INFANTS' PHONETIC ACQUISITION OF VOICE QUALITY PARAMETERS IN THE FIRST YEAR OF LIFE

Allison Benner, Izabelle Grenon, John H. Esling

Department of Linguistics, University of Victoria, Victoria, BC, Canada
abenner@uvic.ca, izabelle@uvic.ca, esling@uvic.ca

ABSTRACT

Little is known about cross-linguistic differences in infants' production and acquisition of voice quality parameters. In our study of Canadian English, Moroccan Arabic, and Chinese Bai infants, we found that for all infants, laryngeally constricted phonatory settings (harsh voice, creaky voice, whispery voice, and whisper) predominate in the first months of life and decline throughout the first year in favour of unconstricted settings (modal voice, breathy voice, and falsetto). To better understand the distribution of voice quality parameters in the infants' utterances, we analyzed the phonatory settings employed in babbling. We found that the babbling of Arabic infants was more likely to feature laryngeal constriction than the babbling of English infants. Bai babbling showed the least stable incidence of laryngeal constriction, possibly reflecting the more complex use of this feature in the infants' ambient language.

Keywords: Voice quality; First language acquisition; Babbling; Laryngeal phonetics.

1. INTRODUCTION

It has long been recognized that voice quality provides indexical information about speakers' age, sex, social status, and regional and linguistic origins, and conveys short- and long-term information about speakers' physical and emotional states [9, 10]. In addition, some languages employ voice quality parameters contrastively, for example as part of a register tone system [3, 5]. However, little is known about how infants and young children produce and acquire the voice quality parameters that are appropriate to their language and culture [7]. Our study of Canadian English, Moroccan Arabic, and Chinese Bai infants is the first cross-linguistic study of infants' production of voice quality settings in the first year of life.

The work of Esling and his colleagues (e.g. [4]) provides a phonetically grounded model for the auditory analysis of voice quality parameters. This model highlights the degree of laryngeal constriction (defined primarily in terms of the degree of sphincteringof the aryepiglottic folds in the larynx) in distinguishing phonation types. Harsh voice, creaky voice, and whisper are all marked by laryngeal constriction. Modal voice, breathy voice, and falsetto involve no laryngeal constriction, with breathy voice constituting the most laryngeally open of the unconstricted settings.

All infants begin their lives with a high larynx, a physiological setting that predisposes them to produce laryngeally constricted sounds. Throughout the first year of life, the larynx descends, and structures in the larynx develop, giving infants the potential for greater phonetic articulatory control over laryngeal parameters [6]. Bettany [1] documented one Canadian English infant's use of laryngeal settings in the first six months of life. She found that this infant engaged in a systematic process of "vocal play" [13] in moving from predominantly laryngeally constricted voice quality settings in the first three months, to increasingly unconstricted settings in the following three months. However, it is not yet known whether infants from other language backgrounds engage in this process. Nor is it clear how laryngeal parameters are exploited in later vocal behaviours such as babbling, which are considered to be early precursors to language development [11] and which have been shown to exhibit language-specific characteristics [2, 8].

The primary purpose of the present study is to document the production of phonatory settings by infants in the first year of life, with particular focus on the incidence of laryngeal constriction in infants' utterances generally and in their babbling specifically. We have analyzed the vocalizations of infants from three language backgrounds that differ in their use of laryngeal constriction: English, which does not employ laryngeal constriction contrastively, Arabic, which employs laryngeal constriction contrastively at the segmental level,

and Bai, which employs laryngeal contrasts at the syllable level in its register tone system.

2. METHODOLOGY

2.1. Subjects

Four infants (2 female, 2 male) from English-speaking families living in Canada were recorded in their home environment. While not all infants were recorded each 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 female, 4 male) from Arabic-speaking homes were recorded in Morocco. The 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. To ensure an adequate sample of babbling, this study includes data from one Arabic infant that was collected two weeks after his first birthday.

Finally, six infants (2 female, 4 male) 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. The number of infants for each age category and language is shown in Table 1.

Table 1: Infants 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

2.2. Recording procedure

A digital camera with integrated microphone was used to film the infants interacting with their caregivers in their home environment. 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

All sounds produced by the 19 infants during the first 20 minutes of the recording sessions were used for the analysis, including sounds that have been labeled as cooing, grunting, coughing, squealing, or babbling in previous research (e.g. [2, 12, 14]). Sounds that could not be judged accurately (e.g. because of background noise) were excluded from analysis.

Infants' vocalizations were classified by trained phoneticians using auditory analysis, supplemented by wide-band spectrograms. A total of 3,197 utterances (English: 932; Arabic: 1,011; Bai: 1,254) were analyzed for this study.

The data have been organized into four age groups: 1-3 months, 4-6 months, 7-9 months, and 10-12 months. Utterances were classified into two broad categories, constricted and unconstricted. Constricted utterances were those produced with harsh voice, creaky voice, whispery voice, or whisper. Unconstricted utterances were those produced with modal voice, breathy voice, or falsetto.

The study also includes an analysis of phonatory settings (constricted versus unconstricted) in the babbling sequences extracted from the data described above. For this study, all CV(C) utterances, whether monosyllabic, reduplicative, or variegated, were considered babbling, including early babbled utterances whose CV timing characteristics would fit the definition of "marginal babbling" [13]. CV(C) utterances produced with laryngeal consonants (pharyngeal or glottal) were excluded from analysis, unless they were articulated as part of a babbling sequence that included at least one oral consonant. This practice was adopted because we currently have no effective way of distinguishing the syllable-like laryngeal vocalizations that infants make in the first month of life from later productions of these sounds after they have begun babbling. A total of 1,025 babbled utterances were analyzed (English: 398; Arabic: 323; Bai: 304).

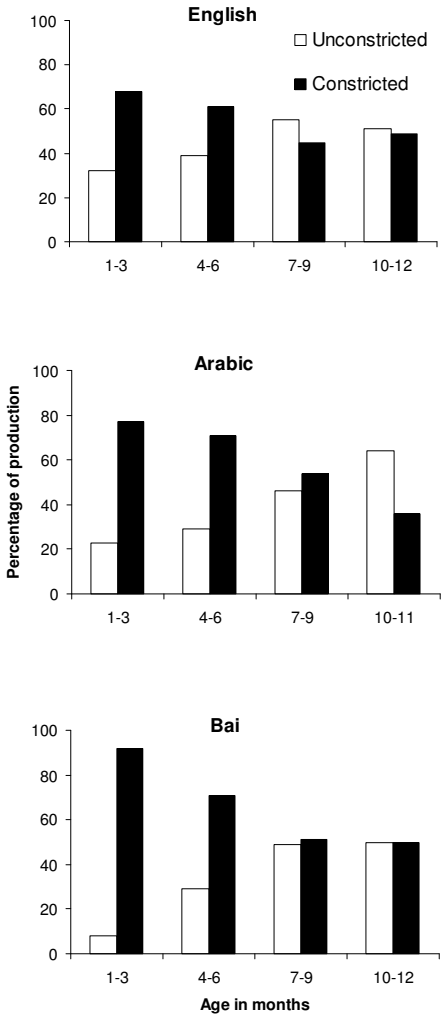
3. RESULTS

3.1. Overall results

As shown in Figure 1, the incidence of laryngeal constriction decreased progressively throughout the first year for infants from all three language groups, while still forming a major part of their vocal repertoire at the 10-12 month period. The incidence of constriction in the Arabic infants declined linearly throughout the first year, from 77% at months 1-3, to 71%, 54%, and 36% during months 4-6, 7-9, and 10-12, respectively. For the English infants, the incidence of constriction was 68%, 61%, and 45% in months 1-3, 4-6, and 7-9,

respectively, and then rose slightly to 49% in months 10-12. The incidence of constriction in Bai infants' vocalizations was 92%, 71%, 51% and 50% in months 1-3, 4-6, 7-9, and 10-12, respectively.

Figure 1: Constricted and unconstricted voice quality settings produced by English, Arabic, and Bai infants.

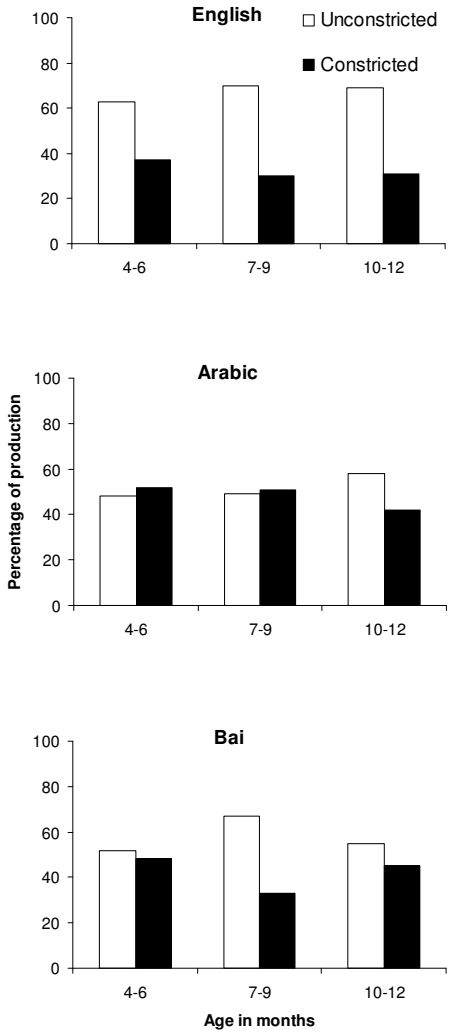


The association between language, age group and degree of constriction (constricted vs. unconstricted) was evaluated using Pearson's chi-square. The only significant association was that between age group and constriction (χ^2 (3) = 93.34, $p < .001$), indicating that the incidence of laryngeal constriction in the utterances of the infants varies primarily as a function of age, irrespective of their linguistic background.

3.2. Babbling

The incidence of laryngeal constriction varies considerably, however, across language groups when we look solely at the babbled utterances. As shown in Figure 2, the incidence of laryngeal constriction in babbling is relatively stable across the first year for the English and Arabic infants, while the pattern is more complex in the babbling of the Bai infants.

Figure 2: Constricted and unconstricted voice quality settings in the babbling of English, Arabic, and Bai infants.



In the babbling of English infants there was relatively little laryngeal constriction; rates for months 4-6, 7-9, and 10-12 are 37%, 30%, and 31%, respectively. The babbling of the Arabic infants was more constricted than that of the

English infants. The incidence of constriction was 52% and 51% in months 4-6 and 7-9 respectively, before falling to 42% in months 10-12. The proportion of constriction in the Bai infants' babbling demonstrated a U-shaped pattern, starting at 48% in months 4-6, declining to 33% in months 7-9, and rising to 45% in months 10-12. While the incidence of babbling appears to demonstrate language-specific properties, the results are not statistically significant; we await further data from the three language groups to confirm the patterns described here.

4. DISCUSSION & CONCLUSION

These results provide evidence for universal and language-specific patterns in the use of laryngeal constriction in the first year of life. In the first months of life, all infants produce primarily constricted voice quality settings. Over the course of the year, as infants systematically explore their evolving phonetic capacities, unconstricted settings make up an increased proportion of their vocal repertoires. Within this general pattern, the distribution of laryngeal constriction in the infants' utterances may vary according to laryngeal features exploited in the infants' ambient language. Of the range of prelinguistic vocalizations produced by infants, babbling is the most likely to reflect emergent phonological properties and as such, to exhibit cross-linguistic differences.

Of the three languages studied, English babbling was the least likely to feature laryngeal constriction, even at an age when the English infants' utterances overall contain a high proportion of constriction. Given that English does not use laryngeal constriction contrastively, this finding was expected. We also found that Arabic babbling consistently included a higher proportion of laryngeally constricted voice quality settings than English babbling. This finding is intriguing, given that Arabic employs laryngeal constriction contrastively only at the segmental level. It is possible that the Arabic infants have noticed the parameter of laryngeal constriction in their ambient language, but have not yet differentiated between segmental and suprasegmental features. Alternatively, it is possible that voice quality settings are more constricted in languages that employ laryngeal constriction at the segmental level. Finally, the rate of laryngeal constriction in the babbling of the Bai infants exhibited the most complex pattern: in months 4-6 and 10-12, the incidence of constriction was similar to that found for the Arabic infants, while for months 7-9, the babbling was primarily unconstricted and more closely resembled the English babbling. It is likely that phonetic acquisition of laryngeal contrasts is more complex in Bai than in English or Arabic, given that Bai employs a range of pitch-dependent phonatory settings in its register tone system, including harsh voice, modal voice, breathy voice, and falsetto [5]. We are extending our study to the second year of life to identify when infants from different language backgrounds begin to use laryngeal constriction contrastively at the segmental and syllabic levels.

5. REFERENCES

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