Perception of Non-native Vowels by Finnish Learners of French

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Abstract

The first language affects second language perception by producing discrepancies that make native-like perception difficult. We measured adult Finnish French learners' identification, quality evaluation and discrimination of non-native phonemes in the back vowel continuum. Results showed that advanced language learners' perception is not solely based on their first language, but instead, they seem to have acquired almost native-like perceptual patterns in the second language.

1. Introduction

The perception of non-native speech sounds is usually based on the first language. It is therefore predicted that the language learner's first language produces discrepancies in the phonemic perception of the second language (L2). Several models are proposed to clarify these L2 perception problems. The Speech Learning Model [1] suggests that certain types of similarities between native and non-native phonemes are a major factor when a language learner is forming new categories for L2 phonemes. Kuhl's [2] Native Language Magnet theory describes how the phonetic categories are structured hierarchically, and how the best instances of categories, or prototypes, function like perceptual magnets drawing the neighbouring sounds toward the prototype, thus shrinking the perceptual space around the prototype. These prototypes are language-specific and they may prevent or hinder the perceptual discrimination in their vicinity.

Studies in second language perception assume that early bilinguals or even late advanced language learners may acquire native-like perceptual patterns [3]. However, some findings suggest that even early bilinguals' perceptual performance is limited [4]. In the present study, our purpose is to find out whether language learners have acquired the perceptual patterns of L2. We examine adult, advanced Finnish French learners' ability to identify, evaluate and discriminate French back vowels. The back vowel continuum used in the present study includes only two categories in Finnish (/o/ and /ɑ/), but three in French (/o/, /ɔ/ and /ɑ/). It is hypothesized that the language learners may acquire a new phoneme category, but the acquisition may not be entirely native-like due to the ongoing learning process and the continued daily use of the first language.

2. Methods

2.1. Subjects

Three voluntary, linguistically different, subject groups participated in the study. The first group (French speakers) consisted of ten native speakers of French (aged 19-30 years, mean 22, four males). They were exchange students at the University of Turku or at the Turku School of Economics and Business Administration, except for one subject who was taking a degree at the University of Turku. Nine native speakers of Finnish (aged 21-27 years, mean 25, one male) formed group 2 (Advanced students). They were advanced students of French language at the University of Turku. In the third group (Finnish speakers), there were 12 naïve native speakers of Finnish (aged 23-31 years, mean 27, three males) who had experience neither in French nor in phonetics. The subjects reported no known hearing deficits.

2.2. Materials and Stimuli

Altogether 12 vowels were synthesized using the Klatt parallel mode speech synthesizer [5], which was linked to the PC-based program HLsyn (High-Level parameter Speech Synthesis System, Version 1.0, Sensimetrics, Inc.). The PC-based Presentation® software (Version 0.52) was the control method on the trialling and on the registration of the responses. The subjects heard the stimuli from the computer's loudspeakers (Philips Multimedia Speaker System, Model A1.1).

The synthesized vowels represented a continuum for French back vowels /o/, /ɔ/ and /ɑ/. The F1 values varied with steps of 20.4 mels (480-740 Hz), and F2 values with steps of 20.9 mels (850-1200 Hz) (see Table 1). Frequency values were based on previous acoustic studies of French [6] and Finnish vowels [7]. A stimulus continuum /o-ɑ/ with a combined 29.2-mel difference in F1-F2 space between neighbouring stimuli was produced by employing the Pythagorean theorem $\sqrt{F1^2 + F2^2} = \sqrt{20.4^2 + 20.9^2} = 29.05$ mel, (see [8]). The higher formant frequencies were set to 2640 Hz for F3, to 3350 Hz for F4 and to 4465 Hz for F5. Stimulus duration was 450 ms. The F0 contour of each token rose from 100 Hz to 120 Hz within the first 120 ms and dropped gradually to 80 Hz by the end of the stimuli.

Table 1. The F1 and F2 values of stimuli in Hz and in mel.

Stimulus number	F1		F2	
	Hz	mel	Hz	mel
1	480	588,5	850	895,5
2	502	608,9	879	916,4
3	523	629,3	908	937,3
4	546	649,7	938	958,2
5	569	670,1	969	979,1
6	592	690,5	1000	1000
7	615	710,9	1032	1020,9
8	639	731,3	1064	1041,8
9	664	751,7	1097	1062,4
10	688	772,1	1131	1083,6
11	714	792,5	1165	1104,5
12	740	812,5	1200	1125,4

2.3. Procedure and data analysis

2.3.1. *Experiment 1: categorisation*

In Experiment 1, the subjects identified each stimulus as a member of one of the following French vowel categories: /o/, /ɔ/ or /ɑ/. The following sample words were given: *hôte* for /o/, *hotte* for /ɔ/ and *hâte* for /ɑ/. The members of group 3 categorised stimuli as Finnish /o/ or /ɑ/; they were not given any sample words, since Finnish orthography is in this respect phonemic. A practicing session consisted of 12 trials, with each stimulus presented once in a pseudo-randomised order. The experimental session consisted of 120 stimuli; all 12 different stimuli were each presented ten times in a pseudo-randomised order. In all experiments, subjects were tested individually in a sound treated laboratory at the Centre for Cognitive Neuroscience at the University of Turku. The subjects were informed in their native language and the instructions were given both verbally and in writing.

The categorisation data were analysed by submitting the proportions of /o/, /ɔ/ and /ɑ/ responses to the logit transformation using SPSS 10.0 software (SPSS Inc.), which determines the distribution by regressively computing the cumulative normal distribution closest, by maximum likelihood criteria, to the data. As a result, the location of the category boundary was determined. The steepness at the boundary was also calculated; it indicates the consistency of the categorisation.

2.3.2. *Experiment 2: goodness rating*

In Experiment 2, the subjects rated the goodness of stimuli on a scale from 1 (poor) to 7 (excellent). The stimulus blocks and the sample words were the same as in Experiment 1. The goodness rating data were analysed by comparing the goodness values of the category prototypes to the rating values at the category boundaries.

2.3.3. *Experiment 3: discrimination*

Experiment 3 measured variable AX discrimination sensitivity. The subjects heard two stimuli on each trial and indicated whether the stimuli were the *same* or *different*. The training session was first provided (11 trials: six *different*, five *same*). The experimental session consisted of 190 pairs (90 *same* and 100 *different*). The stimulus order of *different* pairs was counterbalanced, and the inter-stimulus interval was 800 ms. The *same* and *different* stimulus pairs were formed of every other, odd numbered stimuli (see Table 1). A bias-free measure of discrimination sensitivity, *d'*, was measured for each subject using a differencing model of signal detection theory [9]. The mean sensitivity for stimulus pairs was calculated within the categories and at the category boundaries.

3. Results

3.1. Experiment 1

The results of Experiment 1 showed that French speakers and Advanced students identified the stimulus continuum similarly. Average identification results are displayed in Figures 1. and 2. The location of the /o-ɔ/ boundary was near Stimulus 4, at 4.15 for French speakers (Group 1), and at 3.74 for Advanced students (Group 2). The /ɔ-ɑ/ boundary was located at 7.59 (Group 1), and at 7.29 (Group 2). The values of the category steepness were at 1.50 (Group 1) and at 1.24 (Group 2) for the category /o/, and at 1.62 (Group 1) and at 1.29 (Group 2) in the case of the category /ɔ/. There were no significant differences between French speakers and Advanced students in category boundary locations or in category steepness.

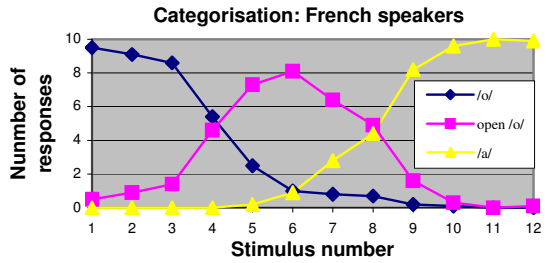

Figure 1. The categorisation results of French speakers (Group 1).

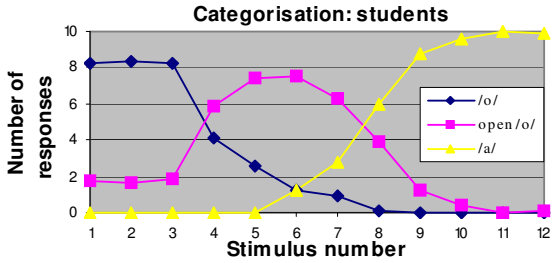

Figure 2. The categorisation results of advanced students (Group 2).

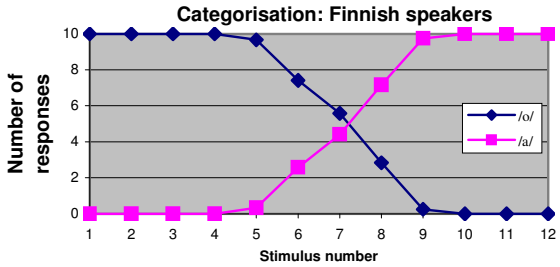

Figure 3. The categorisation results of Finnish speakers (Group 3).

Finnish speakers (see Figure 3.) located the /o-ɑ/ boundary near Stimulus 7 (at 7.08), similarly to the /ɔ-ɑ/ boundary location in French by Groups 1 and 2. The category steepness was at 1.89. The slight difference between three groups at the location of this boundary was not significant, Multivariate ANOVA analysis: $F(2,28)=1.138$, $p=0.335$ (ns). Consequently, this result indicates that the boundary location is the same in both languages, and thus the category /ɑ/ covers the same area on the stimulus continuum used in the present study in both languages. Despite the shared boundary location both in Finnish and French, the Multivariate ANOVA revealed a significant main effect of the group in the

consistency of this boundary, F(2,28)=3.312, p=0.047. Further analysis showed that this main effect was due to the difference between the Advanced students and the Finnish speakers. The Advanced students' identification consistency was low in comparison with the monolingual Finns, (F(1,19)=10.879, p=0.004). Students were thus less consistent in the categorisation of that boundary than the Finnish group, which could indicate uncertainty of decision among students. It is possible that the students' perceptual capacities are modified and they no longer base their identification solely on the first language system, but because of the ongoing nature of the learning process, their responses show inconsistency at the category boundary shared in their first and second languages.

3.2. Experiment 2

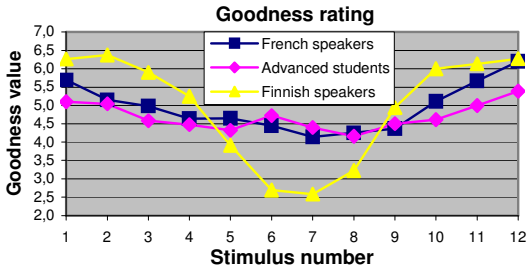

Figure 4. The goodness rating results of the three groups.

Average goodness judgments are displayed in Figure 4. The results of French speakers and Advanced students indicate that Stimulus 1 was prototypical among /o/ tokens (value 5.8 for Group 1, and 5.4 for Group 2), and Stimulus 6 among /ɔ/ tokens (value 4.9 for both groups). Within the /ɑ/ category, Stimulus 12 was the best exemplar (value 6.2) for the French speakers, and Stimulus 11 (value 5.5) for the Advanced students. Naïve Finns judged Stimulus 2 as a prototypical /o/ (value 6.6), and Stimulus 12 as a prototypical /ɑ/ (value 6.4). The prototypical goodness values were compared to the rating values at the category boundaries. The data from all the three groups were submitted to three independent ANOVAs, with one repeated measures factor (goodness) having five levels (or three levels for Group 3: two categories and one boundary). A significant main effect was observed for the goodness: French speakers, F(4,36)=28.088, p<0.0001; Advanced students, F(4,32)=4.795, p=0.004; Finnish speakers, F(2,22)=129.492, p<0.0001.

The further post hoc independent sample t-tests analysis revealed that Advanced students did not differentiate the /ɔ/ category from the neighbouring boundaries by the goodness. Thus, it seems that for students the evaluation is distinct only at the end points of the continuum, and not within the intermediate category /ɔ/. This may imply that the new category is not entirely acquired, i.e. this phonemic category may not possess any stocked memory representations that influence the non-hierarchical evaluation of the new category, according to the Native Language Magnet [2]. The French speakers differentiated the prototype /ɔ/ from the /ɔ-ɑ/ boundary (t(18)=-5.381, p<0.0001), but not from the /o-ɔ/ boundary. Thus, it seems that the /ɔ/ category may have a fairly instable role in the system, which may also be implied by the low prototypicality value 4.9.

The Multivariate ANOVA analysis of the goodness at the shared boundary between Finnish /o-ɑ/ and French /ɔ-ɑ/ revealed the main effect of group, F(2,28)=9.929, p=0.001. Further analysis showed that Finnish speakers differed from other groups: Naïve Finns versus Advanced students (t(19)=4.308, p<0.001) and Naïve Finns versus French speakers (t(20)=3.625, p=0.004). In other words, the shared boundary was evaluated differently in French and in Finnish. It seems that students' goodness rating is not based solely on the first language, since their goodness rating data showed more similarities with the French group than with the Finnish group.

3.3. Experiment 3

The mean sensitivity discrimination results for shared points between groups are displayed in Figure 5. For the Finnish speakers, a repeated measures ANOVA showed a significant main effect of discrimination, accuracy F(2,22)=6.311, p=0.007. The effect was due to the sensitivity at /o-ɑ/ boundary versus sensitivity within /ɑ/ category, t(22)=2.623, p=0.016. The results of French speakers and Advanced students did not indicate significant sensitivity differences between category boundaries and within the categories.

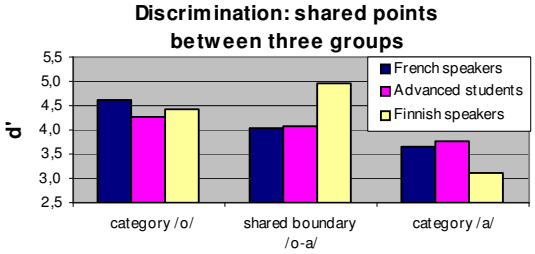

Figure 5. The discrimination sensitivity at the shared points between the three groups.

At the shared boundary between Finnish /o-ɑ/ and French /ɔ-ɑ/, the groups differed in their sensitivity, F(2,28)=4.482, p=0.020. Further analysis showed that Advanced students and French speakers were different from Finnish speakers: Advanced students, t(19)=2.676, p=0.015; French speakers, t(20)=-2.575, p=0.018. Therefore, at the shared category boundary location, the sensitivity was not similar between the groups. Since the Advanced students discriminated the continuum unlike Naïve Finns, but in accordance with target language speakers, it seems that their discrimination sensitivity has altered during second language acquisition.

4. Conclusion

Our results suggest that second language learners are able to perceive non-native phonemes. Adult Finnish French language learners categorise the new vowel phoneme /ɔ/ similarly to native French speakers. However, at the shared boundary between French and Finnish, learners show lower consistency in categorisation in comparison with the native speakers of French and Finnish. This may indicate the existence of the confused perceptual capability due to

language learning, since the location of the category boundary should be familiar to learners from their native language. Learners rate the goodness of the vowels in a similar way as native speakers of the target language. At the shared boundary, the Advanced students' and French speakers' goodness ratings differ from Finnish speakers' results indicating that the learners' goodness rating is based more strongly on the L2 than on the L1. Nevertheless, the learners do not differentiate the new category by goodness from the neighbouring category boundaries; there is thus inconsistency in the evaluations in comparison with the native speakers, which may indicate that no stocked memory representations have been formed for this new category [2].

Discrimination results suggest that only Finnish speakers perceive vowel contrasts differently at the category boundary in comparison with the category centre. The most significant finding in discrimination results, however, is that language learners perform in a manner similar to native French speakers. Although the students' phoneme categorisation and quality evaluation show slight differences from the results of the native French speakers, the learners' discrimination sensitivity suggests that L2 phonemic categories may have been constructed.

As noted already, the learners show important differences from native speakers of their mother tongue. Altogether, we wish to emphasize that the advanced adult language learners perceive the non-native vowel phonemes in a similar manner as native speakers of the L2, but because of the incompleteness of the learning process and the continued daily use of the native language, their perceptual patterns are not entirely native-like. These results support the findings by Flege and MacKay [3] that late bilinguals, or in our case advanced adult language learners, may acquire native-like perceptual aptitudes in second language, with subtle differences in comparison with the native speakers of the target language. As a consequence, we postulate in line with Flege [10] that the establishment of new vowel categories is possible in the course of adulthood, at least when the tests require attention and measure behavior.

5. Acknowledgements

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6. References

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