EFFECTS OF LANGUAGE CHANGE ON VOICE QUALITY IN BILINGUAL SPEAKERS. *CORPUS CONTENT EFFECT.*

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ABSTRACT

The paper investigates the reasons for LTAS sensitivity to language change. Six bilingual Catalan/Castilian Spanish have produced 5 utterances of 8 corpuses with controlled phonetic content. Experiment 1 shows that the LTAS interlanguage effect does not vary when the interlanguage corpus similarity increases. Experiment 2 shows that corpuses with invariant between- or within languages dissimilarities exhibit variable LTAS dissimilarities, i.e. more LTAS dissimilarity in interlanguage comparisons. It is therefore concluded that the corpus content variations due to the languages own characteristics are no cause of the LTAS interlanguage variability.

1. INTRODUCTION

For a long time, the idea that the Long Term Average Spectrum (LTAS) could depend on the language used by the speaker has been a controversial matter (Nolan, 1983). Recent studies have nevertheless established the LTAS sensitivity to language change in a group of Belgian bilingual French-Dutch speakers (Harmegnies and Landercy, 1985; Landercy and Harmegnies, 1986). Further research conducted in Catalan-Castilian bilingual speakers have moreover confirmed the findings reported in the previous Belgian studies, showing also a language effect in the intraspeaker variability of the LTAS (Harmegnies, Bruyninckx, Llisterri and Poch, 1989; Bruyninckx, Harmegnies, Llisterri and Poch, 1990, 1991).

The interpretations of this interlanguage effect are still controversial. On the one hand, one might argue that the observed differences derive from actual voice quality variability induced by the use of different languages. On the other hand, LTAS variability could be considered as rather artifactual from the voice quality viewpoint: bearing in mind the very straightforward facts that 1. different languages have different phonetic inventories and 2. that the LTAS is an average, one might assume that interlanguage LTAS variabilty only relies on variability in the speech samples phonetic contents due to language-specific differences in the phonetic inventory and also to statistical distribution constraints.

Clearly, at least two possible sources of variation are in conflict. In the present paper, we will aim at controlling one of them (the phonetic one) and try to evaluate its own contribution to the phenomena under investigation. For this purpose, we will observe the possible variations of the LTAS interlanguage variability in correlation with the use of corpuses with various degrees of inter- and intralanguage phonetic variability.

2. CORPUSES

2.1. Overall structure

Four different types of corpuses (A, B, C, and D) have been used in the present study. For each type, two corpuses have been composed: one in Catalan ("C") and one in Castilian Spanish ("S"). Eight corpuses are therefore available: 4 in Catalan ("CA", "CB", "CC", and "CD") and 4 in Spanish ("SA", "SB", "SC", and "SD").

2.2. Corpuses of increasing similarity

The first three pairs of corpuses were intended to show gradually increasing interlanguage phonetic similarities.

The A-corpuses are the most dissimilar ones: they consist of 'phonetically balanced' texts in the classical acceptation of the term, i.e. each composed with respect to the distribution of phonetic elements in its own language. The reference inventories we chose were those of Rafel (1979) and Navarro Tomas (1946), respectively for Catalan and Castilian Spanish.

The B-corpuses have been prepared using only the segmental elements which are common to Catalan and Castilian. The phonetic material specific to each language that has been left out is the following: Catalan: [ɛ,ɔ,ə,ʃ,ʒ,ʎ,ʦ,ʤ,ʤ]; Castilian Spanish: [θ,x,j,ĵ]. Both these corpuses consist in sets of meaningful.l sentences. No more requirements have been taken into account in the design of the B-corpuses: they therefore simply consist of natural Catalan and Castilian texts, sampled in a restricted common phonetic inventory.

For corpuses C, we tried to reach a still closer interlanguage similarity by balancing each of them with respect to the other. No other attempt has been made here to follow the general trend of phonetic distribution of the languages, this goal being impossible, because 1. of the reduction in the segmental inventory, and 2. of the differences in statistical distributions of the segments common to Spanish and Catalan.

For corpuses B and C, the interlanguage dissimilarity was measured by means of a two-sample chi-square statistic, which confirmed the increasing similarity of B- and C-pairs (B-corpuses, chi-square= 46.07; C-corpuses, chi-square= 22.20). This evaluation was of course impossible for the A-texts,

because of the structural differences in the phonetic inventories.

As a matter of fact, our C-corpuses are not *perfectly* balanced with respect to each other. They have to be considered as *the most possible* balanced, given that one of our requirements was to produce meaningfull texts in both languages (it should be noticed, however, that the chi-square value found for the C-texts is far from significance, suggesting that the arithmetical differences between distributions are within the same range as those observable in random sampling of a unique population, i.e. of one language).

2.3. Corpuses of invariant dissimilarity

Given the impossibility of composing perfectly balanced texts in different languages, we decided to build up new corpuses (D) which would be, for each language, as dissimilar to corpuses C as corpuses C are dissimilar one to another.

The dissimilarity of the C and D Catalan corpuses, estimated by a chi-square statistic of 22.85 is very close to the interlanguage dissimilarity of the C-texts (chi-square= 22.20, Cfr supra). This is also the case for Spanish C and D texts (chi-square=22.41).

We can therefore consider 3 pairs of corpuses of invariant amount of phonetic dissimilarity: one interlanguage pair (CC with SC) and two intralanguage ones (CC with CD, and SC with SD).

3. SUBJECTS

Six bilingual speakers have been retained for this experiment. Their ages range from 20 to 35, and they are either staff or students at the Universitat Autonoma de Barcelona. They are all competent both in Catalan and in Spanish Castilian. Their linguistic dominance has been established using a questionnaire assessing their use of both languages in a wide range of situations. This test was adapted from Viladot (1981) and has been used in our previous studies. Three subjects show a dominance towards Castilian (two males and one female), and the other three may be considered with a dominance towards Catalan (two males and one female).

4. EXPERIMENTAL SETTING

Five repetitions of each corpus were recorded for each subject. The recordings took place in a single experimental session; the corpuses in one language were recorded first, and a five to ten minutes break was allowed before recording the corpuses in the other language.

Recordings took place in usual laboratory conditions (sound-proof room, controlled position of the subject, professional recording equipment).

The speakers productions were afterwards processed by means of a Brüel & Kjaer 2033 analyzer, which performed one high resolution (12.5 Hz) FFT LTAS in the DC-5kHz frequency range for each utterance.

The 240 LTAS so obtained (6 speakers x 2 languages x 4 types of corpus x 5 repetitions) were stored in an IBM PC AT computer for further processing.

5. DATA ANALYSES

5.1. Experiment 1

In this experiment, we will aim at determining whether the increasing phonetic similarity of pairs of corpuses in Catalan and Spanish does result in diminishing the interlanguage LTAS variability.

For this purpose, we will use several times the experimental device previously designed. This one consisted of intraspeaker spectral comparisons performed both in interlanguage comparisons (Catalan spectra vs Castilian spectra) and in intralanguage comparisons (Catalan spectra vs Catalan spectra and Castilian spectra vs Castilian spectra).

In all our experiments using this device, we reported higher spectral dissimilarities in interlanguage- than in intralanguage spectral comparisons (this is precisely 'the interlanguage effect').

The device will be used three times: firstly with texts A, afterwards with texts B, and finally with texts C. If the corpus content exerts some effects on the LTAS, one might expect a gradual decrease of the interlanguage effect, since these corpuses pairs are of increasing similarity, from A to C.

Each spectral comparison is performed by means of the SDDD dissimilarity index (Harmegnies, 1988).

The means and standard deviations of the SDDD values obtained for each subject in each comparison condition are presented in table 1 (A-corpuses), 2 (B-corpuses) and 3 (C-corpuses). As can be seen, the interlanguage effect is to be found in each table, since the intralanguage values are obviously lower than interlanguage ones (see also fig. 1).

The existence of the effect has moreover been confirmed, for each kind of corpus, by a non-parametric Friedman analysis of variance. These 3 analyses have all delivered the very same result, namely: chi-square= 9.33, p=.0094.

Each Friedman analysis was followed by paired-sampled Wilcoxon T-tests, aimed at locating the sources of significance in the design. In all cases, they showed no differences between the intralanguage values of the two languages under comparison, but significant superiority of the interlanguage values.

Experiment 1 therefore seems to establish that variations in the corpuses contents do not modify the strenght of the language effect.

5.2. Experiment 2

According to the results of experiment 1, one might be tempted to conclude that the differences in phonetic contents of texts from different languages are not responsible for the language effect, and that another source of variance should therefore be considered.

Nevertheless, this conclusion would only be totally valid had we succeeded in building perfectly balanced pairs of corpuses in two different languages. This is not the case, as we have already noticed; and even if the statistical considerations developed above (Cfr 2.2) tend to establish a good phonetic similarity of our two C-corpuses, one could object that the

SA vs. SA		SA vs. CA		CA vs. CA	
m	σ	m	σ	m	σ
2.16	0.17	3.29	0.33	2.46	0.29
3.08	0.29	3.48	0.38	3.47	0.50
2.84	0.33	3.78	0.25	2.65	0.22
2.44	0.26	3.64	0.46	2.34	0.22
2.52	0.24	3.04	0.25	2.49	0.26
2.64	0.38	2.87	0.24	2.27	0.25

Table 1 : intra- and interlanguage SDDD values for texts A.

SB vs. SB		SB vs. CB		CB vs. CB	
m	σ	m	σ	m	σ
2.35	0.15	3.48	0.31	2.56	0.22
3.70	0.72	3.78	0.48	3.58	0.49
3.19	0.33	4.15	0.37	3.00	0.28
3.22	0.62	4.55	0.59	2.44	0.42
3.30	0.23	3.48	0.21	3.06	0.30
2.35	0.16	3.19	0.40	2.86	0.28

Table 2 : intra- and interlanguage SDDD values for texts B

SC vs. SC		SC vs. CC		CC vs. CC	
m	σ	m	σ	m	σ
2.96	0.58	3.66	0.48	3.03	0.67
3.35	0.54	3.90	0.42	3.54	0.21
3.00	0.25	4.00	0.22	3.10	0.32
3.27	0.46	4.49	0.39	2.47	0.19
3.45	0.43	3.60	0.43	3.15	0.33
2.65	0.31	3.72	0.51	3.35	0.31

Table 3 : intra- and interlanguage SDDD values for texts C

CC vs. CC		CC vs. CD		CD vs. CD	
m	σ	m	σ	m	σ
3.03	0.67	3.20	0.42	2.71	0.35
3.54	0.21	3.55	0.36	3.58	0.35
3.10	0.32	3.33	0.30	3.05	0.27
2.47	0.19	2.77	0.28	2.73	0.31
3.15	0.33	3.67	0.48	3.42	0.50
3.35	0.31	3.23	0.33	3.13	0.32

Table 4 : intra- and intertext SDDD values for Catalan texts (C and D)

SC vs. SC		SC vs. SD		SD vs. SD	
m	σ	m	σ	m	σ
2.96	0.58	3.22	0.63	3.28	0.45
3.35	0.54	3.38	0.57	3.54	0.32
3.00	0.25	3.25	0.28	3.45	0.23
3.27	0.46	3.30	0.39	2.81	0.24
3.45	0.43	3.74	0.41	3.83	0.38
2.65	0.31	3.11	0.38	2.95	0.21

Table 5 : intra- and intertext SDDD values for Spanish texts (C and D)

remaining dissimilarity is large enough to produce LTAS changes.

In the present experiment, we will therefore evaluate the behaviors of spectra drawn from our D-corpuses, which are - each in its own language- as different from the corresponding C-corpus as the two C-corpuses are dissimilar one to another.

If the previously reported interlanguage variability in corpuses C is due to languages-related changes in voice quality, it should be larger than the intralanguage, intercorpuses effects that we will now investigate.

Table 4 shows the means and standard deviations drawn from comparisons of the Catalan spectra: it can be seen at first sight that the intercorpuses comparisons do not elicit higher values than the intracorpus ones. This observation is confirmed by a Friedman analysis of variance (chi-square=4, p=.14).

In table 5 are presented the figures relating to the corresponding Spanish texts. Nor are the intercorpuses values higly different from the intracorpus ones. A Friedman analysis of variance nevertheless exhibits weak significance (chi-square=6.33, p=.042); but this is not fully confirmed by paired Wilcoxon T-tests, which deliver significant results in one case only (intratext values from Spanish text C vs intertext values: z= 2.014, p=.028).

The combined graph in figure 2 shows summarized values from tables 4 and 5 (*intra*language comparisons of the C- and D-corpuses, in Catalan and Spanish), together with the previously observed data from table 3 (*inter*language comparisons of the C-texts). This graph clearly shows that the interlanguage effect is far more important than corpus-related effects, if any, within each language.

6. CONCLUSION

The experiments reported in this paper aimed at investigating the reasons for LTAS variations observed when language changes occur. Two possible explanations were in conflict: either the interlanguage effect is due to profound variations in voice quality, provoked by the language change; or the interlanguage effect only results from differences in the corpuses contents, themselves caused by the very characteristics of the languages used by the speakers.

In our first experiment, we have shown that even when the interlanguage phonetic similarity of the corpuses increases, the interlanguage LTAS variability remains invariant. Our second experiment investigated the LTAS variability caused by intralanguage corpus variations as large as those characterizing our two most similar Catalan and Castilian corpuses. The results show important superiority of the language-related effect over the corpus-content-related one.

In conclusion, our investigations firmly plead against the idea that LTAS language-related changes actually derive from phonetic content variations. Other sources of variations should therefore be considered in order to account for the phenomena under investigation which, more than ever, clearly appear to properly consist of voice quality changes.

Additional work is nevertheless desirable in order to reach better generalizability of our observations, performed on a too restricted sample.

Fig. 1 : intra- and inter- language comparisons for texts A, B, C.

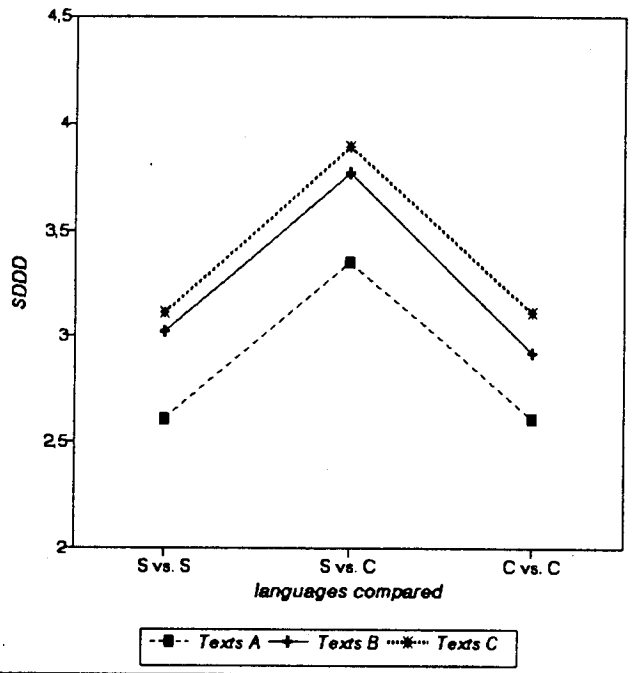
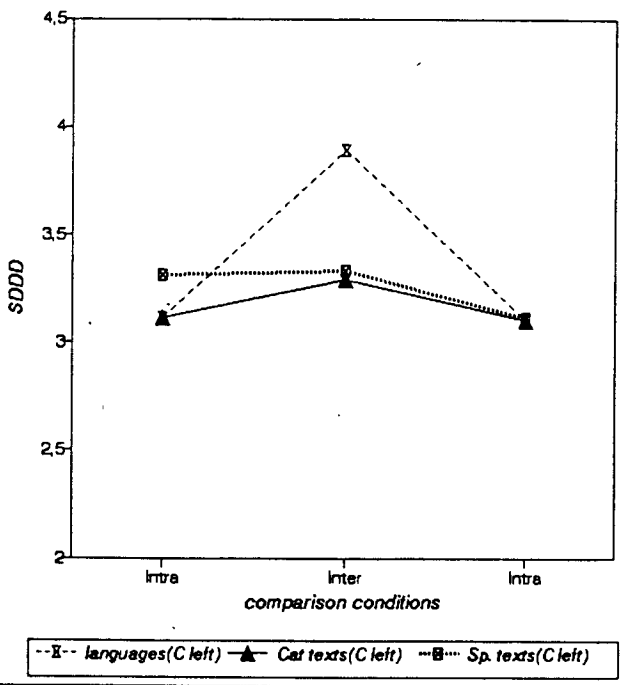


Fig. 2 : languages and corpuses comparisons (texts C and D)



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