

Phonetic Inventories in Italian Children aged 18 - 27 months: a Longitudinal Study

°Claudio Zmarich, *Serena Bonifacio.

°Istituto di Scienze e Tecnologie della Cognizione del C.N.R.,
Sezione di Fonetica e Dialettologia, Padova
*Irccs Istituto per l'Infanzia "Burlo Garofolo", Trieste
zmarich@pd.istc.cnr.it, logopedia@burlo.trieste.it

Abstract

The phonetic inventories of 13 Italian children at 18, 21, 24 and 27 months of age are presented. The children were tape-recorded during a play interaction with the mother, and their vocalizations were phonetically transcribed. The individual phonetic inventories were calculated by applying the criteria put forward by Stoel-Gammon [1]: a consonantal singleton or cluster was attested only if word-initially or word-medially present in two different words at least, in a individual vocabulary of 10 to 50 different word types. Variable forms of the same word type were considered only twice. The collective phonetic inventories were calculated for each month on the bases of the number of subjects producing every phone. Further, the consonants at the onset or coda of the syllables constituting the selected words were classified for place and manner of articulations and their frequencies were calculated. Results for the consonantal structures in words and syllables produced by children have been compared to results for consonantal structures of adult words and syllables attempted by the children of 27 months.

1. Introduction

Whenever it is necessary to evaluate the phonetic ability of a child, we must compare his phonetic output with the one produced by a representative sample of children of the same age and/or linguistic proficiency (as measured for example by the number of words produced). One of the most useful metrics to be used in this regard is represented by the "phonetic inventory". The "phonetic inventory" is the typical product of an independent analysis of a child's lexical corpus. The analysis is called independent because the phones in the children lexical productions are not related to the corresponding adult lexical targets, but are considered *per se*. According to Stoel-Gammon [1], a consonantal singleton or cluster is attested only if present word-initially or word-medially in two different words at least, in an individual vocabulary of 10 to 50 different word types. Variable forms of the same word type are considered only twice. The group phonetic inventories are calculated for each month on the basis of the number of subjects producing every phone. The phonetic inventory could offer an insight into the child's phonetic abilities because individuates which phones are produced most, which less, and which are completely absent.

Furthermore, since this information is tied *ab origine* to the positional reference to the syllable or the word, we could get also information about the phonotactic

preferences/proficiencies of the child in building the hierarchical units of the prosodic chains.

With regard to the ages considered here, the phonetic inventories of children whose native language is English as spoken in the U.S.A. have been traced by [1] (15 to 24 months) and [2] (2- and 3- year-old children). Although there are some minor differences, both studies produced separate inventories for word-initial and word-final consonants. Group inventories "in initial position were composed primarily of voiced anterior stops, nasals and glides; by 24 months, voiceless stops, velars and few fricatives were also included. In final position, inventories consisted primarily of voiceless stops and alveolar consonants" [1]. The most significant progress in word-initial position at 29 months of age was tied to the presence of the affricate [tʃ] and the liquids [r] and [l], whereas word-final position allowed for a greater number of phones to be present. Beyond those also attested in the initial position, voiced fricatives and omosyllabic and eterosyllabic clusters were more peculiar to final position.

As for Italian, only two publications exist in the Italian language carried out on children aged from 18 to 27 months. The first ([3]) used the criteria put forward by [1] to present the phonetic inventories of 4 normally developing children. The main results can be summed up as follows:

- 18th month. Most of the phones are within the word rather than at the onset (this tendency will remain until the 27th month): they are stops, oral voiceless and nasal, and the phone [l].
- 21st month. The voiced oral stops and some fricatives are introduced in the group phonetic inventory, and the phones [p] and [tʃ] also appear.
- 27th month. The group phonetic inventory is almost complete (only [dz, ʎ, r, ʃ] are still lacking).

Here we will present in more details the results of a second study [4], who considered the same 4 children of [3] and 9 more, for a total of 13 children, and compared their results with the statistical properties of phonetic structures of babbling [5], and of adult targets, as represented by a repertory of 696 adult words reported by parents to be possibly present in the speech of 30-months-old children (it is the Italian version of the "MacArthur Communicative Development Inventory", by [6]), and by a statistical study on the phonetic structures of the Italian language [7]. A new comparison will be made here with the phonetic characteristics of the list of adult words attempted by children when they were 27 months old.

2. Experimental procedure

2.1. Subjects

Subjects of this study are 13 at-term born Italian children, 6 males and 7 females. The social level defined on the basis of the parents' academic degree and job is globally of average level. Children are monolingual, and they are exposed to a family context whose language is a northeastern regional variant of Italian ("Giuliano" for the 11 subjects living in Trieste, "Veneto" for the 2 children living in Padova). "Veneto" is highly similar to "Giuliano", which is characterized, with respect to standard Italian, by the pronunciation of the intervocalic /p/ as /nj/ and /k/ as /lj/. The two phones are nonetheless quite infrequent in standard Italian [7]. As assessed by the pediatricist, all of the children had a normal psychomotor development, and they were judged to be free of auditory and articulatory deficits by a certified and experienced logopedist (the second author) at the moment of enrollment. At the first recording stage, both the interactional style of the dyad mother-son in a play situation and the CDI [6] compiled by the parents were assessed, in order to exclude any children with problems of communication in a non-domestic environment and/or with an expressive and receptive vocabulary inferior to the 10th percentile [6].

2.2. Recordings

Children were recorded at the 18th, 21st, 24th, 27th month of age, during a play interaction with the mother in a quiet room, some at home, some in a clinical setting, and some in the kindergarten. Each child was given the same set of small objects to manipulate, to name and to talk about. All of the children produced more than 50% of the words attested as present by parents in CDI. The technical equipment for the recordings consisted mainly of an analogic recorder *UHER 4200* and a DAT recorder *TEAC DA-P20, W-850R*. The microphones were the *UHER M518A* and the *AKG acoustics D 330 BT, MAR II*. They were hand-held at 50 cm from the child's mouth. The duration of the recordings ranged from 45 to 60 minutes.

2.3. Phonetic transcriptions

The phonetic transcriptions were performed independently by the first author and three certified logopedists who used the main IPA symbols and diacritics as well as the symbols suggested for the transcription of atypical speech [8]. Whenever possible, each transcriber attended preferentially to the same children.

The reliability of transcriptions was checked by applying the formula in [9] to 2 different sets of independent transcriptions of a sample of about 260 syllables, drawn by different recordings of 3 different children. By considering all the IPA symbols (without diacritics), the resulting scores for consonants were 67.2%.

2.4. Criteria for word selection, informatic coding and phonetic analysis

Words were selected on the basis of the Vihman and McCune's criteria [10], requiring a stable form-meaning association. Only the denominations, even the repeated ones

provided that the repetition did not follow immediately the adult pronunciation, and the spontaneous productions were considered. Onomatopoeic forms were accepted only if produced as an answer to questions like: "what is this"?

Phonetic Inventories were calculated according to the procedure put forward by Stoel-Gammon [1]: a consonantal singleton or cluster was attested only if word-initially or word-medially present in two different word types at least, in a individual vocabulary of 10 to 50 different word types. Variable tokens of the same word type were considered only twice. The selection started from the beginnings of the recordings and it was strictly progressive. We partly derogated from the rules of [1] in the attempt to better render the great lexical richness of the 27th month. For this reason, when the individual vocabulary exceeded the 50 word types, we disregarded the words constituted by the phones already attested (in the previous words), and progressively looked for the words containing the phones still lacking, up to the achievement of 50 word types.

The selected words were finally converted from the IPA symbols to SAMPA symbols and inserted in a matrix of the statistical package *Systat 8.0* (Spss Inc., 1998) with the following organization: each word was subdivided in syllables, on the ground of the sonority hierarchy and the syllabification rules [11]. Each syllable constituted a case in the systat matrix, and the vowel and the possible consonants before and/or after it were coded in separate columns. Along the same row, some other information coded were relative to the position held by the syllable in the word (initial, medial, final, or monosyllable) and to the syllabic types (just 2 main symbols were used in combination, C and V). We used then the *Systat* functions to transform each phone into its general IPA category of manner and place of articulation, and voicing. Finally we obtained the frequency counts of phones and phonetic classes, separated according to the position occupied in the syllable or in the word. After the determination of the individual phonetic inventories, the group phonetic inventories were calculated for each month on the basis of the number of subjects producing any given phone for any given position. We considered the phones in any given position as consolidated, if produced by at least 12 out of the 13 children, and simply attested, if produced by at least 7 out of the 13 children.

The steps of the coding procedure were repeated also for the infant repertory of the adult words constituting the targets of the lexical attempts of the children at 27 months. Here we preferred analyze directly only this repertory, because each word type could occur a number of time between 1 and 13, and for this reason it is closer to our subjects lexical productions than the CDI [6], or the statistical study on Italian dictionary [7] where each word appears only once (it maintains the true character of a type).

3. Results

3.1. Phonetic inventories in words

The number of word-types systematically increases as children grow. At the first stage of the 18th month the subjects considered are 11 instead of 13, because two subjects did not reach the minimum number of 10 words to be included. The average number of words analyzed for these 11 subjects is

32.7 (range: 14-50). At 21 months the average number of words analyzed for all the 13 subjects is 45.2 (range: 21-50), and at the 24th month and 27th month all the children have a vocabulary of at least 50 words (range of the number of words analyzed: 50-50).

Table 1 shows the phonetic inventories for the consonants, calculated for each stage of 18, 21, 24, and 27 months in 2 different word positions, i.e. in the initial position (IN), when the consonant is at the onset of the word, and in the intervocalic position (IV), when the consonant is within the word. The phonetic inventories calculated on the adult words attempted by the children at 27 months are shown on the bottom (Targ). Consonants appearing word-finally were extremely rare, therefore they are not represented. The occurrence of omosyllabic consonantal clusters, if any, is also tabulated. The consolidated phones are differentiated from the attested phones by an asterisk (*).

18 IN	p* b t k m
18 IV	p t k m
21 IN	p* b t* k m n
21 IV	p* b t* d k* m n* tʃ l*
24 IN	p* b* t* d k m* n f l
24 IV	p* b t* d* k* m* n* f v s tʃ l*
27 IN	p* b* t* d* k* g m n* f v s l* kw
27 IV	p* b t* d* k* g m* n* v s tʃ l*
targ IN	p* b* t* d* k* g m n f s l kw
targ IV	p* b* t* d* k* g m n* f v s tʃ dʒ l* r st

Table 1: Word-initial (IN) and within-word (IV) phonetic inventories at 18, 21, 24, 27 months of age and in the adult target, of the consonants present in more than 50% of children. (*) Consonants attested in more than 90% of children

From the 18th to the 27th month the phonetic inventories increase steadily, with the following modalities:

- 18th month. Most of the phones are at the onset of words: they are stops, oral voiceless and nasal, with a preference for a front place of articulation.
- 21st month. The most facilitating context becomes the intervocalic one: the group phonetic inventory adds the voiced oral stops and introduces some fricatives, and the phones [l] and [tʃ].
- 24th month. Massive entry of fricatives, mainly in the intervocalic position.
- 27th month. Word onset and word medial positions equate, in the number of attested phones, but while the initial inventory have all the consonants requested by the adult targets, the within-word phonetic inventory still lacks 4 singletons or consonantal clusters compared to the targets.

Furthermore, although phones like [b] or [m] are attested in more than half the subjects since the 18th month, they become consolidated only at the 24th month, when they

appear in the inventories of 12 subjects out of 13. The case of the initial [k] is emblematic because it is present in most subjects after the 18th month, but in all of the subjects only when they are 27-months-old.

3.2. Phonetic frequencies in syllables

In the following section we will focus on the syllables constituting the lexical productions considered for the children, and the adult words attempted to by the children at 27 months. Table 2 shows that the mean length of the words as measured by number of syllables, is about two syllables and a half, like the mean length of the targets, and does not vary substantially from the 18th to the 27th month.

stages	syllables	words	s./w.
18 months	733	340	2.15
21 months	1026	560	1.83
24 months	1570	583	2.69
27 months	1482	621	2.38
Targets	1539	650	2.37

Table 2: Counts of syllables and words analyzed at 18, 21, 24, 27 months of age and in the adult targets attempted at 27 months

The frequency of occurrence of each syllabic type over the total number of syllables is represented in Figure 1.

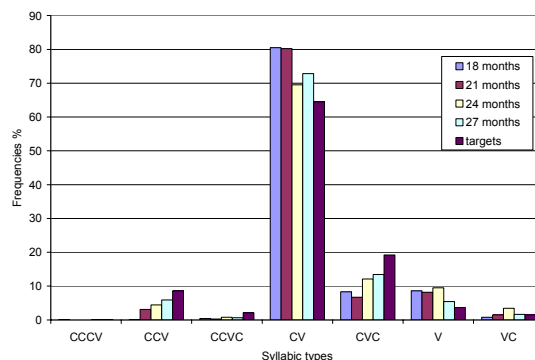


Fig. 1. Frequencies of the syllabic types of the words produced at 18, 21, 24, 27 months of age and in the adult targets attempted at 27 months

The general tendency for the syllables produced by the children is to approximate gradually the percentages of the syllabic types in the adult words. The CV type is overwhelming (around 80 % in the first 2 stages), but its frequency diminishes while more complex types like CVC (closed syllable) and CCV (consonantal cluster) increase. The V type decreases in the last stage. The syllabic type CCVC is rarely produced by children.

In order to analyze the phonetic characteristics of the consonants in the syllables, we classified them into the IPA classes of manner and place of articulation. We chose to analyze only the initial consonants of the CV and CVC

syllabic types (fig. 2 and 3), because coda consonants are rare.

Fig. 2, relative to the manner of articulation, points out the clear picture of a systematic and progressive approach of the frequencies of classes produced by children to the percentages relative to the target words. This tendency is particularly strong for plosives, which decrease from 65% to almost the level of targets (about 45%). The opposite case, an increase, is represented by fricatives (the third more frequent class after plosives and nasals in the targets), affricates, laterals and trills.

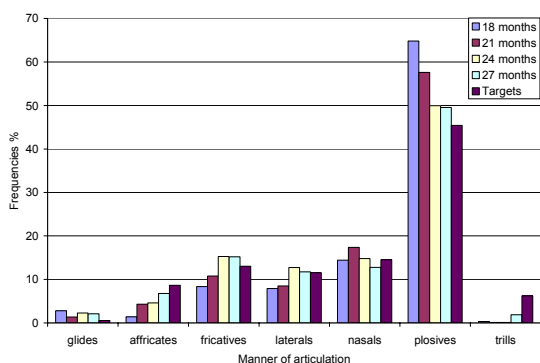


Fig. 2. Frequencies of the initial consonants of CV and CVC syllables classified for manner of articulation and produced at 18, 21, 24, 27 months of age and in the adult targets attempted at 27 months

Fig. 3 replicates, as far as the place of articulation is concerned, the systematic approach, in a more clear-cut way, of all the classes produced by children to the frequencies of the classes in the target words.

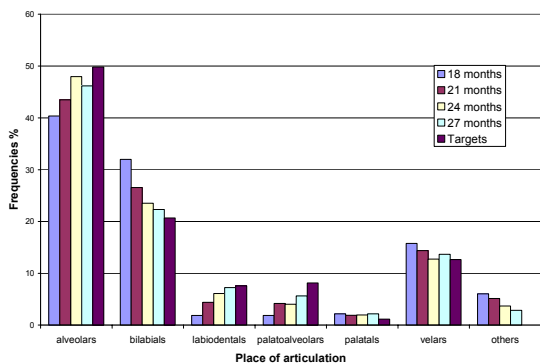


Fig. 3. Frequencies of the initial consonants of CV and CVC syllables classified for place of articulation and produced at 18, 21, 24, 27 months of age and in the adult targets attempted at 27 months

Of the two most prevalent classes in the first stage, alveolars increase, and bilabials decrease. Labiodentals and palatoalveolars (i.e. [ʃ tʃ dʒ]) increase, velars reduce as well as the category "others" (all the classes extraneous to the standard Italian phonological system).

4. Conclusions

From this investigation on the phonetic structures produced by a sample of 13 children at 18, 21, 24 and 27 months of age, the group phonetic inventories result systematically increasing by size and complexity. At first, the only produced consonants are anterior nasal stops and oral stops, which are voiceless because negative VOT makes the voiced stops difficult to produce [12]. Consonants are inserted in the most basic syllable CV, which does not require them to be precisely timed with the following vowels. In the following months, children exploit more the intervocalic position to add voiced stops, fricatives and the [l] phone. Then, affricates and the first consonantal clusters are added, until the phonetic inventories represented by the adult lexical targets are almost attained (but the most frequent phone, [r], is still lacking). The frequency of phonetic classes at the syllable onset (offset frequencies are very low) shows that children are systematically filling the gap with frequencies drawn from the syllables of the targeted adult words.

5. References

- [1] Stoel-Gammon, C., "Phonetic inventories, 15-24 months: a longitudinal study", *J. Speech and Hearing Res.*, 28, 505-512, 1985.
- [2] Dyson, A., "Phonetic inventories of 2-and 3-year-old children", *J. Speech and Hearing Dis.*, 53, 89-93, 1988.
- [3] Bortolini, U., Bonifacio, S., Zmarich, C., Fior, R., "Caratteristiche fonetiche di soggetti a basso rischio neonatale a 18, 21 e 27 mesi", *Età Evolutiva*, 53, 30-41, 1996.
- [4] Zmarich, C., Bonifacio, S., "Gli inventari fonetici dai 18 ai 27 mesi d'età: uno studio longitudinale", *Atti del Convegno Nazionale "Il Parlato italiano"*, M. D'Auria Editore, CD-ROM, Napoli, 2004.
- [5] Zmarich, C., Miotti, R., "The frequency of consonants and vowels and their co-occurrences in the babbling and early speech Italian children", *Proceedings of the 15th ICPHS*, Barcelona, 1947-1950, 2003
- [6] Caselli, M.C., Casadio P., *Il primo vocabolario del bambino*, Franco Angeli, Milano, 1995.
- [7] Batinti, A., *Il sistema fonologico dell'italiano*, Guerra Edizioni, Perugia, 1993.
- [8] *Handbook of the International Phonetic Association*, Cambridge University Press, Cambridge, 1999.
- [9] Shriberg, L.D., Lof, G.L., Reliability studies in broad and narrow phonetic transcription, *Clinical Linguistics & Phonetics*, 5, 225-279, 1991.
- [10] Vihman, M. & McCune, L., "When is a word a word?", *Journal Child Language*, 21, 517-542, 1994.
- [11] Blevins, J., "The Syllable in Phonological Theory", in J.A., Godsmith (Ed.), *The Handbook of Phonological Theory*, Blackwell Publ., 206-244, 1995.
- [12] Bortolini, U., Zmarich, C., Fior, R., Bonifacio, S., "Word-initial voicing in the productions of stops in normal and preterm infants", *Int. J. Pediatric Otorhinolar.*, 31, 191-206, 1995.