Acquisition of [r-l] phonemic contrast by English speaking children.

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1. Introduction

Multiple acoustical cues are a critical component of perceptual and productive distinction between phonemic contrasts. For example, usage of both the spectral and temporal information enables English listeners to discriminate [r] and [l] sounds with a high efficacy. Specifically, the difference in the frequency onset of the third formant (F3) frequency transition between [r] and [l] is used in the discrimination of this contrast. For [r] the onset of F3 is close to the second formant (F2) and has a rising transition. F3 of [l] is high relative to F2 and falls slightly towards the F3 formant of the following vowel. In addition to the spectral cue, the durations of both the steady state and the subsequent frequency transition of the first formant (F1) are used by English listeners in differentiation of prevocalic [r] and [l]. The frequency transition of F1 in [r] is much longer relative to the frequency transition of [l]. Discrimination of [r] and [l] sounds by English listeners and speakers is based on the integrated phonemic percept. It was found that the perceptual ability to integrate acoustical cues improves significantly with age. There is a change among children in the ability to integrate spectral and temporal acoustical cues during perceptual distinction of [r-l] contrast as a function of age. Specifically, with increasing age, children rely more on phonemic similarities than on acoustic dissimilarities. Thus, the attainment of perceptual distinction between phonemic contrasts (at least for [r] and [l]) is a gradual and progressive development in the proficiency of categorical perception.

This study examined development of the incorporation of spectral and temporal acoustical cues in the production of the phonemic contrast between [r] and [l] sounds in the initial prevocalic position for 3 to 6 years old English children.

2. Method

Ninety-six monolingual English children, divided into four age groups (3, 4, 5, 6 years old), participated in this study. All children were native speakers of Canadian English, had normal peripheral hearing (10 dB HL or better for 250 Hz to 6000 Hz) and normal articulation according to age. Each subject was asked to produce 6 words with [r], [l], or [w] in the prevocalic position in two vowel contexts ('rake', 'lake', 'wake', 'rock', 'lock', 'walk'). Three repetitions of each word were recorded using the microphone B&K 4165 and a DAT recorder, SONY DAT-75ES. The recorded speech samples were digitized at sampling frequency of 40 kHz with 16-bit amplitude accuracy.

3. Results and Discussion

Mixed 3 factor repeated ANOVAs with age as the between subjects variable (4 levels) and vowel (2 levels) and consonant (3 levels) types as the within variables were conducted on dependent variables. Separate analyses were conducted on several acoustical features: F1 transition duration; F2 transition duration; F2 onset frequency; F3 onset frequency; and the temporal cue defined as the ratio of the F1 transition to the F2 transition duration. Within each level of consonant type and vowel context, simple main effects were conducted to examine age-related changes in the production of [r], [l] and [w]. For all follow up tests Bonferroni adjustments were used to control the Type 1 error rate. There is a significant change in the use of acoustical cues for distinction of [r-l] contrast by English children as a function of age. Thus, spectral acoustical cues such as the difference between F3 and F2 onsets of formant, and the onset of third transition formant change with age. Specifically, with increasing age, the difference between F3 and F2 onsets of the formant transition of the [r] phoneme decreases in both vowel contexts ($F(3,92)=3.67$, $p<.01$), while the same difference for [l] and [w] phonemes does not change with age (Figure 1). Similarly, the onset of F3 formant transition for [r] phoneme decreases rapidly with age ($F(3,92)=13.52$, $p<.0001$), while that for [l] and [w] phonemes decreases only slightly. The temporal cue such as the F1 transition duration or the F1/F2 transition duration does change significantly with age in the [a] vowel context ($F(3,92)=7.17$, $p<.0001$ for [l]; $F(3,92)=8.27$, $p<.0001$ for [r] and $F(3,92)=5.16$, $p<.002$ for [w]). In this context, the ratio of F1 and F2 transition durations for all of three consonants decreases with age. However, this ratio for the [l] phoneme is lower than that for the [r] and [w] phonemes independent of age.

In conclusion, the results obtained in this study demonstrated that in order to produce phonemic contrast it is necessary to perceptually distinguish phonemes. The results revealed that children with lower perceptual scores produce [r] sounds with greater variability and higher values of F3 and 'F3-F2' as well as higher values of temporal cue in [l] phoneme than children with higher perceptual scores. Moreover, the lack of ability to integrate temporal and spectral cues in the perceptual task demonstrated by the younger groups of children was reflected in their poor productive distinction between the [r] and [l] sounds: the duration of the F1 transition and the F3 onset frequency did not differ in the produced [r] and [l] sounds. Thus, it seems that the attainment of productive distinction of a phonemic contrast is closely related to perceptual ability to focus on similarities and/or dissimilarities between a perceptual percept derived from the integrated information of spectral and temporal cues. The mastery of phonemic categorization is acquired during the process of exposure to spoken English. An effective category formation is a lengthy process that depends on the amount of environmental variability necessary for generalization, as well as on the ability to pay attention to a few acoustical cues at the same time. Thus, from the results discussed here and elsewhere, apparently there exists a strong relationship between the perceptual ability to process information about phonemic percept, and its productive execution.

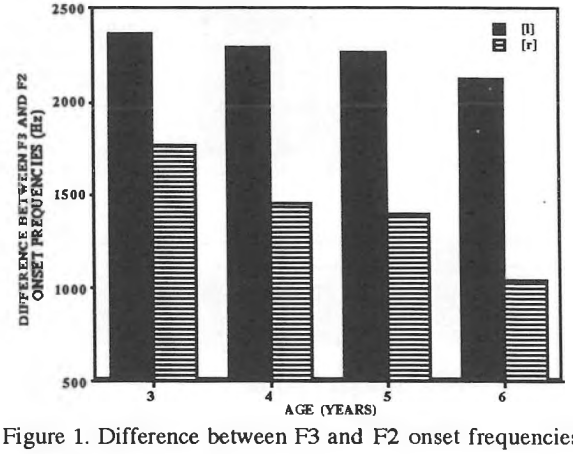

Figure 1. Difference between F3 and F2 onset frequencies for [r] and [l] as a function of age.

ACKNOWLEDGMENT The research was supported by Toronto Hospital for Sick Children Foundation.

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