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Ambient language effects on babbling: pitch contours in Swedish and American 12- and 18-month-olds

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Abstract
Results of a previous listening test have indicated that tonal word accent contours present in 12- and 18-monthers' babbling may provide listeners with perceptually reliable cues to ambient language. In particular, Swedish 18- and, to some extent, 12-monthers were judged to produce more grave accent-like vocalizations than were American English children in the same age-groups.

The present experiment was carried out to evaluate the phonetic substance underlying these listener judgments. It was expected that utterances that had been judged as grave in the listening test would display F0 characteristics typical of Swedish grave accent words, i.e., two-peaked contours with a marked second tone-peak. F0 measurements were made of the same disyllabic babbles that had been used in the listening test.

Results indicated that vocalizations that had been judged as having the grave accent in the listening test differed from those that had not been judged as having the grave accent. Specifically, vocalizations judged as grave displayed higher F0 in the second vowel of the disyllabic vocalizations. Essentially, then, the result supported the view that Swedish 18-monthers (and, to a lesser extent, 12-monthers) may just be beginning to gain command of the tonal aspect of the word accent contrast, and that the relevant tonal contour can be reliably detected in listening.

Introduction
There is a fair agreement that ambient language can influence infants' speech perception at an early age (Kuhl, Meltzoff, 1995, Kuhl, Williams, Lacerda, Stevens, Lindblom, 1992). Thus, experimental evidence has suggested that infants begin to store representations of speech segments in memory as early as at 12 weeks of age (Kuhl, Meltzoff 1995). These representations are thought to form auditory targets that infants try to match in production, thus beginning to establish a ‘perceptual-motor link’.

In spite of many efforts, however, the extent to which babbling is phonetically influenced by ambient language is far from settled, neither is the timing of such an influence (Atkinson, MacWhinney, Stoel, 1968, Boysson-Bardies, Sagart, Durand, 1984, Boysson-Bardies, Sagart, Halle, Durand 1986, 1989, Boysson-Bardies, Vihman, Rough-Hellichius, Durand, Landberg, Arao 1992, Brown 1958, Locke 1983, 1993, Oller, Eilers 1982, Olney, Scholnik 1976, Weir 1966). It is possible, however, that tonal and intonational influences tend to appear earlier than segmental influences (Li, Thompson 1977), one reason being that intonation is a prime phonetic carrier of emotion. Thus, studies of speech directed to Swedish infants (Sundberg 1993, 1998) have demonstrated that mothers tend to enhance tonal word accent contours. Other studies have suggested that expanded tonal movements are efficient in attracting infants’ attention (Fernald, Kuhl 1987).

There is, in fact, some experimental evidence to suggest that tonal features tend to appear relatively early in babbling (Engstrand, Williams, Strömqvist, 1991, Whalen, Levitt, Wang, 1991). Engstrand et al. compared F0 contours in disyllabic utterances produced by 5 Swedish and 5 American English 17-month-olds. The expectation was that the Swedish children would produce more two-peaked F0 contours than the American English children. The reason was, of course, that Swedish children
are heavily exposed to two-peaked pitch patterns associated with the grave tonal word accent. Contrary to expectation, however, no such difference was found at the group level. The single statistically significant effects were 1) that Swedish children displayed a higher second peak in two-peaked utterances than did the American English children, and 2) that Swedish children displayed a higher second peak in grave word candidates as compared to non-grave word candidates. This was an interesting finding in view of the fact that it is the second tone-peak that is particularly affected under emphasis and emotion as well as in infant-directed speech.

In a more recent cross-language study (Engstrand, Williams, Lacerda, 2000) five experienced phoneticians were asked to judge ambient language underlying vocalizations produced by 12- and 18-month-old children acquiring Swedish and American English. There were 8 girls and 8 boys per ambient language and age, thus a total of 64 children. Listeners were encouraged to motivate their choice of ambient language specifying on which language-specific phonetic cues that they had based their response. Results indicated that tonal word accent contours tended to provide reliable cues to ambient language, more so for the productions of the 18-monthers than for those of the 12-monthers. Language-specific segmental properties were reliably discerned just marginally.

The purpose of the present study was to instrumentally verify the listener responses obtained in the Engstrand et al. (2000) listening study. Since F0 is known to be the prime phonetic correlate of the tonal word accents, F0 measurements were made of all disyllabic utterances used in that experiment. It was expected that utterances that had been judged as having the grave accent in the listening test would also display pitch contours with grave accent characteristics. In particular, they would have two-peaked F0 contours with a marked second tone-peak.

Method

Stimuli

The vocalization material consisted of 82 disyllabic babbled utterances (VV, CVCV, CVVC or VCCV) that had been judged by one or several listeners in the previous experiment to carry a grave-like pitch contour. These utterances will henceforth be referred to as the ‘GA stimuli’. Twenty-nine of the utterances were produced by American English children, and 53 were produced by the Swedish children. Another set of 62 disyllabic utterances, that had not been judged by listeners as carrying a grave-like pitch contour (henceforth ‘Non-GA stimuli’), were randomly selected to serve as controls. Of those utterances, 32 were produced by American English children and 30 were produced by Swedish children.

Analysis

All utterances were digitized and acoustically analyzed using the Swell Soundfile editor (AB Nyvalla DSP, 87-98). VC and CV boundaries were identified using conventional acoustic landmarks. F0 maxima and minima were measured in Hz in both vowels, V1 and V2, and filed along with the corresponding time information. F0 values below 55 Hz were discarded. F0 slopes between measurement points were calculated for V1 and V2 using the formula \(F0_{\text{max}} - F0_{\text{min}} / F0_{\text{max}, \text{t}} - F0_{\text{min}, \text{t}}\), where \(F0_{\text{max}, \text{t}}\) and \(F0_{\text{min}, \text{t}}\) represent the time location of the respective F0 maxima and minima.

Results

Figure 1 shows mean F0 max and F0 min (Hz) in V1, and mean F0 max in V2 for Swedish (SW) and American English (AM) 12- and 18-month-olds. The bars above and below the means represent a 95 percent confidence interval. V1 max appear to be slightly higher in the utterances produced by the Swedish children than in those produced by the American English children. In contrast, V1 min are lower in the utterances produced by the Swedish children than in those produced by the American English children. There is, thus, a weak, but statistically non-significant tendency for the Swedish children to produce a somewhat greater F0 fall, i.e., a more grave-like V1 contour, than for the American English children. Also, the slight difference in F0 max in V2 is not statistically significant.

Figure 2 shows mean F0 max and F0 min (Hz) in V1, and F0 max in V2 for stimuli that were judged as not having a grave accent contour in the listening test (Non-GA stimuli, left) vs. the same data for stimuli that listeners did judge as grave (GA stimuli, right). There is no significant
effect of the Non-GA and GA stimuli in $F_0$ max and min in V1. However, the higher $F_0$ max in V2 in the GA stimuli is statistically significant $F(1,142) = 8.640, p<0.004)$. This indicates that stimuli heard as grave in the listening test had a higher second tone-peak than stimuli heard as non-grave. $F_0$ contour slopes presented no significant effects, either across ambient language or stimulus type.

**Figure 1.** Mean $F_0$ max and $F_0$ min (Hz) in V1 and mean $F_0$ max in V2 for Swedish (SW) and American English (AM) 12- and 18-month-olds. The bars above and below the means represent a 95 percent confidence interval.

**Figure 2.** Mean $F_0$ max and $F_0$ min (Hz) in V1 and mean $F_0$ max in V2 for stimuli judged as non-grave (Non-GA, left) and grave (GA, right) in the listening test. The bars above and below the means represent a 95 percent confidence interval.

**Discussion**

Results of a previous listening test (Engstrand et al. 2000) have indicated that tonal word accent contours present in 12- and 18-monthers’ babbling may provide listeners with perceptually reliable cues to ambient language. The present measurements were carried out to evaluate the phonetic substance underlying these listener judgments. The hypothesis was that utterances that had been judged as having the grave accent in the listening test would display $F_0$ characteristics typical of Swedish grave accent words, i.e., two-peaked $F_0$ contours with a marked second tone-peak.

Measurement results comprising all utterances produced by the Swedish and American English children did not show any significant effect of ambient language on any of the $F_0$ parameters tested. This was as expected since the listening test had indicated that the ambient language effect was rather weak and essentially limited to the 18-month-olds. Considered at the group level, then, Swedish 12- and 18-month-olds did not display any measurable evidence of an effect of the ambient language’s grave accent in babbling.

On the other hand, utterances that had been judged as Swedish on the basis of presence of a grave-like pitch contour were found to differ from the remaining utterances. Specifically, stimuli judged as grave turned out to display a higher $F_0$ in the second vowel of these disyllabic vocalizations. This result agrees with that reported in Engstrand et al. (1991), that babbles produced by Swedish 17-month-olds differed in second syllable $F_0$ from babbles produced by American English children of the same age.

The present result also supports the claim made in Engstrand et al. (2000) that at least some Swedish 18-monthers (and, to a lesser extent, Swedish 12-monthers) have just begun to gain command of the tonal aspect of the word accent contrast. This conclusion is justified by the facts 1) that listeners in the Engstrand et al. (2000) experiment correctly classified many utterances as produced by Swedish children on the basis of their tonal properties and 2) that the present measurements have suggested that this was what the listeners actually heard.

In conclusion, then, Swedish children in the age groups studied are influenced by the grave accent to some extent, and expert listeners are able to discern this influence in babbled vocalizations.
References


