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Spoken word recognition in early childhood: Comparative effects of vowel, consonant and lexical tone variation

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ABSTRACT

The majority of the world's languages exploit consonants, vowels and lexical tones to contrast the meanings of individual words. However, the majority of experimental research on early language development focuses on consonant–vowel languages. In the present study, the role of consonants, vowels and lexical tones in emergent word knowledge are directly compared in toddlers (2.5–3.5 years) and preschoolers (4–5 years) who were bilingual native learners of a consonant–vowel–tone language (Mandarin Chinese). Using a preferential looking paradigm, participants were presented with correct pronunciations and consonantal, vowel, and tonal variations of known words. Responses to each type of variation were assessed via gaze fixations to a visual target. When their labels were correctly pronounced, visual targets were reliably identified at both age groups. However, in toddlers, there was a high degree of sensitivity to mispronunciations due to variation in lexical tones relative to those due to consonants and vowels. This pattern was reversed in preschoolers, who were more sensitive to consonant and vowel variation than to tone variation. Findings are discussed in terms of properties of tones, vowels and consonants and the respective role of each source of variation in tone languages.

1. Introduction

The ability to correctly identify the sounds used to contrast meaning in one's native language is essential to language development. This set of sounds, the native phonological inventory, must be acquired and appropriately integrated into word representations in order to initiate and sustain the growth of a vocabulary. Thus far, experimental research on this process has focused almost exclusively on particular types of languages, such as English and French. These types of languages define changes in meaning by varying vowels and consonants. However, most children learn a native language where meaning is contrasted by three sources of phonemic variation: vowels, consonants and tones (Fromkin, 1978). Approximately 70% of the world's languages are tone languages (Yip, 2002). As such, much of what is known about early phonological and lexical development does not capture the linguistic environment in which the majority of learners are immersed. On account of a near-exclusive focus on vowels and consonant systems in experimental research, a major theoretical gap exists with regards to our collective understanding of the role of lexical tones in the emergent lexicon. Moreover, there have been no direct comparisons of children's sensitivity to vowels, consonants and tones as determinants of word meaning. This scenario is potentially limiting, as theories of language development would optimally draw from the natural phonological diversity manifest in human language. An absence of comparative research from tone languages necessarily constrains our interpretation of both research and

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theory in early language development, providing a strong impetus to investigate the acquisition of lexical tones alongside vowels and consonants. The purpose of the current study is to directly compare the development of consonant, vowel and tone sensitivity in one domain of language acquisition: spoken word recognition.

One approach to researching children's sensitivity to phonological variation in word recognition has been to investigate children's abilities to recognize familiar objects when their labels are mispronounced (e.g. Dietrich, Swingley, & Werker, 2007; Havy & Nazzi, 2009; Mani & Plunkett, 2008, 2011; Nazzi, 2005; Nazzi & New, 2007; White & Morgan, 2008). Mispronunciation studies have been conducted using a variety of paradigms, such as habituation, name-based categorization and preferential looking. Preferential looking approaches typically involve presenting children with two visual objects: a target and a distractor. In a common instantiation of this paradigm, children view both objects for a short duration of time (the pre-naming phase). After this phase, a verbal label is presented for an equal duration of time (the post-naming phase). In some trials, the verbal label is correctly produced whereas in others, the label is mispronounced. Proportionate gaze fixations to the visual target are compared prior to and following the production of the verbal label to determine whether the target was identified as an appropriate referent in trials when labels were correctly pronounced versus when they were mispronounced.

Comparisons of mispronunciation effects for vowels and consonants have yielded mixed results, which have been partially attributed to differences in linguistic functions served by vowels and consonants (Nespor, Peña, & Mehler, 2003). In infants and toddlers, some studies have suggested that consonants are more prominent than vowels in early lexical representations, demonstrating that consonant substitutions compromise target recognition to a greater extent than vowel substitutions (Havy & Nazzi, 2009; Nazzi, 2005; Nazzi, Floccia, Moquet, & Butler, 2009). Other studies have suggested that consonant and vowel substitutions influence word recognition in equal measure and that both types of segments are represented with equivalent strength in the developing lexicon (e.g. Floccia, Nazzi, Delle Luche, Poltrock, & Goslin, 2013; Mani & Plunkett, 2007). In the case of both vowels and consonants, sensitivity to mispronunciations appears to vary depending on the specific contrast used (Curtin, Fennell, & Escudero, 2009; Mani, Coleman, & Plunkett, 2008; Mani & Plunkett, 2008, 2011; Van der Feest, 2007; White & Morgan, 2008). Mispronunciation studies are not limited to infants and toddlers: in a study assessing mispronunciations in preschoolers, they demonstrate a transient phase of comparable sensitivity to vowel and consonant changes (Havy, Bertoncini, & Nazzi, 2011).

In contrast to vowel and consonant variation, there have been no studies thus far to investigate effects of tone variation on familiar word recognition in native tone language learners. However, several studies have investigated tone sensitivity in discrimination paradigms as well as the integration of tones into novel words. For example, infants raised in a tone language environment appear to orient toward native tone categories prior to attuning to native vowel and consonant contrasts (Yeung, Chen, & Werker, 2013). In auditory word segmentation, tone language learning infants appear to integrate tones into word-forms in a language-specific manner by 11 months (Singh & Foong, 2012). Later, by 18 months, toddlers learning a tone language integrate lexical tones into newly learned words (Singh, Tam, Chan, & Golinkoff, 2014). Finally, studies with preschool and school-aged children demonstrate that native tone language learners can discriminate familiar words based on lexical tone with a high level of accuracy in auditory discrimination experiments (Burnham et al., 2011; Ciocca & Lui, 2003; Wong, Ciocca, & Yung, 2009). It should be noted that while the focus of these studies was auditory discrimination of tones, Ciocca and Lui (2003) and Wong et al. (2009) measured discrimination via a picture-pointing paradigm. In these paradigms, target words represented minimal tone contrasts. These paradigms are therefore similar to preferential looking in task demands, although data are derived from participants' explicit verbal responses. In combination, these studies have advanced our understanding of the development of lexical tones by demonstrating a sustained sensitivity to native tone contrast from infancy to early childhood. However, the extent to which language learners are sensitive to tones in comparison to vowels and consonants remains unclear.

When considering why vowels, consonants and tones may exert differential effects on word recognition, a potentially relevant factor is that each of these sources of lexical contrast is compositionally distinct. Lexical tone is defined by syllable-level shifts in fundamental frequency (voice-sourced pitch). Secondary determinants of tone include duration, amplitude and voice quality (Howie, 1976), although native tone identification rests primarily on measures of fundamental frequency (Gandour, 1978, 1983; Kuo, Rosen, & Faulkner, 2008). In contrast to tones, vowels are primarily characterized by the height of the first three formants, and identified principally by the first and second formants (Reetz & Jongman, 2008). Like tones, vowels are defined by high concentrations of energy at lower frequencies and represent long-term, steady-state components of speech (Abramson, 1978). In further contrast to vowels and tones, consonants are defined by energy maxima at higher frequencies relative to tones and vowels and represent brief acoustic events, theoretically defined as formant transitions (Ladefoged, 2001). The structural distinctiveness of tones, vowels and consonants may lead us to venture that these three sources of phonological variation may impact upon lexical development in different ways.

The goal of the present study was to investigate the relative impact of vowel, consonant and tone identity on emergent word knowledge in toddlers and preschool children. Previous studies investigating novel word learning have revealed that tone is recognized to be phonemic in toddlers: language-specific integration of lexical tone into word learning is evident at 2 years of age (Singh et al., 2014). As such, responses to mispronunciation effects were studied within a sample of toddlers (2.5–3.5 years), when vowels, consonants and tones are likely to be recognized as lexically relevant and substitutions in any of these phonemes treated as a mispronunciation. Our primary focus was on children's relative sensitivity to tone, vowel and consonant substitutions when recognizing spoken words.