Your brain says what it sees: motor mechanisms of audiovisual speech perception

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Introduction

▪We propose that observation of a speaker's mouth movements affects speech perception through covert production (Skipper et al., in review).

▪Thus seeing and hearing a speaker produce speech should activate the same brain regions underlying speech production.

▪These regions should be sensitive to phonetic visual information.

▪We examined the distribution of brain activity resulting from incongruent audio and visual phonetic information (the McGurk-MacDonald effect).

Methods

▪21 right handed native English speakers; event related fMRI at 3 Tesla (GE Medical Systems, Milwaukee, WI) with spiral acquisition (TR/TE 1.5/24 ms, 71° flip angle, 24 cm FOV, effective resolution 3.75 x 3.75 x 3.8mm).

▪Stimuli:

▪Congruent audiovisual (AV) /pa/, /ka/, and /ta/ and an incongruent AV stimulus (acoustic /p/ with visual /k/, designated /pk/).

▪Audio-alone (A) and video-alone (V) /pa/, /ka/, and /ta/ stimuli.

▪Imaging paradigm:

Functional scan #	Condition	Stimuli Presented	Task
Randomly ordered (1-3)	Audiovisual (AV)	/pk/, /pa/, /ka/, /ta/	Watch/listen to talker
	Audio-alone (A)	/pa/, /ka/, /ta/	Listen to talker
	Video-alone (V)	/pa/, /ka/, /ta/	Watch talker
4	Audiovisual (AV)	/pk/, /pa/, /ka/, /ta/	Watch/listen to talker
Frequency judgment: "Which stimulus did you hear most frequently in the prior run: /pa/, /ka/, or /ta/?"			
5	Active audiovisual (aAV)	/pk/, /pa/, /ka/, /ta/	Watch/listen to talker; classify syllables as /pa/, /ka/, or /ta/ with 3 alternative forced choice (3AFC)
6	Speaking (S)	/pa/, /ka/, /ta/	Read /pa/, /ka/, or /ta/ and repeat out loud

▪Behavioral measures: After scanning (1) participants indicated which consonant was heard most frequently; and (2) performed a forced choice task (see above Table).

▪Data analyses:

▪Deconvolution/regression analysis (Ward, 2001) within individuals.

▪Cortical surfaces inflated; surface-based ANOVA and conjunction/overlap analysis across individuals.

▪ROI analysis.

▪Unless otherwise stated, all imaging data is significant at $p < .05$ corrected using a false discovery rate algorithm.

Results

▪**Table 1**: Two behavioral groups differing in perception of /pk/ stimulus: (1) /ta/ perceivers (McGurk effect) and (2) /ka/ and /ta/ perceivers.

▪**Figure 1**: Congruent AV speech perception activates production areas in the pars opercularis, dorsal and ventral premotor, primary motor, subcentral gyrus and sulcus, supramarginal gyrus, and other posterior temporal sites. /pk/ activates the same regions.

▪**Figure 2**: In all frontal and temporal regions, /pk/ activation is most correlated with /ta/ activation. /pk/ was not significantly more correlated with any of the other syllables for the group who perceived both /ka/ and /ta/.

▪**Figure 3**: The time course of activation: For both groups, frontal regions correlate with perceptual reports throughout. For the /ta/ group, temporal regions show /pk/ initially correlated with audiovisual /pa/, but later with audiovisual /ta/.

▪**Figure 4**: Visual cortex activation: For the /ta/ group, visual regions (e.g., middle occipital gyrus, fusiform gyrus, calcarine sulcus) show /pk/ initially correlated with audiovisual /ka/, but later with audiovisual /ta/.

Conclusions

▪The results support a model in which speech perception is affected by information about mouth movements through the active recruitment of a motor network.

▪The activity pattern suggests that the brain has created an internal copy of the sound it *thought* it heard.

▪The results support a model of active hypothesis-testing in which motor activity simulates speech production to generate internal speech representations used for recognition (Stevens & Halle, 1967).

▪Results suggest visual cortex activity is affected by perceptual classification and auditory information.

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(pdf: http://www.home.uchicago.edu/~skipper/pages/posters.html)

Tables and Figures

Table 1. Behavioral results indicate two groups of participants: those who perceived /ta/ and those who perceived /ka/ or /ta/ when presented /pk/ in scanner.

	3AFC Response During Functional Scan # 5 (%)						Frequency Judgment (%)		
Group	/pa/=/pa/	/ka/=/ka/	/ta/=/ta/	/pk/=/pa/	/pk/=/ka/	/pk/=/ta/	/pa/	/ka/	/ta/
/ta/ (N=13)	97	82	96	2	15	83	23	15	62
/ka - ta/ (N=8)	100	95	94	3	61.5	35.5	12.5	62.5	25

Figure 1. A) The perception of audiovisual speech activated regions involved in speech production. Patterns for audiovisual, audio-alone, and video-alone overlapping speaking. **B) Activation pattern produced by the McGurk effect (/ta/ perception of /pk/).**

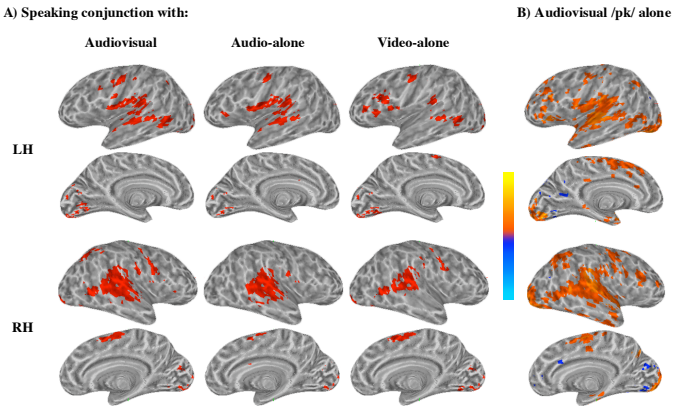


Figure 2. The distribution of activity for /pk/ in regions overlapping speech production is most correlated with the distribution of activity associated with the audiovisual syllable corresponding to the participants perception (i.e., /ta/) for the /ta/ group. Rank between /pk/ and /pa/, /ka/, and /ta/ in regions overlapping production in the two experimental groups in all **A) motor regions** and **B) temporal regions.** (*p <.008; **p<.0007)

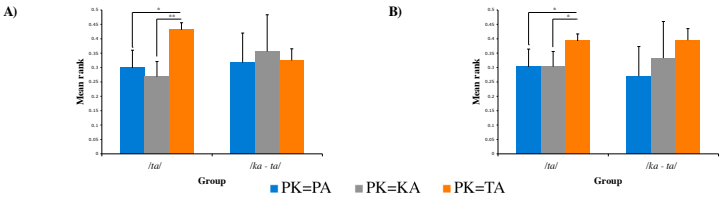
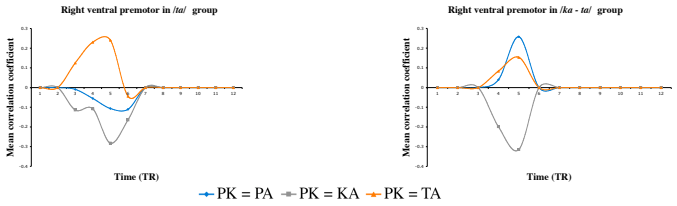


Figure 3. Temporal patterning of activation for the /ta/ group shows consistent correlation between /pk/ and /ta/ in individual regions overlapping speech production but not in the /ka - ta/ group, consistent with each group's perception. Each of the following exemplary regions show significant differences between curves as determined by nonparametric ANOVA.

A) Motor cortex:



B) "Speech perception" cortex: note how activation is initially most correlated with /pa/ (the auditory component of /pk/) but becomes increasingly correlated with /ta/ for the /ta/ group.

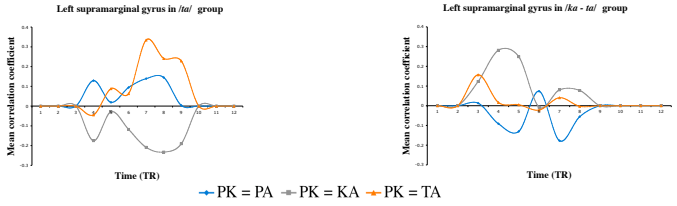


Figure 4. Temporal patterning of activation for the /ta/ group shows early correlation between /pk/ and /ka/ (the visual portion of the stimulus) but later becomes most correlated with /ta/ in primary visual cortex suggesting a feedback mechanism. Note the relative time course between Figure 3A, Figure 3B, and the below plot.