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Gradient language dominance affects talker learning

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ABSTRACT

Traditional conceptions of spoken language assume that speech recognition and talker identification are computed separately. Neuropsychological and neuroimaging studies imply some separation between the two faculties, but recent perceptual studies suggest better talker recognition in familiar languages than unfamiliar languages. A familiar-language benefit in talker recognition potentially implies strong ties between the two domains. However, little is known about the nature of this language familiarity effect. The current study investigated the relationship between speech and talker processing by assessing bilingual and monolingual listeners' ability to learn voices as a function of language familiarity and age of acquisition. Two effects emerged. First, bilinguals learned to recognize talkers in their first language (Korean) more rapidly than they learned to recognize talkers in their second language (English), while English-speaking participants showed the opposite pattern (learning English talkers faster than Korean talkers). Second, bilinguals' learning rate for talkers in their second language (English) correlated with age of English acquisition. Taken together, these results suggest that language background materially affects talker encoding, implying a tight relationship between speech and talker representations.

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1. Introduction

Recent studies suggest a relationship between knowing a language and ability to identify talkers in that language (Goggin et al., 1991; Johnson et al., 2011; Perrachione et al., 2011; Sullivan and Schlichting, 2000; Winters et al., 2008). This radically departs from a viewpoint that speech processing operates over an abstract set of symbols. However, it is not clear what degree of language experience, or what specific *type* of language experience is relevant for talker recognition. On one hand, some studies suggest that limited exposure to a new language is sufficient to facilitate recognition of voices in that language (Sullivan and Schlichting, 2000, in adults; Johnson et al., 2011, in 7-month-olds). On the other hand, other studies suggest that the language-talker relationship is more complex. For instance, listeners are better at learning to identify voices in their native language than in a foreign language (Goggin et al.; Winters et al.). Further, Perrachione et al. recently showed that dyslexic listeners' degree of phonological impairment predicted difficulty in a talker learning task in a familiar (but not an unfamiliar) language. This suggests a link between subtle phonetic knowledge and talker identification. However, it leaves open the possibility that dyslexic listeners had broader deficits in auditory processing, rather than a linked deficit in phonological encoding and talker identification.

A different approach to investigating the link between language knowledge and talker recognition would be to assess normal listeners with extensive language experience but weaker phonetic knowledge—specifically, second-language listeners (Flege, 1988; Flege et al., 2006). If lengthy experience with a language permits excellent talker recognition in that language, then late but skilled learners should be good at talker recognition. However, if *subtle phonetic knowledge* acquired both over the long term and early in life is key, then early learners of a second language

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should be far more adept than late learners at talker recognition in that language.

The goal of the current study was to understand the relationship between language knowledge and listeners' abilities to encode talker characteristics. What role does one's language background play in learning to recognize voices? Below, we review evidence for and against connections between speech processing and talker recognition. We then describe a study designed to elucidate the nature of the relationship between these two abilities.

1.1. Evidence for interaction between speech processing and talker recognition

The speech signal contains not only linguistic information—*what is said*—but also information about the talker—*who says it*. Like vocal communication systems in other species (birds: Falls, 1982; primates: Cheney and Seyfarth, 1980), human speech contains acoustic cues that listeners use to recognize, for example, a talker's age, gender, race, emotional state, and their identity (Perrachione et al., 2010; Ramig and Ringel, 1983; Williams and Stevens, 1972).

A number of behavioral studies suggest that talker-specific acoustic cues are intertwined with speech recognition, with each affecting the other. First, talker variability affects speech processing. Listeners are better able to understand speech from familiar talkers than unfamiliar ones (Nygaard and Pisoni, 1998). Presenting words consistently from the same talker facilitates recognition of a previously presented word as familiar (Goldinger, 1996; see also Church and Schacter, 1994; Schacter and Church, 1992), and provides an extra cue for distinguishing phonologically similar words (Creel et al., 2008; Creel and Tumlin, 2011). Further, identification of speech sounds (Magnuson and Nusbaum, 2007; Nusbaum and Morin, 1992) and words (Mullennix et al. 1989; Nusbaum and Morin, 1992) in a sequence of elements is impaired when the talker changes from element to element. This suggests that variation in talker properties interferes with speech sound identification. One could interpret this to mean that listeners cannot selectively allocate attention to speech sound properties alone. Each of these lines of work suggests that talker information has effects on speech sound processing.

Additional studies suggest that the converse is also true—language knowledge affects talker recognition. Johnson et al. (2011) showed that 7-month-old infants detected a talker change in their native language (Dutch), but not in other languages. Sullivan and Schlichting (2000) looked at voice recognition among adults who had just begun studying a second language. They found an initial improvement in voice recognition after one semester of exposure, but multiple additional years of second-language study did not generate further improvement. However, this study did not include native-speaking controls, and the voice stimuli used were all intended to imitate the same voice. Additional studies have examined native listeners of varied abilities. Perrachione et al. (2011) found that individual dyslexic listeners' degree of impairment in phonological processing predicts their ability to recognize voices in their native language. Goggin et al. (1991) demonstrated that monolingual English speakers identified English-German bilinguals' voices better when those individuals spoke English than when they spoke German (see also Winters et al., 2008). On the other hand, Goggin et al. observed *no* significant difference in voice recognition abilities for English–Spanish bilinguals who were tested on English- vs. Spanish-speaking voices. They suggested that bilinguals might be equally able to recognize voices from either language since they have extensive knowledge of both. Finally, Perrachione et al. (2010) found that listeners even identified talkers better in their own *dialect* (General American vs. African-American English), suggesting that phonetic/phonological familiarity, alone or in conjunction with lexical familiarity, may underlie the language-familiarity effect.

Together, these studies suggest that differences in language processing are correlated with voice recognition. What remains unclear is *how much* (months? years?) and *what type* of language knowledge (lexical? phonological? phonetic?) is necessary for good talker recognition. Studies showing language-specific talker recognition benefits in infants (Johnson et al., 2011) and new language learners (Sullivan and Schlichting, 2000) suggest that relatively little exposure—months—is needed for language effects on talker recognition to emerge. However, if there is a strong relationship between speech-sound knowledge and talker recognition, then one would expect any differences in language exposure to affect talker recognition in that language.

1.2. Evidence for separation of talker and speech information

While the research just reviewed suggests intimate connections between speech processing and talker processing, other studies suggest that talker recognition and speech perception are computed by different cognitive processes and may be neurally dissociable. Much of the work suggesting dissociation comes from the neuroimaging and neuropsychology literatures. Neuroimaging results (e.g. Belin et al., 2004; Von Kriegstein et al., 2003; though see Perrachione et al., 2009) suggest that talker recognition is mediated by different brain structures (the right superior temporal sulcus) than those supporting speech-sound recognition in the left temporal lobe. (Van Lancker et al., 1989; see also Van Lancker et al., 1988) report that damage to the right temporal lobe is associated with difficulty recognizing famous voices, while other aspects of speech perception remain seemingly intact. Right-hemisphere damage leading to voice-recognition deficits is consistent with a functional dissociation between voice recognition and speech-sound processing. Interestingly, Van Lancker et al. also found that difficulty discriminating *unfamiliar* voices was associated with damage to either hemisphere, suggesting a more complex pattern.

Some behavioral evidence also suggests that language knowledge is not the sole factor in recognizing talkers. Specifically, listeners can identify time-reversed famous voices, indicating that they do not need identifiable verbal content to recognize at least some talkers (Van Lancker et al., 1985). Moreover, listeners with the same language background differ dramatically in their ability to recognize unfamiliar voices (Pollack et al., 1954) and in their judgments of talker

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