor's sample were 111 and 85 ms for /o/ and /ɔ/, respectively; the comparable values from our corpus are 122 and 83 ms. These comparisons indicate that in Swiss French, as in standard French, the vowels in *côte* and *cotte* are well differentiated by both spectral and temporal information.

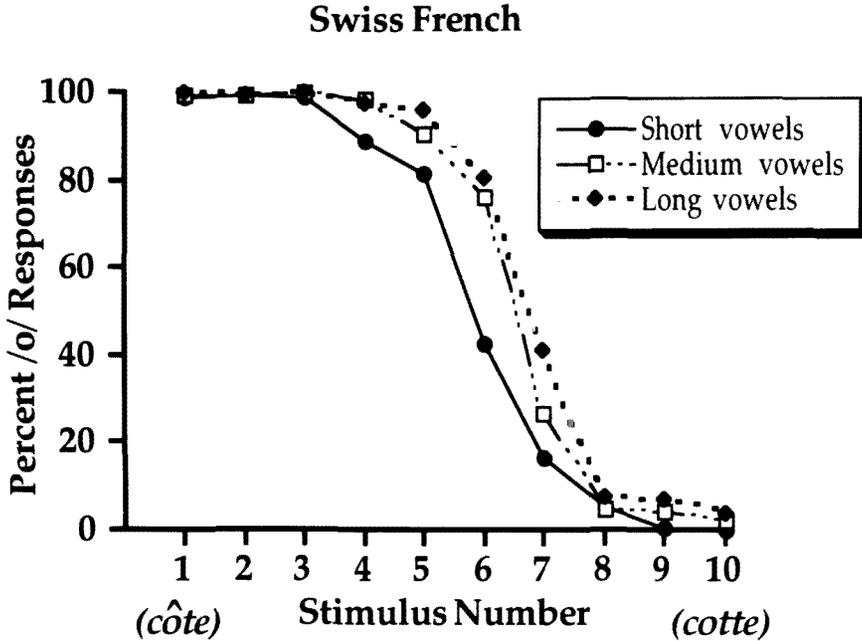


Figure 3

Group identification functions from native speakers of Swiss French for three *côte-cotte* (/o/- /ɔ/) series that differ in vowel duration. Experiment 2.

Method

Participants. The listeners were ten monolingual native French speakers who were from the French-speaking section of Switzerland and attended the University of Neuchâtel. They reported no history of a speech or hearing disorder.

Stimuli. The stimuli were identical to those used in Experiment 1. Although these stimuli had been synthesized on the basis of exemplars of standard French, the Swiss French participants reported that the stimulus set contained good exemplars of the intended words (*côte* and *cotte*), making allowances for the “artificial” quality of the stimuli due to synthesis. That is to say, they clearly heard the words as native-language exemplars.

Procedure. Testing took place at the University of Neuchâtel. The procedures were identical to those used to test the native speakers of standard French in Experiment 1.

Results and discussion

The group identification functions, which are highly orderly, are shown in Figure 3. It is clear that these French-speaking listeners, unlike the native speakers of standard French, did use temporal information in addition to spectral information when identifying the vowels. As vowel duration increased across the series, there was a clear shift in the identification function toward the /ɔ/-end of the continuum, yielding an increase in /o/ responses. Indeed, the Swiss French data look remarkably similar to the English data (see Figure 2).

As for the previous experiment, for each subject we computed the percentage /o/ responses across the ten stimuli within each series to use as the dependent measure in our analyses. Averaged across subjects, the mean percentage /o/ responses was 53.3, 60.2, and 63.2 for the short, medium, and long series, respectively. A repeated measures ANOVA on these data revealed a highly significant effect of vowel duration, $F(2,18)=26.76, p < .001$.

We also performed a two-way ANOVA directly comparing the vowel duration effect in the English group from Experiment 1 and the Swiss French group from this experiment, with language group as a between-subjects factor and vowel duration as a within-subjects factor. The ANOVA revealed, as expected, a highly significant effect of vowel duration, $F(2,36)=39.21, p < .001$; however, there was no significant effect of language group, $F(1,18)=2.90, p > .10$, nor was there a significant interaction between vowel duration and language group, $F(2,36) < 1$. Thus the magnitude of the vowel duration effect was just as large for the native speakers of Swiss French as it was for the native speakers of English. Although the interpretation of this finding is somewhat complicated by the fact that it involves the comparison of a native-language contrast for one group (Swiss French) and a foreign-language contrast for the other group (English), the comparison does indicate that the magnitude of the vowel duration effect for the Swiss French group was at least as large as that seen for a group of listeners known to be highly sensitive to vowel duration differences in their own language (English).

GENERAL DISCUSSION

The main finding of the current investigation is a clear dissociation in the way in which native speakers of standard French and native speakers of Swiss French map the acoustic signal of speech onto native-language vowel categories during perception. More specifically, our results suggest that native speakers of the two dialects treat vowel duration in fundamentally different ways, with speakers of Swiss French, but not standard French, using temporal information in addition to spectral information when identifying a vowel contrast in their language.

Our interpretation of this finding rests on the different role that vowel duration plays in the overall phonological system of the two French dialects. As we outlined in the introduction, although standard French and Swiss French are very similar to one another, vowel duration plays a much more prominent role in the phonological system of Swiss French than standard French (Carton, 1979; Delattre, 1959, 1965; Gottfried & Beddor, 1988; Malmberg, 1964; Métral, 1977; Tranel, 1987). In Swiss French, there are two common vowel contrasts that are acoustically distinguished jointly by temporal and spectral differences, /o/ versus /ɔ/ and /a/ versus /a/, and there are a number of contrasts that are acoustically differentiated only by temporal information. In standard French, however, there are no contrasts that are distinguished only by temporal information, and only one common vowel contrast, /o/ versus /ɔ/, is jointly distinguished by temporal and spectral information.

In the current study, we first replicated Gottfried and Beddor's (1988) finding that even though the /o/-/ɔ/ contrast is acoustically distinguished in part by duration in standard French, native speakers of this dialect are indifferent to vowel duration when identifying the contrast, and instead rely solely on spectral differences between the vowels. In discussing their own findings, Gottfried and Beddor suggest that native speakers of standard French are insensitive

to the temporal information because vowel duration plays such a minor role in the overall phonological system of the language. We reasoned that if their account is correct, then native speakers of Swiss French should show a sensitivity to vowel duration differences in perception, inasmuch as vowel duration plays a much more prominent role in Swiss French. This is precisely what we found in our main experiment: native speakers of Swiss French did not rely only on spectral information, but also used temporal information when identifying the /o/-/ɔ/ contrast. Thus, the overall prominence of a given acoustic property (such as vowel duration) in a dialect's phonological system seems to have important processing consequences for how that property is used during phonetic perception. (For a general discussion of how the overall sound structure of a given language might shape the relative perceptual weighting of acoustic properties over the course of development, see Jusczyk, 1993.)

The present findings underscore the importance of considering dialect differences within a language when trying to understand how listeners map the acoustic signal of speech onto linguistic categories during the initial stages of speech processing (see Eimas, 1997, for a discussion of possible dialect effects with respect to another aspect of spoken language processing, the nature of the prelexical segmentation unit). They also have implications for models of speech perception, per se. There is now a vast amount of evidence indicating that phonetic contrasts are generally specified by a multiplicity of acoustic properties, rather than a single property, and that these properties can be acoustically quite diverse. Somehow the listener integrates these various properties during online processing to arrive at the perception of a unitary phonetic segment. Indeed, listeners appear to be extremely sensitive to the multiple acoustic consequences of articulation, and it has been suggested that they will in fact make use of any acoustic property that is consistently correlated with a segmental contrast when trying to identify the individual segments of the language (see Bailey & Summerfield, 1980; Repp & Liberman, 1987).

The standard French listeners in our study, as in Gottfried and Beddor's (1988), appear to provide a counter-example. As we have said, vowel duration is known to covary with spectral information in acoustically differentiating /o/ from /ɔ/ in the production of standard French, yet the native speakers of standard French showed no evidence of using this durational covariation when identifying the two vowels. If, as we and Gottfried and Beddor have suggested, this is because vowel duration plays only a minor role in the phonological system of the language, then it is not the case that listeners use all potentially useful information when identifying specific phonetic contrasts. Rather, there are constraints on the use of relevant phonetic information in perception that derive at least in part from characteristics of the overall linguistic system. Determining the nature and scope of these constraints, both within and across languages, will be an important challenge for future research.

Received: January 30, 1997; revised version received: July 7, 1997; accepted: August 17, 1997

REFERENCES

- AINSWORTH, W. A. (1972). Duration as a cue in the recognition of synthetic vowels. *Journal of the Acoustical Society of America* **51**, 648–651.
- BAILEY, P. J., & SUMMERFIELD, Q. (1980). Information in speech: Observations on the perception of [s]-stop clusters. *Journal of Experimental Psychology: Human Perception and Performance*, **6**, 536–563.

- BOHN, O. -S. (1995). Cross-language speech perception in adults: First language transfer doesn't tell it all. In W. Strange (Ed.), *Speech perception and linguistic experience: Issues in cross-language research* (pp. 279–304). Baltimore: York Press.
- CARTON, F. (1979). *Introduction à la phonétique du français*. Paris: Bordas.
- DELATTRE, P. (1959). Rapports entre la durée vocalique, le timbre et la structure syllabique en français. *The French Review*, **23**, 547–552.
- DELATTRE, P. (1965). *Comparing the phonetic features of English, French, German, and Spanish: An interim report*. New York: Chilton Books.
- EIMAS, P. D. (1997). Infant speech perception: Processing characteristics, representational units, and the learning of words. In R. L. Goldstone, P. G. Schyns, & D. L. Medin (Eds.), *Psychology of learning and motivation*. Vol. 36 (pp. 127–169). San Diego: Academic Press.
- GOTTFRIED, T. L., & BEDDOR, P. S. (1988). Perception of temporal and spectral information in French vowels. *Language and Speech*, **31**, 57–75.
- JUSCZYK, P. W. (1993). From general to language-specific capacities: the WRAPSA Model of how speech perception develops. *Journal of Phonetics*, **21**, 3–28.
- MALMBERG, B. (1964). *La phonétique*. Paris: PUF.
- MARTINET, A. (1971). *La prononciation du français contemporain*. Paris: Droz.
- MERMELSTEIN, P. (1978). On the relationship between vowel and consonant identification when cued by the same acoustic information. *Perception & Psychophysics*, **23**, 331–336.
- MÉTRAL, J. -P. (1977). Le vocalisme du français en suisse romande: considérations phonologiques. *Cahiers Ferdinand de Saussure*, **31**, 145–176.
- PETERSON, G. E., & LEHISTE, I. (1960). Duration of syllable nuclei in English. *Journal of the Acoustical Society of America*, **32**, 693–703.
- REPP, B. H. (1982). Phonetic trading relations and context effects: New experimental evidence for a speech mode of perception. *Psychological Bulletin*, **92**, 81–110.
- REPP, B. H., & LIBERMAN, A. M. (1987). Phonetic category boundaries are flexible. In S. Harnad (Ed.), *Categorical perception: The groundwork of cognition* (pp. 89–112). Cambridge, U.K.: Cambridge University Press.
- STRANGE, W. (1989). Dynamic specification of coarticulated vowels spoken in sentence context. *Journal of the Acoustical Society of America*, **85**, 2135–2153.
- TRANEL, B. (1987). *The sounds of French: An introduction*. Cambridge, U.K.: Cambridge University Press.
- WALTER, H. (1982). *Enquête phonologique et variétés régionales du français*. Paris: PUF.
- WHALEN, D. H. (1989). Vowel and consonant judgments are not independent when cued by the same information. *Perception & Psychophysics*, **46**, 284–292.
-

Copyright of Language & Speech is the property of Kingston Press Ltd. and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.