THE ORGANIZATION OF CONSTRAINTS ON PHONOLOGICAL SPEECH ERRORS

EMANUELA MAGNO CALDOGNETTO, LIVIA TONELLI, KYRIAKI VAGGES, FIERO COSI

Centro di Studio per le Ricerche di Fonetica del C.N.R.
Via G. Oberdan, 10
35122 Padova, Italia

ABSTRACT

The intrinsic and extrinsic constraints are taken into account in the analysis of 455 consonantal errors - part of a corpus containing about 1500 Italian lapses. Parameters governing both types of constraints, and the hierarchical organization of the extrinsic ones are discussed. Our results provide evidence for some phonological properties of Italian.

1. Since the pioneering paper by Victoria Fromkin [1] the list of those working on speech errors has come to include - as the rich literature on the topic shows [2,3,4,5,6,7,8,9,10] - linguists, psycholinguists, cognitive psychologists, and neurolinguists, as well as phoneticsians, in the common effort to shed light on the organization of language performance. Research has centered mainly on two related questions: a) to what extent grammatical units and structures represented in the human mind match the processing representations b) to what extent principles and rules which govern grammatical knowledge serve the process of speech production planning.

This paper is concerned with the second topic, and, in particular, with the parameters governing the phonological intrinsic and extrinsic constraints on the occurrence of speech errors.

An analysis of the Italian data was carried out along the lines of van den Broecke & Goldstein's [11] and Shattuck-Hufnagel's work [12,13]. The difference between our results and those obtained for the English data seem to reflect specific properties of the phonological system of Italian.

2. Our analysis is based on a corpus of 455 spontaneous speech errors that involve consonantal phonemes collected at the Centro di Studio per le Ricerche di Fonetica [14] as part of a larger project on speech production. The errors were classified by means of the now-classic superficial typology which includes exchanges: ma è senza senso --> ma è senza senso (but it is without any sense), contextual substitutions: insufficienza mentale --> insufficienza mentale (mental insufficiency), i dati bibliografici --> i dati bibliografici (the bibliographic data), and non-contextual substitutions: questi succhi di frutta finiscono subito --> questi succhi di frutta finiscono subito (these fruit juices sell out immediately).

Table 1. Confusion matrix of speech errors.

|   | p | b | t | d | k | g | f | v | s | z | j | tʃ | dʒ | m | n | l | ɹ | r |
| p | 671 | 182 | 415 | 6  | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 3 | 1 | 1 | 1 |
| b | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| t | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| d | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| k | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| g | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| f | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| v | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| s | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| z | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| j | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

For the purpose of this analysis, insertions, deletions and shifts were not considered.

3. The evaluation of the intrinsic constraints, i.e. the restrictions on the occurrence of speech errors on the paradigmatic axis, is based on the inspection of the confusion matrix given in Tab. 1. The symmetry (χ²=12.40 p<.5) of the matrix leads to the same results obtained for English by Shattuck-Hufnagel and Klatt [15]; for any given
pair of phonemes there is no preference for one of them to act as intonational or as target, i.e., the behaviour of speech errors is not governed by the parameter "dominance". The next analysis was carried out in order to evaluate the weight of a second parameter: the influence of "similarity" as a function of the intrinsic phonetic/phonological characteristics of phonemes on speech errors. For this purpose we basically followed the methodological approach proposed by van den Broeke and Goldstein [11]. We employed a "behavioral" feature system obtained a posteriori by means of hierarchical clustering and multidimensional scaling analysis of the substitution patterns.

Figure 1. Hierarchical clustering representation.
The dendrogram in Fig. 1 shows a clustering involving the voiced stops /p, b, d, k/ at a lower similarity level. A cluster is formed by the voiced phonemes separated from the voiceless phonemes with the exception of /f/. The confusions obtained by the multidimensional scaling technique yield more information, since the groupings derived from the clustering analyses are not sufficient to represent the structure underlying all the phonemes examined. In fact, in Fig. 2 voiced and voiceless consonants form two well distinguished groups: resonant constitute another separate group, with the exception of /v/; a fourth group is made up by the stop consonants. Finally, Fig. 2b shows four separate groups which correspond to the places of articulation: labial, dental-alveolar, palatal, velar, with the possible exception of /l/.
The groupings observed above were incorporated in the following a posteriori matrix, in which the features (crifative and clateral) were added in order to distinguish the consonants considered in an unambiguous way. The matrix in Tab. 3, compared with the matrix elaborated by van den Broeke and Goldstein [11] on the basis of different English corpora, shows the nature of the interaction in speech errors [15,16,11]; in fact, the degree of involvement of phonemes in layered units comes inversely proportional to the differences expressed in number of features:

<table>
<thead>
<tr>
<th>Feature</th>
<th>p</th>
<th>b</th>
<th>d</th>
<th>k</th>
</tr>
</thead>
<tbody>
<tr>
<td>voiced</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>nasaled</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>aspirated</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>stop</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>voiceless</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3. A posteriori feature matrix for consonantal speech errors.

4. In the second set of constraints is constituted by the extrinsic constraints, i.e., the structural and contextual factors which influence the occurrence of speech errors on the syntagmatic axis: for this study we analyzed the following factors:
- the role of syllabic structure;
- the positional role of segments within words;
- the influence of lexical stress;
- the influence of the phonological segmental context.

In order to evaluate the role of syllable structure, we excluded from our computation all non-syllabic substitutions and ambiguous errors, as well as all errors involving geminates. As far as the geminates are concerned, there is still some theoretical disagreement about their monosyllabic status, and hence, about their classification [14]. Consequently, the analysis was carried out on a corpus of 240 errors.

A high rate (95%) of the errors concern the interaction between phonemes in syllable onset position. This finding has been made in the literature on speech errors as an argument in support of the claim that the onset position is the site where some more evidence for a different structural configuration of the syllabic unit. In fact, 15 of the 105 onsets involve nuclear and codas: 15 Plan & 15 plum (the bus); 15 involve interaction between onsets and codas; the phonetic features [similari to bison,a lighh]. The parameter which constrains errors to occur in syllable initial position with such high rate is constituted, in our opinion, by the phonological segmental structure in syllable onsets.
results fit with the slot-and-filler framework proposed by Shattuck-Hufnagel [28,12,13]: the likelihood for two phonemes to interact in speech errors depends on their degree of similarity. Our data show that the factors by which intrinsic similarity is established reflect the phonological organization of Italian. On the paradigmatic axis the dimensions <manner> <place> <voice> <sonority> correspond to the categories on which phonological processes depend; on the syntagmatic axis the hierarchical organization of the different domains on which "similarity of strength" works, reflect the fact that, in Italian, underlying syllable structure is substantially neither altered within the word domain nor it is influenced by stress.

REFERENCES