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How who is talking matters as much as what they say to infant language learners

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ABSTRACT

Human vocalizations contain both voice characteristics that convey who is talking and sophisticated linguistic structure. Inter-talker variation in voice characteristics is traditionally seen as posing a challenge for infant language learners, who must disregard this variation when the task is to detect talkers' shared linguistic conventions. However, talkers often differ markedly in their pronunciation, vocabulary, and grammar. This is true even in monolingual environments, given factors like gender, dialect, and proficiency. We therefore asked whether infants treat the voice characteristics distinguishing talkers as a cue for learning linguistic conventions that one talker may follow more closely than another. Supporting this previously untested hypothesis, 12-month-olds did not freely combine two talkers' sentences distinguished by voice to more robustly learn the talkers' shared grammar rules. Rather, they used this voice information to learn rules to which only one talker adhered, a finding replicated in same-aged infants with greater second language exposure. Both language groups generalized the rules to novel sentences produced by a novel talker. Voice characteristics can thus help infants learn and generalize talker-dependent linguistic structure, which pervades natural language. Results are interpreted in light of theories linking language learning with voice perception.

1. Introduction

Vocal signals transmit biologically important information for a variety of species. For some species, vocal signals transmit not only voice characteristics that reflect gender and individual identity, but also a communication code (Fitch, 2000). Human vocalizations in the form of speech transmit one such code that is highly sophisticated—a language with abstract grammatical structure that, once learned, can be used to comprehend and form novel sentences expressing novel ideas.

Research on language development has emphasized that voice characteristics reflecting who is talking can vary orthogonally to linguistic structure (Graf Estes & Lew-Williams, 2015; Houston & Jusczyk, 2000, 2003; Jusczyk, Pisoni, & Mullenix, 1992; Rost & McMurray, 2010; Seidl, Onishi, & Cristia, 2013; Singh, 2008; Singh, White, & Morgan, 2008; van Heugten & Johnson, 2012). For example, average pitch may vary considerably across two talkers uttering the same word or sentence. Research has long demonstrated that such "paralinguistic" variation can disrupt infants' encoding (Graf Estes & Lew-Williams, 2015; Jusczyk et al., 1992) and detection (see Newman, 2008) of talkers' common linguistic structure. Therefore, this variation is traditionally viewed as posing a challenge for infant language learners. Yet while this variation can no doubt vary orthogonally to linguistic structure, in practice it often *co-varies* with linguistic structure. This is because one talker often differs from another not only in voice but also in language usage. Talkers often differ in language usage owing to a variety of everyday factors, including gender, dialect, and proficiency

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(Dąbrowska, 2012; Labov, 1973; Li, et al., 2016). Developmental research has hardly overlooked such sociolinguistic variation, but has for the most part considered infants' sensitivity to voice variation separately.

1.1. Voice variation may cue infant learners to talker-dependent structure

Since voice characteristics convey who is talking at the same time as that person's pronunciation, vocabulary, and grammar are all being conveyed, this information may cue infant learners to linguistic norms associated with certain talkers—even at the level of abstract grammar. If Talker A adheres to abstract grammar rules that Talker B frequently violates, then the voice characteristics distinguishing Talker A from Talker B offer a reliable cue for learning those rules. This hypothesis builds on speculation in the bilingual literature concerning how infants learn two languages in parallel with minimal cross-language interference. A number of investigators speculate that infants exploit a broad range of probabilistic cues to the language currently being spoken (Curtin, Byers-Heinlein, & Werker, 2011; Mitchel & Weiss, 2010; Weiss, Gerfen, & Mitchel, 2009; Weiss, Poepsel, & Gerfen, 2015). The range that these investigators have in mind is not confined to linguistic cues, which have received focal attention in the past (e.g., Bosch & Sebastián-Galles, 2001; Mehler, Dupoux, Nazzi, & Dehaene-Lambertz, 1996; Sundara & Scutellaro, 2011). Rather, it also includes contextual cues like who is talking. The hypothesis under consideration in the present study concerns the more general challenge, relevant to monolingual and bilingual infants alike, of negotiating sociolinguistic variation. It therefore extends to questions concerning how infants in general might learn the linguistic norms of talkers of their own gender (Li et al., 2016), of talkers modeling their own mother tongue (Christophe & Morton, 1998; Jusczyk, 1993; Mehler et al., 1996), and of talkers modeling the dominant linguistic system in their own language community (Chambers, 2005; Floccia, Delle Luche, Durrant, Butler, & Goslin, 2012; Gonzales, Gerken, & Gómez, 2015; Koenig & Harris, 2005; Labov, 2008). On our hypothesis, voice characteristics distinguishing one talker from the next might cue infant learners to such talker-dependent structure.

Consider when an infant hears a given language from two caregivers, but only one caregiver learned the language as a native language (L1); the other learned it as a second language (L2) in adulthood (late L2 learner). Voice characteristics distinguishing these two language models might cue the infant to conventions of the language that only the native-speaking model closely follows. For example, individuals who learn a language with agreement morphology as a native language typically learn this aspect of the grammar much better than late L2 learners of the language. Such a native-learning advantage is particularly well documented in research on gender agreement, in which nouns are divided into gender classes, and words linked to the nouns must take gender-congruent forms. In Spanish, for example, nouns are divided into masculine and feminine classes. Determiners must take masculine forms like *un* and *el* when linked to masculine nouns (e.g., *un/el chico*, '$a_{[masc]}$/$the_{[masc]}$ $boy_{[masc]}$') but feminine forms like *una* and *la* when instead linked to feminine nouns (e.g., *una/la chica*, '$a_{[fem]}$/$the_{[fem]}$ $girl_{[fem]}$'). Native Spanish learners master this grammatical system very early on. By age 3, they rarely make agreement errors, like pairing a feminine determiner with a masculine noun or masculine determiner with a feminine noun (Bedore & Leonard, 2005). In contrast, late L2 learners show persistent difficulty with this system, making significantly more such errors even after learning the language for many years and attaining high proficiency in other respects (Montrul, Foote, & Perpiñán, 2008). These learners' agreement errors are seen as resulting from processing or representational deficits under communicative pressure (Montrul et al., 2008).

When an infant receives Spanish input from both a caregiver who learned the language as a native language and a caregiver who learned it as an L2 in adulthood, the infant may have difficulty learning the gender agreement system by freely combining these two caregivers' input. The infant may learn this system more readily by instead keeping these caregivers' input separate, using contextual information like talker voice. Through such "talker segregation", the infant may manage to learn how the native-speaking caregiver pairs words separately from how the error-prone nonnative-speaking caregiver does so. Importantly, the native-speaking caregiver's word pairings are likely to be more consistent not only in terms of gender congruency between the specific words themselves (e.g., $un_{[masc]}$ pairs with $chico_{[masc]}$), but also in terms of more abstract morpho-phonological relations cueing this congruency. Such morpho-phonological relations exist between the masculine determiners and masculine nouns' canonical final vowel *–o* (e.g., ***un/el chico***). They also exist between the feminine determiners and feminine nouns' canonical final vowel *–a* (e.g., ***una/la chica***). These morpho-phonological relations are likely to be weaker in the late L2 learner's input because late L2 learners are more likely to pair determiners with gender-incongruent nouns even when these nouns are overtly marked for gender (e.g., ****el chica***; Montrul et al., 2008). Learning how the native-speaking caregiver pairs words more or less independently of how the nonnative speaking caregiver pairs them may therefore facilitate grammar learning at the level of these abstract relations. The ability to learn these relations is of interest because they may function as "frequent frames" (Mintz, 2003), or joint cues more generally (Gerken, Wilson, & Lewis, 2005), for grouping nouns into separate gender classes (see Lew-Williams & Fernald, 2010). They may also provide a basis for linking an overtly marked masculine or feminine noun to a gender-congruent determiner that has not yet been heard together with that particular noun (Braine, 1987). Infants possess this type of linking capacity as early as 12 months of age (Gómez & Lakusta, 2004).

Our hypothesis can be understood in terms of exemplar models of language development like WRAPSA (Jusczyk, 1993, 1997) and PRIMIR (Werker & Curtin, 2005; Curtin et al., 2011). In these models, instances of linguistic patterns (e.g., word forms) are encoded in memory as acoustically detailed memory traces, or exemplars, that incorporate paralinguistic information like voice characteristics. Exemplars cluster together based on perceptual similarity. Linguistic abstractions emerge when information is combined across a cluster of exemplars to reveal their common structure. These models thus allow for the possibility that infants learn abstract talker-dependent rules by combining information across exemplars from the relevant talker(s) clustering by voice.

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