THE ORGANIZATION OF CONSTRAINTS ON PHONOLOGICAL SPEECH ERRORS

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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, psycolinguists, cognitive psycologists, and neurologists, as well as phoneticians, 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 the 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 sensa senzo (but it is without any sense), contextual substitutions : insufficienza mentale --> insufficienta mentale (mental insufficiency), i dati bibliografici --> i dati bibliogratici (the bibliographic data) and non-contextual substitutions : questi succhi di frutta finiscono subito --> questi ciucchi di frutta finiscono subito (these fruit juices sell out immediately).

Table 1. Confusion matrix of speech errors.

		intrusion																				
		p	b	t	d	k	g	f	v	s	z	ʃ	ts	dz	tʃ	dʒ	m	n	ɲ	l	ʎ	r	j
	p		6	7	1	18		4	1	6					2		3					1	
	b	3				1	1	1	2			1			1	1	2			1		1	
	t	8	1		4	15	1	4	1	6	2		3	1	7	1	2	3	1	2			
	d	1		5			2	1	1							6	1	1		2			
	k	17	2	15			1	1	1	5		1			1	1	2	1		1		1	
	g	1	1	2	1	1											1			1			
	f	7	1	2	1	2			2	3													
	v	1	1		2			2		7	1				1		2	1		4		1	
	s	7		3	2	6		2	8		1	1					1	2				2	
	z								3									5		2		1	
	ʃ		1				1	1	1	4													
	ts			1						3					3								
	dz															3		2					
	tʃ	2	1	6		3			1	4		5					1	2		1			
	dʒ			1	6										1			2		1			
	m	2	1	1	1	1	1	1	4	1							6			1		3	
	n			3	1				1	1	4	1	2	2		3		2		2	2	2	
	ɲ																						
	l		1	4		1	1		3	1	2				1		1	1				12	
	ʎ																		1				
	r	1	1	1		2					1				1		3	2		9			3
	j																			1		3	

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 ($X^2=12.40$ $p<.5$) 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 intrusion 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 Broecke and Goldstein [11]. We employed a "behavioral" feature system obtained a posteriori by means of hierarchical clustering and multidimensional scaling analyses of the substitution patterns.

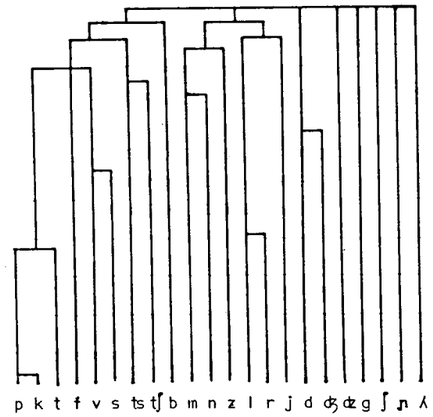

Figure 1. Hierarchical clustering representation.

The dendrogram in Fig. 1. shows a clustering involving the voiceless stops /p,t,k/. At a lower similarity level, a cluster is formed by the voiced phonemes separated from the voiceless phonemes with the exceptions of /v,b,ʃ/. The configurations obtained by the multidimensional scaling technique yield more information, since the groupings derived from the clustering analysis are not sufficient to represent the structure underlying all the phonemes examined. In fact, in Fig.2a voiced and voiceless consonants form two well distinguished groups; resonants 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 <fricative> and <lateral> 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 Broecke and Goldstein [11] on

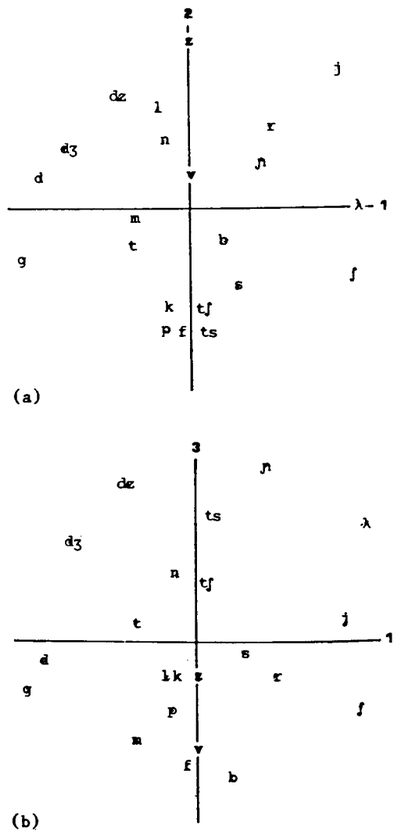

Figure 2. a) dimensions 1 and 2, b) dimensions 1 and 3 of the three-dimensional MDS configuration.

the basis of two different English corpora and a German corpus, shows a first difference concerning the specification of the feature <stop> and a second difference regarding the inclusion of the feature <resonant>. Both properties are evident in the configuration of our data and both of them are part of the phonological representation : in Italian a segment-structure rule operates in order to eliminate palatal articulation within stop consonants, and a syllable structure rule eliminates non-resonant consonants from syllable coda position.
As the matrix in Tab. 3 illustrates, the phonetic/ phonological similarity of phonemes constrains

their interaction in speech errors [15,16,11]; in fact, the degree of involvememt of phonemes in lapses is inversely proportional to their differences expressed in number of features :

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

	p	b	t	d	k	g	f	v	s	z	ʃ	ts	dz	tʃ	dʒ	m	n	ɲ	l	ʎ	r	j
voice	-	+	-	+	-	+	-	+	-	+	-	-	+	-	+	+	+	+	+	+	+	+
reson	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+
nasal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-
stop	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
place	l	l	a	a	v	v	l	l	a	a	p	a	a	p	p	l	a	p	a	p	a	p
cont.	-	-	-	-	-	-	+	+	+	+	-	-	-	+	+	+	+	+	-	+		
later	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-

34.5%, 32.1%, 18.7%, 5.5%, 7.0% and 2.2% of the errors occur respectively betweem phonemes differing in 1, 2, 3, 4, 5, and 6 features.
4. 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-contextual 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 mono- versus biphonematic status, and, hence, about their syllabification [14]. Consequently, the analysis was carried out on a corpus of 240 errors.
A high rate (93%) of the errors concern the interactions between phonemes in syllable onset position. This finding has been used in the literature on speech errors as an argument in favour of the break down of the syllables in two groups: the onset and the rhyme [17,18,7]. This argument has already been challenged by Vennemann [19] and Davis [20]; our data furnish some more evidence for a different structural configuration of the syllabic unit. In fact, 1% of the errors involve interaction between nuclei and codas: il pulman --> il pluman (the bus); 3% involve interaction between onsets and codas: bisogna stimolarlo --> bisogna stimorarlo (it must be stimulated); and 3% of errors involve interactions between onsets and nuclei: lavati --> alvati (wash yourself). The parameter which constrains errors to occur in syllable initial position with such high rate is constituted, in our opinion, by the phonological strength: segments in syllable onsets, i.e. in strong positions [21,22,19] are more available and hence more prone to interact.
The parameter "similarity of strength" seems to govern, also, the next two constraints, i.e. lexical stress and word position, both operating within the word domain.
For their evaluation, only between-word errors were considered (N=123); in fact, within-word errors would, by their nature, limit the array of possible interactions [12,13]. Futhermore, we removed from the computation the compounds and the monosyllabic words, which, however, constituted only the 3% of the whole corpus.
The fact that 48% of the errors concern phoneme pairs in word initial position and the finding that 42% of the errors involve interactions between phonemic segments in stressed syllables, strongly supports the influence of both "word position constraint" and "lexical stress constraint" [23,24].
In order to evaluate which constraint has greater strength, a separate analysis was carried out. We considered only the errors (N=52) in which all the interacting phonemes occurred in stressed syllables but were located in different word positions.

Table 4. Distribution of errors in stressed position in different word position.

Initial initial	Medial Medial	Final Final	Different Position
67.30%	19.83%	1.92%	11.53%

As Tab. 4 illustrates, the results furnish some evidence for a hierarchical organization of both constraints: word onsets influence the occurrence of speech errors more strongly than lexical stress. As far as the last constraint is concerned, i.e. the phonological context, there is no way to establish, in a straightforward manner, its influence on the occurrence of speech errors. The interactions between phonemes followed by different syllable nuclei make up 44% of the errors, 38% concern identical syllable nuclei and 18% is constituted by CV sequences for which there is no way to establish whether whole syllables are involved in errors or simply consonantal phonemes followed by identical vowels.
5. Within a model of language production, our analysis starts at Garrett's [25,26] positional level, on which "superficial phrasal geometry" has been established, and it aims "to delineate underlying representations from which superficial phonetic phenomena can be derived" [27]. The

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 organisation 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.

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