

LANGUAGE-SPECIFIC PHONETIC PRODUCTION PATTERNS IN THE FIRST YEAR OF LIFE

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ABSTRACT

The production of sounds by infants from 1 to 12 months is evaluated according to place of articulation to verify the hypothesis that infants' production becomes language-specific towards the end of the first year. This study is based on an analysis of 4,499 sounds produced by 19 infants raised in one of 3 linguistic contexts: Canadian English, Moroccan Arabic, and Bai.

Our results reveal that towards the end of the first year (10-12 months), infants show a preference for producing sounds at places of articulation that reflect their linguistic background, a finding that parallels results obtained in perceptual studies. Contrary to our expectations, however, the infants' production at the end of the first year, albeit language-specific, does not directly correspond to the adult model. In the case of Bai infants, in particular, it was found that these infants use laryngeal constriction at a segmental level, while this phonetic feature is not employed in the adult model at a segmental level but at a syllable/word level for tone register contrasts.

Keywords: First language acquisition; Production; Infants; Vocalizations; Place of articulation.

1. INTRODUCTION

As early as 10 months of age, infants' ability to *perceive* consonantal contrasts appears to become language-specific: the perception of sound contrasts used in their surrounding language is perceived with increasing accuracy, whereas perception of sound contrasts not present in the language they are exposed to is significantly atrophied [8]. It has been suggested that infants' *production* of consonant-like sounds also becomes oriented to the target language at a similar developmental period [2].

Most previous research that has reported language-specific features in infants' prelinguistic vocalizations is based primarily on the study of infants' babbled utterances (e.g. [2, 5, 10]). It

remains unclear at what point and in which ways infants' production becomes attuned to their ambient language when all infant vocalizations are considered. The present study addresses this issue by evaluating the developmental change in the sounds produced by English, Arabic, and Bai infants from 1 to 12 months.

It has been shown that when considering all sounds produced by infants (i.e. not just babbled utterances), newborns produce almost exclusively laryngeal sounds, that is, sounds produced in the larynx and pharynx [1, 3, 7]. Laryngeal sounds are not common in English, but are widespread in many other languages. While English contains only one laryngeal sound, the voiceless glottal fricative [h], Moroccan Arabic contains three: a voiceless pharyngeal fricative [ħ], a voiced pharyngeal approximant [ʕ] and a glottal fricative [ʔ] generally considered voiceless [6]. Both of [ħ] and [ʕ] are produced with a primary articulation at the aryepiglottal or epilaryngeal level [12]. Bai (a Tibeto-Burman language spoken in China), on the other hand, does not make use of any pharyngeal or glottal segments. Nevertheless, Bai employs laryngeal constriction as part of its pitch-dependent register tone system [4].

Accordingly, it is expected that English, Arabic, and Bai infants' production will be comparable at the beginning of the first year, with a higher proportion of laryngeal sounds produced as compared to labial, coronal, and dorsal sounds. However, as infants build the phonological system appropriate to their language, which, based on perceptual studies, occurs around 10 months [8, 11], we hypothesize that their production should also begin to reflect language-specific patterns. That is, the proportion of laryngeal (pharyngeal and glottal) consonants produced by English and Bai infants should be reduced considerably at the 10-12 month period, whereas the production of laryngeal sounds should be maintained in the production of Arabic infants, though slightly reduced in favour of the production of other sounds that also occur in Arabic.

2. METHODOLOGY

2.1. Subjects

Four infants (2 girls, 2 boys) from English-speaking families living in Canada were recorded in their homes. Although not all infants were recorded every month, the data presented in this paper include a recorded session of at least one infant per month from 1 to 12 months.

Nine infants (5 girls, 4 boys) from Arabic-speaking families were recorded in Morocco. The Arabic infants were recorded 1 to 3 times during their first year, and the months at which they were recorded varied across infants. To date, we are missing data for this group at 2, 6, and 12 months.

Finally, six infants (2 girls, 4 boys) from Bai-speaking families were recorded in their homes in China. Like the English infants, the Bai infants were not recorded every month, but the data in this article include at least one recorded session per month from 1 to 12 months.

2.2. Recording procedure

A digital camera with integrated microphone was used to film the infants interacting with their caregivers. The camera was directed at the infant and held at a reasonable distance so as to not distract the infant from the caregiver while ensuring proper capture of the sounds produced by the infant.

2.3. Analyses and categorization

As the focus of this study was on the *phonetic* development of infants throughout their first year, all sounds produced by the 19 infants during the recording sessions were used for the analysis, including sounds typically labeled vegetative, grunts, cooing, vocalization, pre-babbling, babbling, and so forth in the previous literature. Since the recordings were performed in a natural context (the infant's home), some sounds had to be discarded due to background noise, technical problems, or the impossibility of determining the source of the sound (e.g. the sound may have come from another child in the house).

Judgments based on an auditory phonetic analysis of the sounds were made by trained research assistants. A total of 4,499 consonantal sounds (English: 1,195; Arabic: 1,696; Bai: 1,608) were analyzed in terms of place of articulation.

The data have been organized into four age groups: 1-3 months, 4-6 months, 7-9 months and 10-12 months. The number of infants contributing to the data in each group is provided in Table 1.

Table 1: Number of infants contributing to the data per age group and language.

Age group	Language		
	English	Arabic	Bai
1-3 months	2	3	3
4-6 months	2	5	2
7-9 months	3	3	5
10-12 months	1	3	6

Given the difficulty of precisely identifying place of articulation, particularly for very young infants [9], the infants' consonantal utterances have been grouped into four broad, relatively reliable categories: labials, coronals, dorsals, and laryngeals. Sounds involving any contact with the lips, either bilabial or labiodental sounds, have been labeled as "labials". The category "coronals" includes all sounds produced with the tip or blade of the tongue, whether involving constriction or direct contact at the dental, alveolar, or palatal area. Sounds involving the back of the tongue and/or velum have been categorized as "dorsals". Finally, all sounds produced in the pharynx and larynx, either involving the glottal or aryepiglottic folds, have been classified as "laryngeals".

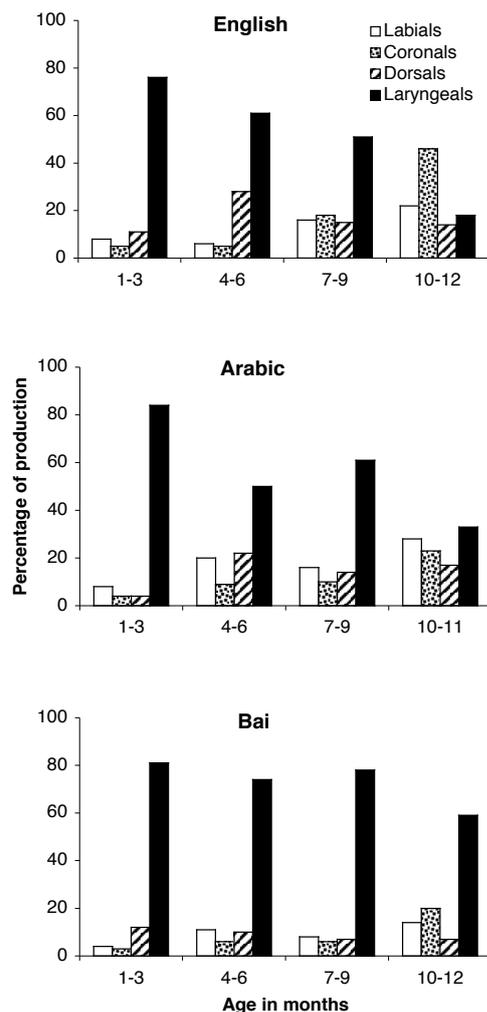
3. RESULTS

The results for English, Arabic, and Bai infants presented in percentage of production of sounds according to place of articulation and age group are presented in Figure 1.

As shown in Figure 1, laryngeal sounds (i.e. glottal and pharyngeal sounds) predominate in the vocalizations of infants before the age of 10 months, irrespective of their linguistic background. At the earliest age (1-3 months), the infants produce almost exclusively laryngeal sounds (English=76%, Arabic=84%, Bai=81%). However, the use of different places of articulation varies considerably across age groups. This variation was found to be statistically significant according to a two-way association Pearson's chi-square test ($\chi^2(9) = 180.47, p < .001$). While younger infants (1-3 months) produce almost exclusively laryngeal sounds, older infants progressively increase their production of sounds involving the lips (labials), the tip and blade of the tongue (coronals), and the back of the tongue and velum (dorsals).

The association between language and place of articulation was also found to be significant ($\chi^2(6) = 53.54, p < .001$), suggesting that infants' production becomes language-specific during the first year. The possible influence of the surrounding language is more noticeable at 10-12 months, where the production of English, Arabic, and Bai infants clearly differs.

Figure 1: Percentage of infants' production in terms of place of articulation according to infants' linguistic background and age group.



English infants produce proportionally fewer laryngeals than Arabic and Bai infants at the 10-12 month period. The consonants most commonly produced by English infants at the end of the first year are coronals (46%), followed by labials (22%), laryngeals (18%), and dorsals (14%).

In contrast, Arabic infants at the same period (10-11 months) still produce a considerable

proportion of laryngeals (33%); these consonants predominate in the utterances of Arabic infants towards the end of their first year. However, the Arabic infants also produce a fair amount of labials (28%), coronals (23%), and dorsals (17%) during the 10-12 month period.

Bai infants also appear to produce mostly laryngeal consonants at the end of their first year; these sounds comprise 59% of their consonantal repertoire. Their production of coronals (20%) and labials (14%) is increased compared to the 1-3 month period, but their production of laryngeals predominates at the end of the first year.

Further chi-square and Cramer's V analyses were performed on the data, split according to the different age groups (1-3, 4-6, 7-9, and 10-12 months) to test the strength of association between language and place of articulation for each of the four age groups. The results indicate that despite the significant association between language and place of articulation for all age groups (for all chi-square results $p < .01$), the strength of the relationship between these two variables is very weak at 1-3 months (Cramer's V = .104), but considerably stronger at 10-12 months (Cramer's V = .239). These results suggest that as infants approach the end of their first year, their production becomes distinctive from one language group to another, presumably due to the influence of their ambient language.

4. DISCUSSION

At the beginning of their first year, infants in our study were found to produce overwhelmingly laryngeal consonants, regardless of whether these were common sounds in the language to which they were exposed. At the 10-12 month period, the distribution of place of articulation was found to differ considerably between the three language groups. While the production of laryngeals was considerably reduced in the speech of English infants, these sounds remained favoured by the Arabic and Bai infants. As English makes use of only one glottal sound, the English infants' tendency to reduce their production of laryngeals suggests that their production has begun to resemble the adult model. The fact that Arabic infants continue to produce a considerable proportion of laryngeals towards the end of their first year also suggest a language-specific effect, as Moroccan Arabic uses three laryngeal consonants—two more than English.

The findings on the Bai infants call for particular scrutiny. The fact that Bai infants continue to produce mostly laryngeal consonants even at the 10-12 month period is unexpected, given that Bai does not contain any laryngeal contrasts at the segmental level. However, Bai uses laryngeal constriction contrastively in its tonal register system. It is possible that infants pick up on this feature, and interpret the laryngeal constriction as productive in the language, even though it is used by adults for tonal register contrasts rather than for segmental contrasts. Hence, the Bai infants' production may reflect their sensitivity to phonetic characteristics of the Bai language, even though they use the articulatory feature of laryngeal constriction differently than adults.

This interpretation is consistent with other research in L1 acquisition, which has extensively shown that infants do not directly "copy" adult forms, but instead, generalize forms and rules in a process of trial and error. For instance, English-learning infants will typically generalize the regular past tense *-ed* to both regular and irregular verbs before learning to apply the *-ed* form only to regular verbs. A similar phenomenon may be occurring in phonetic development, where some articulatory features are noticed but applied to the "wrong" forms. It is expected, however, that after the first year, Bai infants' production of laryngeal consonants will eventually decrease and that laryngeal constriction will be seen in infants' acquisition of tonal register contrasts. Our study is being extended to the second year of life to test and confirm this prediction.

In sum, by the end of their first year, the distribution of consonantal sounds produced by these infants appeared to become language-specific, though not directly comparable to the adult model. The cross-linguistic difference in the proportion of laryngeal sounds produced at the 10-12 month period indicates that infants' production is clearly influenced by the phonology of their ambient language. It seems, therefore, that production and perception are parallel processes in infants' gradual attunement to the phonetic contrasts that are relevant in the language to which they are exposed.

5. ACKNOWLEDGEMENTS

We are very grateful to Sonya Bird, Thomas Magnuson, Antoine Tremblay, Laurence White,

Chakir Zeroual and three anonymous reviewers for their comments on earlier versions of this article. We are also indebted to all the parents and infants who kindly participated in our study, and to Qian Wang for her help with data collection in China.

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ⁱ For our auditory phonetic judgments, we found this recording method acceptably reliable. The categorization of infants' production into broad categories (as explained in 2.3) also increases the reliability of our data, as most inter-rater disagreement occurred *within* those categories.