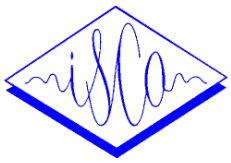

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PHONOLOGICAL MECHANISMS OF FRENCH SPEECH ERRORS

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Abstract

The present study, which reports the first stage of analysis of five corpora containing a total of 1488 errors, was aimed firstly at classifying French speech errors and determining whether our results are consistent with those obtained by most authors; secondly, by restricting our analysis to the phonological level, we have tried to discover the underlying mechanisms of phonologically-based lapsus linguae. Most of the results obtained are in line with those of previous studies. The results on phonological errors thus corroborate Shattuck-Hufnagel's (1980) availability and similarity theory. However the results on vowel errors showed in particular that speech errors are not confusions and cannot be compared to phonological neutralizations, given that the similarity principle must be based on robust features.

Accurate analysis of the feature substitution hierarchy showed that a permutation graph whose axes are the dimensions of the vocal tract is the best model for predicting speech errors .

1. INTRODUCTION

Many papers and books have been devoted to speech errors (lapsus linguae or slips of the tongue): see the well-known reference books by Fromkin 1973 and 1980, Cutler 1982, Lorenzi 1983 and bibiliography by Cutler 1982. In a recently published paper, Magno Caldognetto and Tonelli (1993) clearly summarize the different research trends explaining the causes of this normal (Fromkin 1971) and frequent phenomenon. Studies were mainly devoted to (i) typology (Fromkin 1973), (ii) phonological planning (Fromkin 1973 and 1980; Cutler 1982; Magno Caldognetto et al. 1991); (iii) and lexical access (Cutler 1982; for an updating bibliography, see Magno Caldognetto et al. 1991).

The present study, which reports the first stage of analysis of 1488 lapsus linguae, was aimed firstly at classifying French speech errors and determining whether our results are consistent with those obtained by most authors. Secondly, by restricting our analysis to the phonological level, we have tried to discover the underlying mechanisms of phonologically-based lapsus linguae (for a more complete study, see Rossi et al.(forthcoming)).

We consider speech errors to be deviations from the intent of the speaker, resulting in an unintentional modification in form, i.e., alterations in a unit belonging to the symbolic level and not to the level of mere substance.

1. TYPOLOGY

1.1 Describing errors by unit

Errors by unit

Cor	F	Ph	Syl	W	Str	Total
TD	1	41	9	36	13	100
PR	4	44	1	36	15	100
CR	7	46	8	34	5	100
Mean	4	43.5	6	35.5	11	100

Table1. Error frequencies (%) by unit and corpus. Cor= corpus;F=feature;Ph=phoneme;Syl=syllable;W=word; Str=structure (grammatical errors).

Hereafter, T will be used to denote the target or speaker's intent, E to denote the error, I the "intruder" which takes the target's place, and O, the contextual origin of the lapsus. For the sake of legibility in the exemples, T is underlined twice, E is underlined once, and O is in boldface print.

The different phonological error units are defined as follows:

(i) **Feature and phoneme errors**. It is likely that most phoneme errors are feature errors, but until this hypothesis is proved, a restrictive definition of feature and phoneme errors must be made. Feature errors can be defined as contextual perseveration or anticipation errors where the E phoneme is absent from the context, but where T minus E is a feature present in O (T - E = 1 feature):

(1) il faut déchaisir, ... dessaisir les juges

Phoneme errors occur when E is a phoneme which is different from T and equal to O, if the error is contextual:

(2) l'opéra Pastille, ... Bastille

(ii) **Syllable errors** exist when E and T are different syllables:

(3) c'est surtout géoagriphe, ... géographique

In each of our corpora (Table I), phoneme errors were more frequent than word errors. Phoneme and word errors together represented the major part (80%) of all errors. These results confirm those of previous studies on this topic for other languages.

Feature and syllable errors were uncommon. This fact is also consistent with former results. However we cannot conclude from it that features and syllables are not a psychological reality at the cognitive and/or production level. It will be shown below that features in fact play a fundamental role in the lapsus mechanism. Syllable substitution errors were indeed rare here, but all segmental errors found obeyed the structural law defining the syllable: swapped phonemes came from identical syllabic sites. This fact, already emphasized by most authors (see Fromkin 1973 and Shattuck-Hufnagel 1983), was confirmed in our corpora.

1.2 Describing errors by type

The phoneme errors in our corpus were substitutions, metatheses, omissions, and adjunctions. Phoneme substitutions (67%) outnumbered all other types of phonological errors. Syntagmatic errors represented the greater majority (93%) of the phoneme substitution errors, whereas only 43% of word substitutions were syntagmatic. This fact suggests that the causes and mechanisms of phonological errors are different from those of words. While higher-order units are closely tied to the situation and semantic context by their meaning, phonological units are embedded in a phonic context on which their production hinges, making the semantic context essentially irrelevant.

For the syntagmatic substitutions, we noted substantially more anticipations (see (4)) than perseverations (see (5)): 58% vs 42%.

(4) le motabolisme, ... métabolisme

(5) déboutés du broit, ... droit d'asile

The observed predominance of anticipations is in line with all previous results in the literature. However, phoneme anticipations were less frequent than word anticipations (58% vs. 74%). The prevalence of phoneme perseverations (42%) over word perseverations (26%) emphasizes the fundamental role of backward short-term memory in speech production, which strongly interferes with symbolic and motor planning.

2. FEATURES OR PHONEMES?

2.1 Random vs. Similarity Model

At first sight, phoneme errors could be regarded as confusions. The frequency of occurrence of the French vowels as a Target and as an Intruder in a substitution were compared with their frequencies in current speech. The value obtained for the Bravais-Pearson coefficient ($r = 0.85 > r^9_{0.01} = 0.80$) showed that the frequency of occurrence of each of the vowels in the errors is correlated with their frequency of occurrence in current speech. On the other hand, the number of times each vowel played the role of intruder (i.e. was preferred) was highly correlated with the number of times it played the role of target (i.e. was rejected) ($r = 0.96 > r^9_{0.01} = 0.80$). Moreover there were no preferred vowels in the substitutions: I-vowels and T-vowels were statistically the same). But we must go further to determine whether each intruder has a preferred target. In other words: Is the likelihood of finding a given phoneme in place of another directly proportionate to their similarity, as assumed by Shattuck-Hufnagel and Klatt (1980)? The degree of similarity of two phonemes can be defined in terms of their components (features). If we consider the distinctive acoustic features, we can see that substitutions mainly occurred between vowels which differ by one feature only (ex. I/E):

Differing by			
Distinctive F.		Dist.+Redundant F.	
1F.	82%	1F.	56%
2F.	18%	2F.	37%
3F.	0%	3F.	06%

If we consider the distinctive and redundant features the number of features by which the T and I pairs differed in substitutions increased, but substitutions differing by one feature were still significantly high. The two predictions made in the Shattuck-Hufnagel's and Klatt's model, namely similarity and availability, were confirmed by our results: (i) for similarity, a large predominance of substitution pairs differing by one feature only, and (ii) for availability, a strong correlation between occurrence frequency of vowels and probability of errors.

2.2 Evidence for Feature and Phoneme Errors

The other conclusion we can deduce from the results on the similarity principle concerns the psychological reality of features in backward short-term memory and production planning.The mechanisms of feature substitution are the following:

1. One feature substituted or added: I + T = E # I

(6) la meilleure façon, ... façon

E# I T

2. One feature substituted or added: I + T = E = I

(7) la cliricalisation, ... clericalisation
E=I T

3. More than one feature substituted: E = I

(8) l'anconographie janséniste, ... iconographie
E = I T

Only type-1 errors were interpreted as feature errors. We could say that type 1 and type 2 are both feature errors. Now types 1 and 2 involve one feature only, and the resulting error is either similar to or different from intrusion, respectively, depending on the number of features distinguishing T and I. Type-3 errors, which involve more than one substituted feature, always result in an error similar to intrusion. In all cases, the resulting error is a speech sound which exists in the concerned language (Well's law, Fromkin 1973). These two conditions (multi-feature substitutions and Well's Law) must be satisfied for a substitution to be interpreted as a phoneme error. The probability indeed that the resulting error will be an impossible speech sound increases considerably when the difference between T and I increases, provided errors are interpreted as feature substitutions and not phoneme substitutions. Hence the fact that the resulting sound is always a possible one in the language in question demonstrates that in the case of multi-feature difference and substitution, the error must be regarded as a phoneme substitution. This confirms Fromkin's assumption (1973,17).

3.FEATURES

As shown by the chi-square test, the rank and the frequency of the acoustic features (Peripheral, Compact, Grave, Flat, Nasal) in substitutions were independent of the availability of vowels. Peripheral and compact differed significantly from the random order: peripheral (a/O, a/E, i/E, y/OE, u/O) was preferred significantly more often than the other features, and compact (e/ɛ, o/ɔ , ϕ/oɛ; a/u, a/y, a/i) was rejected significantly more often. This difference between the peripheral and compact features is puzzling, since they both belong to the same openness dimension Two remarks can be made: (i) If substitution is viewed as the neutralization of a phonological opposition in the production process, the most frequently neutralized feature is an openness feature (peripheral). At the perceptual level, however, neutralizations (i.e. confusions) occur primarily on tonality features such as grave and flat. The compact feature creates a more complex state of affairs. Compact should discriminate e/ɛ, o/ɔ, ϕ/oɛ. Substitution errors did not occur in these pairs, whereas at the perceptual and phonological levels, confusions between them are highly prevalent. In conclusion we can say that in speech production, errors are not caused by confusions. While similarity between sounds is a prerequisite for substitutions to occur, a robust feature-based difference should also be required by the similarity principle. (ii) The compact feature discriminates pairs such as a/y, a/i, a/u. These pairs entered into a small number of substitutions. In this case, the low frequency of errors in speech production is consistent with the low frequency of confusions at the perceptual and phonological levels.

3.1 Towards a Feature Representation Model

Why then did compact behave differently from peripheral in speech errors? Careful analysis showed that:

(i) The vowels in the most frequent substitutions, i/E and a/E (differing by peripheral), are articulated on the same alveo-pharyngeal axis and are articulatory neighbors. However, compact oppositions such as a/y and a/u call an additional feature into play, labial or velar, and the members of the a/i pair are far away on one and the same dimension. Thus, the different behavior of the peripheral and compact features points out the fundamental role of the articulatory dimensions in speech errors.

(ii) Substitutions were significantly more frequent between vowels articulated along the alveo-pharyngeal dimension than between those articulated along the velar or labial dimension. We therefore suggest that alveo-pharyngeal is the preferred dimension in substitutions, while velar and labial, especially velar, tend to be spared from speech errors.

These facts provide evidence for a feature representation wherein the most frequently substituted vowels are represented along the same (alveolar-pharyngeal) dimension, as in the vocal tract, and the additional dimensions (labial and velar) are secondary. The best representation of relations between vowels is a permutation graph whose axes reproduce the dimensions of the vocal tract (Fig.1).

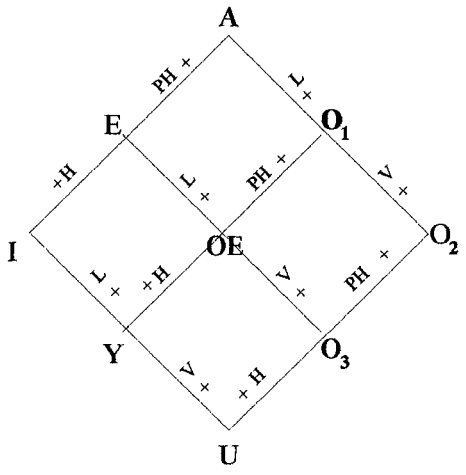

Fig.1 Permutation graph for French vowel errors.PH=pharyngeal; L=labial; V=velar; H= high.

One way of representing the relations among the vowels is to calculate the distances between them. A simple way to do this is to determine the length of the path between two vowels, as in the theory of graphs. This length is highly correlated with the normalized frequency of substitutions ($r = 0.96 > r^4_{0.01} = 0.80$

This strong correlation says that the shorter the articulatory distance between two vowels, the greater the probability that they will be substituted for each other, provided that the availability and the robust feature principles are satisfied. The structure of the graph is also a good predictor of substitutions. Thus, the universal maximum /a/, with its neighbors /E/ and /O/, is more likely to appear in substitutions than the universal minimum /u/, which is rejected. These results clearly show that in speech errors the representation of vowels is articulation-based. This statement appears to be a truism as far as errors in speech production are concerned. It does not, however, if we look more deeply into the levels of representation.

3.2 Source Levels of Errors

The implications of the articulatory model in substitution clearly suggest that phonological errors are triggered during the "abstract motor programming stage" (Laver 1980) or stages 1 and 2 of speech motor control (Levelt 1989 , 421) , where vowels should be represented as associated articulatory dimensions or features. This first claim is validated by the conclusions drawn from the span of anticipation.

For perseverations, we could assume that for several milliseconds (2 or 3 syllables) in iconic memory, a shifting articulatory representation is present at a lower level, which is the result of conversion of a motor program to neuromuscular commands. But defined as such, the content of iconic memory, necessary for speech control, cannot trigger speech errors. In the output of a neuromuscular conversion, the articulatory dimensions by which vowels are produced are embedded in a specific context where they are constrained and severely modified. Yet substitutions clearly demonstrate that intruders are abstract units which fit into the target context. Hence we can tentatively assume that in perseverations, intruders are triggered at the symbolic representation level in immediate memory.

Since the above findings on the organization and nature of features are the same in perseverations and in anticipations, we are led to hypothesize that phonological symbolic representation is articulation-based, both in backward immediate memory (perseverations) and in symbolic planning (anticipations). The features by which the vowels are defined and discriminated are the dimensions of the vocal tract.

CONCLUSION

We have drawn up a typology of French speech errors.Most of the results we obtained are in line with those of previous studies for other languages.

Concerning phonological planning, our findings corroborate Shattuck-Hufnagel's availability and similarity theory. However, speech errors are not confusions and the similarity principle must be based on robust features. Hence, speech error substitutions and phonological neutralization derive from two different processes. The feature substitution hierarchy showed that an articulatory model is better at accounting for vowel errors. The distance between two nodes in the graph, provided that the availabilty, preferred dimension, and robust feature principles are taken into account is the best criterion for predicting phonological errors.

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