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Long and short vowels in Swiss French: Their production and perception[1]

FRANÇOIS GROSJEAN, SÉVERINE CARRARD, CORALIE GODIO AND LYSIANE GROSJEAN

Université de Neuchâtel, Switzerland

JEAN-YVES DOMMERGUES*

**Université Paris 8, France*

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ABSTRACT

Contrary to what is stated in much of the literature which is based in large part on Parisian French, many dialects of French still have long and short vowels (e.g. in Switzerland and Belgium). This study had two aims. The first was to show that Swiss French speakers, as opposed to Parisian French speakers, produce long vowels with durations that are markedly different from those of short vowels. The second aim was to show that, for these two groups, vowel duration has a different impact on word recognition. A production study showed that Swiss French speakers make a clear duration difference between short and long vowels (the latter are more than twice the length of the former on average) whereas the Parisian French do not. In an identification study which used stimuli pronounced in Swiss French, it was shown that words articulated with long vowels created no recognition problem for Swiss French listeners whereas they did so for Parisian French listeners. These results are discussed in terms of models of speech perception and word recognition.

1 INTRODUCTION

There is a dominant view in the phonetic sciences that vowel duration is no longer distinctive in French. Delattre (1965) stated, forty years ago, that the short/long distinction applies to two pairs of vowels only but that it is very unstable. The pairs

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he gives are /ɛ/ /ɛː/ as in 'mettre' (to put) and 'maître' (master), and /a/ /ɑː/ as in 'tache' (spot) and 'tâche' (task). Delattre adds that because of the instability of these duration differences, it is often said that duration is not distinctive in French. (It should be noted that in Delattre's second example, there is also a spectral difference between the two vowels for those who distinguish them). Malmberg (1964) concurs and writes that vowel duration plays a limited role in French. In most cases, duration is determined by the position of the vowel in the phonetic string. Finally, Tranel (1987) writes that since vowel length in standard French is predictable given vowel quality and context, this characteristic alone is not as a rule sufficient to mark differences of meaning between words. He continues by stating that length is said to play no distinctive role in standard French although a very small number of speakers may still make a distinction between /ɛ/ and /ɛː/ in a few pairs of words, such as 'mettre' (to put) and 'maître' (master), 'lettre' (letter) and 'l'être' (the being), etc.

Although Tranel (1987) reflects the standard line, he should be given credit for stating that duration is no longer distinctive in Parisian (standard) French but that other French dialects do have vowel-length contrasts which correspond to distinctions in meaning. Tranel cites Belgium (we should add Switzerland too) where some speakers have long vowels which immediately precede a 'mute e' in word final position. This is the case, for example, for feminine forms such as 'amie' /amiː/ (female friend) and 'sûre' /syːr/ (feminine form of sûr) which contrast with masculine forms 'ami' /ami/ (male friend) and 'sûr' /syr/ (masculine form of sûr). Thus, Tranel is one among a few phoneticians (e.g. Martinet, 1971; Walter, 1982; Francard, 2001; and the project 'La phonologie du français contemporain : usages, variétés et structure (PFC)' – Durand and Lyche, 2003) who do acknowledge that French regroups a number of dialects some of which show distinctive differences in duration.

Swiss French is one such dialect of French. To simplify things, we will consider Swiss French as a whole but we should keep in mind that there are, here too, a number of regional differences within Switzerland (e.g. the French spoken in Vaud, Fribourg, Neuchâtel, etc.). Swiss French, in general, is very similar to Parisian French, at all linguistic levels, although they do differ on a few aspects mainly at the lexical and the phonological level (Bayard, Jolivet, Knecht, and Rubattel, 1984; Knecht, 1979, 1985). In the domain of phonology, Swiss French has maintained two distinctions which have practically disappeared in Parisian French (Tranel, 1987; Léon, 1996) and this in favour of the first element of the pair: /a/ as in 'patte' (paw) versus /ɑ/ as in 'pâte' (dough), and /ɛ̃/ as in 'brin' (twig, blade) versus /œ̃/ as in 'brun' (brown). Swiss French also makes a distinction in certain areas of Romandie between /o/ and /ɔ/ in final open syllables, as in 'peau' /po/ and 'pot' /pɔ/, 'sceau' /so/ and 'sot' /sɔ/, whereas in Parisian French the /o/ – /ɔ/ distinction only exists in closed syllables such as 'paume' and 'pomme'; hence 'pot' and 'sot' would be pronounced /po/ and /so/ in standard French. To this we should add that Swiss French has specific characteristics in its prosody; it shows more pitch movement on

penultimate syllables in phonological phrases than Parisian French. Finally, it has been said that Swiss French is spoken slightly more slowly than Parisian French but no comparative study has produced empirical evidence for this.

Of central interest to us here is the phonological difference between long and short vowels in Swiss French that is particularly prominent in a number of minimal pairs. The following vowels are concerned: /i/ and /i:/ in such pairs as 'vit' (s/he lives) and 'vie' (life), 'ami' (male friend) and 'amie' (female friend); /ɛ/ and /ɛ:/as in 'renne' (reindeer) and 'reine' (queen), 'mettre' (to put) and 'maître' (master); /e/ and /e:/ as in 'armé' (armed) and 'armée' (army); /a/ and /a:/ as in 'voix' (voice) and 'voie' (way, path); /u/ and /u:/ as in 'roux' (ginger) and 'roue' (wheel); and /y/ and /y:/ as in 'cru' (believed, raw) and 'crue' (flood). In Parisian French, these pairs are homophonous as speakers no longer differentiate them in production (they have opted for the short form) whereas the two forms and their meanings are distinct in Swiss French. In addition to these pairs which differ in duration only, Swiss French, like Parisian French, has pairs which differ in both duration and spectral information. This is the case for /a/ and /ɑ/ as in 'tache' (spot) and 'tâche' (task), 'patte' (paw) and 'pâte' (dough), and it is also the case for /o/ and /ɔ/ as in 'côte' (rib, slope) and 'cotte' (tunic, overalls), 'saute' (jump) and 'sotte' (feminine form of stupid), etc. And, of course, both dialects show vowel duration variability due to phonetic, phonotactic, prosodic, syntactic and other factors.

Métral (1977) undertook a survey of how Swiss French speakers perceived their own pronunciation. He used a questionnaire developed by Martinet (1971) and put the same questions to 400 people (mainly primary school teachers). All the people polled in Métral's study acknowledged dialectal differences between Swiss French and Parisian French. As concerns duration, when asked what differentiates words such as 'vit' and 'vie' (pronounced with a short and long /i/), 'roux' and 'roue' (short and long /u/), 'cru' and 'crue' (short and long /y/), the great majority of those who differentiated them (they practically all did) mentioned duration as the sole variable (75% for /i/, 81% for /u/ and 86% for /y/). Note that these percentages go up if you also take into account the answers that mentioned two variables, one of them being duration (78%, 85% and 90% respectively). French Swiss speakers are therefore quite conscious of the long and short vowels in their dialect and of their use to differentiate minimal pairs.

Not only is duration perceived as being distinctive in self reports in the French-speaking part of Switzerland, but it is also perceived as playing an important role in differentiating pairs that are different on both spectral information and duration. For the 'saute'/sot/ – 'sotte' /sɔt/ distinction, for example, 100% of Métral's Swiss French subjects reported noticing that the former is longer. When asked to explain what accounts for the difference, they gave practically the same importance to spectral information (i.e. timbre; 66% mentioned it at least once) as they did to duration (53%). It is interesting to note that Martinet's subjects (excluding the Southern French speakers) put much more emphasis on the spectral difference (90%) than on the duration difference (62%).

Although phoneticians have shown some interest in the vowel duration difference between Parisian French and Swiss French, this has not been the case with psycholinguists working in the domain of processing. One recent study, Miller and Grosjean (1997), is an exception. They used the Gottfried and Beddor (1988) stimuli which had been used to show a trading relation[2] between perceptual cues in English listeners but not in French listeners. Gottfried and Beddor synthesized three series of stimuli that ranged from 'côte' /kot/ to 'cotte' //kɔt/ and where the 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/. In addition, the three series differed from one another in overall vowel duration. The two cues in the trading relation were therefore spectral change and vowel duration. The elements of the /kot/ – /kɔt/ series were presented in random order and listeners were asked to indicate if they heard 'côte' or 'cotte'. Gottfried and Beddor found that English and French listeners differed markedly in the way in which the change in vowel duration across the series affected identification. Whereas it had a clear effect for the English listeners (the identification function shifted towards the /ɔ/ end of the series as vowel duration increased), it had no effect on the French listeners (the functions were not displaced relative to one another along the stimulus continuum as a function of change in vowel duration). In other words, French listeners only based themselves on spectral changes to identify the items. Miller and Grosjean (1997) asked whether this was also true of Swiss French listeners. They hypothesized that given the importance of vowel duration in their dialect, native speakers of Swiss French, unlike native speakers of Parisian French, would use durational differences in addition to spectral differences when identifying the 'côte' – 'cotte' contrast. This is exactly what they found: as vowel duration increased across the series, there was, as for English listeners, a clear shift in the identification function toward the /ɔ/ end of the continuum, yielding an increase in the /o/ responses. In fact, there was no statistical difference in the results between the Swiss French listeners and English listeners whereas a difference was clearly present when the Swiss results were compared to those of Parisian French listeners (both English and Parisian French groups had also been tested by Miller and Grosjean). They concluded their study by stating that 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.

In the current study, we leave the speech perception level (identification experiments are typical of this level) and move up to the word recognition level. In addition, we put aside pairs of words that differ both on spectral and durational information and concentrate on words that differ mainly on vowel duration in all dialects of Swiss French, and more specifically, on final vowel duration (words such

[2] In a trading relation, when one perceptual cue is attenuated, another takes on the principal role of signalling the contrast.

as 'ami/amie', 'joli/jolie', 'connu/connue', etc.).[3] We are concerned here with length as the distinctive characteristic, allowing access to different morphological information in Swiss French (e.g. 'joli/jolie') or different meanings (e.g. 'clou', the noun, and 'cloue', the verb). The aims of the study were as follows. The first aim was to show that Swiss French speakers produce long vowels with durations that are markedly different from those of short vowels (in the order of a 2:1 ratio). We also wished to compare these productions with those of Parisian French speakers based on the hypothesis that they should have very similar durations for both elements of a pair (e.g. 'joli/jolie'). If the Parisian French speakers nevertheless produce a difference, it would be very small and variable among speakers. To meet this first aim, we simply asked speakers of the two dialects to produce a number of these pairs (each element was read in isolation) and we compared the lengths of the final vowels. The second aim was to show that long and short vowel duration has a different impact on word recognition depending on the group, Swiss French and Parisian French. Here, we asked listeners of the two dialects to listen to these same word pairs. They were pronounced in Swiss French and were embedded in light white noise so as to draw the attention away from the object of the study. Our expectation was twofold. We expected speakers of Swiss French to recognize both items of these pairs but we could not say whether the level of identification would be the same. The reason is that words with long vowels are slightly less frequent and this might have an impact on the processing. As for speakers of Parisian French, we expected them to do less well overall than the Swiss French speakers since they are not used to a Swiss French accent. We also expected words with long vowels to be identified less well than their short vowel counterparts since they would not be pronounced that way in Parisian French. However, we could not exclude some level of identification since there is a written form of each word (in French one sees and writes 'connue', 'jolie', etc.) and there is also dialectal contact between speakers of the different varieties of French. Parisian French speakers may have heard Belgians and Swiss French speakers make this vowel duration distinction when pronouncing the elements of these word pairs and this might explain some recognition of these kinds of words.

2 METHOD

2.1 Participants

Twenty-four participants, between the ages of 18 and 28, were used in the study. All were native speakers of French and none reported speech or hearing defects. Twelve were students at the University of Neuchâtel, Switzerland. They were born

[3] Long vowels differ from short vowels in terms of duration (as is seen in this paper) but also, it would seem, in Fo, amplitude and spectral characteristics. For example, depending on the Canton, Fo can rise and fall during the long vowel; in addition, some Swiss French dialects end their long vowels with palatalization (e.g. in the Vaud Canton) whereas other dialects do not (e.g. in Neuchâtel). In this paper, we will concentrate on duration only and leave aside, for a future study, other acoustic variables.

and had lived their whole life in the Neuchâtel canton. Twelve other participants were students at the University of Paris 8. They were born and had lived all their life in Paris. There were 7 males and 5 females in each group, thus controlling for sex in the study.

2.2 Material

Thirty pairs of words of the type 'ami/amie', 'pointu/pointue', 'aimé/aimée', were chosen for the study (see Appendix). All ended in an open syllable with a vowel that could take one of two forms: short or long. There were 8 one-syllable pairs and 22 two-syllable pairs. The final vowel could be one of the following: /i, e, y, u/. The elements of the pairs were either a verb and a verb (e.g. 'lié/liée', 'mordu/mordue'), adjective and adjective (e.g. 'joli/jolie'), noun and verb (e.g. 'clou/cloue') and noun and noun ('ami/amie'). It should be noted that some pairs belonged to more than one category (e.g. 'doré/dorée' which is both a verb-verb pair and a noun-adjective pair).

For the production study, the pairs were distributed across two written lists of stimuli such that if the first element was in one list, the second was in the other. There were as many first and second elements in each list. To these stimuli (30 in each list), an equal number of filler items were added to diversify the nature of the words to be read. The fillers were masculine and feminine words which ended mostly with one or two consonants and which were either one- or two-syllable long. The fillers were different in the two lists. To these two lists of 60 words each were added five warm up items used to calibrate the recording.

For the perception study, similar lists were built but contained additional filler items. Each list comprised 120 words in isolation, 30 experimental (see above) and 90 fillers. The latter were of the same type as in the production study. In addition, five filler items were added to each list. The recording of these lists took place in a sound booth with a SONY WM-D3 recorder and a SONY ECM-T150 microphone and were read individually by a female native speaker from Neuchâtel who possessed short and long vowels in her dialect. The stimuli were then digitized and analyzed with Praat (a speech analysis programme) to make sure that the final vowels of the experimental items were pronounced differently (see section 2.4 for the conventions followed during the measurement phase). The mean length of the 30 short vowels produced by the Neuchâtel speaker was 133 ms (S.D. 18 ms) and that of the long vowels 361 ms (S.D. 41 ms), a difference of 228 ms. Light white noise was then added to the recordings so that the S/N ratio was 20 dB. The noise always started 500 ms before the word and finished 500 ms after. Four tapes were then prepared, two for the first list (ascending order, descending order) and two for the second. They contained the 120 items plus five warm up items at intervals of six seconds to give time for a written response.

2.3 Procedure

So that the production study would not influence the perception study, we ran the perception study first. The two studies were conducted in Neuchâtel for the

Swiss group and in Paris for the Parisian French group. The perception study took place in a language laboratory with a two week interval between the first and the second list. Lists and order were changed so that an equal number of participants heard them in the different configurations. In the instructions, participants were told that the object of the study was the perception of words in noise. They would hear individual words (nouns, adjectives and verbs in various forms) and they were asked to write them down and to give a confidence rating on a scale of 1 to 7. A short break was given after groups of 40 words.

For the production study, which was run at least one week after the second part of the perception study, participants were recorded individually in a quiet room with a SONY WM-D3 recorder and a SONY ECM-T150 microphone. They were told that for the perception in noise study, several voices were needed. They were asked to read each word on the list twice with a normal list intonation. They were given a ten minute break between the first list and the second. Half the participants started with the first list and the other with the second.

2.4 Data analysis

For the production study, the duration of the final vowel of each first production was measured by one of the authors. To do so, both the speech wave and the spectrogram were used in the Praat program as well as auditory feedback. The onset of the vowel corresponded to the first major decrease in the periodicity on the speech wave and the start of the vowel formants on the spectrogram. When the two did not coincide, a point midway was chosen. The offset of the vowel corresponded to the end of the formants (or of the first formant if the others were not visible) and to the beginning of the flat section of the speech wave. Since vowel measurements are by nature difficult, a short reliability study was undertaken. An independent judge took 20 productions from each of four speakers (two Swiss French and two Parisian French), half from the first list and half from the second, and undertook the same measurements. Comparisons of the two series of measurements showed a grand mean difference of 2 ms. None of the four mean differences were significant. Three of the correlations were 0.99 and the fourth, 1.0. With such reliable data, the rest of the measurements continued to be done by just one person. There were no missing values in the Swiss French data and only three missing values in the Parisian French data (out of 720 measurements), one for each of three participants. These were due to words being skipped. To replace them within a participant's data, we took the grand mean for both long and short vowels and inserted that value in the participant's missing data cell.

For the perception study, a first analysis concerned the correctly identified words. We considered as correct those words that corresponded exactly to the ones given (e.g. 'taillé' for 'taillé') or that were straight homophones (e.g. 'tailler' for 'taillé' or 'amis' for 'ami', where the singular and plural form have exactly the same pronunciation). In addition, we also considered as correct those words that were

misspelled but had the same pronunciation (e.g. 'hindoux' for 'hindou', 'fanné' for 'fané'). Confidence ratings were tabulated along with these words. Concerning missing data, there were only two 'no answer' cases (out of 720) in the Parisian French group and none in the Swiss French group. These were not replaced but percentages were adjusted accordingly. As for the missing confidence rating data, there were three cases in the Neuchâtel French group and nine in the Parisian French group. They were replaced by participant means as in the production analysis.

A second analysis of the perception study concerned the errors. These were broken down into three categories: Sound addition, Vowel length change and Other. In Sound addition we took into account items (words or non words) that had a single sound addition (e.g. 'parure' for 'parue') or an addition along with a change (e.g. 'panir' for 'panée'). In Vowel length change, we took into account changes in vowel duration, from short to long (e.g. 'panée' for 'pané') or from long to short (e.g. 'bossu' for 'bossue'). To this category, we included items with an additional change along with a vowel duration change (e.g. 'fourru' for 'bourrue'). Finally, the Other category included single sound substitutions (e.g. 'lie' for 'nie'), multiple additions (e.g. 'blouse' for 'loue') and other changes (e.g. 'oreille' for 'dorée').

3. RESULTS

3.1 Production study

The aim of the production study was to show that Swiss French speakers produce long vowels with durations that are markedly different from those of short vowels. As can be seen on the left hand side of Figure 1, which presents mean vowel duration (in milliseconds) as a function of speaker group (Swiss French and Parisian French) and final vowel category (words that end with long or short vowels), this is indeed the case. The result is striking: short vowels (such as the /i/ in 'joli') have a mean duration of 150 ms and long vowels (signalled graphically by the 'ie' in 'jolie') have a mean duration of 342 ms, a substantial 192 ms (or 128%) increase.

When one compares these results with those of the Parisian French speakers (see the right hand side of Figure 1), the difference is clear. The latter give very similar durations to all final vowels: 169 ms for 'short' vowels and 178 for 'long' vowels (a 9 ms difference). Thus, whereas Swiss French speakers clearly differentiate long and short vowels, Parisian French speakers do not. Analyses of variance reflect this situation. There is a group effect in both the by participants and by items analyses: the mean Swiss French and Parisian French vowel durations are 246 ms and 173 ms, respectively ($F1(1,22) = 11.83$, $p<0.01$; $F2(1,116) = 355.54$, $p<0.001$). There is a word type effect: short and long final vowels last 160 and 260 ms respectively (($F1(1,22) = 93.19$, $p<0.001$; $F2(1,116) = 675.73$, $p<0.001$). Finally, there is a significant interaction: ($F1(1,22) = 78.20$, $p<0.001$; $F2(1,116) = 567.05$, $p<0.001$). Pair-wise comparisons show that there is no significant

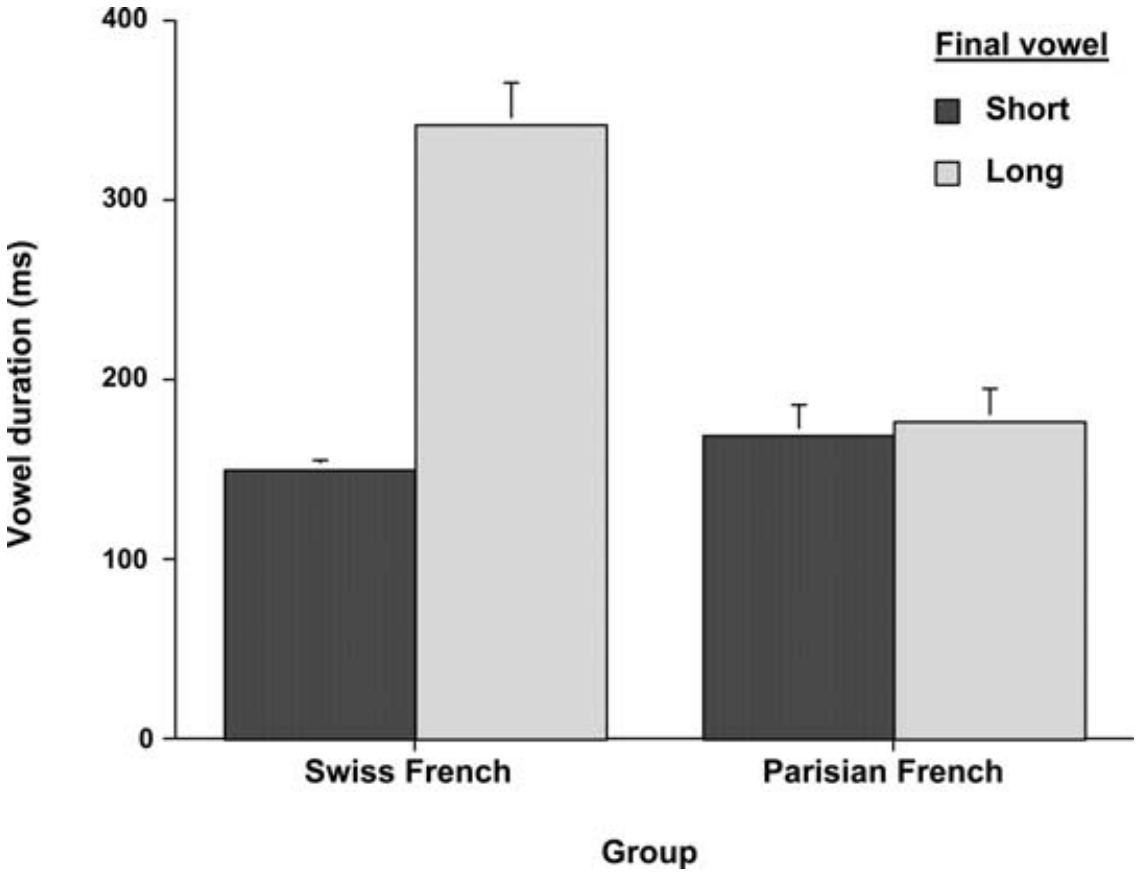

Figure 1. *Mean final vowel duration (in milliseconds) as a function of group (Swiss French and Parisian French) and final vowel category (in words that end with short or long vowels). Error bars represent +1 standard error of the mean.*

difference between the duration of the final vowel of short and long vowel words in the Parisian French group (the 9 ms difference is due to chance), no difference between the two groups (Parisian French and Swiss French) for the short vowels, but of course a very real difference for the short and long vowels in the Swiss French group.

We conclude from this that the Swiss French make a clear duration difference between short and long vowels whereas the Parisian French do not. A phonological difference in duration in the Swiss French dialect is clearly reflected in the duration of the speech wave. This said, it would probably be premature to state that durational difference has disappeared completely from Parisian French. We noticed, for example, that two of the twelve Parisian French participants showed slightly larger differences (in the order of 30 ms) than the others and one can therefore expect that some speakers may produce even more distinct durations. This could be due to the last remnants of a quasi-extinct phonological difference, but also to dialectal contact with other speakers, the dialectal origin of the speaker's family, etc.

In the next section, we examine how vowel duration differences are perceived, first by the Swiss French and then by the Parisian French.

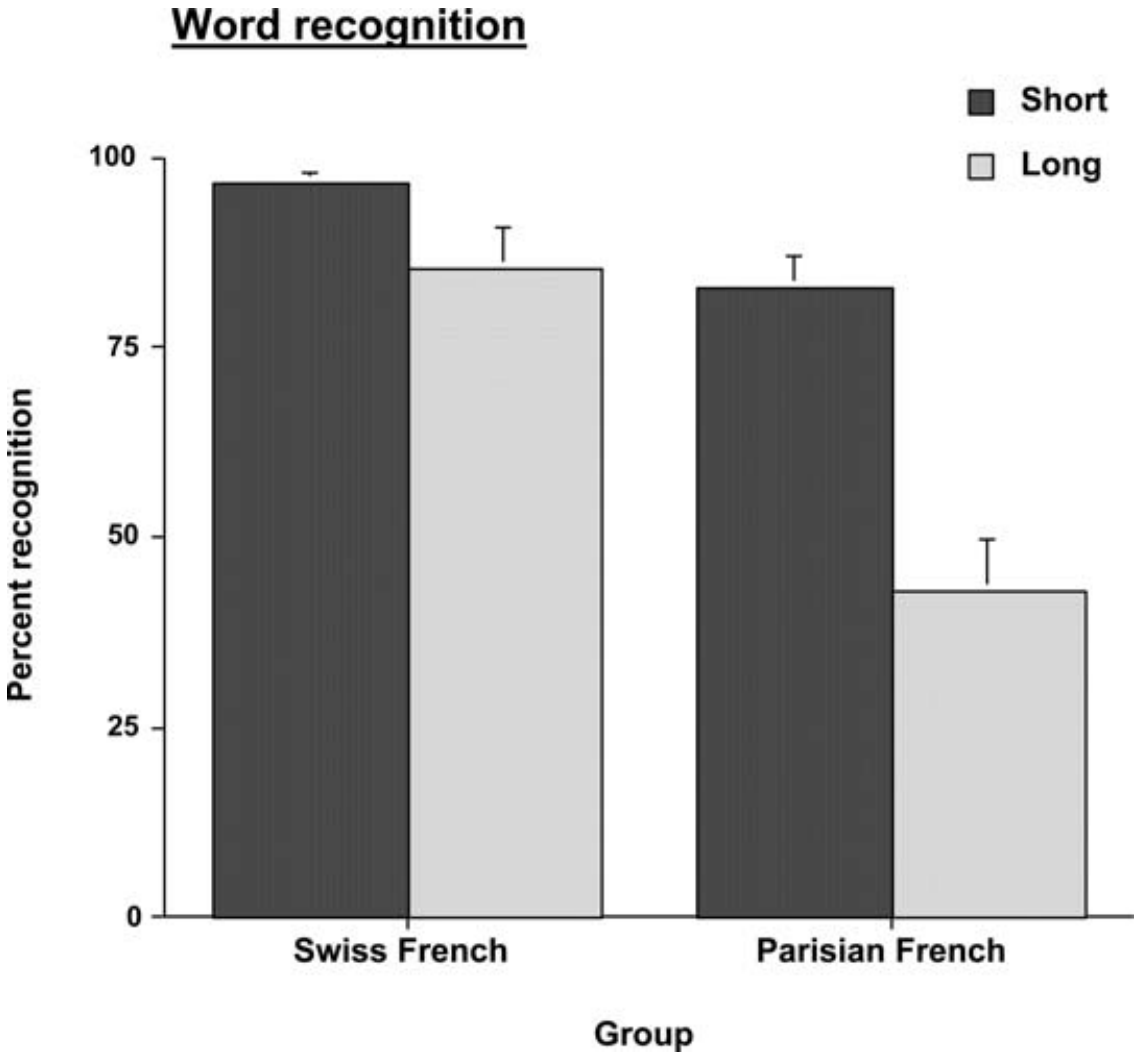

Figure 2. *Percent word recognition as a function of group (Swiss French and Parisian French) and final vowel category (in words that end with short or long vowels). Error bars represent +1 standard error of the mean.*

3.2 Perception study

The aim of this study was to show that long and short vowel duration has a different impact on word recognition depending on the dialectal group, Swiss French and Parisian French. As can be seen in Figure 2 which presents, in percentages, word recognition as a function of group (Swiss French and Parisian French) and vowel category (in words that end with short or long vowels), the Swiss French show good recognition of words with final short and final long vowels (left part of the figure). This said, they do slightly better with the former (96.67%) than with the latter (85.56%). In comparison, the Parisian French have good recognition of words with final short vowels (83.06%) but poor recognition of words with final long vowels (43.1%). Two analyses of variance confirm these patterns. There is a main effect of group: an average of 91.11% recognition for the Swiss French and 63.05% for the Parisian French (by participants: $F1(1,22) = 26.82$, $p<0.001$; by items: $F2(1,116) =$

110.29, $p<0.001$). There is also a main effect of word type: words with final short vowels are recognized more accurately than words with final long vowels: 89.86% and 64.30% respectively ($F1(1,22) = 42.02$, $p<0.001$; $F2(1,116) = 91.54$, $p<0.001$). And finally, there is an interaction: the difference in recognition between words with final short and long vowels is much larger for the Parisian French group than for the Swiss French group: 40.01% and 11.11% respectively ($F1(1,22) = 13.43$, $p<0.01$; $F2(1,116) = 29.31$, $p<0.001$).

The reason the Swiss French recognize a higher percentage of words overall than the Parisian French is due, of course, to the better recognition of words with long vowels in the former group but also to the fact that the pronunciation of the words corresponds to that of the Swiss French dialect. For the Parisian group, a Swiss accent is heard less often and hence lowers the recognition rate. As for the low recognition level of words with long vowels in the Parisian French group (only 43.1% are recognized, on average), it is directly tied to the fact that long vowels do not exist in their dialect. Hence words articulated with these vowels create recognition problems which lead to less than optimal recognition. However, since there is a written form of each word (e.g. 'jolie', 'parue'), it may influence the listener to sometimes choose the form with the additional 'e' grapheme (see General Discussion). In addition, dialectal contact between speakers of the different varieties of French does exist. The Parisian French will have heard Belgians and Swiss French speakers lengthen their vowels and this too could explain the recognition of words in this category.

One surprising finding is that the Swiss French recognize words with short vowels slightly more accurately than words with long vowels as was indicated above: 96.67% and 85.56% respectively (the pair-wise comparison is significant in the by items analysis ($p<0.01$) but not in the by-participants analysis). We suspected that word frequency might have a part to play and so we obtained subjective frequency ratings from 20 Swiss French and 20 Parisian French speakers, all different from the participants in this study. They were asked to rate the frequency of the experimental words and a number of fillers on a 1 to 7 scale. Both elements of a pair were tested but with a three-day interval. We thus obtained 120 mean frequency ratings: 60 for the Parisian French (30 words with a short vowel and 30 with a long vowel) and another 60 for the Swiss French. An analysis of variance of the frequencies (by items) showed an effect of word type: long vowel words were slightly less frequent than short vowel words: means of 4.38 and 4.79 respectively ($F(1,116) = 4.32$, $p<0.05$). There was no group effect (which shows that the Parisian French and Swiss French share this aspect of the language) and no interaction. We then regressed percent recognition on frequency and obtained the residuals which were fed into a by items analysis of variance. (This approach controls for frequency as would, for example, an analysis of covariance). All main effects remained highly significant and the pairs comparison for the Swiss French words with long and short vowels was also significant but at a higher probability level ($p<0.05$). This shows that frequency accounts to some extent for the difference in the recognition results. (Of course, if one considers the p value dichotomically, as significant or

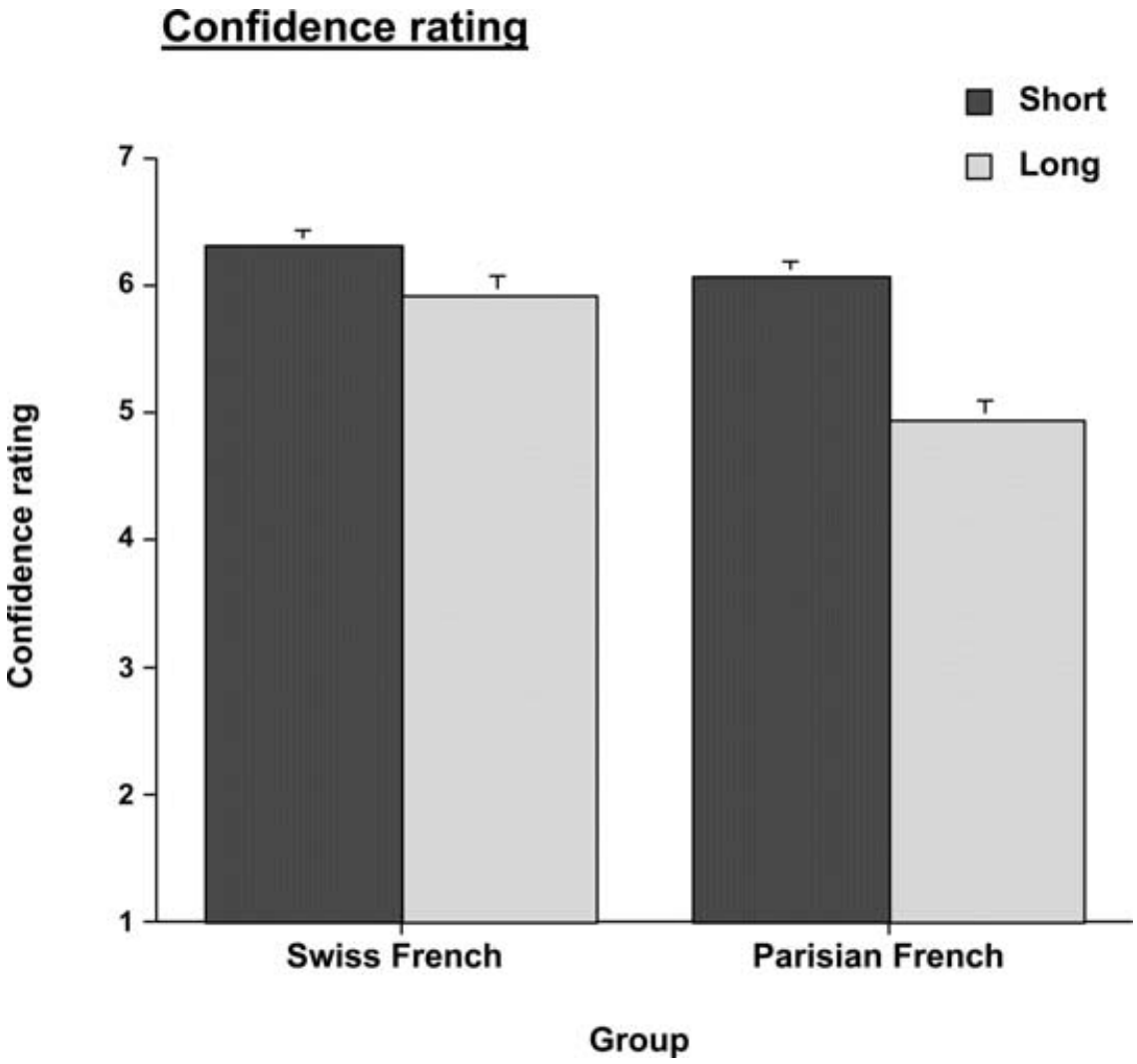

Figure 3. *Mean confidence rating as a function of group (Swiss French and Parisian French) and final vowel category (in words that end with short or long vowels). Error bars represent +1 standard error of the mean.*

non significant, then frequency does not come through as clearly as an explanatory factor). Another variable could be the frequency of the actual vowels: long vowels could be less frequent than short vowels. There may be other factors at play still.

Figure 3 presents mean confidence rating as a function of group (Swiss French and Parisian French) and final vowel category (in words that end with short or long vowels). What is striking is the fairly good similarity with Figure 2. First, the Swiss French appear to feel more confident on average about the words they have suggested than the Parisian French: 6.11 and 5.50 respectively. This is confirmed in the by items analysis of variance ($F2(1,116) = 19.61$, $p<0.001$) but not in the by participants analysis ($F1(1,22) = 3.20$, N.S.). Second, words with short final vowels are given higher confidence ratings, on average, than words with long final vowels: 6.18 and 5.42, respectively. This is confirmed by both analyses of variance ($F1(1,22)$, $= 36.44$, $p<0.001$; $F2(1,116) = 30.51$, $p<0.001$). Third, the difference in confidence ratings between words with final short and final long vowels is

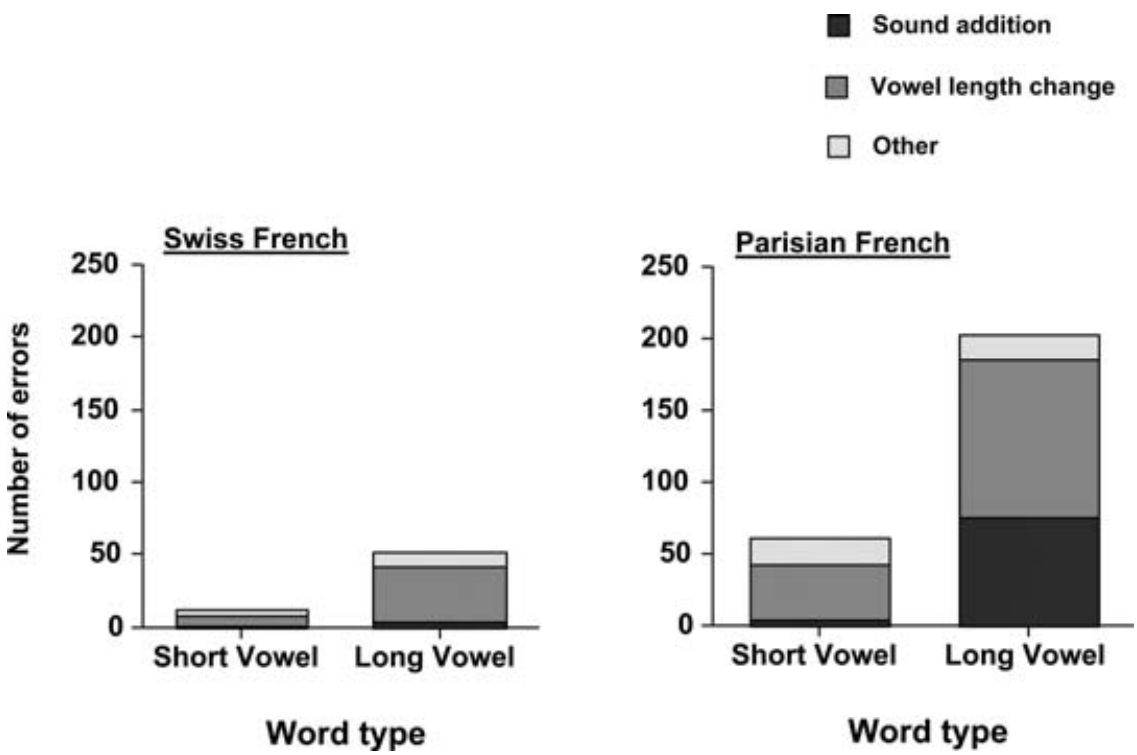

Figure 4. *Number of errors in the Swiss French and the Parisian French groups as a function of word type (words that end with short or long vowels) and error category (Sound addition, Vowel length change, and Other).*

larger for the Parisian French group than for the Swiss French group: 1.12 and 0.4 respectively. This interaction is also significant by participants ($F1(1,22) = 8.13$, $p<0.01$) and by items ($F2(1,116) = 6.73$, $p<0.01$). As noted above, the group effect is less strong than the other effects and this may come from the fact that both groups feel quite confident in the words they suggest (the ratings are quite high). This said, we have a strong interaction which is due primarily to the rather low confidence ratings given by the Parisian French to words that end with a long vowel. As with the recognition results, we factored out word frequency by regressing confidence ratings on this variable and we obtained the residuals which were fed into a by-item analysis of variance. All main effects remained significant (all three effects had been significant in the by items Anova) but this time the pairs comparison for the Swiss French words with long and short vowels was no longer significant. This last finding only gives further credit to the fact that word frequency accounts for some of the difference found between the two types of words in the Swiss French group. Of course, this does not exclude other factors such as the frequency of the two types of vowels: as proposed above, long vowels are probably less frequent than short vowels in Swiss French. In sum, the confidence ratings largely confirm the word recognition results.

The error analysis we undertook of the items that were recognized erroneously gives us an interesting insight into the recognition results involving our two groups of participants. Figure 4 presents the number of errors in the Swiss French and

the Parisian French groups as a function of word type (words that end with short or long vowels) and error category (Sound addition, Vowel length change, and Other). As can be seen, and as Figure 2 led us to expect, there are fewer errors made by the Swiss French than the Parisian French, and fewer errors with the short vowel words than with the long vowel words. If we take each participant group separately, some interesting observations can be made. In the Swiss French group (left side of the figure), the distribution of errors among the three error categories is similar for the two types of words ($\chi 2(2) = 0.22$, N.S.): the largest category is Vowel length change (46 errors in all) followed by Other (13), and by Sound addition (5). In the Vowel length change category, the majority of the errors (38 on 46) are long vowel words perceived as short vowel words (e.g. 'jolie' heard as 'joli', 'posée' heard as 'posé'). This can be explained, in part, by word frequency and perhaps by sound frequency (words with short vowels are more frequent and short vowels themselves are probably more frequent). The few errors that go in the opposite direction (a short vowel word being perceived as a long vowel word) can be explained either by the fact that listeners knew they had the two possibilities (and they chose the wrong one) or by the background noise which they might have taken for a vowel lengthening. In the Other category, the great majority of errors (10 out of 13) are substitutions (e.g. 'nu' heard as 'mu', 'nie' heard as 'lie') which is probably explained by the presence of the background noise.

If we compare the Swiss French results with the ones we obtained for the Parisian French group (right side of Figure 4), we find both similarities and differences, in addition to the fact that the Parisian French make many more errors, especially when listening to long vowel words. For the short vowel words, the order is the same as for the Swiss French: Vowel length change (39 errors), Other (18) and Sound addition (4): $\chi 2(2) = 0.94$, N.S. This is not surprising as both groups have words with short vowels and recognize them along the same principles. For the long vowel words, however, although the most frequent error category is also Vowel length change (109 errors) for the Parisian French, the second most important category is now Sound addition with a fairly high total (76 errors), and Other (18) is the last category. This difference in the error distributions in the two groups is statistically significant ($\chi 2(2) = 18.42$, $p<0.001$) as is the difference in the short and long vowel word distributions within the Parisian French group itself ($\chi 2(2) = 30.29$, $p<0.001$).

When one examines the sound additions in the words proposed by the Parisian French (in both categories), we find that 69 of the 76 sound additions involve /R/ (e.g. 'bourrure' is heard in place of 'bourrue'; 'parure' is heard instead of 'parue', etc.). An explanation for this could be that the Parisian French listeners hear that these words are continuing 'beyond' the regular final vowel duration and 'fill in' that gap with a sound that contains some friction similar to the underlying noise. In this case, the best candidate is the French /R/ sound. This is an even stronger possibility if one considers the fact that vowels preceding an /R/ are lengthened in everyday speech, something listeners are attuned to. Had these long vowel words

been heard without noise, different sound additions might have emerged, even if they had been less numerous.

A final finding in the errors made by the Parisian French listening to short and long vowel words concern the Other category. The total is 18 in each word category, but the underlying pattern of errors is quite different. Whereas for the short vowel words, substitutions total 14 of the 18 errors, one finds only 6 in the long vowel words ($\chi 2(1) = 7.2$, $p<0.01$). How can one explain this difference? Once again, one can refer to the space that needs to be filled in by the listener. Whereas one sound can take the place of another in short vowel words (e.g. 'posé' is heard as 'posait', 'trou' as 'tronc' or 'trop', etc.) – the sounds are more or less of the same duration – one sound only cannot replace a long vowel in the long vowel words. (It will be recalled that substitutions concern single sounds in this study). The space to fill in is too large and so listeners propose several sounds (e.g. 'nie' is heard as 'lire', 'mine' or 'mire'; 'panée' is heard as 'panir' or 'panier', etc.).

4. GENERAL DISCUSSION

The first aim of this study was to show that Swiss French speakers produce long vowels with durations that are markedly different from those of short vowels. We found that this was indeed the case as the long vowel in such pairs as 'ami/amie', 'joli/jolie', 'connu/connue' was more than twice the length of the short vowel. We also wished to compare these productions with those of Parisian French speakers and we found that the latter did not differentiate between the two vowels. The second aim was to show that long and short vowel duration has a different impact on word recognition depending on the group, Swiss French and Parisian French. We expected speakers of Swiss French to clearly recognize both items of the pairs and this was in fact the case: their overall recognition score was over 90%. However, we found an 11% difference between short and long final vowel words (long vowel words being recognized less well) and this was explained in part by word frequency. We also proposed that the lower frequency of long vowels could be a reason but we have no empirical data to corroborate this suggestion. As for speakers of Parisian French, we expected them to do less well overall than the Swiss French. This is indeed what we found as their overall recognition rate was 63.05% (as compared to 91.11% for the Swiss French). Some of this difference may be due to the different accent (after all, as compared to the Swiss French, they showed a 13% decrease in recognition rate for words with final short vowels), but much of it is due to their very real difficulties with the words that contained long final vowels (they recognized fewer than half of them). These words are simply not pronounced that way in Parisian French. This said, the percentage recognition was not zero, which may be explained by the fact that there is a written form of each long vowel word (e.g. 'jolie', 'amie') which may influence listeners to sometimes choose the form with the additional 'e' grapheme. Although studies bearing on the influence of orthography on spoken word recognition (e.g. Donnwerth-Nolan, Tanenhaus and Seidenberg, 1981; Hallé, Chéreau and Segui, 2000; Jakimik, Cole and Rudnicky,

1985; Seidenberg and Tanenhaus, 1979; Taft and Hambly, 1985; Ventura, Morais, Pattamadilok, and Kolinsky, 2004; Ziegler and Ferrand, 1998) do not agree on the level at which this influence takes place, they do show that spelling plays a role in spoken word recognition as it seems to be doing here. In addition, dialectal contact between speakers of the different varieties of French does exist. The Parisian French listeners may have heard Belgians and Swiss French produce this vowel duration distinction when pronouncing the elements of these word pairs and this may have had an impact on their word recognition.

Thus, when the phonology of a dialect includes short and long vowels, the production and the perception systems of the speakers of that dialect take this into account quite naturally. In production, the temporal difference is made, and in perception, the word recognition results are high for both types. This was the case for the Swiss French. When the dialect has only one category of vowel duration, however, it is no surprise that there is only one duration produced in output, and that it is the word that corresponds the most closely to the prototypical duration that is identified. When the duration changes, recognition is impeded. This is what we found for the Parisian French. Hence, the phonology of a language or dialect is intimately tied to the perception and production of that language or dialect.

Models of speech production (such as those by Garrett (1980), Dell (1986), Levelt, Roelofs and Meyer (1999)) have no problem accounting for different acoustic realizations of short and long vowels in speakers who have this phonological distinction, and for similar acoustic realizations when they do not. In speakers who show the difference, there are two phonological segments in their linguistic competence each with its own timing information; in speakers who do not, there is only one such segment with its relevant information. Models of word recognition (e.g. McClelland and Elman, 1986; Marslen-Wilson, 1987; Norris; 1994; Gaskell and Marslen-Wilson, 1997) can account, in different ways, for the good recognition shown by the Swiss French listeners when processing words with final short and long vowels since the word forms exist in their internal lexicon. However, most models have more difficulties accounting for recognition when the spoken word form does not exist in the lexicon, as in the case of 'amie', 'bourrue', etc. for Parisian French speakers. Some kind of link needs to be made with the orthographic representation (the written form of 'amie', 'bourrue', etc.) to explain some success, and special mechanisms need be invoked to take into account dialectal varieties heard through language contact. Current recognition models do not deal with issues such as inexistent phonemes in a particular dialect.

Research of this type will need to be continued in different directions. First, other word pairs could be used such as those where the long and short vowels are situated within the word (ex. 'faites' and 'fête', 'renne' and 'reine', 'mettre' and 'maître'). Will the duration difference be as great as for words that end on these vowels and how well will they be recognized? And does this depend, in part, on whether these words, and the kind in our study, are produced in context or not (our items were single words)? Second, our stimuli were embedded in light white

noise so as to draw attention away from the object of study. We saw in the error data that this probably had some influence on the answers given (e.g. the addition of a final /R/ sound). What would have happened if noise had not been added? Third, would differences be found if one tested speakers from other parts of Switzerland or took into account age, sex, educational levels, as well as type of discourse? Finally, tasks where the listener is under time pressure (on-line tasks) should be used to track the process that leads to recognition, or non recognition, of these kinds of words. These types of issues still need to be studied to better understand the perception and production of long and short vowels in Swiss French.

Address for correspondence:
François Grosjean
Laboratoire de traitement du langage et de la parole
Université de Neuchâtel,
Ave. du Premier-Mars 26
2000 Neuchâtel
Switzerland
e-mail: francois.grosjean@unine.ch

REFERENCES

Bayard, C., Jolivet, R., Knecht, P., and Rubattel, C. (1984). Le français en Suisse romande – approches sociolinguistiques. *Le français moderne*, 52: 137–182.

Delattre, P. (1965). *Comparing the Phonetic Features of English, French, German and Spanish: An interim report*. New York: Chilton Books.

Dell, G. S. (1986). A spreading-activation theory of retrieval in sentence production. *Psychological Review*, 93: 283–321.

Donnwerth-Nolan, S., Tanenhaus, M. and Seidenberg, M. (1981). Multiple code activation in word recognition: Evidence from rhyme monitoring. *Journal of Experimental Psychology: Human Learning and Memory*, 7 (3): 170–180.

Durand, J. and Lyche, C. (2003). Le projet 'Phonologie du français contemporain' PFC) et sa méthodologie. In: Delais-Roussarie and J. Durand (eds.), *Corpus et variation en phonologie du français: méthodes et analyses*. Toulouse: Presses Universitaires du Mirail, pp. 213–270.

Francard, M. (2001). L'accent belge: mythes et réalité. In: M.-A. Hintze, A. Judge, and T. Pooley (eds), *French Accents: Phonological, Sociolinguistic and Teaching Perspectives*. London: AFLS/CILT, pp. 251–268.

Garrett, M. F. (1980). Levels of processing in sentence production. In: B. L. Butterworth (ed.), *Language Production: Speech and Talk*. New York: Academic Press, pp. 177–220.

Gaskell, G. and Marslen-Wilson, W. (1997). Integrating form and meaning: A distributed model of speech perception. *Language and Cognitive Processes*, 12(5/6): 613–656.

Gottfried, T. L. and Beddor, P. S. (1988). Perception of temporal and spectral information in French vowels. *Language and Speech*, 31: 57–75.

Hallé, P., Chéreau, C. and Segui, J. (2000). Where is the /b/ in [apsyrd]? Is it in French listeners' minds? *Journal of Memory and Language*, 43: 618–639.

Jakimik, J., Cole, R. and Rudnicky, A. (1985). Sound and spelling in spoken word recognition. *Journal of Memory and Language*, 24: 165–178.
Knecht, P. (1979). Le français en Suisse romande: aspects linguistiques et sociolinguistiques. In: A. Valdman (ed.), *Le français hors de France*. Paris: Champion, pp. 249–258.
Knecht, P. (1985). La Suisse romande. In R. Schläpfer (ed.), *La Suisse aux quatre langues*. Geneva: Editions Zoé, pp. 125–170.
Léon, P. (1996). *Phonétisme et prononciations du français*. Paris: Nathan.
Levelt, W. J. M., Roelofs, A., and Meyer, A. S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences*, 22: 1–75.
Malmberg, B. (1964). *La phonétique*. Paris: PUF.
Marslen-Wilson, W. (1987). Functional parallelism in spoken word-recognition. *Cognition*, 25: 71–102.
Martinet, A. (1971). *La prononciation du français contemporain*. Genève: Droz.
McClelland, J. and Elman, J. (1986). The TRACE model of speech perception. *Cognitive Psychology*, 18(1): 1–86.
Métral, J-P. (1977). Le vocalisme du français en Suisse romande: considérations phonologiques. *Cahiers Ferdinand de Saussure*, 31, 145–176.
Miller, J. L. and Grosjean, F. (1997). Dialect effects in vowel perception: The role of temporal information in French. *Language and Speech*, 40(3): 277–288.
Norris, D. (1994). Shortlist: A connectionist model of continuous speech recognition. *Cognition*, 52(3): 189–234.
Seidenberg, M. and Tanenhaus, M. (1979). Orthographic effects on rhyme monitoring. *Journal of Experimental Psychology: Human Learning and Memory*, 5(6): 546–554.
Taft, M. and Hambly, G. (1985). The influence of orthography on phonological representations in the lexicon. *Journal of Memory and Language*, 24: 320–335.
Tranel, B. (1987). *The Sounds of French: An Introduction*. Cambridge: Cambridge University Press.
Ventura, P., Morais, J., Pattamadilok, C. and Kolinsky, R. (2004). The locus of the orthographic consistency effect in auditory word recognition. *Language and Cognitive Processes*, 19(1): 57–95.
Walter, H. (1982). *Enquête phonologique et variétés régionales du français*. Paris: PUF.
Ziegler, J. and Ferrand, L. (1998). Orthography shapes the perception of speech: the consistency effect in auditory word recognition. *Psychonomic Bulletin & Review*, 5(4): 683–689.

APPENDIX

The stimuli used in the production and perception studies.

Words with a final short vowel in Swiss French	Words with a final long vowel in Swiss French
aimé	aimée
ami	amie
bossu	bossue
bourru	bourrue
brûlé	brûlée
bu	bue
clou	cloue
coller	collée
connu	connue
cri	crie
doré	dorée
écrou	écroue
fané	fanée
gagné	gagnée
hindou	hindoue
joli	jolie
lié	liée
loup	loue
mordu	mordue
nid	nie
nu	nue
pané	panée
paru	parue
penser	pensée
pointu	pointue
posé	posée
su	sue
taillé	taillée
trou	troue
ventru	ventrue