Phonetic variability as a static/dynamic process in speech communication: a cross linguistic study

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Résumé:
Dans ce travail nous explorons différentes causes de la variation phonétique. L'analyse d'un corpus multilingue de plusieurs types de parole nous permet d'observer une distinctivité variable des voyelles de chaque système en fonction du contexte de production. Cette variabilité peut être attribuée 1/ à la spécificité des systèmes vocalique, 2/ à la quantité d'information véhiculée dans le message linguistique.

1. Some causes of phonetic variations

Phonetic realizations of phonological categories are characterized by a great amount of variation (Peterson & Barney, 1952). Some variations appear to be necessary for an appropriate perception of speech (Elman & MacClelland, 1986). Phomene realizations have to be considered from a dynamic point of view as well as from a static one (Lindblom, 1990). A question raised could be to make explicit the way this dynamic process works. It has been proposed that, when producing vowels, speakers tend to maintain a maximum of discriminability ("Adaptative dispersion": Liljenkrantz & Lindblom, 1972, Johnson, 2000). Some studies show that vowel reduction or centralisation appears within languages with heavy stress (Lindblom, 1963) and affects particularly unstressed vowels. Gendrot & Adda-Decker (2004) observed that centralisation can affect non stress languages as well as stress ones. In this way, reduction could be interpreted as a consequence of a purely physiological process (consequence of speeded-up speech).

Our study is a cross-linguistic investigation of quantitative variations of phonetic realizations. We hypothesize that vowel discriminability in a language is relative to 1/ the properties of the phonological system, 2/ the amount of informational context in the linguistic message. Recent evolutions of linguistics stipulate now that linguistic fields such as phonetics, phonology, syntax, semantics, etc. are not autonomous modules and cannot be described separately (Blache & Meunier, 2004). Linguistic information is disseminated throughout the different fields. Each one contains a more or less important part of information vehiculed in the message. Our hypothesis is that the reduction of vowel systems (decrease of dicriminability) is a consequence of the distribution of linguistic information in the message. But this dynamic process is relative to a static one: the properties of each vocalic system. The questions we ask are the following: why, when and how do variations appear? What is universal in these processes?

2. Method

In the present work, we plan to compare the production of vowels by speakers of French, Spanish and English. In English, there are between 13 and 15 oral vowels while French distinguishes some 10 or 12. The density of these two systems is therefore similar, but the specific vowels in each differ considerably. In contrast, Spanish has a relatively sparse inventory, with only 5 vowels. These three languages thus offer the opportunity to distinguish the effects of density, without a concomitant difference in the phonological nature of the vowels present in the two systems (French and Spanish), from the effect of differing inventories of vowels within comparably dense systems (French and English). Four speakers of each language were recorded producing three different types of speech (isolated vowels, within words and within texts). Durations and 3 formants (F1, F2, and F3) were analyzed for four speakers in each language for the 3 speech conditions.

3. Results

Results from formant analysis show a reduction of the vocalic system in the 3 languages. This reduction is proportional to the amount of context (fig1). At the same time, we observed an

increasing dispersion of each vowel values with respect to the increasing amount of context (fig2).

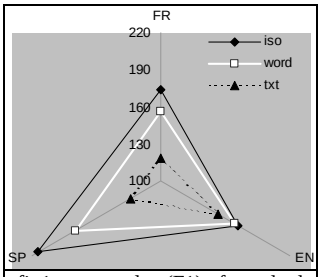

fig1: mean value (F1) of standard deviations of the productions of all vowels in each language (reduction)

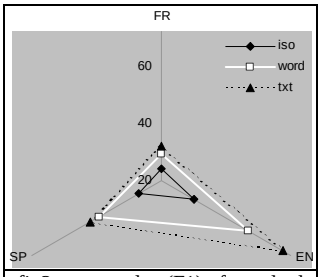

fig2: mean value (F1) of standard deviations of each vowel in each language (variation of each vowel)

As a consequence, in isolated vowels, vowel systems are large whereas each vowel space is reduced. At the opposite extreme, in text production, each vowel space is larger within a general reduced space. The consequence is a maximum of vowel discriminability in isolated pronunciation and a minimum in text production. The intermediate reduction in word production cannot be attributed to speeded-up speech. The durations of vowels within words are not significantly shorter than the durations of isolated vowels. Our interpretation is that the presence of semantic information allows lower dicriminability as long as vowel identification is provided by meaning. In addition, some differences between the languages can be observed: the contextual reduction in English is lesser as long as vowel dispersion is already high in isolated vowel production. Conversely, vowel reduction in Spanish texts is strong as long as production of isolated vowels shows hyperspace effect. These results suggest that a low density system could be more 'plastic' than a high one.

3. Conclusions

We propose that phonetic variations can be interpreted through two different dimensions: 1/ some variations may be strutured by the *static properties* of each phonological system (density but also phoneme frequency, system of features, prosodic system, phonotactics, etc.); 2/ some other variations may result from a punctual adjustment of the information flow through linguistic message and may be called *dynamic adjustment*. For both dimensions, specific and universal effects can be observed, depending on the structure of each language and the respective weight of each linguistic level in language processing. In this way, the usual question “how can we explain/interpret variations?” could be extended to “how can variations elucidate the process of information flow within the linguistic message?”.

References

Blache, P. & Meunier, C. (2004) "Language as a complex system: the case of phonetic variability", *VI Congreso de Lingüística General* , Mai 2004, Saint-Jacques de Compostelle, Espagne.

Elman J., McClelland J. (1986) "Exploiting lawful variability in the speech wave", in *Invariance and Variability in Speech Processes*, Perkell J.S, Klatt D., LEA, London, 360-381.

Gendrot, C. & Adda-Decker, M (2004) "Analyses formantiques de corpus radiophoniques multilingues", *Actes de la conférence MIDL 2004*, Paris, Novembre 2004.

Johnson, K. (2000) "Adaptative dispersion in vowel perception", Phonetica, 57, 181-188.

Liljenkrantz, J. & Lindblom, B. (1972), "Numerical simulation of vowel quality systems: The role of perceptual contrast", *Language*, 48, 839-862.

Lindblom, B (1963) "Spectrographic study of vowel reduction", *Journal of the Acoustical Society of America*, 35, 1773-1781.

Lindblom, B. (1990) "Explaining phonetic variation: a sketch of the hyper- and hypospeech theory", *Speech Production and Speech Modelling*, Hardcastle and Marchal (eds.), Kluwer Academic Publishers, 403-439.

Peterson G.E., Barney H.L. (1952) "Control methods used in a study of the vowels", *Journal of the Acoustical Society of America*, 24 (2), 175-184.