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The relationship between auditory–visual speech perception and language-specific speech perception at the onset of reading instruction in English-speaking children

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ABSTRACT

Speech perception is auditory–visual, but relatively little is known about auditory–visual compared with auditory-only speech perception. One avenue for further understanding is via developmental studies. In a recent study, Sekiyama and Burnham (2008) found that English speakers significantly increase their use of visual speech information between 6 and 8 years of age but that this development does not appear to be universal across languages. Here, the possible bases for this language-specific increase among English speakers were investigated. Four groups of English-language children (5, 6, 7, and 8 years) and a group of adults were tested on auditory–visual, auditory-only, and visual-only speech perception; language-specific speech perception with native and non-native speech sounds; articulation; and reading. Results showed that language-specific speech perception and lip-reading ability reliably predicted auditory–visual speech perception in children but that adult auditory–visual speech perception was predicted by auditory-only speech perception. The implications are discussed in terms of both auditory–visual speech perception and language development.

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Introduction

Speech perception is an auditory–visual event; when the auditory signal is degraded, visual speech information enhances the percept (Sumby & Pollack, 1954) and even in clear listening conditions as evidenced by what is called the McGurk effect. In a typical demonstration of the McGurk effect, when the auditory syllable /ba/ is dubbed onto the lip movements for /ga/, the resultant percept among most native English speakers is "da" or "tha" (McGurk & MacDonald, 1976). McGurk is also commonly used as an index of visual speech influence in auditory–visual speech perception research. In the experiment reported here, the McGurk effect is used as a measure of auditory–visual speech perception development.

Infants as young as 4½ months both *match* auditory and visual speech information, as shown by vowel matching across modalities (e.g., Kuhl & Meltzoff, 1982), and *integrate* auditory and visual information, as shown by their perception of the McGurk effect. For instance, Rosenblum, Schmuckler, and Johnson (1997) habituated 5-month-old English-language environment infants on matching auditory–visual /va/ and then presented three McGurk-like stimuli: auditory + visual /va/, auditory /ba/ + visual /va/ (perceived as "va" by adults), and auditory /da/ + visual /va/ (perceived as "da" by adults). Infants attended more to auditory /da/ + visual /va/ than the other two presentations, providing evidence that infants integrate auditory and visual speech information just as adults do. More recently, Desjardins and Werker (2004) and Burnham and Dodd (2004) found similar results. Notably, Burnham and Dodd used the auditory /ba/ + visual /ga/ form of the McGurk effect and found that 4½-month-old infants perceive the emergent "da" or "tha"—speech sounds not presented in habituation. These studies appear to show both that auditory–visual speech perception is well developed during infancy and that auditory and visual speech is integrated at a relatively language-general phonetic level rather than a language-specific phonemic level (Werker & Logan, 1985) given that speech perception is more phonetically based than phonemically based during the first half year of life (Werker & Tees, 1983, 1984).

Turning to toddlers and children, in the original McGurk study, McGurk and MacDonald (1976) tested three age groups—preschoolers (3- to 5-year-olds), school children (7- and 8-year-olds), and adults (18- to 40-year-olds)—and found that visual speech influence increased with age, a finding consistently supported by subsequent studies (Hockley & Polka, 1994; Massaro, 1984; Sekiyama & Burnham, 2008). In addition, Massaro, Thompson, Barron, and Laren (1986) found that, in a visual-only condition, adults were better lip-readers than 4- to 6-year-old children, and Ross and colleagues (2011) found that 5- to 14-year-old children displayed considerably less audiovisual enhancement than adults, with improvement in auditory–visual integration continuing until adolescence. Together, these results suggest that, over and above early integration of auditory and visual speech during infancy, there is a further increase in the use of visual speech information from early childhood to adulthood.

Research on variables that are possibly related to auditory–visual speech perception development is scarce, but three studies do suggest that articulation ability and auditory–visual speech perception development may be linked.

First, using a series of McGurk as well as auditory-only and visual-only speech stimuli, Desjardins, Rogers, and Werker (1997) tested adults and two groups of young children: one whose members were previously found to make articulatory substitution errors (e.g., substituting other consonants in lieu of dental fricatives /θ/ or /ð/) and another whose members did not make such errors. Although adults and the two child groups performed comparably in the auditory-only condition, adults were more prone to the McGurk effect than children; in turn, the children who made fewer phonemic substitution errors were more influenced by visual speech input (and also were better at lip-reading in the visual-only condition) than those children who made more substitution errors. The authors concluded that the experience of correctly articulating speech sounds results in superior representation of visible speech categories and a more effective integration of visual and auditory speech (Desjardins et al., 1997). However, it should be noted that later research from the same laboratory by Weikum and colleagues (2007) showed that young (4- and 6-month-old) infants' attention to visual information for differences between languages is attenuated by 8 months, so it is quite possible that the articulation–visual

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