

The frequency of consonants and vowels and their co-occurrences in the babbling and early speech of Italian children

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ABSTRACT

The phonetic aspects of babbling and early words were longitudinally investigated in four Italian children from the 10th to the 18th month of age. The speech occurrences were classified for consonantal and vocalic categories, and the frequencies of single vowels and consonants, their co-occurrences in the syllable and the types of syllables have been compared with frequencies drawn from the segmental and syllabic characteristics of the infant lexical targets and Italian language in general.

1. INTRODUCTION

A substantial agreement exists in the literature over the fact that most of the phones and the type of their associations in syllables produced at the beginning of babbling are drawn from a restricted set of the potential types constituting languages, and their frequency in children is universal and not influenced by characteristics specific to the native language. The consonantal phones tend to be essentially plosives and glides, and since they tend to occur at the syllable onset as singletons, the most frequent type of syllables tends to have a CV structure [1]. Further, MacNeilage and Davis, noting the active role played by the mandibular oscillatory movement in shaping acoustical effects, and the more passive positioning of the tongue, formulated an intra-syllabic hypothesis of the segmental organization which constitutes a tenet of the *Frame, then content* theory [2]. This hypothesis makes precise predictions regarding the co-occurrences of vowels and consonants within this CV syllable: coronal consonants associate with front vowels, labial consonants with central vowels and dorsal consonants with back vowels. According to the authors [3] the pervasiveness of these (and a few others) characteristics in the early infant vocal development reflects their basic importance to the operation of the movement control system, and this is the reason why they are widely reflected in present-day languages.

Disagreement among researchers emerges, however, about when, where and how linguo-specific influences appear, and the segmental content eventually dissociates from the mandibular frame. While it is important to note that questions relative to the influence of the native language on phonetic development are open to experimental

verification, for Italian only some data relative to two children from 10 to 16 months are available [4], and because of the typical infant variability, their results could not represent the behaviour of the normal population. Further, to our knowledge, no study for Italian has so far taken into consideration the phonetic patterns of children's lexical targets and compared them to the children's speech patterns, as done for instance by some authors for American English [1, 3]. The main purpose of this paper will be consequently to try to fill this gap.

2. METHOD

The children attending the study were one male (Davide) and three females. They were born full-term, and the course of development was reported to be normal and free of any specific problems relating to their speech and hearing apparatus. Parents are middle-class, and their language is Italian, as it is spoken in the northeastern part of the country. The children were recorded every two weeks from at least the 8th month onwards, during play situations and in the presence of the mothers. The recordings, lasting 45 minutes each, were performed with digital tape-recorders and professional microphones at the children's home in a noise-free environment. The analysis of 5 sessions is presented here, referring to the entrance in the 10th, 12th, 14th, 16th and 18th month (see table 1).

	10 th	12 th	14 th	16 th	18 th
Alessia	9;28	11;18	13;17	15;10	18;10
Caterina	9;05	11;12	13;14	15;14	17;17
Giorgia	9;08	11;22	13;21	15;19	17;24
Davide	9;09*	11;21	13;07	15;16	17;23

Table 1: Ages of the children in months and days at each session. *For the first stage of Davide, a supplementary session at 9;28 was considered.

The phonetic transcriptions were performed independently by a number of experienced transcribers (the two authors and three logopedists) who used the main IPA symbols and diacritics as well as those suggested for the transcription of atypical speech (ext IPA) [5], and who also exploited cues and playback facilities offered by most

commercial packages for acoustical analysis. Whenever possible, each transcriber followed preferentially a single different child. Babbling occurrences were selected according to Oller's definition [6], while words were selected on the basis of the Vihman and McCune's criteria [7], requiring a stable form-meaning association. Adding to these, we considered also the words repeated immediately after the adult as well as the onomatopoeic forms. As to babbling, isolated CV syllables were accepted, but only vowels produced with loosely defined "modal" voice were analyzed. Two successive syllables were considered to refer to different utterances if separated by an audible inspiration, or by a silence lasting more than 250 ms. In the presence of vocalic modulations, the number and type of occurring vowels was specified, keeping in mind the possibility that a vowel may have very long transitions. The validity of the transcription was checked with two different procedures. For Davide, the first author and the transcriber who worked on the same subject, strained to jointly classify the 10 % of the whole corpus, discussing every disagreement. The final agreement score for the IPA symbols was quite high (98,3%). As for the other subjects, the percentage score was calculated on the transcriptions, performed by 2 independent experts, of randomly selected samples of 10 consecutive utterances for each recording. By applying the formula in [8] to all the IPA symbols (without diacritics), the resulting score was 67.3%. Finally, the IPA symbols were converted to SAMPA code for statistical treatment.

3. RESULTS

Results will be described in relation to three main stages: the babbling utterances produced from 10 to 14 months (BAB-1), amounting to 1538 items, the babbling utterances produced from 16 to 18 months (BAB-2), amounting to 1388 items, and the lexical tokens produced from 16 to 18 months (WORD-2), amounting to 583 items. All the children were producing around 50 words (lexical types according to the Vihman & McCune's criteria) at the session for the 18th month. The syllables analysed are 7307. The frequencies of the types are expressed as percentages, with respect to the total number of the syllables within each stage, in table 2. The same table presents the frequencies of the syllabic types of the lexical items constituting three kinds of databases for Italian: the first two are relative to infant language and are constituted by (1) a list of the lexical types attempted by the four children (TARGETS, 177 words), and (2) the lexical items of the MacArthur Communicative Development Inventory (CDI, 696 words) [9: appendix E] for the children from 18 to 30 months, while the third one is relative to the adult language [10, 11].

As it can be seen from the tables, the most frequent syllabic type is always CV, followed by V for most of the children. Children seem to evolve according to the kind of productions: while in the BAB-2 stage there are minimal signs of increase in syllabic complexity (lower percentages of the CV type, higher percentages of CCV

type), the WORD-2 stage presents an entirely different situation: the most complex types like CCV and CCVC decrease (VC type as well), the CV type increases dramatically. The decrease of the V type in the WORD-2 stage probably reflects its relatively low frequency in the three databases for Italian. The comparison with TARGETS and with the adult language evidences that the children still produce too many CV and V syllables (the simplest types), and too few CCV and CVC syllables (the more complex types).

	ccv	ccvc	cv	cvc	v	vc	N
BAB-1	2,3	0,2	67,5	7,1	20,2	2,7	2895
BAB-2	2.7	0.3	65.3	7.3	21.2	3.0	2958
WORD-2	1,6	0.1	74.9	7.2	14.8	1.4	1164
Targets	10.0	3.5	57.0	17.8	7.3	3.0	370
CDI	7.5	3.3	63.0	18.0	4.4	2.6	1840
[11]	7.2	2.2	56.0	14.4	10	7.2	652, 854

Table 2: Frequency of occurrence (%) of the syllabic types.

The subsequent analyses will deal only with the initial consonants and following vowels in the CV and CVC syllabic types, which, however, considered together, represent at least 72.6% of the total syllables produced. The tables 3 and 4 present the five most frequent vowels and consonants, respectively, produced by the children in the three main stages.

Alessia			Caterina			Davide			Giorgia		
bab 1	bab 2	wor 2	bab 1	bab 2	wor 2	bab 1	bab 2	wor 2	bab 1	bab 2	wor 2
a 31.1	a 389	a 438	a 156	a 273	a 323	e 198	a 215	a 297	æ 186	ɔ 189	a 340
e 146	e 102	i 132	ɔ̃ 102	i 101	ɔ 125	ɪ 135	e 103	o 187	a 152	a 184	o 203
ɔ̃ 8.1	i 9.6	o 7.5	ε 9.6	ε 8.8	i 11.9	a 8.0	o 9.9	Λ 9.5	ε 11.3	o 10.2	ɔ 17.8
ε 11.0	ε 8.3	ɔ 6.6	ɑ 7.8	u 7.1	ɑ 7.1	i 6.7	ɔ̃ 9.1	ɔ̃ 7.1	ɔ 8.9	ɔ̃ 9.3	u 6.2
i 8.2	ɔ̃ 4.3	ε 5.6	e 7.4	æ 6.5	5 5.3	ɔ̃ 5.9	i 8.2	e 7.1	ɔ̃ 5.5	ε 5.3	ɔ̃ 4.1

Table 3: List of the 5 most frequent vowels (%) for each child.

Apart from the general prevalence of the vowel /a/ from the beginning, and its increase in frequency along with the children's age, another common trend is represented by the preference accorded, in BAB-1, to the front vowels and the avoidance of the rounded back vowels. The statistics relative to the three sources for Italian, as shown in table 4, evidence both a prevalence of /a/, although not so massive as in the children's speech, and the high percentages scored by /o/, attested also in the children's

statistics of the WORD-2 stage.

From table 4, the most frequent consonant is /t/, and high scores generally characterize alveolar plosives and nasals. The only phone which is neither plosive nor approximant is /tʃ/, produced by Caterina in the WORD-2 stage (it is not an uncommon phone in children's lexical targets, scoring around 4%). The comparison with the three databases for Italian (tab.5), while emphasizing the common relevance of /t/ and nasal and oral voiceless plosives, at the same time reveals that children are very far from the high scores totalized by one of the most frequent, but also more articulatory complex, phones in the databases for Italian, i.e. /r/. The scores of the children and the adults' references are more similar for /l/.

Alessia			Caterina			Davide			Giorgia		
bab 1	bab 2	wor 2	bab 1	bab 2	wor 2	bab 1	bab 2	wor 2	bab 1	bab 2	wor 2
t	t	t	t	k	k	t	t	k	t	t	t
270	296	221	200	240	233	219	190	191	259	242	273
n	n	l	d	t	t	d	n	t	l	l	p
224	119	207	116	172	179	130	161	173	157	194	100
d	l	p	k	d	n	b	k	m	n	k	n
145	100	169	92	88	143	97	112	125	136	110	165
j	m	m	b	b	p	p	p	n	k	p	k
79	88	136	84	84	113	6.7	7.8	10.1	8.3	74	128
p	d	n	p	l	tʃ	n	d	d	p	n	m
34	73	113	70	80	7.7	5.4	7.0	6.5	7.6	3.8	832

Table 4: The 5 most frequent consonants (%) for each child

VOWELS			CONSONANTS		
TARG	CDI	Ital. [11]	TARG	CDI	Ital. [11]
a	a	a	t	r	r
365	270	28.7	170	130	17.7
o	o	e	t	t	t
199	238	23.3	144	12.1	12.6
e	e	o	t	l	n
162	23.1	21.7	105	10.5	10.9
i	i	i	l	n	s
138	138	15.7	9.4	8.9	8.4
u	u	u	r	k	k
58	4.8	4.5	6.1	8.5	7.3

Table 5: List of the 5 most frequent vowels (left) and consonants (right) (%) for the three databases for Italian.

In order to organize the data in the form required to test the intra-syllabic prediction of the *Frame, then content* theory, the vowels were classified as front ([i ɪ e ə æ]), central ([ʌ a ə ɐ ɨ ɨ]) and back ([u ʊ ɔ o ɑ]) along the longitudinal articulatory dimension. In the same way, consonants were classified as a function of the active articulator, producing the place categorization of bilabials ([p b m w]), coronals ([t d n j]) and dorsals ([k g ŋ q]).

Fig. 1 presents the frequencies of the three main categories for vowels. Although the intra- and intersubject variability is very high (not shown) and even the three databases for

Italian are not concordant, the distributions for the BAB-2 stage are more similar to those of the TARGET database than the WORD-2 stage (too many central vowels).

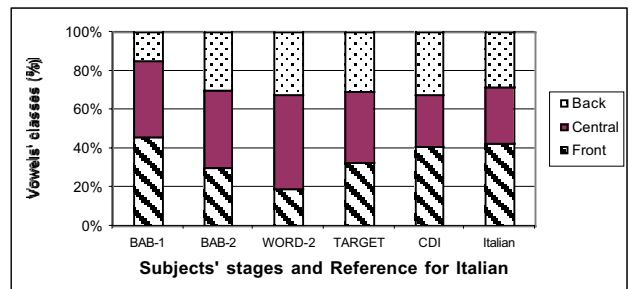


Fig.1: Frequency of occurrence (%) for the vocalic classes in the front-back articulatory dimension

Fig. 2 presents the frequencies of the three main categories for consonants. We added the phone [l] to the coronals, because it is quite frequent in children. The distributions are quite clear-cut and evidence the prevalence of the coronals over the other two classes, as happens also in the datababases of reference. The high percentages of bilabials in WORD-2 and in TARGETS databases are a feature also found in almost all the children acquiring English [1].

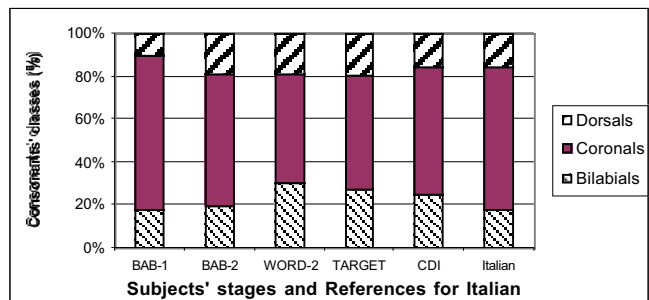


Fig.2: Frequency of occurrence (%) for the consonantal classes of articulatory place.

We focus now on the individuation of the ways the classes of consonants and vowels co-occur in the syllables of children and adults. Table 4 describes the relationship between the observed and expected frequencies, by reporting their ratio for each cell (the expected value is 1.0). The predicted associations are highlighted in bold. The χ^2 statistical test has been applied to each single column of each table, to assess whether the frequency of the determined combinations would give a significantly different result (*p< .05) from the frequency of the expected ones, drawn from the overall frequency of each vowel class within each respective sample. The predicted proclivities in the C-V associations are not so general as found by MacNeilage and Davies in their studies. These results were obtained by excluding [l] from the coronals (otherwise the results would even have been more contrary to the predicted trends). Only two children, Caterina in the BAB-1 stage and Davide in all the stages (except for the D-V association), conform to the predicted trends. The other two children are more variable, and do not follow any predominant pattern, apart from the preference of Giorgia for the D-B association.

	BAB-1			BAB-2			WORD-2		
	B	C	D	B	C	D	B	C	D
F	0.820	1.004	1.289	0.998	0.977	1.191	1.219	0.852	0.592
C	1.181	0.993	0.792	1.281	0.930	0.776	1.126	0.907	0.827
B	0.904	1.024	0.632	0.285	1.227	1.191	0.247	1.532	2.237
p<05				*			*		
F	0.381	1.354	0.947	0.472	0.766	1.591	0.278	0.578	2.202
C	1.398	0.915	0.642	1.325	1.235	0.538	1.333	1.127	0.528
B	1.243	0.587	1.777	1.727	1.183	0.335	1.176	1.224	0.560
p<05	*	*	*	*	*	*	*		*
F	0.586	1.220	1.011	0.279	1.396	0.764	0.738	1.721	0.233
C	2.006	0.510	0.774	1.313	0.729	1.346	1.099	0.699	1.331
B	1.455	0.683	1.333	1.185	1.063	0.654	0.968	1.143	0.826
p<05	*	*		*	*			*	
F	1.094	0.965	1.052	1.443	0.820	0.962	2.836	0.203	0.000
C	1.008	1.032	0.816	1.424	0.898	0.791	1.485	0.796	0.711
B	0.667	1.056	1.189	0.381	1.189	1.208	0.280	1.305	1.420
p<05				*	*		*	*	

Table 6: Ratio of the observed-to-expected co-occurrences for the Bilabial (B), Coronal (C) and Dorsal (D) consonants with the Front (F), Central (C) and Back (B) vowels. Subjects are (from top to bottom): Alessia, Caterina, Davide and Giorgia.

These results can therefore be summarized as follows: the observed-to-expected ratios are greater than 1 in only 16 of the 36 predicted associations, only 10 of them reach statistical significance and most of them are concentrated in the first stage. The most frequent association is B-C (7 ratios greater than 1, 5 statistically significant). In order to ascertain the patterns of association characterizing the target lexicon, and thus its potential influence, we applied the χ^2 analysis to the two children's targets databases (tab. 7). Two predicted results were verified, although not at the statistically significant level, for the B-C and the C-F associations in TARGETS, against a not predicted one (D-C). As for CDI, there was one significant predicted association (C-F), and one not predicted (D-C).

Tar	B	C	D
F	1.076	1.276	0.315
C	1.108	0.766	1.340
B	0.807	0.998	1.272
p<05			*

CDI	B	C	D
F	1.157	1.155	0.333
C	1.068	0.792	1.455
B	0.809	1.041	1.192
p<05		*	*

Table 7: Ratio of the observed-to-expected co-occurrences, in the infant databases TARGETS and CDI, for the (B), (C) and (D) consonants with (F), (C) and (B) vowels.

4. CONCLUSIONS

One of the main results of this study is the evidence for a progression from the not linguo-specific phonetic patterns of the BAB-1 stage to those of the BAB-2 stage, which are more similar to the patterns of Italian. At the same time, the frequencies of the syllabic types and the vocalic and consonantal classes characterize the WORD-2 stage as less advanced than the BAB-2 stage compared to the target lexicon of Italian. This apparent regression characterizes also the children acquiring English [3]. As for C-V co-occurrences, our results would tend to give importance to the idiosyncratic factors, with two children out of four not manifesting the patterns predicted by [2, 3]. Furthermore, the fact that the predicted C-V patterns seem to be quite common mainly in the initial BAB-1 stage but not very much in the two infant target databases could suggest that, whenever present in children, they are not derived from imitation, but from fundamental motoric propensities [3].

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