

PRODUCTION AND PERCEPTION OF LARYNGEAL CONSTRICTION IN THE EARLY VOCALIZATIONS OF BAI AND ENGLISH INFANTS

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1. INTRODUCTION

This exploratory study investigates the relationship between infants' production of laryngeal voice quality in the first year of life and adult perceptions of these features in infant vocalizations, building on the work of the Infant Speech Acquisition (InSpA) team at the UVic (Benner et al., 2007; Esling et al., 2006) and the phonetic model provided by Esling (2005). In exploring this relationship, the study focuses on two languages that differ in their use of laryngeal voice quality: English, a Germanic language that uses voice quality non-contrastively in paralinguistic expression (Laver, 1980); and Bai, a Tibeto-Burman language that employs laryngeal voice quality distinctively at the syllabic level in its register tone system (Esling & Edmondson, 2002).

2. METHOD

2.1 Infant Production

Four Bai infants (2 female, 2 male) and four English infants (3 female, 1 male) were recorded monthly in spontaneous interaction with a primary caregiver using a Sony DCR-HC26 digital video camera recorder with an integrated microphone at 16-bit and 44,000 samples/second. Recordings were segmented into vocalizations using SoundForge 8.0. A vocalization was defined as any non-crying sound of at least 500 msec separated from other sounds by at least 2 seconds of silence. A total of 2400 utterances (1200 for each language group; 300 for each of the age groups 0-3 months; 4-6 months; 7-9 months; and 10-12 months) were analyzed using auditory coding and wide-band spectrograms. Utterances were classified by utterance type (babbling, non-babbling, or mixed) and laryngeal voice quality (constricted, unconstricted, or dynamic). Constricted utterances were produced with harsh, creaky, or whispery voice; unconstricted utterances with modal, breathy, or falsetto voice; and dynamic utterances alternated between constricted and unconstricted laryngeal settings.

2.2 Adult Perception

Forty adult native speakers of Bai (24 female, 16 male, aged 20 to 75) and 40 adult native speakers of English (19 female, 21 male, aged 22 to 77) participated in the listening task, which was conducted on a laptop computer with headphones, using E-prime 2.0. Participants rated 36 randomly ordered infant vocalizations on a 5-point scale according to how important they judged the utterances to be in learning to speak their native language (English or Bai).

Following the listening task, participants were asked to discuss factors that contributed to their ratings.

The 36 infant vocalizations (18 Bai, 18 English) were excerpted from the infant utterances included in the production study. All sounds were produced by infants aged 10-12 months and were selected to equally represent the laryngeal voice quality and utterance type categories used in the production component of the study (see 2.1 above).

3. RESULTS

3.1 Infant Production of Laryngeal Voice Quality

As shown in Tables 1 and 2, for Bai and English infants, constricted vocalizations decline and unconstricted utterances increase over time, but constricted sounds decrease less markedly for Bai infants and unconstricted sounds increase more for English infants. Production of dynamic utterances increases in months 4-6 for all infants, but Bai infants' production of these sounds steadily increases as the year progresses, compared to English infants'. Chi-square analysis of the relationship between laryngeal voice quality and age revealed a significant association between age and laryngeal voice quality for Bai infants ($\chi^2 = 129.423$, $p < .001$) and English infants ($\chi^2 = 239.015$, $p < .001$). Differences in the development of laryngeal voice quality between the two language groups become significant in months 10-12 ($\chi^2 = 19.362$, $p < .001$).

Table 1. Laryngeal Voice Quality: Bai Infants.

Age	Constricted	Dynamic	Unconstricted	Total
0-3	257 (86%)	22 (7%)	21 (7%)	300
4-6	186 (62%)	85 (28%)	29 (10%)	300
7-9	162 (54%)	89 (30%)	49 (16%)	300
10-12	129 (43%)	113 (38%)	58 (19%)	300
Total	734 (61%)	309 (26%)	157 (13%)	1200

Table 2. Laryngeal Voice Quality: English Infants.

Age	Constricted	Dynamic	Unconstricted	Total
0-3	248 (83%)	45 (15%)	7 (2%)	300
4-6	158 (53%)	127 (42%)	15 (5%)	300
7-9	145 (48%)	89 (30%)	66 (22%)	300
10-12	105 (35%)	89 (30%)	106 (35%)	300
Total	656 (55%)	350 (29%)	194 (16%)	1200

3.2 Infant Production of Utterance Type

Production of utterance types is shown in Tables 3 and 4 for Bai and English infants, respectively. The most notable

result is that while Bai infants produce babbling at least as early as English infants, babbling develops more slowly, only increasing significantly in months 10-12. In months 7-9, the two language groups differ significantly in the development of utterance type ($\chi^2 = 18.419, p < .001$). These differences remain significant in months 10-12, but the differences are less marked ($\chi^2 = 8.743, p < .005$).

Table 3. Utterance Type: Bai Infants.

Age	Non-babbled	Mixed	Babbled	Total
0-3	234 (78%)	59 (20%)	7 (2%)	300
4-6	227 (76%)	60 (20%)	13 (4%)	300
7-9	234 (78%)	51 (17%)	15 (5%)	300
10-12	159 (53%)	47 (16%)	94 (31%)	300
Total	854 (72%)	217 (18%)	129 (11%)	1200

Table 4. Utterance Type: English Infants.

Age	Non-babbled	Mixed	Babbled	Total
0-3	277 (92%)	23 (8%)	0 (0%)	300
4-6	197 (66%)	89 (30%)	14 (5%)	300
7-9	192 (64%)	61 (20%)	47 (16%)	300
10-12	100 (33%)	71 (24%)	129 (43%)	300
Total	766 (64%)	244 (20%)	190 (16%)	1200

Concerning the relationship between laryngeal voice quality and utterance type, for both language groups, non-babbled utterances are most likely to be constricted (for Bai: 89%, 69%, 62%, and 48% in months 0-3, 4-6, 7-9 and 10-12, respectively; for English: 84%, 64%, 60%, and 58%). Beyond months 0-3, mixed utterances are most likely to be dynamic (for Bai: 48%, 49%, and 47% in months 4-6, 7-9, and 10-12, respectively; for English: 60%, 41%, and 52%). Babbling only occurs frequently for both language groups in months 10-12, by which time laryngeal voice quality begins to differ significantly between the two language groups. Among Bai infants, 36% of babbled utterances are constricted, 39% are dynamic, and 24% are unconstricted. The corresponding figures for English infants are 20%, 27%, and 53%, illustrating the tendency for English infants' babbling to be unconstricted. Chi-square analysis of the relationship between utterance type and laryngeal voice quality by language showed no significant language differences for non-babbled and mixed utterances, but highly significant differences for syllabic utterances in months 10-12 ($\chi^2 = 14.199, p < .001$).

3.2. Adult Perception

Results for adult perception, reported only briefly here, suggest that Bai and English infants' production patterns mirror, to some extent, Bai and English adults' auditory preferences. Bai listeners show no obvious preference for any of the laryngeal voice quality categories in the listening task, all of which are exploited in Bai tonal distinctions. By contrast, laryngeal voice quality significantly affects English listeners' ratings ($F(2, 476) = 27.941, p < 0.001, r = .205$). English listeners prefer unconstricted utterances to dynamic utterances, which they in turn prefer to constricted utterances.

In terms of utterance type, Bai listeners significantly prefer babbling to non-babbling ($F(1, 238) = 207.204, p > .001, r = .327$), as reflected in overall mean ratings of 3.94 and 3.16 for babbling and non-babbling, respectively. English listeners' mean ratings reflect the same significant preference ($F(1, 238) = 866.605, p > .001, r = .749$), but the preference for babbling is stronger, as reflected in a mean overall rating of 3.98 for babbled utterances versus 2.44 for non-babbled vocalizations. Given the importance of laryngeal voice quality in Bai, it is possible that Bai listeners judge the ability to produce a range of laryngeal voice qualities (as tends to happen in infants' non-babbled utterances) to be nearly as important as their ability to produce syllables, as in babbling. By contrast, English listeners may regard the production of various laryngeal voice qualities as less important to language development, reflecting emotional expression rather than linguistic or phonetic development. Results of the interviews conducted with participants following the listening task, while not reported here, bear out this speculation.

4. DISCUSSION

The results of this exploratory study suggest that adults are attuned to laryngeal voice quality in infants. In turn, the results of the production study suggest that infants become attuned to the use of laryngeal voice quality features in their ambient language early in development, and that these features are reflected in their evolving patterns of production in the first year of life.

REFERENCES

- Benner, A., Grenon, I., & Esling, J. H. (2007). Infants' phonetic acquisition of voice quality parameters in the first year of life. In J. Trouvain & W.J. Barry (Eds.), *Proceedings of the 16th International Congress of Phonetic Sciences, vol. 3* (pp. 2073-2076). Saarbrücken: Universität des Saarlandes
- Esling, J. H. (2005). There are no back vowels: The laryngeal articulator model. *Canadian Journal of Linguistics, 50*, 13-44.
- Esling, J. H., Benner, A., & Grenon, I. (2006). Phonetic development in the first year of life: A comparison of English, Moroccan Arabic, and Bai infants. Paper presented at the conference of the British Association of Academic Phoneticians, Edinburgh, April 2006.
- Esling, J. H., & Edmondson, J. A. (2002). The laryngeal sphincter as an articulator: Tenseness, tongue root and phonation in Yi and Bai. In A. Braun & H. Masthoff (Eds.), *Phonetics and its Applications: Festschrift for Jens-Peter Koster on the Occasion of his 60th Birthday* (pp. 38-51). Stuttgart: Franz Steiner Verlag.