Audiovisual processing of pharyngealization and length in Emirati Arabic

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Abstract

This paper addresses a gap in the literature on audiovisual speech perception. Previous research has examined how the perceived primary place-of-articulation of a speech sound is influenced by visual information. Visual influences on the perceived length of a speech sound or on the presence of pharyngealization have not been examined. The experiments reported here demonstrate that the perception of both singleton/geminate and pharyngealized/plain is susceptible to visual influence.

Key words: Audiovisual, perception, geminate, pharyngealization, Arabic

Introduction

Most studies of the McGurk effect have demonstrated that the perceived place-of-articulation of a sound can be shifted by visual information. Arabic has contrasts that are not so clearly about (primary) place-of-articulation. Geminate involves holding a constriction for a longer time; pharyngealization involves a secondary constriction which is not itself visible. The two experiments below test whether Arabic speakers are visually sensitive to these contrasts. The prediction in **Experiment One** is that the consonant length in a video will shift perceived *auditory* consonant length to match. In **Experiment Two**, we predict that video of pharyngealized or plain sounds will shift *auditory* perception of pharyngealization to match –here the perceiver is not seeing the pharyngeal gesture, but its visual effects on surrounding sounds.

Experiment One: Audiovisual Perception of Geminization

In comparison to hearing, vision is poor at timing perception. This means that when there is a conflict, we generally perceive timing in line with information from hearing (Goldstone & Lhamon, 1974). This is the modality appropriateness hypothesis (Welch, 1999) and it suggests (contra this experiment) that visual timing influences on hearing are unexpected.

Procedures

An audio continuum between /abah/ (singleton) and /abbah/ (geminate) was created by morphing between clear endpoints (recordings of a native Emirati Arabic speaker). The same speaker was video recorded and 8 videos each for

singleton and geminate (free of any obvious irregularities) were chosen for use. For both singleton and geminate conditions, two interleaved audio staircases were presented with random switching. Each staircase had 12 turns. For the first 6 turns of each staircase, the audio was presented alone; after 6 turns, the audio was accompanied by videos of either singleton or geminate. There were 40 native Arabic speaking female participants.

Results & Discussion

Each participant's data was fit to a psychophysical curve.

participants' data were unfittable and were eliminated from analysis. A paired t-test comparing the fitted thresholds between "Long" and "Short" was significant [$t = -3.1105$, $df = 32$, $p = 0.0039$]. This demonstrates that people can integrate audiovisual speech timing information. This is surprising, as the auditory system typically dominates the audiovisual perception of timing.

Figure 1. Results of Experiment One – Standard-Error bars are shown.

Experiment Two: Pharyngealization

Most Arabic dialects have *pharyngealized* consonants. This is a secondary articulation that involves a constriction at the upper part of the pharynx (Ladefoged & Johnson, 2011). Pharyngealization typically spreads to neighbouring segments (Zawaydah, 1999). In Gulf Arabic, this pharyngealization is accompanied by some degree of lip rounding (Watson, 1999).

Procedures

This experiment was identical in structure to **Experiment One** except that the sounds were /aḏah/ (plain) and /aḏʰah/ (pharyngealized). The audio continua and videos were created in the same way as in **Experiment One**. The same participants as in **Experiment One** were run in this experiment.

Results & Discussion

Each participant's data was fit to a psychophysical curve. 15 participants' data were unfittable and were eliminated from analysis. A paired t-test comparing the fitted thresholds between "Pharyngealized" and "Plain" was significant [$t = -2.4992$, $df = 24$, $p = 0.0197$]. As predicted, more pharyngeal were heard with a pharyngeal video and similarly for plain.

Figure 2. Results of Experiment Two – Standard-Error bars are shown.

This shows that Arabic speakers are sensitive to visual cues to pharyngealization, and can integrate these cues into a combined audiovisual percept. Clearly, participants are not seeing the secondary constriction at the pharynx itself, as this is necessarily occluded. Instead, pharyngealization is being detected via other visual cues such as jaw-retraction and lip rounding.

Conclusions

The use of visual cues to length and secondary articulations has not received much attention. These experiments address this gap by showing that visual information about the duration (singleton versus geminate) of a consonant and the presence of a secondary articulation (pharyngealization) on segments can be detected visually and integrated into an audiovisual percept.

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