

AN ULTRASOUND PILOT STUDY OF NORTH AMERICAN ENGLISH /ɪ/ PRODUCTION IN ONE TYPICALLY DEVELOPING ENGLISH-SPEAKING MONOLINGUAL CHILD

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1. INTRODUCTION

This paper presents an articulatory study of North American English /ɪ/ productions of one typically developing child. North American English /ɪ/ is of interest because it exhibits acoustic stability despite considerable articulatory variability. It is also often one of the last sounds to be acquired by children. While there is a growing body of research on articulatory variability in adult production of /ɪ/ (e.g. Campbell et al., 2010; Mielke et al., 2010), there remains virtually no articulatory data on children's /ɪ/ production during acquisition.

1.2. Child /ɪ/

North American English /ɪ/ is an articulatorily complex sound that has been described as "notoriously difficult for American children to learn to produce" (McGowan et al., 2004, p. 871). Findings on child production of /ɪ/ are often contradictory; Templin (1957) reported that 75% of children were able to produce /ɪ/ in word initial, medial, and final position by age 4, whereas Sander (1972) observed that while over 50% of children began articulating /ɪ/ by age 3, they were not "customarily producing the sound" until age 6 (p. 62), and Smit et al. (1990) listed age 8 as the 'recommended age of acquisition' for /ɪ/. Despite this apparent lack of consensus on developmental trajectories, there is consistent evidence to suggest that children demonstrate the greatest degree of difficulty producing /ɪ/ in prevocalic position. McGowan et al. (2004) reported that children attained adult-like postvocalic and syllabic /ɪ/ by 31 months of age, but showed no evidence of producing prevocalic /ɪ/ at this age. Smit et al. (1990) found that children had more difficulty producing /ɪ/ in word-initial position, and were more likely to use [w] in these contexts.

1.1. Adult /ɪ/

Research on adult production of North American English /ɪ/ suggests a great deal of inter- and intra-speaker variability in articulation. In a cineradiographic study of British and American English speakers' production of /ɪ/, Delattre and Freeman (1968) proposed eight different tongue shapes to describe this variability, frequently observing both 'bunched' (types 3 and 4) and 'retroflexed' (type 7) postures (Fig. 1) within and between speakers of American English. Zawadski and Kuehn (1980) also reported bunched and retroflexed tongue shapes and noted that speakers exhibited a greater degree of lip rounding in prevocalic /ɪ/ contexts. Mielke et al. (2010) observed bunched/retroflexed variability within and between speakers and found that retroflexion rates were highest in prevocalic contexts (and before /l/), and lowest next to coronals, most

likely due to demands placed on the tongue that were antagonistic to retroflexion.

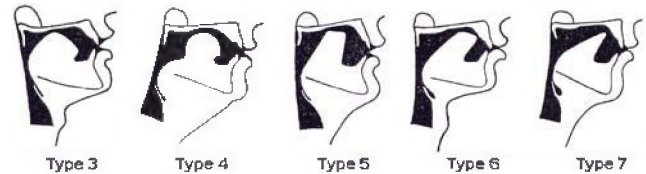


Figure 1. Delattre and Freeman (1968) /ɪ/ shapes reported for rhotic varieties of North American English

2. METHODS

The current study uses ultrasound imaging to investigate the articulations of one typically-developing North American English-speaking monolingual child, aged 4;3, during production of 35 lexical items containing /ɪ/ in prevocalic (e.g. *rocks, frog*), postvocalic (e.g. *car, pear*), and syllabic (e.g. *earth, flower*) contexts. Ultrasound is a safe, non-invasive way of obtaining images of the tongue in real time, making it ideally suited to an investigation of this sort. The experiment was conducted in a soundproof booth and consisted of one 45-minute session that included four short recordings, each approximately five minutes in length. The participant was seated on her mother's lap during recording and a hand-held transducer was placed gently under her chin to capture mid-sagittal views of the tongue during speech. An effort was made to ensure the transducer remained in a constant and stable position relative to the head during recording, despite considerable head movement (an inevitability in research with young children). The participant was asked to identify photographs of familiar objects presented to her one at a time on a computer screen positioned in front of her, and prompted with 'this is a ___' or 'we call these ___'. Audio was recorded in mono at a sampling rate of 44.1 kHz. A condenser microphone positioned near the speaker's mouth was connected to a USBPre preamp and A/D converter outside the booth, which was connected to a computer running Audacity software. Ultrasound was recorded using a Terason T3000 portable ultrasound machine. Video was recorded with a USB video camera, and UltraSpeech software was used to capture ultrasound and video images, at a rate of 30 fps. Audio tokens were coded impressionistically as adult-like, non-adult-like, or near-adult-like by the researcher and one other coder. Only tokens where consensus was reached were included in the analysis. Praat was used to determine formant values. Video and ultrasound images were inspected visually in order to code for tongue shape and lip rounding at the peak (most /ɪ/-like point) of each /ɪ/ gesture.

3. RESULTS

The participant accurately named all target items with the exception of ‘crow’, which was identified as ‘bird’ and included as a syllabic token. In total, at least two repetitions of each target were recorded. Preliminary coding of 63 audio tokens showed adult-like productions in 38 of 40 postvocalic and syllabic targets, and non-adult-like productions (generally [w]-like) in 15 of 23 prevocalic targets. The remaining 8 prevocalic targets consisted of near-adult-like productions and only included targets that were adjacent to coronal segments (*mushrooms*, *tree*, *truck*, *stripes*, *Shrek*). Analysis of video and ultrasound images showed type 4 tongue shapes consistently in postvocalic and syllabic positions, with characteristic concavity at the tongue dorsum and a bunched, tip down posture (e.g. Fig. 2, *pear* and *sunflower*). There was an absence of /ɪ/-like tongue shapes in prevocalic targets coded as non-adult-like (e.g. Fig. 3, *road* and *zebra*), however, a pattern emerged in prevocalic, coronal-adjacent targets, where tongue shape at the peak of the near-adult-like gesture closely resembled the shape of the preceding coronal (e.g. Fig. 4, *mushrooms*). Lip rounding was generally observed in all prevocalic contexts, as expected.

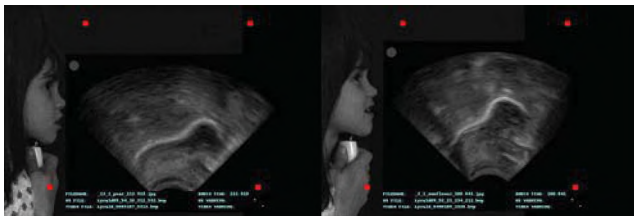


Figure 2. Type 4 /ɪ/ gestures - *pear* (L), *sunflower* (R).

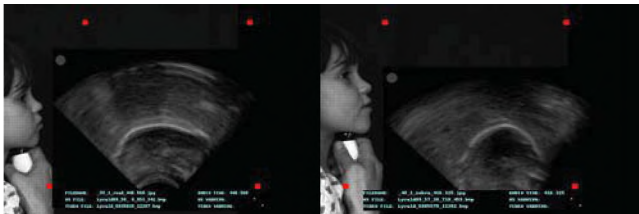


Figure 3. Non-adult-like gestures - *road* (L) and *zebra* (R).

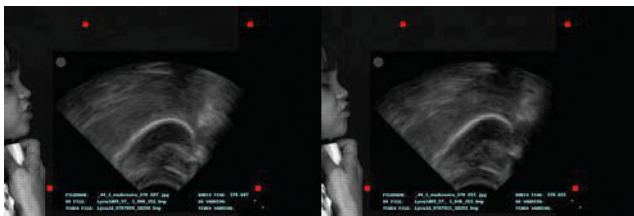


Figure 4. Coronal /f/ gesture (L) with adjacent near-adult-like gesture (R) - *mushrooms*.

4. DISCUSSION AND CONCLUSIONS

Preliminary results indicate an established bunched /ɪ/ production strategy for this participant in postvocalic and syllabic, but not prevocalic, contexts. These findings are consistent with child /ɪ/ production literature on the developmental lag in prevocalic contexts during acquisition.

While the participant’s prevocalic productions demonstrated no overt /ɪ/ gestures, she may be exhibiting an early-stage production strategy in prevocalic contexts next to coronals. These targets, coded during the audio stage as near-adult-like, were produced with tongue shapes similar to those found in the preceding coronal segments and not unlike bunched /ɪ/s, suggesting that coronals may play a facilitative role during acquisition of prevocalic /ɪ/. Mielke et al. (2010) reported that adult’s retroflexed tongue postures were most likely to occur in prevocalic position and least likely to occur next to coronals. Tiede et al. (2011) have argued that children might attempt different vocal tract configurations during acquisition, particularly in contexts where the articulatory demands are greater. It is conceivable that the participant could develop a retroflex strategy for non-coronal adjacent prevocalic /ɪ/, which would be consistent with a common adult pattern. If there is a relationship between articulatory variability during /ɪ/ production in childhood and covert variability observed in adulthood, children’s acquisitional trajectories will prove informative. While reported findings are preliminary and based on the productions of one child, they provide strong motivation for longitudinal research with more than one participant.

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