Infant Dependence on Acoustic Cue Redundancy: Discrimination of the Word-Final Voicing Contrast, /t/-/d/.

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INTRODUCTION

Several studies have investigated the perception of vowel duration as a cue to word-final stop voicing in children and adults. The findings have indicated that the ability to rely on a single cue in making such discriminations develops with age (Greenlee, 1980; Krause, 1982). Similarly, an increased reliance on redundant acoustic information has been observed for adult second-language learners of English (Crowther & Mann, 1992; Flege & Wang, 1989), which also suggests that acoustic redundancy is more important during language acquisition. Several studies that have examined discrimination of this contrast in infants and have suggested that, like adults, infants rely primarily on vowel duration differences in discrimination of final stop voicing contrasts (Eilers, 1977; Eilers et al., 1977). However, the role of acoustic cue redundancy and the prominence of the vowel duration cue over other cues in infant perception of final stop voicing distinctions was not been clearly established in this work. Therefore, it is difficult to relate these infant results to the findings from the adult and second language learners.

The present study was designed to investigate further perception of word-final stop voicing contrasts in infants and adults in order to test three hypotheses about infant phonetic discrimination skills. The first hypothesis was that, like second language learners, infants will show a greater reliance on acoustic cue redundancy than will native English-speaking adults. Thus, removing one or more of the multiple acoustic cues that distinguish this contrast would be expected to produce a drop in discrimination performance. The second hypothesis was that vowel duration would be the most salient cue for infants, as has been repeatedly demonstrated in native English-speaking adults and has been suggested by Eilers et al (1977). Accordingly, infants were expected to show their best discrimination performance when the vowel duration cue is present. Finally, previous cross-language studies have indicated that infants are becoming more sensitive to the phonetic structure of the native language in the latter half of the first year of life (Werker & Pegg, 1992). Given that the infants in this study were being tested on a native language contrast, it was hypothesized that older infants (10-12 month olds) may show better discrimination performance than younger infants (6-8 month olds).

METHOD AND DESIGN

To address these hypotheses, discrimination of a word-final stop consonant voicing contrast, /bid/-/bit/, was examined in English-learning infants at two ages, 6-8 months and 10-12 months, and in English-speaking adults. A set of natural speech tokens were edited to create three stimulus conditions which differ in the acoustic cues that signal the /t/ - /d/ contrast in word final position. The three conditions were: 1) the full cue condition (FC), in which vowel duration, burst cues and closure cues are present, 2) burst and closure cues neutralized condition (BCCN), and 3) vowel duration neutralized condition (VDN). Each subject was tested on discrimination of the /bit/ vs /bid/ contrast in each of the three conditions using the headturn procedure in the category change paradigm (Kuhl, 1987). In this procedure, the infant listens to a background stream of syllables that correspond to one category. At irregular intervals, the syllables change to another target category for a short period. All of the subjects were tested with /bid/ as the background category and /bit/ as the target category. The infant learns to respond to this change with a headturn; a visual reinforcer is used to condition a correct anticipatory headturn. Adults are simply instructed to raise their hand when the sound changes. The testing for each condition consisted of a short conditioning phase followed by a test phase. In the test phase, the subject was presented 25 test trials; approximately half are change trials and half are control (no change) trials.

RESULTS

Performance was evaluated in each condition with respect to three dependant variables: 1) percent correct (across the 25 test trials), 2) proportion of subjects in each group who met a pre-established discrimination criterion of 7 out 8 consecutive correct responses[1], and 3) number of test trials required to reach criterion (among those who subjects who met the discrimination criterion). Mean percent correct for each stimulus condition is plotted for each age group in Figure 1 below.

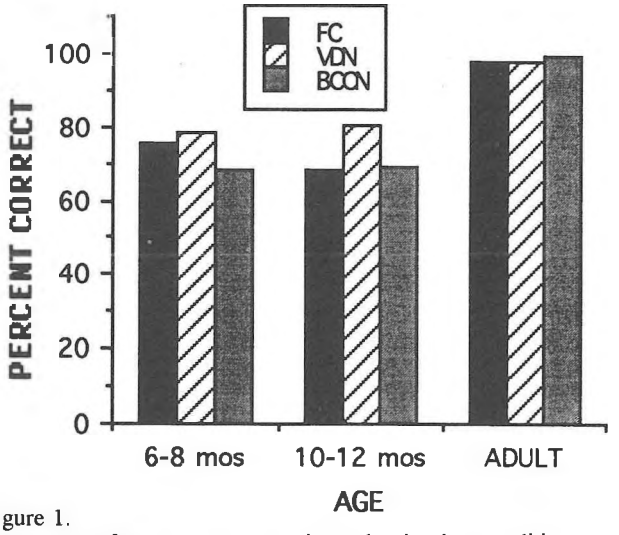

Figure 1.
Percentage of correct responses in each stimulus condition.

[1]The use of a preset criterion is common with the headturn procedure. This criterion corresponds to a significance level of $p < .05$.

Adults performed at ceiling levels for all three conditions with respect to each dependant variable. No infant age differences were observed with respect to any of the dependant variables.

To assess the effect of cue redundancy, performance in the full cue (FC) condition was compared to accuracy in each reduced cue condition (BCCN and VDN). Performance on the FC condition was greater than performance on the BCCN condition with respect to both the proportion of infants reaching criterion and the number of trials required to reach criterion performance level, though not for percent correct. However, performance on the FC condition was never better than performance on the VDN condition. When the vowel duration difference was removed (in VDN condition), performance was either maintained (re: proportion reaching criterion) or improved (re: percent correct scores) relative to the FC condition.

The relative saliency of the various kinds of acoustic cues that distinguish the /bid/ - /bit/ contrast was also examined by comparing performance in the two reduced cue conditions (VDN and BCCN). These analyses revealed that infants consistently performed significantly better in the VDN condition than in the BCCN condition. This pattern was evident in the analyses of all three dependant variables.

DISCUSSSION

Three hypotheses were addressed in this study. It was hypothesized that infant discrimination performance would show some improvement in the later half of the first year of life. The present findings failed to support this hypothesis. Although age-related changes in infant speech perception have been noted in previous work, similar age differences were not apparent in discrimination of final stop voicing in English-learning infants.

Another hypothesis which motivated this study was that, in perception of phonetic contrasts, infants would show greater dependency on acoustic cue redundancy than would adults. The present findings provide partial support for this hypothesis in that infants showed better discrimination performance in the FC condition than in the BCCN condition. However, infant discrimination in the full cue condition was less accurate compared to the VDN condition in which the vowel duration differences were absent.

The third hypothesis was that vowel duration would be the most salient perceptual cue for infants, consistent with previous findings with adults. Surprisingly, the findings failed to support this hypothesis and, instead indicated that burst and closure cues were more salient for the infants than were the vowel duration differences. This pattern of results differs from findings of prior research on adult perception of such contrasts which showed a prominent use of the preceding vowel duration cue by adults. Also, at least one infant study has suggested that infants of 6-12 months also make use of the vowel duration difference cue (Eilers et al., 1977). However, the present findings are consistent with findings from studies with older children and with second language learners in showing that a certain level of linguistic sophistication is necessary before vowel duration difference information becomes useful as a cue to final stop consonant voicing.

In conclusion, the finding that infants are better able to use burst and closure cues in their discrimination of final stop voicing, differs from the findings from previous adult studies which clearly show vowel duration to be a prominent perceptual cue. Thus, infants and adults appear to favor different acoustic cues in discriminating word final stop voicing contrasts. Consequently, considerable caution should be exercised in using research findings with adults as a basis for deriving infant aural rehabilitation regimes. Furthermore, infant responses and acoustic needs are likely to chnage through out language development. Therefore, further research is needed to describe the normal course of speech perception development, both to better understand normal language development and to facilitate determination of the specific clinical intervention needs of infants and children with communication delays and disorders.

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