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Language *and* Speech

# Dialect Effects in Speech Perception: The Role of Vowel Duration in Parisian French and Swiss French

Language *and* Speech
54(4) 467–485

DOI: 10.1177/0023830911404924
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**Abstract**
The current experiments examined how native Parisian French and native Swiss French listeners use vowel duration in perceiving the /ɔ/-/o/ contrast. In both Parisian and Swiss French /o/ is longer than /ɔ/, but the difference is relatively large in Swiss French and quite small in Parisian French. In Experiment 1 we found a parallel effect in perception. For native listeners of both dialects, the perceived best exemplars of /o/ were longer than those of /ɔ/. However, there was a substantial difference in best-exemplar duration for /ɔ/ and /o/ for Swiss French listeners, but only a small difference in best-exemplar duration for Parisian French listeners. In Experiment 2 we found that this precise pattern depended not only on the native dialect of the listeners, but also on whether the stimuli being judged had the detailed acoustic characteristics of the native dialect. These findings indicate that listeners use fine-grained information in the speech signal in a dialect-specific manner when mapping the acoustic signal onto vowel categories of their language.

**Keywords**
dialect differences, French, speech perception, Swiss French, vowel duration

## Introduction

It is well established that languages differ in the role duration plays in differentiating vowels. Some languages, such as Thai, have vowel contrasts (e.g., /a/-/aː/, /i/-/iː/) that are distinguished primarily

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by the duration of the vowel (Abramson & Ren, 1990). Other languages, such as English, do not have vowels distinguished primarily by duration, although they do have vowel contrasts (e.g., /ɪ/-/i/, /ɛ/-/æ/) that are distinguished by duration in conjunction with spectral information (Peterson & Lehiste, 1960). In yet other languages, such as standard French, vowel duration appears to play only a minimal role in differentiating vowels (see below).

Just as languages can differ in the role of vowel duration, so too can dialects. A case in point, and the focus of the current paper, is Parisian French and Swiss French. Parisian French (standard French) is spoken in and around Paris as well as in many other parts of France (excluding the south); Swiss French is spoken in the French part of Switzerland (called Suisse Romande or Romandie). The two French dialects are very similar at all linguistic levels and are mutually intelligible. Apart from a few lexical items or set expressions, a native speaker of Parisian French will have no problems understanding someone speaking Swiss French, and vice versa. The differences that do exist between the two dialects are primarily phonological and lexical in nature (Bayard, Jolivet, Knecht, & Rubattel, 1984; Knecht, 1979, 1985).

One such difference involves vowel duration. As noted above, vowel duration seems to play little role in distinguishing vowels in modern Parisian French (Carton, 1979; Delattre, 1965; Malmberg, 1964; Martinet, 1971; Strange, Weber, Levy, Shafiro, Hisagi, & Nishi, 2007). There appear to be no clear cases in which a vowel contrast is distinguished primarily by vowel duration, and only one clear case, /ɔ/ versus /o/, in which vowel duration systematically covaries with spectral information to differentiate the vowels (see Gottfried & Beddor, 1988, for discussion of this point). The situation in Swiss French is markedly different (see Grosjean, Carrard, Godio, Grosjean, & Dommergues, 2007, for a review). Many vowel pairs, such as /i/-/iː/, /ɛ/-/ɛː/, /a/-/aː/, are differentiated primarily by vowel duration,[1] and other pairs, especially /ɔ/-/o/, /a/-/ɑ/, are differentiated by duration in conjunction with spectral information (see Durand & Lyche, 2003; Grosjean et al., 2007; Métral, 1977; Walter, 1982). (Note that this is also true of the French spoken in Belgium, Francard, 2001; Tranel, 1987.) Thus, overall, vowel duration plays a much more prominent role in the phonological system of Swiss French than Parisian French.

Miller and Grosjean (1997) investigated the perceptual consequences of this difference for the identification of the one vowel contrast that is differentiated (in part) by duration in both dialects, /ɔ/ versus /o/, with /o/ being longer than /ɔ/. Their study was based on an earlier study by Gottfried and Beddor (1988) that examined this contrast in Parisian French. More specifically, Gottfried and Beddor used a multiple-cue, trading-relation identification paradigm to examine listeners' differential use of duration and spectral information to distinguish /ɔ/ in *cotte* from /o/ in *côte*. For their study they synthesized three speech series ranging from a good exemplar of *côte* to a good exemplar of *cotte*. Within each series the vowel contrast was specified in an identical manner by a change in formant frequency values from those appropriate for /o/ to those appropriate for /ɔ/. The three series differed from one another in vowel duration. The main finding of interest from the perspective of the current paper concerns identification performance for these stimuli by a group of native French listeners.[2] As expected, within each series as the formant values varied from those appropriate for /o/ to those appropriate for /ɔ/, vowel identification changed accordingly from predominately /o/ to predominately /ɔ/ responses. Thus, the listeners clearly used spectral information to identify the vowels. Of critical interest was whether they would also use vowel duration. This would be seen as a trading relation, such that the increase in vowel duration across the three series would shift the identification function toward the /ɔ/-end of the series, yielding more /o/ responses for the longer vowels, especially in the region of the /ɔ/-/o/ category boundary where the spectral information was ambiguous for the two vowels. No such trading relation was found for the native French listeners, indicating that they did not use duration information for vowel identification. And this was true not only for a two-choice identification task in which listeners simply indicated whether

each token was /ɔ/ or /o/, but also for a second identification task in which listeners used a five-point scale to indicate how /ɔ/-like versus /o/-like each token was. Thus even though /o/ is longer than /ɔ/ in Parisian French, the native French listeners did not show evidence of using this duration difference when identifying the vowels, but relied solely on spectral information. Gottfried and Beddor suggested that this lack of sensitivity to vowel duration in identification was a reflection of the limited role that vowel duration plays in the overall phonological system of Parisian French.

Taking this finding as a starting point, Miller and Grosjean (1997) investigated whether Swiss French listeners, unlike their Parisian French counterparts, would use duration (as well as spectral information) to identify these vowels. As noted earlier, vowel duration plays a much more prominent role in Swiss French than Parisian French. Accordingly, it might be the case that for these listeners duration as well as spectral information is used for identification of the /ɔ/-/o/ contrast. To test this possibility, Miller and Grosjean used Gottfried and Beddor's (1988) stimuli and two-choice identification task with two new groups of French listeners, native speakers of Parisian French and native speakers of Swiss French. Their findings were clear-cut. The Parisian French listeners identified /ɔ/ and /o/ solely on the basis of the spectral information; no trading relation was observed. In contrast, the Swiss French listeners showed clear evidence of a trading relation, using both spectral and duration information to identify the vowels. Following Gottfried and Beddor, they interpreted their findings in terms of the role duration plays in the overall phonological system of the dialect: Vowel duration plays a prominent role in Swiss French and, in line with this, Swiss French listeners use duration when identifying /ɔ/ and /o/. In contrast, vowel duration plays little role in Parisian French and, as a consequence, Parisian French listeners ignore vowel duration when identifying /ɔ/ and /o/. They also noted that the findings for the Parisian French listeners were especially interesting in light of the longstanding view in the speech perception literature that phonetic contrasts are specified by multiple acoustic properties and that listeners are exquisitely sensitive to these properties during perception, using all available sources of information to identify phonetic segments (see, e.g., Bailey & Summerfield, 1980; Repp & Liberman, 1987). The finding that Parisian French listeners did not use vowel duration to identify /ɔ/ and /o/ even though the vowels differ acoustically in the dialect, but instead relied solely on spectral information, presents an apparent exception.

The purpose of the current investigation was to further examine the dialect difference in the perception of the /ɔ/-/o/ contrast by Parisian French and Swiss French listeners. The impetus comes from a companion production study in which we examined more closely how /ɔ/ and /o/ pattern acoustically in the two dialects. (This study is described briefly in the Appendix.) When Miller and Grosjean (1997) conducted their investigation, they assumed that /ɔ/ and /o/ are differentiated by duration to a similar degree in the two dialects. (This assumption was based on the results of a pilot production study they had conducted on Swiss French.) As such, there was no apparent acoustic basis for the dialect effect they found in perception, and they attributed the perceptual dialect effect instead to a distinction in the role vowel duration plays in the overall phonological systems of Parisian and Swiss French.

But the assumption about how /ɔ/ and /o/ pattern acoustically in the two dialects turns out to be wrong. In our companion production study (see Appendix) we found that although /ɔ/ and /o/ are indeed differentiated by duration in both dialects, the duration difference between the two vowels is substantially larger in Swiss French (mean = 109 ms) than in Parisian French (mean = 20 ms). This difference in how the vowels are produced in the two dialects raises questions about Miller and Grosjean's (1997) interpretation of their findings. Specifically, the perceptual dialect effect they found might not be due (at least entirely) to the relative importance of vowel duration in the overall phonological system of the dialects, as they propose, but might derive at least in part from how the two vowels, /ɔ/ and /o/, pattern acoustically in the two dialects: In Swiss French the vowel duration difference is large, and Swiss French listeners show a sensitivity to this difference; in Parisian French the vowel duration difference is quite small, and Parisian French listeners—at least

as tested in an identification paradigm—do not reveal a sensitivity to this difference. This analysis raises the possibility that a perceptual paradigm more sensitive than an identification task might reveal that Parisian French listeners are indeed sensitive to the small duration difference that exists in their dialect, just as Swiss French listeners are sensitive to the large vowel duration difference that exists in their dialect. We investigated this possibility in Experiment 1. Experiment 2 is a follow-up to Experiment 1 that manipulates stimulus/listener conditions.

## 2 Experiment 1

To test the possibility that Parisian French listeners, like their Swiss French counterparts, are sensitive to the way in which /ɔ/ and /o/ vary acoustically in their dialect, we used a perceptual technique that is known to reflect listeners' highly tuned sensitivity to fine phonetic detail. The technique involves assessing which tokens listeners consider to be the best exemplars of a phonetic category. It is now well established that phonetic categories (for both vowels and consonants) have a rich internal perceptual structure with some members perceived as better exemplars than others (e.g., Kuhl, 1991; Samuel, 1982). Moreover, this perceived structure reflects fine-grained phonetic patterns in a speaker's language. For example, Miller and her colleagues have shown that which tokens are perceived to be the best exemplars of a voicing category in English varies systematically with changes in speaking rate and place of articulation, and does so in a way that reflects the acoustic changes rendered by rate and place in production (e.g., Allen & Miller, 2001; Volaitis & Miller, 1992). In addition, Flege and his colleagues (Flege, Schmidt, & Wharton, 1996) have shown that the way in which changes in speaking rate alter the perceived internal structure of voicing categories is itself influenced by one's native language. And Kuhl and her colleagues have shown that the internal structure of a vowel category not only varies systematically with the speaker's native language, but also that this variation is evident very early in language development (Kuhl, Williams, Lacerda, Stevens, & Lindblom, 1992).

Given the ubiquity of perceived internal structure for phonetic categories, we expected that for both Parisian French and Swiss French listeners, tokens of both vowel categories, /ɔ/ and /o/, would vary in perceived category goodness as vowel duration was changed, with some tokens perceived as better exemplars than others. That is, we expected that for both vowels only a limited range of vowel durations would be perceived as good exemplars of the vowel category. The question was whether the specific durations of the two vowels that are perceived as the best exemplars of the respective categories differ systematically for native speakers of the two dialects in a way that reflects the vowel duration differences that exist in the two dialects.

To assess how Parisian French and Swiss French listeners differentially map vowel duration onto the best exemplars of /ɔ/ and /o/, we created four speech series using synthesis/editing techniques based on samples of natural speech taken from the companion production study (see Appendix). Two series were based on the speech of a native Parisian French speaker and the other two were based on the speech of a native Swiss French speaker. For each dialect, one series ranged from *cotte* with a very short vowel to *cotte* with a very long vowel, and the other ranged from *côte* with a very short vowel to *côte* with a very long vowel, all in the context of *je dis* …. Within a series, the spectral characteristics clearly specified vowel identity as /ɔ/ or /o/, such that there was no ambiguity in category membership. Perceived category goodness within each series ranged from vowels that were too short, to vowels that were of appropriate duration, to vowels that were too long. Two groups of listeners were tested: Native Parisian French listeners were tested on the two Parisian French series and native Swiss French listeners were tested on the two Swiss French series. In all cases the task was to judge the goodness of each vowel using a 1–7 rating scale, with

a higher number signifying a better exemplar of the vowel category. This task requires listeners to focus on within-category detail.

If both Parisian French and Swiss French listeners are sensitive to vowel duration differences, and in a way that reflects how vowel duration patterns in their dialect, then we can make the following two predictions. First, for both groups of listeners the vowels judged to be the best exemplars of /o/ will be longer than those judged to be the best exemplars of /ɔ/. Second, the difference between /ɔ/ and /o/ will be smaller for Parisian French listeners than for Swiss French listeners.

## 2.1 Methodology

*2.1.1 Participants.* Sixteen native speakers of Parisian French and 16 native speakers of Swiss French served as listeners in the experiment. The Parisian French listeners attended the University of Paris 8, and the Swiss French listeners attended the University of Neuchâtel. Care was taken to ensure that no participant had ever lived in the other dialectal area (Parisian French listeners in the French part of Switzerland and vice versa). Occasional exposure to the other dialect through the spoken media was accepted, however, as it is a reality of life in the two countries.

*2.1.2 Stimuli.* The stimuli consisted of four speech series, two based on natural productions of Parisian French and two based on natural productions of Swiss French. For each dialect, one of the series consisted of tokens of *je dis cotte*, with the duration of /ɔ/ in *cotte* varying across tokens from very short to very long, and the other consisted of tokens of *je dis côte*, with the duration of /o/ in *côte* varying across tokens from very short to very long.

The four series were created on a PC using the Kay CSL/ASL system for LPC-based analysis and synthesis (KayPENTAX). They were made from speech samples from one of the Parisian French female talkers and speech samples from one of the Swiss French female talkers recorded in the companion production study (see Appendix). Stimulus creation involved five major steps, as follows.

Step 1. We created two *je dis* precursor phrases, one based on the speech of the Parisian French talker and one based on the speech of the Swiss French talker. For both the Parisian French and the Swiss French talker, we selected one instance of *je dis cotte* and isolated the stretch of speech corresponding to *je dis* (including the stop closure for the following /k/ in *cotte*). We then edited the speech (i.e., deleted pitch periods and stretches of closure) to equate the durations of *je dis* for the two talkers. The final Parisian French and Swiss French *je dis* precursors were both 404 ms long; this included 304 ms of *je dis* proper plus 100 ms of stop closure for the following /k/. Thus the final *je dis* segments were edited versions of natural speech.

Step 2. For each of the two talkers, we also selected one instance of *cotte* and one instance of *côte* (in each case the *cotte* came from a different token from that used to create the *je dis* precursor). The final closure and /t/ burst were excised from each, leaving the consonant-vowel (CV) syllables /kɔ/ and /ko/. After some minor waveform editing, these CVs were analyzed using pitch-synchronous LPC analysis. This yielded LPC analysis parameter files, which were eventually used for synthesis. These parameter files were modified in order to equate the duration of the initial consonant (/k/), as well as the duration of the following vowel (/ɔ/ or /o/), across all four tokens (Parisian /kɔ/, Parisian /ko/, Swiss /kɔ/, and Swiss /ko/). The frames in the parameter files for the initial consonant were defined as those frames corresponding to the stretch of speech from the onset of the release burst for /k/ (the onset of the CV file) to the onset of periodicity for the vowel (/ɔ/ or /o/); these frames were edited to yield a consonant duration of 38 ms. The frames for the vowel were defined as those frames corresponding to the stretch of speech from the onset of

periodicity for the vowel to the offset of the vowel (the end of the CV file); these frames were edited to yield a vowel duration of 80 ms. The LPC analysis parameter files for the four CV segments were also equated for overall amplitude contour.

Step 3. The four LPC analysis parameter files created in Step 2 were used to create four sets of parameter files, one each for Parisian /kɔ/, Parisian /ko/, Swiss /kɔ/, and Swiss /ko/. Each set comprised tokens that ranged from a CV with a very short vowel to a CV with a very long vowel. To create the tokens with vowels shorter than 80 ms, frames from the middle of the vowel were systematically deleted. To create tokens with vowels longer than 80 ms, one frame from the middle of the vowel was systematically duplicated. The final result was a set of LPC analysis parameter files for each of the four CVs. These parameter files were submitted to speech synthesis, resulting in four sets of CV waveforms (one each for Parisian /kɔ/, Parisian /ko/, Swiss /kɔ/, and Swiss /ko/); within each set vowel duration ranged from very short to very long. We then selected 34 stimuli from each set. The 34 were chosen so as to match vowel duration as closely as possible for each of the 34 steps (ranging from very short to very long) across the four sets. The shortest vowel durations were 4, 4, 5, and 3 ms, respectively, for Parisian /kɔ/, Parisian /ko/, Swiss /kɔ/, and Swiss /ko/. The longest vowel durations were 282, 284, 281, and 282 ms, respectively, for Parisian /kɔ/, Parisian /ko/, Swiss /kɔ/, and Swiss /ko/. Within each set of 34, step size (in vowel duration) averaged approximately 8 ms, with adjacent steps differing by two or three pitch periods.

Step 4. A final closure and /t/-burst segment from a token of *je dis cotte* (not used for the *je dis* precursor or for the /kɔ/ CV syllable) was isolated for each of the two talkers. In each case, the isolated segment consisted of a 150 ms closure followed by a 50 ms release burst, yielding a final /t/ (closure plus release) that was 200 ms long. The 200 ms final /t/ from the Parisian French talker was appended to each of the 34 Parisian /kɔ/ tokens (yielding /kɔt/) and to each of the 34 Parisian /ko/ tokens (yielding /kot/). Similarly, the 200 ms final /t/ from the Swiss French talker was appended to each of the Swiss /kɔ/ (yielding /kɔt/) and /ko/ (yielding /kot/) tokens. The result was four series of target words, one each for Parisian *cotte*, Parisian *côte*, Swiss *cotte*, and Swiss *côte*.

Step 5. Finally, for each dialect, the *je dis* precursor was appended to each of the 34 target words within each series. The final result was two *je dis cotte* series, one Parisian French and one Swiss French, and two *je dis côte* series, one Parisian French and one Swiss French. Each of the four series consisted of 34 stimuli, with vowel duration ranging across the series from very short to very long. Although the *je dis* precursor consisted of edited natural speech, and the target words (*cotte* and *côte*) consisted of a mix of edited natural speech and synthesized speech, the entire sentences (*je dis cotte* and *je dis côte*) sounded very natural, with no discernible breaks between natural and synthesized stretches of speech.

The stimuli were digitally transferred to another PC, output at 20 kHz, and recorded onto digital audio tape via the analog input channel of the recorder. Four stimulus tapes were created, one for each of the four series. The four tapes were constructed in a like manner, each consisting of one block of familiarization trials, one block of practice trials, and 14 blocks of test trials (for a total of 476 test trials). Each block consisted of the 34 stimuli within the series in a different random order. The inter-stimulus interval was 1500 ms for the familiarization block and 2700 ms for the practice and test blocks. Additionally, 500 ms beeps were recorded between the test blocks, and at two locations within each test block, in order to facilitate the participants' use of response sheets, as described below.

*2.1.3 Procedure.* The Parisian French listeners were tested on the Parisian French *je dis cotte* and *je dis côte* series at the University of Paris 8, and the Swiss French listeners were tested on the Swiss French *je dis cotte* and *je dis côte* series at the University of Neuchâtel. The same testing

procedure was used in both locations. All listeners participated in two sessions conducted on separate days. During one session they were tested on *je dis cotte* and during the other they were tested on *je dis côte*; the order was counterbalanced across participants. The listeners were tested in small groups in a quiet room and listened to the stimulus tapes over headphones at a comfortable listening level.

Each session consisted of three phases: familiarization, practice, and test. At the beginning of the session, the listeners were informed that during the session they would hear many versions of *je dis cotte* (or *je dis côte*). They were told that the versions would vary in the duration of the vowel in *cotte* (or *côte*) and that the vowel would range from very short to very long. They were also told that they would be asked to judge each token of *je dis cotte* (or *je dis côte*) with respect to the "goodness" of the vowel's duration, using a scale ranging from 1 (the worst version) to 7 (the best version). The answer sheets contained a diagram of the 1–7 scale, with 1 labeled "plus mauvaise (trop courte, trop longue)" and 7 labeled "meilleure." The listeners were encouraged to use the full range of the scale.

During the familiarization phase of the session, the listeners were presented with the familiarization block of stimuli and were told to simply listen to each item and think of what rating along the 1–7 scale they would assign; during this phase no responses were collected. After this phase the listeners proceeded to the practice phase, where they were presented with the practice block of stimuli. In this phase they were asked to indicate their rating of each item by writing a number from 1 to 7 on a prepared answer sheet. (These responses were not used in the analyses reported below.) The listeners then proceeded to the test phase, where they were presented with the 14 blocks of test stimuli. The blocks were separated by beeps, and beeps also separated the stimuli within each block into sections of 11 or 12 items. The location of the beeps corresponded to notations on the answer sheets. The listeners were instructed to follow along and, if they lost their place on the answer sheet, to simply wait until the next beep and then begin writing their responses in the corresponding location on the sheet. This procedure kept listeners "on track," so that their ratings would stay in alignment with the stimuli being presented. Listeners received a break roughly midway through the session.

*2.1.4 Data analysis.* The data were analyzed in accord with procedures developed in earlier research using the goodness-rating paradigm (e.g., Allen & Miller, 2001; Miller & Volaitis, 1989) and involved determining a *best-exemplar range* for each series, for each listener.

To do so, we first calculated the mean goodness rating across the 14 repetitions of each stimulus in each series, for each listener. This resulted in two goodness functions for each listener, one for the *cotte* series and one for the *côte* series. We then applied a smoothing algorithm to each function in order to guard against local perturbations in the functions yielding spurious results in the analyses reported below. The algorithm calculated a running average of three data points, with each point averaged with the preceding and following data points; the first and last data points in each function were not changed. The smoothed data were used in all the analyses and figures presented in the paper. Examination of the individual goodness functions revealed that one Parisian French listener yielded a goodness function for *cotte* that was essentially flat; this listener's data for both *cotte* and *côte* were therefore excluded from further analysis. This left the data from 15 Parisian French listeners and 16 Swiss French listeners for the final analyses.

Using the smoothed data, we next determined the location of a best-exemplar range for each series, for each listener. The best-exemplar range for a given series was defined as the range of stimuli along the series for which the goodness ratings were at least 90% of the maximal rating given for any stimulus in the series. The lower and upper limits of this best-exemplar range were

determined as follows. First, the maximal rating for the function was determined, and the value corresponding to 90% of this rating was calculated. Next, the two points at which the goodness function crossed this 90% value—one with a shorter vowel duration than the stimulus with the maximal rating (the lower limit) and one with a longer vowel duration than the stimulus with the maximal rating (the upper limit)—were identified. This was done by linear interpolation between the adjacent stimuli that straddled the 90% value in each case. In the few cases in which an individual function did not dip below the 90% value by the endpoint stimulus, the endpoint vowel duration (shortest or longest) was taken to be the limit (lower or upper, respectively) of the best-exemplar range.

## 2.2 Results and discussion

The group goodness functions for *cotte* and *côte* are shown in the top of Figure 1 for the Parisian French listeners and in the bottom of Figure 1 for the Swiss French listeners. As can be seen, for all four functions goodness ratings first increase as vowel duration increases and then decrease as vowel duration becomes too long. Thus in each case there is a limited range of stimuli judged as particularly good exemplars of the vowel. However, the relative locations of this range of stimuli for *cotte* and *côte* are strikingly different for the two listener groups. For the Parisian French listeners, the *cotte* and *côte* functions peak in roughly similar locations, with the *côte* function slightly shifted to longer vowel durations relative to the *cotte* function. In contrast, for the Swiss French listeners, the *côte* function peaks at considerably longer vowel durations than the *cotte* function.

Quantitative support for these observations comes from an analysis of the lower and upper limits of the best-exemplar ranges for the two series, for the two listener groups (see the Data analysis section above). These limits are shown in Table 1. The lower and upper limits for each series, for each listener, were submitted to a three-way ANOVA, with Dialect (Parisian vs. Swiss) as a between-subjects factor and both Vowel (*cotte* vs. *côte*) and Limit (lower vs. upper) as within-subjects factors. This analysis yielded a three-way Dialect × Vowel × Limit interaction, $F(1, 29) = 8.50$, $p < .01$.

To explore the basis of this interaction, we conducted two separate sets of ANOVAs on the data. The first set considered the Parisian and Swiss French listeners separately. For each listener group, the analysis was a two-factor ANOVA with Vowel (*cotte* vs. *côte*) and Limit (lower vs. upper) as within-subjects factors. For the Parisian French listeners, there were significant main effects of Vowel, $F(1, 14) = 6.10$, $p < .05$, and Limit, $F(1, 14) = 126.04$, $p < .001$, but no significant Vowel × Limit interaction, $F(1, 14) < 1$. Thus for the Parisian French listeners, the best-exemplar range shifted toward longer vowel durations for *côte* compared to *cotte*, and this shift was statistically equivalent at the lower and upper limits. The size of the shift (averaged across limits) was 8 ms. For the Swiss French listeners, there were significant main effects of Vowel, $F(1, 15) = 62.09$, $p < .001$, and Limit, $F(1, 15) = 249.10$, $p < .001$, as well as a significant Vowel × Limit interaction, $F(1, 15) = 14.91$, $p < .005$. Individual comparisons indicated that the effect of vowel was significant at both the lower, $t(15) = 6.04$, $p < .001$, and upper, $t(15) = 8.14$, $p < .001$, limits; the interaction was due to a larger effect at the upper limit (82 ms) than the lower limit (52 ms). Note that the average shift in location of the best-exemplar range from *cotte* to *côte* (in ms vowel duration, averaged across limits) was considerably larger for Swiss French (67 ms) than Parisian French (8 ms). This difference in shift size was statistically significant, $t(29) = 6.34$, $p < .001$.

The second set of ANOVAs considered the two vowels, *cotte* and *côte*, separately. For each vowel, the analysis was a two-factor ANOVA with Dialect (Parisian vs. Swiss) as a between-subjects factor and Limit (lower vs. upper) as a within-subjects factor. For *cotte*, there was a main effect of Limit, $F(1, 29) = 301.18$, $p < .001$, but no effect of Dialect, $F(1, 29) < 1$, and no interaction of

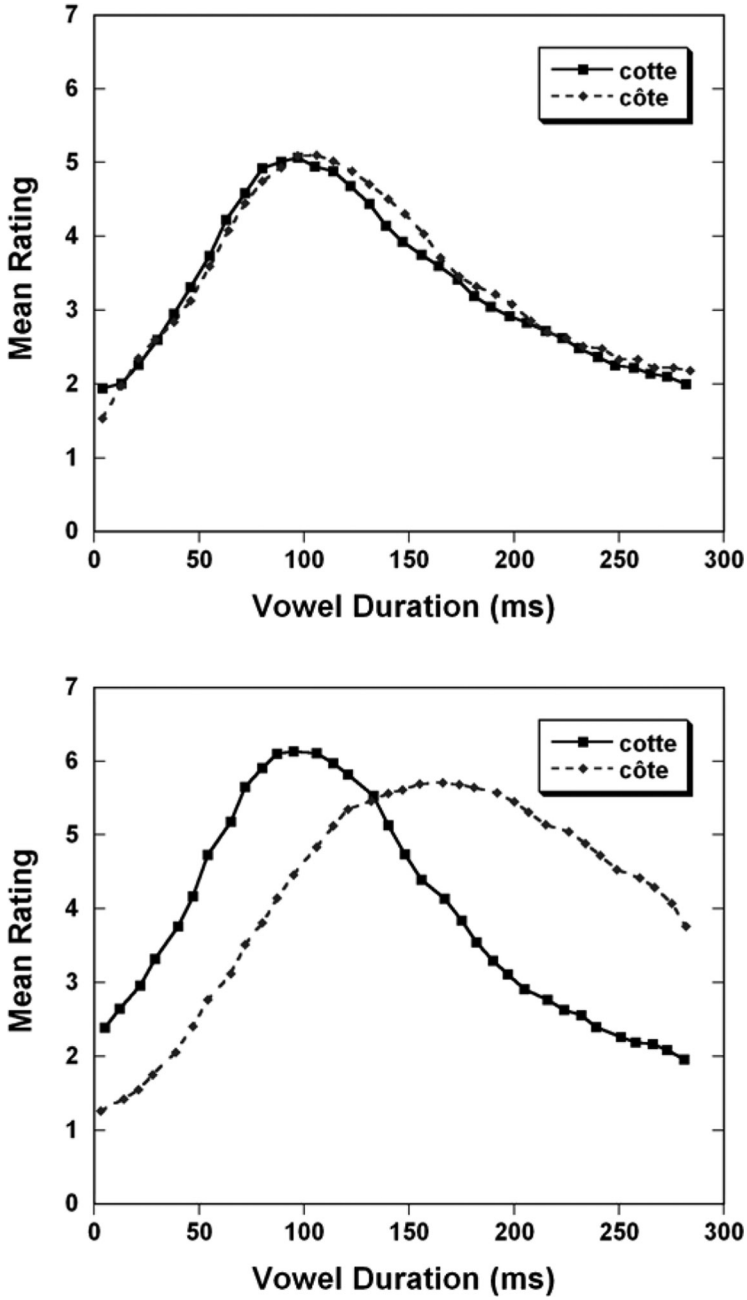


**Figure 1.** Mean goodness ratings, for *cotte* and *côte*, as a function of vowel duration for Parisian French listeners tested on the Parisian French series (top panel) and Swiss French listeners tested on the Swiss French series (bottom panel). The functions are based on the smoothed data

Dialect and Limit, $F(1, 29) < 1$. Thus the best-exemplar range for *cotte* covered the same vowel durations for Parisian and Swiss French. For *côte*, however, there was a difference across dialects. The ANOVA revealed significant main effects of Dialect, $F(1, 29) = 34.11$, $p < .001$, and Limit,

**Table 1.** Lower and upper limits of the best-exemplar range (in ms vowel duration, with standard error in parentheses) for Parisian French listeners (Parisian French series) and Swiss French listeners (Swiss French series) for *cotte* and *côte*, in Experiment 1. Difference scores (*côte* – *cotte*) are also given

| | Parisian French listeners/ Parisian French series | | Swiss French listeners/ Swiss French series | |
|---|---|---|---|---|
| | lower limit | upper limit | lower limit | upper limit |
| *cotte* | 72 (6.3) | 130 (8.4) | 72 (4.9) | 129 (4.7) |
| *côte* | 79 (4.9) | 139 (8.2) | 124 (7.4) | 211 (10.1) |
| Difference | 7 | 9 | 52 | 82 |

$F(1, 29) = 218.20$, $p < .001$, as well as a significant Dialect × Limit interaction, $F(1, 29) = 7.48$, $p < .05$. Individual comparisons indicated that the effect of dialect was significant at both the lower, $t(29) = 5.01$, $p < .001$, and upper, $t(29) = 5.54$, $p < .001$, limits; the interaction was due to a larger effect of dialect at the upper limit (72 ms) than the lower limit (45 ms). Thus the best-exemplar range for *côte* was located at longer vowel durations for Swiss than Parisian French, and was also wider for Swiss than Parisian French. Interestingly, the widening of the best-exemplar range for /o/ in Swiss French corresponds to the way in which /o/ is produced in Swiss French. Analyses from the companion production study (see Appendix) showed that Swiss French talkers not only produce a longer /o/ than do Parisian French talkers, but that they also produce a larger spread of vowel durations for /o/ than do Parisian French talkers. Correspondingly, Swiss French listeners judge a larger range of vowel durations to be best exemplars of /o/ than do their Parisian French counterparts.

Note further that the above analyses showed that the dialect effect in perception originated from a difference in *côte*, and this too corresponds to the way in which the vowels are produced. Specifically, the best-exemplar range for *cotte* encompassed the same vowel durations in Parisian and Swiss French, whereas the best-exemplar range for *côte* was shifted toward longer vowel durations in Swiss compared to Parisian French. This perceptual pattern closely mirrors the results of the acoustic analyses in the companion study (see Appendix), which showed similar vowel durations for /ɔ/ in the two dialects, but a much longer /o/ in Swiss compared to Parisian French.

Overall, the results of Experiment 1 confirm our two predictions. First, for both Parisian French and Swiss French listeners, the best exemplars of /o/ (in *côte*) were longer than the best exemplars of /ɔ/ (in *cotte*). Second, this effect was substantially smaller for the Parisian French listeners (averaging only 8 ms) than for the Swiss French listeners (averaging 67 ms). Thus both Parisian French and Swiss French listeners are sensitive to vowel duration differences, and both groups of listeners perceive the duration difference between /ɔ/ and /o/ in a way that reflects how these two vowels pattern acoustically in their dialect.

A question that arises concerns the extent to which such dialect-specific perceptual processing rests on the fine-grained acoustic characteristics of the stimuli themselves being dialect-appropriate. In the current experiment, the Parisian and Swiss French listeners heard speech series that were based on natural productions of Parisian and Swiss French speech, respectively. Although we were careful to equate the temporal characteristics of the stimuli across the dialects, they likely differed in various fine-grained spectral parameters of the target word and precursor phrase in a dialect-specific manner. We tested the importance of such dialect-specific acoustic information in Experiment 2. We used the same stimuli and procedures as in Experiment 1, and we again tested native speakers of Parisian French and native speakers of Swiss French. However, in the new experiment

we tested Parisian French listeners on the Swiss French series and Swiss French listeners on the Parisian French series. We expected to find a larger vowel duration difference between the best exemplars of /ɔ/ and /o/ for Swiss French listeners than Parisian French listeners, as we had in Experiment 1. The issue was whether this effect would be modulated in any way by listening to stimuli based on speech from the non-native, rather than native dialect.

# 3 Experiment 2

## 3.1 Methodology

*3.1.1 Participants.* Sixteen new native speakers of Parisian French and 16 new native speakers of Swiss French served as listeners in the experiment. As in Experiment 1, the Parisian French listeners attended the University of Paris 8, and the Swiss French listeners attended the University of Neuchâtel. Also as in Experiment 1, care was taken to ensure that no participant had ever lived in the other dialectal area (Parisian French listeners in the French part of Switzerland and vice versa). Again, occasional exposure to the other dialect through the spoken media was accepted as it is a reality of life in the two countries.

*3.1.2 Stimuli.* The stimuli were the same as those used in Experiment 1.

*3.1.3 Procedure.* The procedure was the same as that used in Experiment 1 except that the Parisian French listeners were presented the Swiss French stimuli and the Swiss French listeners were presented the Parisian French stimuli.

*3.1.4 Data analysis.* The data were analyzed as in Experiment 1. Examination of the individual goodness functions revealed that one Parisian French listener yielded goodness functions for both *cotte* and *côte* that were monotonically increasing as a function of vowel duration. This listener's data were therefore excluded from further analysis, leaving the data from 15 Parisian French listeners and 16 Swiss French listeners for the final analyses.

## 3.2 Results and discussion

The group goodness functions for *cotte* and *côte* are shown in the top of Figure 2 for the Parisian French listeners and in the bottom of Figure 2 for the Swiss French listeners. As in Experiment 1, for all four functions goodness ratings first increase as vowel duration increases and then decrease as vowel duration becomes too long. Thus in each case there is a limited range of stimuli judged as particularly good exemplars of the vowel. A visual comparison of Figure 2 with Figure 1 indicates that the Parisian French and Swiss French listeners in the current experiment judged the series based on the non-native dialect in a manner that was generally similar to the way in which the Parisian French and Swiss French listeners in Experiment 1 judged the series based on the native dialect, with some interesting differences emerging across the two experiments. This observation was confirmed with a set of statistical analyses on the lower and upper limits of the best-exemplar ranges for the two new listener groups. These limits are shown in Table 2.

First consider the Parisian French listeners judging the Swiss French vowels. A two-factor ANOVA with Vowel (*cotte* vs. *côte*) and Limit (lower vs. upper) as within-subjects factors revealed a strong effect of Limit, $F(1, 14) = 407.80$, $p < .001$, but no effect of Vowel, $F(1, 14) < 1$. The Vowel × Limit interaction was not significant, $F(1, 14) = 4.42$, $p > .05$, and individual comparisons

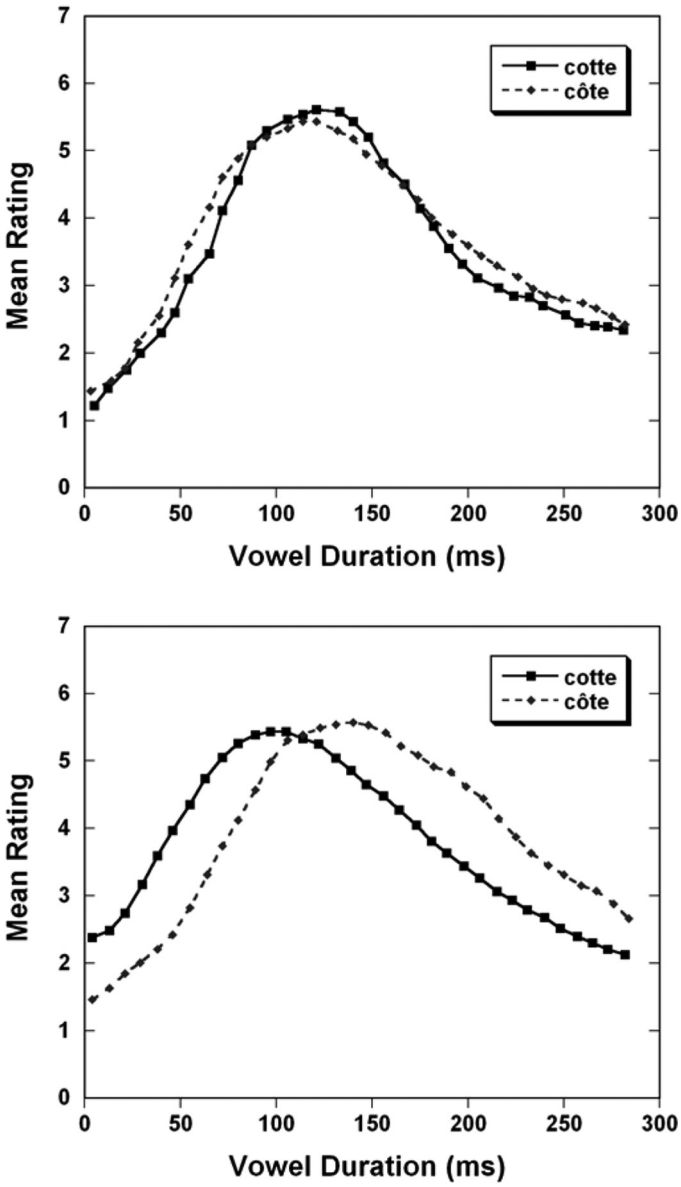


**Figure 2.** Mean goodness ratings, for *cotte* and *côte*, as a function of vowel duration for Parisian French listeners tested on the Swiss French series (top panel) and Swiss French listeners tested on the Parisian French series (bottom panel). The functions are based on the smoothed data

confirmed that the effect of vowel was not significant at either the lower, $t(14) = .66$, $p > .10$, or upper, $t(14) = .59$, $p > .10$, limit. Recall that the Parisian French listeners in Experiment 1 did show a statistically significant effect of vowel, with the best-exemplar range for *côte* shifted by approximately 8 ms toward longer vowel durations compared to that for *cotte* (see Table 1). Thus, although the Parisian French listeners in Experiment 2 clearly did not yield the large vowel effect that the

**Table 2.** Lower and upper limits of the best-exemplar range (in ms vowel duration, with standard error in parentheses) for Parisian French listeners (Swiss French series) and Swiss French listeners (Parisian French series) for *cotte* and *côte*, in Experiment 2. Difference scores (*côte* – *cotte*) are also given

| | Parisian French listeners/ Swiss French series | | Swiss French listeners/ Parisian French series | |
|---|---|---|---|---|
| | lower limit | upper limit | lower limit | upper limit |
| *cotte* | 93 (5.5) | 149 (5.6) | 78 (9.2) | 139 (8.8) |
| *côte* | 87 (7.5) | 156 (10.9) | 110 (8.0) | 174 (8.7) |
| Difference | −6 | 7 | 32 | 35 |

Swiss French listeners had shown in Experiment 1 for these Swiss French series, they also did not yield the small effect of vowel duration shown by the Parisian French listeners in Experiment 1 for the Parisian French series. Indeed, they showed no effect of vowel duration at all. Thus only when the Parisian French listeners were judging vowels with dialect-appropriate acoustic characteristics (Experiment 1) did the small (statistically significant) effect of vowel emerge, with longer vowel durations required for /o/ than /ɔ/.[3]

Next consider the Swiss French listeners judging the Parisian French vowels. A two-factor ANOVA with Vowel (*cotte* vs. *côte*) and Limit (lower vs. upper) as within-subjects factors revealed strong effects of Vowel, $F(1, 15) = 27.30$, $p < .001$, and Limit, $F(1, 15) = 241.53$, $p < .001$, but no Vowel × Limit interaction, $F(1, 15) < 1$. For these listeners the best-exemplar range for *côte* (averaged across limits) shifted by approximately 34 ms toward longer vowel durations compared to that for *cotte* (see Table 2). Recall that the Swiss French listeners in Experiment 1 also showed a clear and even larger effect of vowel; for those listeners, the best-exemplar range for *côte* shifted by approximately 67 ms toward longer vowel durations compared to *cotte* (see Table 1). (Even the 67 ms shift falls short of the difference between /o/ and /ɔ/ in production, which averages 109 ms.) Moreover, the Swiss French listeners in Experiment 1 also showed a larger vowel effect at the upper than the lower limit, resulting in a wider best-exemplar range for /o/ than /ɔ/ (in line with the larger spread of vowel durations for /o/ than /ɔ/ in production). In contrast, for the Swiss French listeners in Experiment 2, the vowel shift was statistically of the same magnitude at the lower and upper limits. Thus, the Swiss French listeners judged longer vowels to be the best exemplars of /o/ than /ɔ/ when listening to both Swiss French and Parisian French speech series, although only when judging the Swiss French vowels did the perceptual results correspond more closely to the way in which /o/ and /ɔ/ vary in duration in Swiss French.[4]

Taken together, the findings of Experiments 1 and 2 suggest that both Parisian French and Swiss French listeners applied knowledge of how /ɔ/ and /o/ pattern in the speech of their own dialect when judging the speech of both dialects. However, when the detailed acoustic characteristics were appropriate for the native dialect (Experiment 1), the correspondence between acoustic patterns in production and perceived best exemplars showed a more fine-grained correspondence than when they were not (Experiment 2).

## 4 General discussion

As reviewed in the introduction, vowel duration plays a much more prominent role in the phonological system of Swiss French than Parisian French. In Swiss French, there are vowel pairs differentiated primarily by vowel duration (e.g., /i/-/iː/, /ɛ/-/ɛː/, /a/-/aː/), as well as vowel pairs

distinguished jointly by spectral and duration information (e.g., /ɔ/-/o/, /a/-/ɑ/). In contrast, in Parisian French there are no vowel pairs distinguished primarily by duration, and only one vowel pair, /ɔ/ versus /o/, that is distinguished jointly by duration and spectral information. In an earlier perceptual study, which focused on the /ɔ/-/o/ contrast, Miller and Grosjean (1997) showed that Parisian and Swiss French listeners were differentially sensitive to vowel duration: Swiss French listeners, but not Parisian French listeners, used vowel duration in identifying tokens as /ɔ/ versus /o/ (Miller & Grosjean, 1997; see also Gottfried & Beddor, 1988, for comparable results for Parisian French listeners). They attributed this dialect difference to the larger role that vowel duration plays in the overall phonological system of Swiss than Parisian French.

In the present experiments we explored an alternative interpretation of this perceptual dialect difference. The impetus for the study was based on new acoustic analyses of Parisian and Swiss French speech (see Appendix) showing that the duration difference between /ɔ/ and /o/ is large in Swiss French, but quite small in Parisian French. Thus it could be that both Parisian and Swiss French listeners are sensitive to the duration difference that exists between /ɔ/ and /o/ in their own dialect (large in Swiss French, small in Parisian French), but the identification tasks used previously were not sufficiently sensitive to reveal this perceptual effect in the case of the small vowel duration difference for Parisian French.

To test this possibility, we assessed the perception of /ɔ/ and /o/ by native Parisian French listeners and native Swiss French listeners using a goodness-rating paradigm. In the task, listeners judged the relative goodness of tokens of /ɔ/ (in *cotte*) that varied in duration, and they judged the relative goodness of tokens of /o/ (in *côte*) that varied in duration. The goodness-rating technique assesses how listeners map the acoustic signal onto the internal structure of phonetic categories, and is known to reveal a listener's highly tuned sensitivity to fine phonetic detail in the acoustic signal. We predicted that if listeners are sensitive to vowel duration in a dialect-specific manner, then for both Parisian and Swiss French listeners, the best exemplars of /o/ should be longer than those of /ɔ/, and, importantly, this difference should be larger for the Swiss French than the Parisian French listeners. The speech stimuli used in the task were based on naturally produced utterances by a native speaker of the appropriate dialect—Parisian French for the Parisian French listeners and Swiss French for the Swiss French listeners.

The findings were clear-cut. For both Parisian and Swiss French listeners, the vowels judged to be the best exemplars of /o/ were longer than those judged to be the best exemplars of /ɔ/. Moreover, the difference in vowel duration between the best exemplars of /ɔ/ and /o/ was quite small for the Parisian French listeners and quite substantial for the Swiss French listeners. Thus both groups of listeners revealed a sensitivity to the vowel duration difference between /ɔ/ and /o/, and did so in a way that mirrored the duration difference between these vowels in their native dialect.

That the effect was quite small for the Parisian French listeners suggests that the Parisian French listeners in Gottfried and Beddor (1988) and Miller and Grosjean (1997) might have been sensitive to vowel duration when identifying /ɔ/ and /o/, but the effect was too subtle to be measured in the identification tasks they used. On this account, even in Parisian French, where vowel duration plays only a minimal role in the overall phonological system of the language, listeners are sensitive to the small duration difference that exists between /ɔ/ and /o/. Thus, although the earlier findings for Parisian French listeners in Gottfried and Beddor and in Miller and Grosjean appeared to provide an exception to the longstanding view that listeners use all available acoustic information when perceiving phonetic contrasts (see, e.g., Bailey & Summerfield, 1980; Repp & Liberman, 1987), the current Parisian French data provide further support for this view.

In a follow-up experiment, we assessed the extent to which dialect-specific perceptual processing depends on the speech itself being dialect-appropriate by using the same stimuli and procedures, but

now testing Parisian French listeners on the Swiss French stimuli and Swiss French listeners on the Parisian French stimuli. The most striking difference between the Swiss French listeners and Parisian French listeners found in Experiment 1 was replicated, with the Swiss French, but not the Parisian French listeners, showing a large duration difference between the best exemplars of /ɔ/ and /o/. This finding on dialect specificity is reminiscent of the numerous demonstrations that listeners tend to apply native-language strategies when listening not only to their native language, but also to a non-native language (for discussion, see Costa, Cutler, & Sebastián-Gallés, 1998).

However, there were subtle differences between the two experiments. Most notably, when Parisian French listeners were judging Swiss French vowels, the small difference in vowel duration between the best exemplars of /ɔ/ and /o/ that occurred in the previous experiment for Parisian French vowels disappeared. This underscores the subtlety of the Parisian French listeners' sensitivity to the vowel duration difference between /ɔ/ and /o/, perhaps in part because of the limited role of vowel duration in the overall phonological system of Parisian French and suggests that to reveal the sensitivity both the technique must be sufficiently sensitive (thus, it is found in a within-category goodness-rating task but not in identification tasks) and the stimuli must be dialect-appropriate (thus it is found for Parisian French speech but not for Swiss French speech). Taken together, the findings of Experiments 1 and 2 suggest that both Parisian French and Swiss French listeners are highly sensitive to fine phonetic detail in their native dialect, including the nature of the vowel duration difference between /ɔ/ and /o/.

Finally, it is of interest to consider our findings on a vowel contrast distinguished by both duration and spectral properties in relation to those reported by Grosjean et al. (2007) for vowels distinguished primarily by duration. In a production study, Grosjean et al. asked native speakers of Swiss French and native speakers of Parisian French to produce target words that were minimal pairs in Swiss French, with the words differentiated by the duration of the vowel, for example, *ami* versus *amie* (/i/-/iː/) and *clou* versus *cloue* (/u/-/uː/). (In Parisian French, where vowel duration is not contrastive, the words are essentially homophones.) As expected, the Swiss French speakers produced a large difference in vowel duration for the short and long vowels within a pair, whereas for the Parisian French speakers the two types of vowel had essentially the same duration. Moreover, the durations of the Parisian French short and long vowels were similar to the duration of the short Swiss French vowels. This is roughly in accord with the pattern we found in our companion production study (see Appendix). Specifically, we found a large difference in duration between /ɔ/ and /o/ for Swiss French speakers and a smaller (though clearly present) difference in duration for the Parisian French speakers, with the durations of both /ɔ/ and /o/ in Parisian French being similar to the duration of /ɔ/ in Swiss French.

Grosjean et al. (2007) also conducted a perception experiment, in which they asked native speakers of Swiss French and native speakers of Parisian French to transcribe the minimal pair target words described above, produced by a native speaker of Swiss French and clearly differentiated by vowel duration. Not surprisingly, the Swiss French listeners performed well, with a mean score of 91% correct. The Parisian French listeners, however, had some difficulty with the task, yielding an overall recognition rate of only 63% correct. Part of the problem may have arisen because of listening to a non-native dialect but, interestingly, the majority of errors occurred for the words with long vowels, and the most frequent type of error was misidentification of the long vowel as a short vowel (e.g., identifying *jolie* as *joli*). These findings indicate that Swiss French listeners are much more sensitive to vowel duration differences than are Parisian French listeners when recognizing spoken words. Overall, the findings reported in Grosjean et al. are in accord with the current results, documenting a clear dialect difference—in both production and perception—for the use of vowel duration in Parisian and Swiss French.

## Acknowledgements

This research was supported in part by a grant to the first author from the National Institutes of Health (NIDCD DC000130) and by grants to the third author by the Swiss National Science Foundation (1214-058848.99 and 100012-103384/1). We extend our thanks to Sharon Clayman, Eliza Floyd, Jodie Parnes, Isabelle Racine, Sandra Schwab, and Carole Yersin Besson for their assistance in carrying out the research. Michèle Mondini is now at Svox, AG, Zurich, Switzerland.

## Notes

1 The fundamental frequency (F0), amplitude, and spectral characteristics may also vary in vowels distinguished primarily by duration in Swiss French. For example, depending on the Canton, F0 can rise and fall during the long vowel; in addition, some Swiss French regional dialects end their long vowels with palatalization (e.g., in the Vaud Canton) whereas others do not (e.g., in Neuchâtel).

2 The description provided by Gottfried and Beddor (1988) implies that the dialect of their native French listeners was Parisian (standard) French.

3 For completeness, we also conducted a three-way ANOVA that combined the data for the Parisian French listeners in Experiments 1 and 2. Experiment (1 vs. 2) was a between-subjects factor, and Vowel (*cotte* vs. *côte*) and Limit (lower vs. upper) were within-subjects factors. Although the separate analyses on the Parisian French listeners in Experiment 1 and the Parisian French listeners in Experiment 2 reported in the main text clearly revealed an effect of vowel in Experiment 1 but not Experiment 2, this was not reflected in the three-way ANOVA. The effect of Experiment, $F(1, 28) = 3.75$, $p > .05$, and the interactions with Experiment (Experiment × Vowel, $F(1, 28) < 1$; Experiment × Limit, $F(1, 28) < 1$; Experiment × Vowel × Limit, $F(1, 28) = 1.53$, $p > .10$) were all non-significant.

4 Again, for completeness, we also conducted a three-way ANOVA that combined the data for the Swiss French listeners in Experiments 1 and 2. Experiment (1 vs. 2) was a between-subjects factor, and Vowel (*cotte* vs. *côte*) and Limit (lower vs. upper) were within-subjects factors. The different patterns we found for the Swiss French listeners in the two experiments were reflected in a significant three-way Experiment ×Vowel × Limit interaction, $F(1, 30) = 8.93$, $p < .01$.

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## Appendix

In a companion study to the main experiments reported in this paper, we measured the duration of /ɔ/ and /o/ in the speech of eight native speakers of Parisian French and eight native speakers of Swiss French (four male and four female in each case).

*Stimuli and recording procedure.* The /ɔ/-/o/ contrast was measured in four word pairs, *cotte/côte*, *top/taupe*, *pomme/paume*, and *sotte/saute*. The eight target words and 12 filler words (with the vowels /i/, /a/, or /u/) were each placed in the sentence frame *je dis* _____, and these 20 sentences were randomized 11 times, with the constraint that for a given randomization the two target words from a given pair could not occur consecutively. The 11 randomized sentence lists were used to create 11 sets of cards, with each card containing the written version of the sentence (e.g., *je dis cotte*). These cards were used to cue talkers during the recording procedure.

The same procedure was used at the two testing sites, University of Paris 8 and University of Neuchâtel. The talkers were recorded individually onto digital audio tape. Each talker read the 11 sets of randomized sentences from the cards described above, one sentence at a time. The cards were placed on a specially made lectern that sat on a table in front of the talker and flashed a small light (battery-operated LED) once every seven seconds. On each trial, the experimenter (seated next to the talker) turned over a card, presenting a written sentence to be read. The talker was instructed to wait until the next light flash, and then to read the sentence clearly, at a comfortable speaking rate. The experimenter then turned over the next card, and the talker waited for the next light flash to read the sentence on this card. With this procedure, the talker read one sentence at a time, at an evenly spaced pace, working through all 11 sets of cards. A short break was given between each set while the experimenter placed the next set of cards on the lectern. The first set of sentences was considered practice and was not analyzed. This left ten sets of sentences, yielding ten instances of each of the target words, for each talker, for acoustic analysis.

*Acoustic analyses.* For each of the 16 talkers (eight per dialect), each of the ten sentences containing a given target word, i.e., each target sentence, was input from the analog output channel of a digital audio recorder to a PC at a 20 kHz sampling rate using the Kay CSL/ASL system (KayPENTAX). Each target sentence was stored in a separate file, and measurements were made from these files. The acoustic measurements were made from the CSL waveform display, with supporting information from a simultaneous spectrographic display. The analyses reported below are based on means across the ten instances of a given target sentence, for a given talker. (In a very few cases, a given instance was not measured because the target word was mispronounced, there was extraneous noise, etc.; in those cases, the means are based on fewer than ten instances.)

Vowel duration was measured for each instance of each target word. For *cotte/côte* and *top/taupe*, vowel onset was defined as the onset of periodicity following the frication/aspiration for word-initial /k/ and /t/, respectively, and vowel offset was defined as the offset of periodicity (and the onset of closure for word-final /t/ and /p/, respectively). For *pomme/paume*, vowel onset was similarly defined as the onset of periodicity following the frication/aspiration for word-initial /p/, whereas vowel offset was defined as the onset of nasality for word-final /m/, seen as a distinctive change in the waveform pattern. Finally, for *sotte/saute*, vowel onset was defined as the onset of periodicity following the frication for /s/, and vowel offset was again defined as the offset of periodicity (and the onset of closure for word-final /t/).

In addition to vowel duration, we also measured the duration of the precursor *je dis* for each instance of each target sentence; this was used as an indicant of speaking rate. The *je dis* duration was defined as the interval between the onset of clearly discernible energy for *je* to the onset of the target word, defined as closure onset for /k/, /t/, and /p/ in *cotte/côte*, *top/taupe*, and *pomme/paume*, respectively, and as frication onset for *sotte*/*saute*.

*Results.* In a preliminary set of analyses we confirmed that, in general, speaking rate (as measured by the duration of the precursor *je dis*) was consistent across dialects and, for each dialect, consistent across target words within a given pair. The main analyses concerned vowel duration. The mean durations of /ɔ/ and /o/ were 104 ms (*SD* = 16 ms) and 124 ms (*SD* = 17 ms), respectively, for Parisian French, and 98 ms (*SD* = 17 ms) and 207 ms (*SD* = 38 ms), respectively, for Swiss French, yielding a mean vowel duration difference of 20 ms in Parisian French and 109 ms in Swiss French.

To analyze the data further, for each target word pair (*cotte/côte*, *top/taupe*, *pomme/paume*, and *sotte/saute*) we conducted a two-way analysis of variance (ANOVA), with Dialect (Parisian vs. Swiss) as a between-subjects factor and Vowel (/ɔ/ vs. /o/) as a within-subjects factor. For all four

target word pairs, there were main effects of Dialect, $F(1, 14) > 10.00$, $p < .01$ in each case, and Vowel, $F(1, 14) > 60.00$, $p < .001$ in each case, as well as a Dialect × Vowel interaction, $F(1, 14) > 30.00$, $p < .001$ in each case.

We explored the source of the interactions with two sets of individual comparisons. The first set focused on the /ɔ/-/o/ difference for each word pair within each dialect. These comparisons indicated that the vowel duration difference between /ɔ/ and /o/ was highly significant for all four target word pairs for the Swiss French talkers, $df = 7$, $p < .001$ in each case, and, importantly, was also significant for three of the four target word pairs for the Parisian French talkers: for *cotte/côte*, *top/taupe*, and *sotte/saute*, $df = 7$, $p < .05$; for *pomme/paume*, $t(7) = 1.57$, $p > .10$. The second set of comparisons directly compared a given vowel (/ɔ/ or /o/), in a given target word, across the two dialects. These comparisons indicated that the effect of dialect was not significant for /ɔ/ in *cotte*, *top*, *pomme*, $df = 14$, $p > .10$ in each case, or *sotte*, $df = 14$, $p > .05$, whereas there was a highly significant effect of dialect for /o/ for all four target words (*côte*, *taupe*, *paume*, and *saute*), $df = 14$, $p < .001$ in each case.

*Conclusion.* Taken together, the analyses indicate that, overall, /ɔ/ and /o/ are differentiated by duration in both dialects, but that the difference between the two vowels is greater in Swiss French than in Parisian French, owing to a longer /o/.