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Statistical learning of speech sounds is most robust during the period of perceptual attunement

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ABSTRACT

Although statistical learning has been shown to be a domain-general mechanism, its constraints, such as its interactions with perceptual development, are less well understood and discussed. This study is among the first to investigate the distributional learning of lexical pitch in non-tone-language-learning infants, exploring its interaction with language-specific perceptual attunement during the first 2 years after birth. A total of 88 normally developing Dutch infants of 5, 11, and 14 months were tested via a distributional learning paradigm and were familiarized on a unimodal or bimodal distribution of high-level versus high-falling tones in Mandarin Chinese. After familiarization, they were tested on a tonal contrast that shared equal distributional information in either modality. At 5 months, infants in both conditions discriminated the contrast, whereas 11-month-olds showed discrimination only in the bimodal condition. By 14 months, infants failed to discriminate the contrast in either condition. Results indicate interplay between infants' long-term linguistic experience throughout development and short-term distributional learning during the experiment, and they suggest that the influence of tonal distributional learning varies along the perceptual attunement trajectory, such that opportunities for distributional learning effects appear to be constrained in the beginning and at the end of perceptual attunement. The current study contributes to previous research by demonstrating an effect of age on learning from distributional cues.

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Introduction

Statistical learning is the ability to extract statistical regularities and learn from the ambient environment (Kirkham, Slemmer, & Johnson, 2002; Saffran, Johnson, Aslin, & Newport, 1999). This domain-general learning mechanism plays a key role in various aspects of cognitive development across the lifespan (Conway & Christiansen, 2005; Escudero & Williams, 2014; Krogh, Vlach, & Johnson, 2013; Saffran, Aslin, & Newport, 1996; Turk-Browne, Jungé, & Scholl, 2005). In the linguistic domain, statistical learning has been shown to facilitate the acquisition of phonetic categories (Wanrooij, Boersma, & Van Zuijen, 2014) and words (Saffran et al., 1996). Sounds from different categories within a language overlap not only in speech production but also in the mental representation of phonetic space. To acquire native categories, infants must pay attention to and use the distributional frequency of speech sounds (Saffran et al., 1999). The current study focused on a specific type of statistical learning—learning from frequency distributions, arguably used in phonetic category formation among infants.

Since the introduction of the frequency distribution model by Maye, Werker, and Gerken (2002), several variations have been used to test how input statistics can alter rapid phonetic category learning and discrimination in infants. In their pioneering work, Maye and colleagues created a continuum of speech sounds based on a voiced versus voiceless unaspirated stop consonant contrast ([ta]–[da]) and exposed infants to the full continuum of stimuli arranged with unimodal or bimodal frequency distributions. Phonetic distributional learning studies typically involve these two statistical distributions, differing in the number of Gaussian peaks (tokens with relatively high frequency) along a phonetic continuum (Fig. 1). A unimodal distribution is characterized by one peak, corresponding to single category learning. In contrast, a bimodal distribution is marked by two different peaks, corresponding to the learning of two categories. Infants are familiarized with one of the two types of frequency distributions, followed by a measurement of their discrimination ability of tokens presented with equal frequency in the two distributions.

A recent study demonstrates very young infants' rapid distributional learning ability. Dutch infants of 2–3 months were presented with either a unimodal or bimodal distribution based on the English /æ/–/ε/ vowel contrast—a non-native contrast in Dutch—during sleep. Following a 12-min exposure phase, larger mismatch responses were found in the bimodally trained infants when compared with

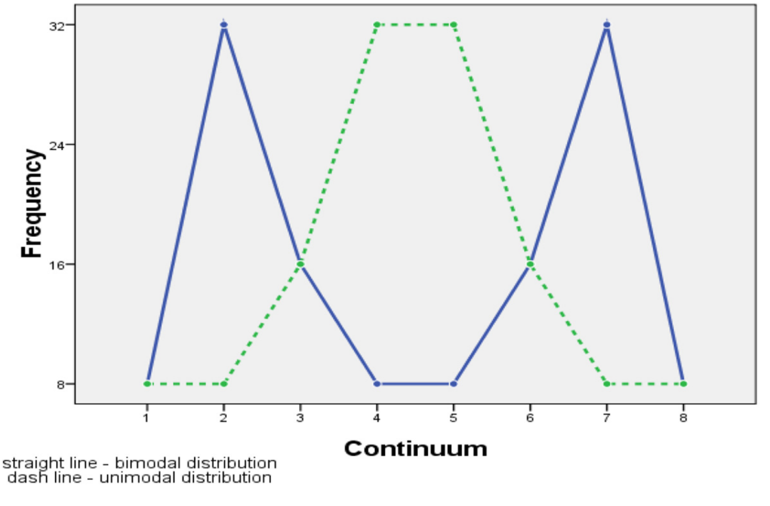

Fig. 1. Example of unimodal (dotted line) and bimodal (solid line) frequency distributions. In Maye et al. (2002), Token 1 represents the endpoint [da] stimulus and Token 8 represents the endpoint [ta] stimulus on the abscissa. The ordinate axis shows the presentation of frequency during familiarization.