

Patterns of vowel space utilization in Hungarian caregiverese addressed to young children: An evaluation of the MIPhI model

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***Abstract.** This paper reviews changes in how mothers utilize the vowel space as reflected by corner vowel productions of mothers with 2;0, 3;0 and 4;0 years old sons speaking Hungarian. Patterns in mothers' corner vowel production were examined within the framework of the "Mother-Infant Phonetic Interaction model" (MIPhI) which suggest that mothers' speech sound accuracy is adjusted to the perceived accuracy level of their child's sound production. The study evaluates the model for caregiverese addressed to older children. In general, mothers with older children produce their vowels in a more frontal position. An increase in vowel space between mothers with 2;0 as opposed to 3;0 year-olds may be related to the mother's perception of their children's difficulty in acquiring the high back long rounded vowel. This perception is reflected by the hyperarticulated production of /u:/ in caregiverese addressed to both 2;0 and 3;0 year-olds. An increase in children's accuracy of the other two corner vowels may be reflected by mothers' more anterior production of those vowels when addressing 3;0 and 4;0 year-olds. In agreement with the MIPhI model, mothers appear to change the utilization of their acoustic vowel space in concert with developmental changes reflected by their children's vowel production accuracy.*

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1. Introduction

1.1. Properties of caregiverese

Previous research has established that caregivers use a special register coined “caregiverese” when addressing young children. Major characteristics of caregiverese include higher mean F_0 , exaggerated pitch contours, emphatic stress, longer and more frequent pauses, a slowed rate of speech and less complex syntax and semantics. At the level of speech sound production, it has been found that caregiverese uses overspecified consonant and vowel productions (e.g., Englund & Behne, 2006; Kuhl, 2000). Being exposed to hyperarticulated speech sounds through caregiverese supports speech sound discrimination in children due to an increased perceptual salience of extreme vowels (Kuhl, 2000). Since the presence of hyperarticulated vowels in caregiverese has been identified in several language communities (Kuhl, Andruski, Chistovich, Chistovich, Kozhevnikova, Ryskina et al., 1997), it has been suggested that the use of extreme vowels may be a commonly occurring speech phenomenon that aids young children in exploring and acquiring recognizable language specific dimensions in the speech of adults speaking the environmental (native) language.

1.2. The Mother-Infant Phonetic Interaction (MIPhI) model

Sundberg (1998) hypothesized that the acoustic/phonetic properties of caregiverese change with the child’s increased speech performance. The argument put forward is that, as speech sounds are produced more accurately by the developing child, the need to teach children to perceive and produce differences in vowel qualities through exposure to hyperarticulated speech sound production decreases. Thus, with the child’s development, caregivers decrease the extent to which they exaggerate certain acoustic/phonetic properties of their speech sounds in child directed as compared to adult directed speech. In vowel production, it would follow that caregivers produce less hyperarticulated sounds as their children develop higher levels of speech competence. That is, the extent of overspecification of vowels would decrease as the child develops production skills for more accurate speech patterns.

1.3. The emergence of language specific vowel representations

In adults, research has confirmed the existence of native language phonetic prototypes that contain information about acoustic features (e.g., frequency and duration) and phonetic characteristics of speech sounds as reflected by categorical perception (Näätänen, 2001; Näätänen, Lehtokoski, Lennes, Cheour, Huotilainen, Iivonen et al., 1997; Ylinen, Shestakova, Huotilainen, Alku & Näätänen, 2006). Results suggest that, by the time these prototypes are fully developed, pre-attention change detection processes utilize both the acoustic and phonetic representations of speech sounds (Winkler, Lehtokoski, Alku, Vainio, Czigler, Csépe et al. et al., 1999).

In as much as these native language prototypes function as templates of speech sound recognition, they guide the acquisition of language specific speech sound inventories in young children. Neurophysiological studies provide evidence that infants develop language specific memory traces of their native vowels between 6-12 months

of age (Cheour, Ceponiene, Lehtokoski, Allik, Alho & Näätänen, 1998). Thus, by the end of the first year of life, infants can reliably differentiate and recognize all speech sounds that are present in their native language speech sound inventory. Further, recent initial results indicate that speech perception in 6-12 months old infants activates Broca's area, suggesting the early emergence of a perceptual-motor link for speech perception during the second half of the first year of life (Imada, Zhang, Cheour, Taulu, Ahonen & Kuhl, 2006). Taken together, these results show that language specific speech sound recognition is neurologically linked to speech sound production by the end of the first year of life.

2. Rationale

The presence of language specific speech sound representations in one-year-olds provides a strong foundation for the acquisition of speech sound production. From the beginnings of language, typically developing children produce increasingly accurate speech sounds. Results suggest that 2;0 years old monolingual Hungarian-speaking boys produce 75% of their vowels accurately, as judged by perceptual judgments of naïve raters. In 3;0 years old boys, 88.5% of vowels are judged to be correct, while at 4;0 years, vowel accuracy is 94% for boys (Zajdó, 2002; Zajdó & Stoel-Gammon, 2003). Overall, vowel accuracy increases with age. The current study was designed to evaluate the MIPhI model by examining vowel productions of mothers with 2;0, 3;0 and 4;0 years old sons. The model proposes that mothers' vowels become less hyperarticulated as their children's speech production accuracy increases. Corner vowel productions of mothers are studied in terms of the utilization of the vowel space, to evaluate whether mothers with older children produce less extreme vowels.

3. Methodology

3.1. Participants and stimuli

Twenty four mothers in three groups were examined: eight mothers with their 2;0 years old sons, eight with a 3;0 year-old and eight with a 4;0 years old son. The mother-infant pairs were playing with pre-named puppets in a natural setting. Mothers were instructed to model the names of the puppets while playing with their children. Puppet names were pV:1pV:1 structured. The consonant quality /p/ was selected because the production of the labial consonants has minimal effects on tongue position. Vowels examined included the three Hungarian long corner vowels /i:/, /a:/ and /u:/. Mother-child conversations were digitally recorded in a sound attenuated room, by using the Sound Forge acoustic software (Version 7.0) with recording attributes set to 32 kHz, 16 bit, mono.

3.2. The creation of a common reference plane

To compare corner vowel production patterns in mothers with 2;0, 3;0 and 4;0 year old children, a common reference plane was created. The 40-dimension spectra of all utterances produced by the mothers were merged together and were reduced by principal component analysis. The reference plane includes 2563 measurement points.

The first two principal components explain 63.9% of the variability. Figure 1 shows the reference vowel space. Figure 2 contains the graphs of the first two eigenvectors. Table 1 contains data about the contribution of the first four eigenvectors to the variability of the data set. (For a full description of the method, consult Van der Stelt, Zajdó & Wempe, 2005; Zajdó, Van der Stelt, Wempe & Pols, 2005).

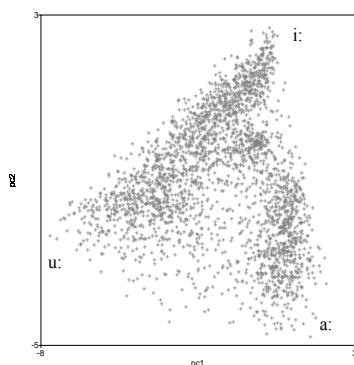


Figure 1. Reference pc1-pc2 vowel space for all mother’s corner vowels, resulting in 2563 measurement points. X axis: 1st principal component; Y axis: 2nd principal component. Corner vowel qualities are shown.

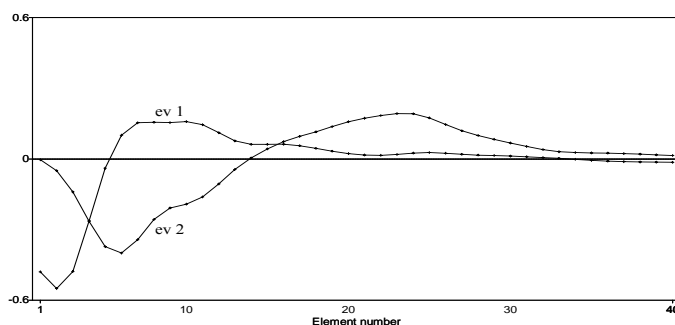


Figure 2. Graphs of the first two eigenvectors of a PCA of the measurement points identified for the combined dataset of utterances from all mothers, explaining 63.9% of the total variance (see Table 1).

eigenvector 1	39.8%	39.8%
eigenvector 2	24.1%	63.9%
eigenvector 3	6.7%	70.6%
eigenvector 4	5.6%	76.2%

Table 1. Percentage of variance explained by each of the first four eigenvectors in the PCA for the analyzed vowels of all mothers. The last column contains the cumulative percentages explained.

4. Results

In order to examine the position of mother's corner vowel productions within the reference plane, 100 measurement points from each vowel quality production data set were randomly selected. The measurement points were then projected onto the pc1-pc2 common reference plain. The ellipses projected for each corner vowel category represent 1 sd from the mean for each corner vowel quality (see Figure 3).

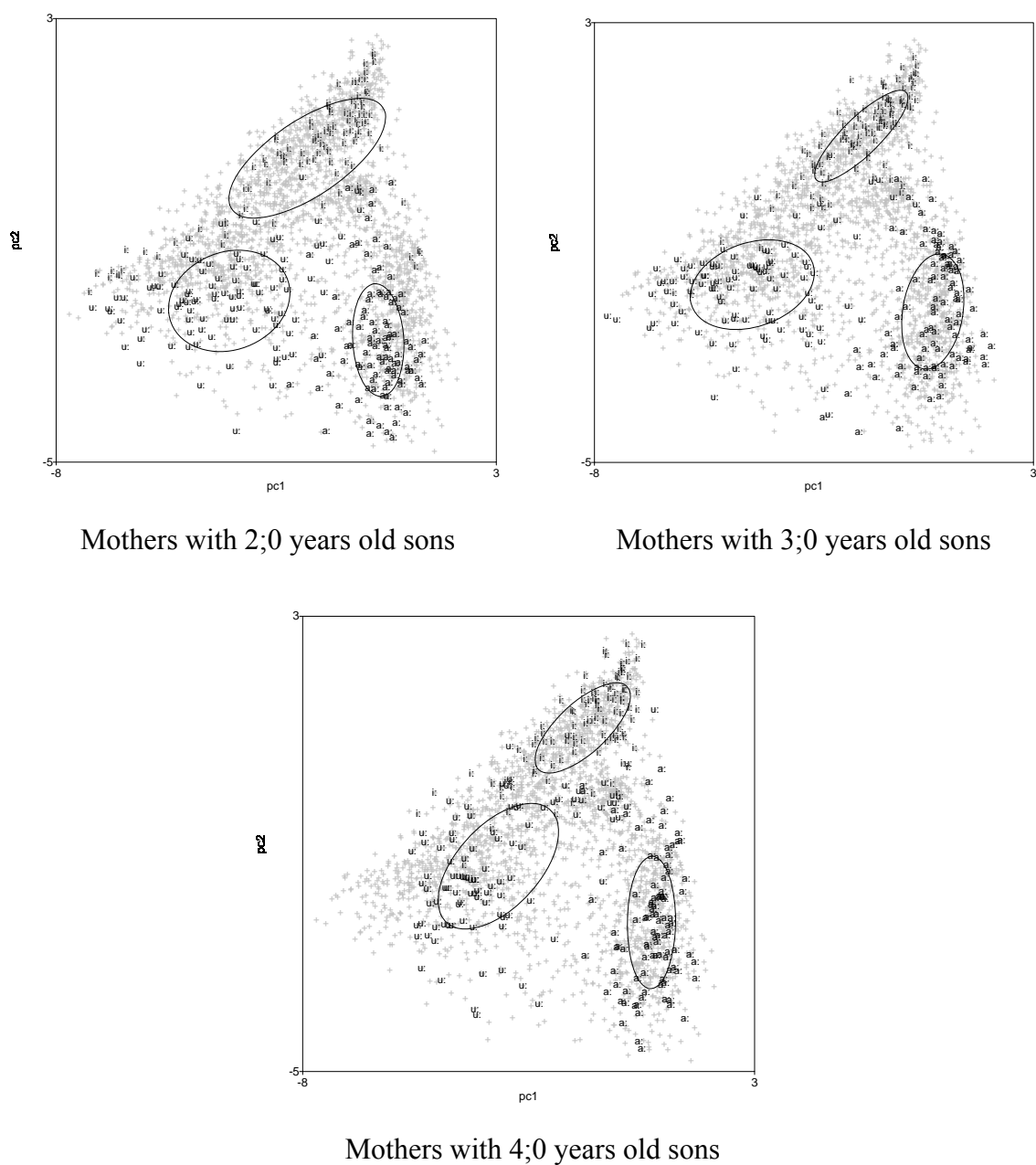


Figure 3. Corner vowels of mothers with 2;0, 3;0 and 4;0 years old sons projected onto the pc1-pc2 common reference plane. Ellipses indicate 1 sd from the mean for each vowel quality.

To compare the positions of the individual corner vowel categories in all age groups, Figure 4 shows all ellipses indicating 1 sd from the mean for each vowel category from mothers with 2;0, 3;0 and 4;0 years old sons. Ellipses of all nine datasets are projected onto the pc1-pc2 common reference plane (see Figure 4).

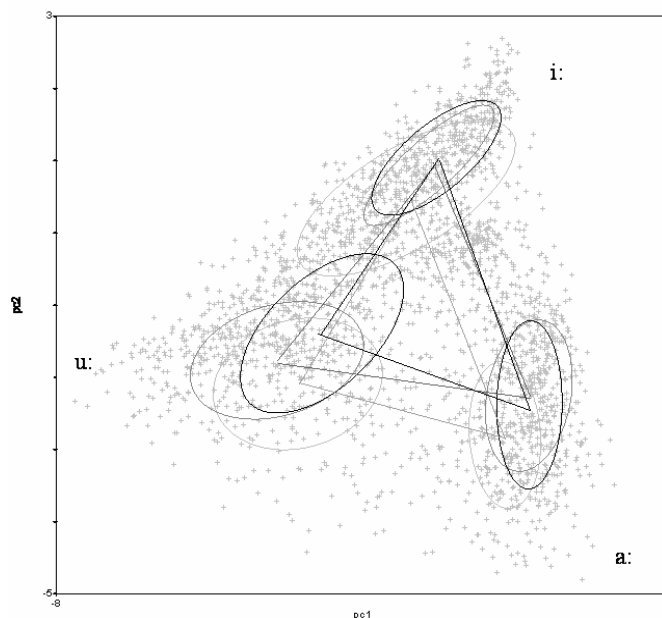


Figure 4. Corner vowels and vowel triangles of mothers with 2;0 (light gray line), 3;0 (medium grey line) and 4;0 (black line) years old sons projected onto the pc1-pc2 common reference plane. Ellipses indicate 1 sd from the mean for each vowel quality.

Results indicate that the positioning of the vowel triangle defined by the 100 randomly selected measurement points within the vowel space in mothers' speech changes with the child's development. Overall, it appears that mothers' corner vowel productions reflect a process from more posterior towards more anterior vowel productions. That is, mothers with 2;0 years old children produce individual productions of a vowel category in a more posterior position within the vowel space in comparison to the vowels of mothers with older children.

One potential explanation for the more fronted vowel productions of mothers with older children could be that, since older children produce more accurate vowels, mothers would model tokens for children by producing faster speech with less overspecified vowels. However, results from diverse languages (e.g., Fourakis, 1991; Johnson & Martin, 2001; Padgett & Tabain, 2005) suggest that a faster rate of speech is typically associated with a reduction in the size of the acoustic vowel space. In contrast, our results indicate that the size of the acoustic vowel space is not reduced in the speech of mothers with older children. Calculations show that, if the size of the vowel quadrilateral is taken to be 100% in the speech of mothers with 2;0 years old boys, then the size of the acoustic vowel

space increases to 124.6% for mothers with 3;0 years old boys and to 107.7% for mothers with 4;0 years old sons.

The significant increase (+ 24.6%) in size between the vowel spaces of mothers with 2;0 years old as opposed to 3;0 years old sons is due to the production of more frontal high front and low central corner vowels along with slightly raised but still quite posteriorly produced high back long rounded vowel productions in the speech of mothers with 3;0 year-olds. One potential explanation for mothers with 3;0 years old sons to produce even more extreme high back long rounded vowels is the children's difficulty with acquiring the production of this vowel. Previous results (e.g., Zajdó, 2002; Zajdó & Stoel-Gammon, 2003) show that, in comparison to unrounded vowels, rounded vowels are produced with higher accuracy later in development. While /u:/ is produced with 68% accuracy in 2;0 years old boys, at 3;0 years its accuracy increases to 89%, while still being only at 86% in 4;0 years olds. In comparison, the /a:/ vowel is produced with 83, 93 and 95% accuracy in the three age groups, respectively, while the production of the /i:/ vowel reflects 88, 95 and 91% accuracy in the three age groups. Thus, it is reasonable to speculate that mothers keep their high back long rounded vowel production in an extreme position when their children are 2;0 and 3;0 years old, to aid them in their learning of that individual vowel quality. In contrast, mothers produce more frontal positions for /i:/ and more frontal and higher /a:/ vowels that are less challenging for children in the older age groups to produce when talking to 2;0 vs. 3;0 and 4;0 year-olds.

5. Summary

Results suggest that mothers change their production of vowels as they talk to older children with higher accuracy of speech sound production when modeling tokens to their children. The results provide support for the MIPhI model in as much as they indicate changes in vowel production in caregiverese that reflect adjustments to the level of speech production accuracy in children.

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