PERCEPTION OF A FRICATIVE-STOP CONTINUUM BY ADULTS AND CHILDREN

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1. INTRODUCTION

The purpose of this study was to determine if there are differences between the identification functions of normally articulating children and adults for perception of a consonant manner contrast, in this case, a continuum of synthesized alveolar fricative and stop "like" sounds. Based on previous research addressing age differences in categorical perception [1, 2], the following hypotheses were made. Compared to adults, children will exhibit: (1) Less enhanced discriminability at category boundaries than adults, i.e., wider category boundaries, (2) A greater range in the shape of their individual response functions, and (3) Less stability in their internal representation of the fricative-stop manner contrast, as reflected by greater internal and external response variability scores. In addition, a misarticulating child, who substituted alveolar stops for fricatives, provided an opportunity to explore the hypothesis that: (4) Misarticulating children who do not produce a perceptually differentiated alveolar fricative-stop contrast will exhibit less stability of their internal representation of the fricative-stop contrast than normally articulating children.

2. METHOD

2.1 Subjects

Three men and 3 women, 25 - 28 years of age (subjects A1 - A6), formed the adult group. Three boys and 3 girls, ages 4 years 2 months to 5 years 8 months (subjects C1 - C6), formed the child group. All these subjects had age appropriate articulation skills and produced age-appropriate, clearly distinguishable /s/ and /t/ sounds. One additional 5 year-old girl was included who misarticulated several sounds and used an alveolar stop for fricative substitution pattern (subject MC). All subjects passed a hearing screening, had age-appropriate receptive language ability, had English as a first language, and had never received speech or language therapy.

2.2 Stimuli

The Computerized Speech Research Environment (CSRE) software [3] was used to generate the experimental stimuli, following the parameters described in [4]. A continuum of seven "alveolar-like" consonant segments (C) was synthesized that represented a range in manner from fricative to stop. These segments were each combined with a synthesized vowel-consonant syllable, (VC) /ip/, to form CVC stimuli /Cip/. The VC portion remained constant across the seven point continuum, i.e., Stimulus 1 through 7. The initial consonant segment was varied by manipulating the slope of the rise time of the prevocalic noise source (frication) and as a consequence, noise duration. Frication duration included the noise rise time and a 25 ms segment of steady-state noise at 60 dB. Amplitude of frication increased from 20 dB at onset to 60 dB at onset of the steady state noise segment. The C segment of Stimulus 1 had a rise time of 120 ms. Noise rise time decreased in 20 ms decrements for consecutive stimuli, with a 19 ms decrement between Stimuli 6 and 7, giving Stimulus 7 a noise rise time of 1 ms. All other parameters remained constant across the stimuli. An additional CVC, "Pip", was synthesized for subject training procedures. The Experimental Control System of CSRE randomized the presentation of the stimuli for each subject and recorded the subjects' responses.

2.3 Procedures

Each subject completed a practice listening task to ensure that he or she understood what was expected and could respond reliably. The listening stimuli were then presented using a two-option, forced choice, picture identification paradigm. The presentation of training items and experimental stimuli followed procedures described in [2] with the exception that 8, rather than 16 tokens of each stimulus were presented to accommodate the shorter attention spans of the child subjects. Once training was completed, the subject was presented with the seven experimental stimuli, four times each, in random order. After presentation of these 28 tokens, the subject took a short break. The training tasks and presentation of the experimental stimuli were then repeated. Thus, each subject heard 8 presentations of each of the seven stimulus items on the continuum.

3. RESULTS

Identification functions obtained for the adults, children and for MC are shown in Figures 1, 2 and 3, respectively. Phoneme boundaries (50% crossover point) are indicated by the horizontal dashed lines. The width of phoneme boundary zones, i.e., the number of stimuli for which identifications were not categorical, was also determined using the following criterion. Six out of eight assignments of a stimulus to one of the categories meant that the stimulus was perceived categorically ($p < 0.10$ in binomial distribution). Phoneme boundaries for the adults ranged from Stimulus 2 to between Stimuli 5 and 6 (M=3.67). Results for the children were less well defined as subjects C3 and C4 did not have a boundary. For the other four children, boundaries ranged from Stimulus 1 to between Stimuli 6 and 7 (M=2.83). The phoneme boundary zone is also referred to as the "zone of uncertainty", corresponding to the number of stimuli that are identified at chance levels. This zone covered a range of five stimuli for the child group (Stimuli 1 through 5) and only one stimulus for the adult group (Stimulus 4). MC had a four stimuli "zone of uncertainty" (greater than any other adult or child subject).

Analysis of the subjects' responses to the two end point stimuli on the continuum revealed that the adults identified Stimulus 1 as "sip" more frequently than the normally articulating children ($X^2(1, N=48)-4.47, p<.05$). Both groups identified Stimulus 7 as "tip" for 100% of their responses. It is evident that the range of response patterns for the children's identification functions is greater than the adults'. MC's function has the majority of stimuli in the "zone of uncertainty", including Stimulus 7. This differed from all other subjects who identified Stimulus 7 unequivocally as "tip".

Response variability scores were determined using the procedures described in [1]. The internal response variability score was calculated with respect to the particular subject's phoneme boundary while the external response variability score was calculated with respect to the adult groups' mean boundary.

Internal response variability scores ranged from 3 to 24 for the adult group (Mean=12.3; SD=7.6) and from 1 to 17 for the child group (Mean=11.0; SD=7.3) External response variability scores ranged from 3 to 21 for the adult group (Mean=10.2; SD=7.5) and from 2 to 20 for the child group (Mean=11.8; SD=6.2). While means and standard deviations were similar for each group for both external and internal variability scores, the

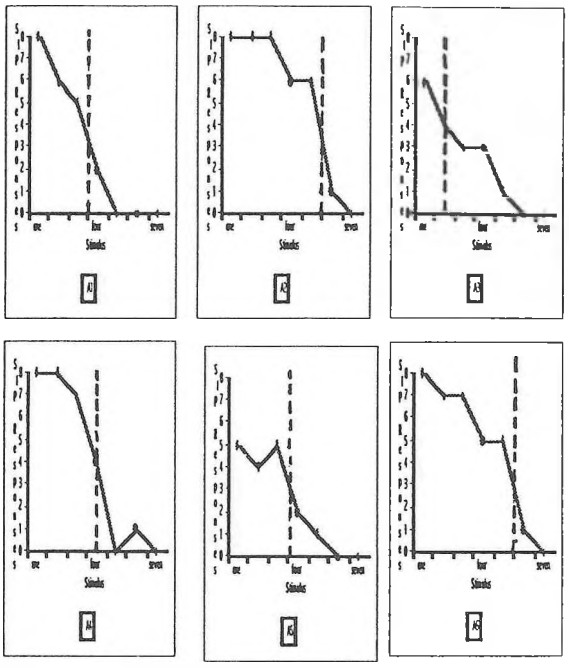

Figure 1. Adult "sip" identification functions.

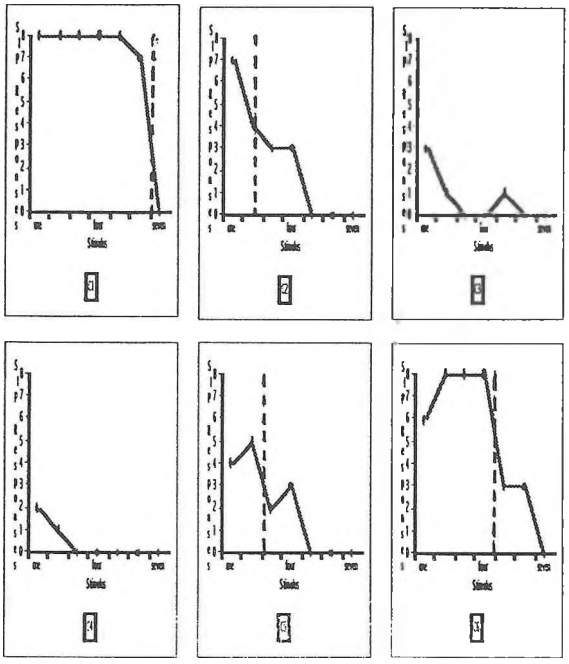

Figure 2. Child "sip" identification functions.

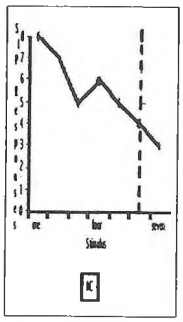

Figure 3. Misarticulating child "sip" identification function.

children's mean internal variability score does not include subjects C3 and C4 because they did not have a phoneme boundary. MC's internal response variability score of 23 was the second highest, and her external response variability score of 25 was the highest of all subjects.

4. CONCLUSIONS

(1) As predicted, the child group had wider boundaries, i.e., they exhibited less enhanced discriminability for fricative versus stop manner categories on this seven step synthetic continuum than the adult group.

(2) As predicted, the child subject group exhibited a greater range in their response patterns than the adult group: phoneme boundaries could not be calculated for two of the children and the children responded significantly differently to Stimulus 1.

(3) Contrary to what was predicted, the normally articulating adult and child subjects showed similar group mean and standard deviations in their internal and external response variability scores, suggesting that they were similar in the stability of their internal representation of the fricative-stop contrast represented by this seven step continuum varying in noise rise time and corresponding noise duration. A greater number of subjects would provide a more robust test to support or refute this finding.

(4) MC had the widest "zone of uncertainty" (including Stimulus 7) and the highest external response variability score of any adult or child subject. This suggests that her internal representation of the fricative-stop contrast was less stable than the normally articulating subjects. Future research considerations include testing these hypotheses for a group of misarticulating subjects who use a stop for fricative substitution, and investigating the effect of perceptual training on a fricative-stop continuum (vis a vis [2]) on these subjects' stop and fricative productions.

5. REFERENCES

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