

Phonological vowel contrast : the case of the French median vowels

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ABSTRACT

This study focuses on the relations that preside over production and perception processes of speech, in order to propose a model that accounts for the link between these two processes. Our experimental protocol led us to collect data in vowel production and perception which can be analyzed globally or individually. In this preliminary study we have examined phonological units in relation to perception of speech, studying two different varieties of the French : the Centre and the South ones. Considering the overall population, our results support the Motor Theory of Speech. For south French speakers, a phonetic distinction due to phonotactic constraints is correlated with a perceptual distinction although these two sounds represent only one phoneme. However if we look at the correlation individually, a lot of variation appears. Some South French speakers show a pattern where a phonetic distinction in production is not associated with a perceptual distinction, thus supporting the idea that there is a phonological level.

1. INTRODUCTION

The notion of phonological representations is very difficult to apprehend, one way to cope with this problem is to study the link between production and perception. Here, we will study the link between items in production and corresponding perceptual targets, for French vocalic segments, through an experimental method and acoustic-phonetic measures.

If we consider the Motor Theory of speech (Liberman and Mattingly) [1], where perception is supposed to be mapped on articulatory gestures, we can advance the hypothesis that the phonological representation of let's say, a vowel, lies precisely in this direct link between production and perception. Thus two phonemes will be distinguished in production as well as in perception, but we should also expect that, although two sounds are in complementary distribution, as there are two phonetic realizations, there should be two distinct perceptual targets as well.

On the other hand, if phonological representations are independent units they might not be apprehended at all by the comparison of production and perception. There might only be representation of what is important to be distinguished in the environment : phonemes.

We'll try to shed light on this problem by studying the case of French median vowels.

French has a geographic-dependent distribution in two different zones of the median vowels [e, ε][ø, œ][o, ɔ]. In the North and South dialects these six vowels are in complementary distribution, the more open ones appear in closed syllables and the closed ones in open syllables, thus leading to only three phonemes. Whereas, in the Centre dialect, we find minimal pairs, justifying the status of phoneme for each of these vowels (Table 1).

	CENTRE : 6 phonemes (standard form))	NORTH/SOUTH : 3 phonemes
CV	"pré" vs "près"	CV "lait" "-lé"
CVC	"prête"	neutralization of the opposition CVC "laide"
CV	"pot"	C V "pot"
CVC	"saule" vs "sol"	neutralization of the opposition CVC "sol" "saule"
CV	"feu" vs "de"	CV "feu" "de"
CVC	"jeune" except for specific context : [-z]"heureuse" [-t]"émeute" "meute"	neutralization of the opposition CVC "jeune" "émeute"
		Except in Lyon CVC "jeune"

Table 1 : Phonetic diversity of the median vowels for the Centre and North-South zones.

Our research will thus investigate the phonemic status of the vowels of the North-South zone.

In the case of the French intermediate vowels, the Motor Theory of speech [1] drives us to postulate that to each sound in production corresponds a perceptual target. The Centre and North-South speakers will show the same scheme, in the vocalic area, as in the hypothetic representation of Figure 1.

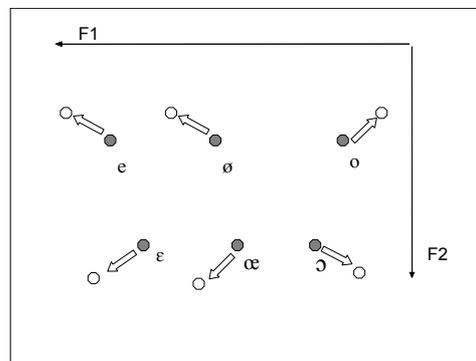


Figure 1 : Representation of the relation between production (full circles) and perception (empty circles) in the F1/F2 plan, according to the Motor Theory of Speech assumption, for French median vowels.

If the phonological representations are independent units, the South and North speakers will have a unique perceptual target for the allophones of a phoneme. These speakers will have a different scheme, in the vocalic area (figure 2), from the Centre speakers.

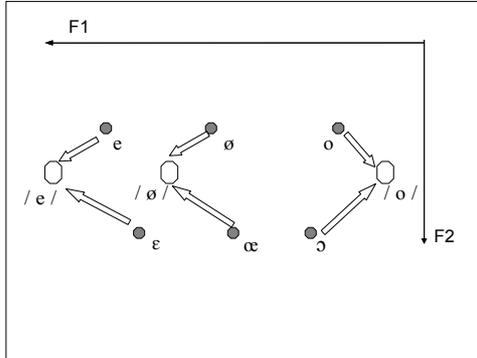


Figure 2 : Representation of the relation between production (full circles) and perception (empty circles) in the F1/F2 plan according to the assumption in favour of a perceptual phonological filter, for French median vowels

2. METHOD

2.1. Protocol

Protocols are organized in two tasks : 1) production and 2) perception, and are realized via a software planned for this experimentation. The sounds used in perception are synthetic sounds. The production recordings are done in a sound-proof room, on a PC at 22KHz, 16 bits, mono.

Production task

The subject has to pronounce a word, then the syllable in which the target vowel appears and then the vowel in isolation produced as in the word. The software sets up a random display of the stimuli, repeated 5 times.

The LPC acoustic analysis has been done using software Winsnorri[®] [3]. Measurements were done in the middle of each vowel.

Perception task

This task allows us to establish the perceptual vocalic area of the subjects who have done the production task. It's a MOA (Method Of Adjustment) task, on the first two formants [2]. The subjects have to choose the "best" vowel corresponding to the one included in the word written on the screen.

2.2. Corpus and Subjects

A large corpus has been elaborated for the production experiment : each French vowel appears after 9 consonantal contexts (154 words). In order to control perceptual effect on intermediate vowel process, these specific vowels appear in closed and open syllables. This work presents the study of the dental context /d/ only, which is the context of the written words of the perception task (Table 2).

items (syl)	centre production (standard)	South-North production
do (cv)	[dø]	[do]
domaine (cv)	[dømɛ̃]	[domɛ̃]
dôme (cvc)	[dom]	[dòm]
dors (cvc)	[dɔʁ]	[dɔʁ]
deux (cv)	[dø]	[dø]
de (cv)	[dœ]	[dø]
vendeuse (cvc)	[vãdøz]	[vãdœz]
odeur (cvc)	[odœʁ]	[odœʁ]
dé (cv)	[de]	[de]
dès (cv)	[dɛ]	[dɛ]

Table 2 : Phonetic transcription of the corpus of this study by zone.

Our experiment will be completed with 60 subjects : 20 from the centre of France, 20 from the South of France and 20 from the North, with 10 men and 10 women for each zone.

We already have recorded 32 speakers (16 from the centre and 16 from the South). In the present study we present the results of 20 of these persons : 10 from the Centre of France and 10 from the South, with 5 men and 5 women for each of these two zones.

3. RESULTS

Our experiment is based on the link between production and perception. Using a perceptual experiment in English (MOA task) Johnson & al.[2] have shown that prototype representations of perceptual target corresponded to an hyper-articulation of production segments. Considering the overall population, and even for most of the individual results, our data reproduce the hyper-articulation effect. In fact, on the F1/F2 plan, the vocalic production space is included in the vocalic perception space. High vowel are higher, low vowels are lower, front and back vowels are both more extreme.

In his study, Johnson also show a strongest stability of the perceptual space comparatively to the production one. Oppositely, the results of this work, which goes in opposite direction of Johnson's observations, presents perception values with higher standard deviation than production ones, for the global and individual results. It confirms the observation of a precedent study (J. Al-Tamimi, M. Girard, and E. Marsico [4]) which is that production space seems to be more stable than perception one.

Our results will be analyzed in a global perspective first. Then considering an important individual variability we'll look at individual data, which show interesting differences from the global results.

3.1. Global results

Based on our data, a first observation can be made regarding the effective pronunciation of word of the

corpus. Actually, the dictionaries give phonetic pronunciations, that are supposed to represent standard French. Frequently, this norm doesn't map the effective pronunciation. Major part of our production's data corresponds to the descriptions presented in Table 1, except three results contradicting the expectations that dictionaries propose.

First of all, the phoneme /ɔ/ in "domaine" doesn't seem to be a linguistic reality, for our subjects from the Centre of France at least. There's no statistic differences between the vowel in "do" and the one in "domaine" for people from the Centre, on the other hand the vowels in "dors" and "domaine" have a significant difference ($t(8)=6,57$; $p<.001$). This example of production is conflicting with the standard norm which is presented by dictionaries and which is supposed to be talked in Centre of France. There should have been an evolution in the production of the word "domaine" in the Centre of France that is not reproduced in dictionaries. Likewise, "de" and "odeur" don't seem to be produced in the same way in the Centre of France : they present a significant difference ($t(8)=4,13$; $p<.01$).

Compared items		Differences between items by zone			
		Centre		South	
		production	perception	production	perception
do (CV)	domaine (CV)	-	-	-	-
dôme (CVC)	dors (CVC)	***	***	-	**
do (CV)	dôme (CVC)	-	-	*	-*
dors (CVC)	domaine (CV)	***	**	***	**
de (CV)	deux (CV)	*	**	-	-*
vendeuse (CVC)	odeur (CVC)	***	***	-	-
de (CV)	odeur (CVC)	**	-	***	***
deux (CV)	vendeuse (CVC)	-	-	***	**
dé (CV)	Dès (CV)	***	***	-*	-

Table 3 : Statistic results for intermediate vowels, for a comparison production / perception (t Student analyses on pairs of items). _=non significant ; _*=tendency, $p<.1$; *= $p\leq .01$; **= $p\leq .001$; ***= $p\leq .0001$.

In Table 3, we have represented in bold type the results in perception correlated exactly with the production one. Globally, a difference between two items in production appears in perception too, even if the segments represent the same phoneme. Subjects seem to have a perceptual representation for each phonetic sound as predicted by the Motor Theory of speech.

However for the South speakers, differences are made in perception for some items ("dors""dome", $t(8)=4.19$; $p<.01$) despite its absence in production. It could be explained by the speaker's knowledge of the rules of French standard form. It's easy to admit that a regional form of language is hard to maintain with the various contacts that exist between the different varieties that occur in France. The standard form is learned at school,

and conveyed by the media.

3.2. Individual results

The pitfall with using global observation is that it hides the individual variability which is very present in our study. Studying this variability could reveal different individual strategies governing the relation between the production and perception of speech, and different level of phonetic changes.

In the present study, observing the individual data leads us to think that a phonological perceptual representation could exist for some people. The figures 3, 4 and 5 are representations of individual data for three different subjects from South of France. It shows ellipses that map data for single persons in production and perception, for a pair of CV-CVC words.

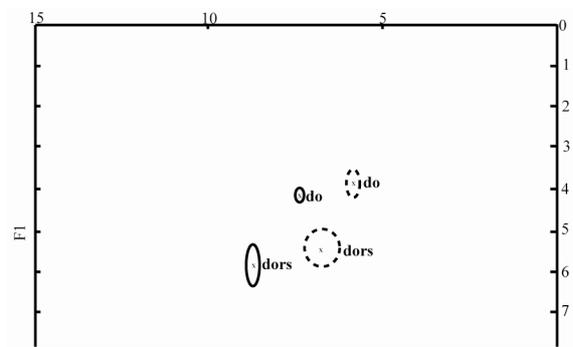


Figure 3 : Ellipse representations of production (solid lines) and perception (dotted lines) for a single South female speaker in F1/F2 plan in Bark. Word pair : "do"- "dors".

In Figure 3, we can see the results for a woman from the South of France, for pair CV-CVC "do"- "dors". As we had seen in the observation of the global population data, the perceptual targets are dissociated. It's not a phonemic representation ; the two phonetic productions are represented as well in perception.

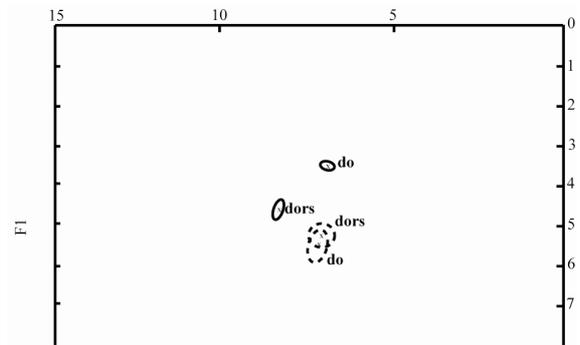


Figure 4 : Ellipse representations of production (solid lines) and perception (dotted lines) for a different single South female speaker in F1/F2 plan in Bark. Word pair : "do"- "dors".

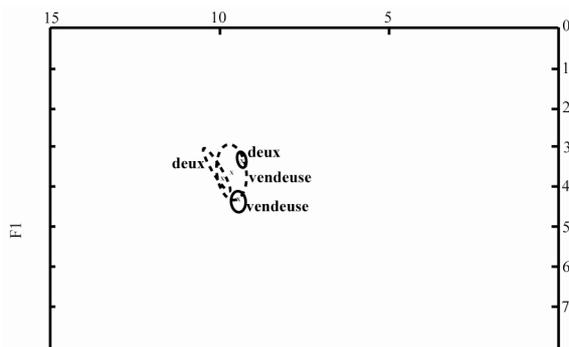


Figure 5 : Ellipse representations of production (solid lines) and perception (dotted lines) for a single South male speaker in F1/F2 plan in Bark. Word pair : "deux"- "vendeuse".

Figures 4 and 5 are data of two South subjects for the pairs CV-CVC "do"- "dors" (Figure 4) and "deux"- "vendeuse" (Figure 5).

Perceptual target ellipses are close to each other despite the distinction which is made in production. In the choice of the best vowel representing these pairs of words, the subjects don't make differences between their two phonetic productions. These individuals develop a categorization of their speech percepts according to what is pertinent in their speech environment. This type of scheme can suggest a phonemic representation.

Two possible non exclusive explanations can be proposed here. The first is concerned with a possible ongoing phonetic change that has not yet reached the entire population. And the second one raises the question of individual strategies. In the first scenario, the subjects who present a unique perceptual representation for a phoneme may have a different level of evolution comparatively to the individuals presenting the two perceptual representations. The two occurrences in production may have disappeared in perception because of their redundancy relatively to the environment. Thus, explaining part (or all) of the variability.

Individual strategies might be a good account of the observed variation : the different individual patterns corresponding to different arrangements in the relation between production and perception. Nonetheless, we have no clear definitions of what "phonological representations" may stand for. Furthermore, the notion of strategies implies the definition of a goal to achieve which in the current state of knowledge is hard to define. At this stage, we can not conclude, the issue is still open.

4. CONCLUSIONS

This work has studied the relations between phonological units and perception of speech. For our subjects and on our corpus, the link between perception of speech and production seems to be close to the one described by the Motor Theory of Speech. To an articulatory pattern corresponds an associated perception. However, the study of individual results shows schemes that may support the idea of a phonological filter. In spite of the different phonetic manifestations, a unique unit is perceived. But

this level of experimentation doesn't help to know the real nature of the perceptual representation, and the individual strategies that allow to access this representation.

Obviously, studying a larger number of subjects will definitely give more strength to our conclusions. Another important point will be to see if more subjects give rise to even more variability, or will lead to the emergence of a limited number of relation types between production and perception.

Variability in production and in perception has been studied, but separately for the two processes. Nevertheless, in a cognitive perspective, it seems fundamental to propose a unified model of the processes that govern speech.

This kind of approach conveys sensitive positions, as inter-modalities tasks comparisons, and also complex result patterns have to be analysed. But, this preliminary study is a foremost experimental contribution, which opens an interesting investigation area.

ACKNOWLEDGMENTS

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REFERENCES

- [1] A. Liberman and I. Mattingly, "The motor theory of speech perception revised," *Cognition*, vol 21, pp. 1-36, 1985.
- [2] K. Johnson, E. Flemming, and R. Wright, "The hyperspace effect: Phonetic targets are hyperarticulated," *Language*, vol 69, pp. 505-528, 1993.
- [3] Y. Laprie, "Snorri, a software for Speech Sciences", in *Esca workshop, Method and tool innovations for Speech Science Education*, Matisse, London, 1999.
- [4] J. Al-Tamimi, M. Girard, and E. Marsico, "Variabilité inter-langue et inter-individuelle en production et en perception : étude préliminaire en arabe dialectal et en français" 24ème Journée d'Études sur la Parole, Nancy : 24-27 June 2002, pp : 169-172, 2002.