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Acoustic characterization of the question-statement contrast in 4, 7 and 11 year-old children

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Abstract

Prosodic features of the speech signal include fundamental frequency (F0), intensity and duration. In order to study the development of prosody independent from segmental aspects of speech, we considered the question-statement contrast. In English, adults mark the contrast using changes in fundamental frequency, duration and intensity, with F0 being the most prominent cue. Declarative questions are marked by rising intonation whereas statements are marked by falling intonation. While previous studies have noted that young children can signal this contrast in imitative paradigms, little is known about the acoustic cues children use at different stages in development. The present study sought to provide an acoustic characterization of prosodic cues used by 12 children from three age groups, 4-year-olds, 7-year-olds and 11-year-olds, for elicited productions of declarative statements and questions. Results indicated that 4-year-olds were unable to reliably signal questions using rising fundamental frequency contour. Instead, they used increased final syllable duration to mark questions. Children in the 7-year-old group used all three cues, fundamental frequency, intensity and syllable duration, to contrast questions from statements. The oldest group relied primarily on changes in fundamental frequency and less so on intensity and duration cues. An age-related pattern is evident in that children employ different combinations of acoustic cues to mark the question–statement contrast across development. The impact of motor and cognitive-linguistic complexity on the development of prosodic curve is discussed.

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1. Introduction

Prosody, the variations in pitch, stress, and timing of speech, can be quantified in terms of funda-

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mental frequency (F0), intensity and duration (Bolinger, 1989; Lehiste, 1976; Netsell, 1973). These acoustic cues are employed individually or in concert to play various linguistic and communicative roles such as to attract attention, to signal given versus new information, to distinguish kinds of speech acts (e.g., questions versus statements), to contrast the meaning of an utterance, to convey

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affective state, and to achieve many other functions. Prosodic manipulations have been noted in the earliest communicative gestures, such as infant cries (Gilbert and Robb, 1996; Lind and Wermke, 2002; Protopapas and Eimas, 1997; Wermke et al., 2002). Recent findings indicate that people with severely impaired speech can also control prosody despite little or no segmental (speech sound) clarity (Patel, 2002, 2003, 2004; Vance, 1994; Whitehill et al., 2001). While there was a time when prosody was thought of as merely an overlaid signal on top of the "meaningful" segmental units, the interconnections between prosodic cues and speech segments are now widely acknowledged. In fact, over the past few decades, some researchers have suggested that typical development of prosodic control precedes and may facilitate segmental control (Bloom, 1973; Crystal, 1978; Katz et al., 1996; MacNeilage and Davis, 1993; Menyuk and Bernholtz, 1969; Snow, 1994).

The prosody of questions varies across languages and question types (Bolinger, 1989; Geluykens, 1988; Hirst and Di Cristo, 1998; House, 2002; Ladd, 1996). In English, the meaning of declarative statements (e.g., "He plays piano.") can be contrasted from declarative questions (e.g., "He plays piano?") using prosodic cues alone; declarative statements are marked by falling intonation whereas declarative questions are generally¹ marked by rising phrasefinal intonation (Cruttenden, 1981; Lieberman, 1967; Hirst and Di Cristo, 1998). In this paper, we focus on children's production of this grammatical (or attitudinal²) distinction because it provides a lens into the development of prosody independent from segmental aspects of speech. Previous studies on acquisition of intonation have focused on young children, noting that by age five children can signal question phrase-final intonation in imitative paradigms (Allen and Hawkins, 1980; Loeb and Allen, 1993; Snow, 1994, 1998). It is acknowledged, however, that prosodic control for a variety of linguistic and affective tasks continues to develop beyond age five and into the early teens (Cruttenden, 1985; Crystal, 1986; Local, 1980; Wells et al., 2004) suggesting that

¹ While it is commonly assumed that declarative questions have a rising pitch contour, Geluykens (1988) did not find empirical evidence of this pattern in spontaneous speech.

² Some argue that this distinction between declarative statements and questions is attitudinal in that the statement conveys certainty while the question form conveys surprised doubt (Cruttenden, 1981).

the acoustic profile of the question-statement contrast may undergo change across childhood.

Acoustic correlates of phrase-final intonation for declarative questions versus statements in English speaking adults include changes in F0, duration, and intensity, with F0 being the most prominent cue (Cruttenden, 1986; Lieberman, 1967). Lieberman (1967) found that read statements such as "Joe ate the soup" were characterized by a falling terminal F0 whereas the question form "Joe ate the soup?" was marked by rising terminal F0. These changes in F0, however, may not be restricted to the phrase-final syllable. O'Shaughnessy (1979) found that questions were marked by a rising F0 throughout the entire sentence. Recently, Srinivasan and Massaro (2003) noted that statements and questions can be discriminated on the basis of F0 contour, amplitude, and duration cues. Thus, even within the adult literature there appear to be individual differences in the acoustic cues that speakers use in order to mark the question-statement contrast. This transfer of informational cues between prosodic features has been referred to as *cue trading* (Howell, 1993; Lieberman, 1960). Given that the acquisition of motor control of speech happens in parallel with general motor development, cognitive development and language learning, we hypothesized that children at different stages in development may also employ cue trading strategies that rely on different cue combinations to signal prosodic contrasts.

While the acquisition of phrase-final intonation has been studied to some extent, the predominant methodology has been comparative studies across development with imitation protocols being used to elicit contrasts from young children. In terms of falling intonation, Snow (1994) conducted a longitudinal analysis of nine girls between 16 and 25 months of age to examine phrase-final falling of F0 for declarative statements and phrase-final lengthening. Snow's study sought to determine whether phrase-final falling and lengthening resulted from one another or if they were independent. Results indicated that younger children acquired control of intonation earlier than duration. He found that phrase-final lengthening did not appear until the two-word phase (early syntax) and was judged to be a learned behavior.³ In fact,

³ It should be noted that there are cross linguistic differences in phrase-final lengthening, with English having more extreme lengthening compared to other languages (Oller and Smith, 1977).

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