

Cross-modal effects of pseudo-sign articulation (overt and covert) on the premotor cortex: an adaptation fMRI study

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Introduction

Speech production results in auditory feedback that is used to reach acoustic targets, and this perception-production interface results in strong neural coupling between oral-motor and auditory brain regions.

However, for deaf signers, visual feedback often falls outside the signer's visual field, and it is unclear whether motor and visual cortices are strongly coupled because signers do not look at their hands.

The visual-motor mappings for sign may not emerge from feedback coupling. Rather, visual-motor mappings for sign language may emerge primarily via associative learning between visually perceived hand movements (of other signers) and somato-sensory perception of one's own hand movements.

This study investigates predictions generated by this model using neuroimaging adaptation methods. We predict that visual motor adaptation will occur in fronto-parietal cortices.

Methods

Participants

Deaf native and early ASL signers (n = 14, 8 females, mean age: 30.3 ± 4.5)

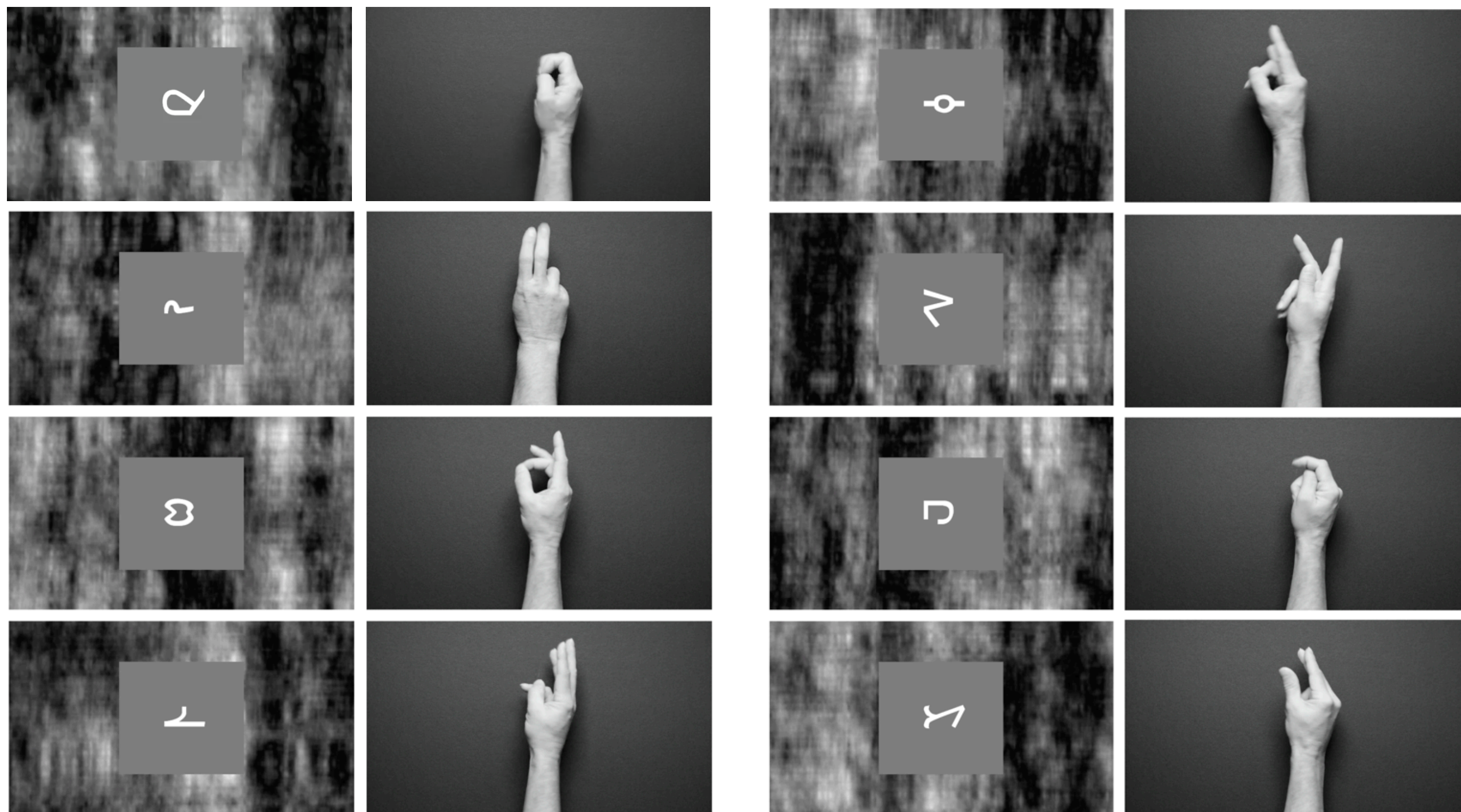
Imaging methods

The fMRI study consisted of four event-related adaptation scans and two blocked-design functional localizers to identify regions involved in viewing (VIEW-LOC) and producing (PROD-LOC) hand and foot movements. The preprocessing and analyses of structural and EPI MRI data were carried out using AFNI (Cox, 1996).

Statistical Analysis

We used the neural activation clusters identified in both VIEW-LOC and PROD-LOC as areas of investigation for our whole-brain analysis of BOLD responses acquired from the adaptation scans.

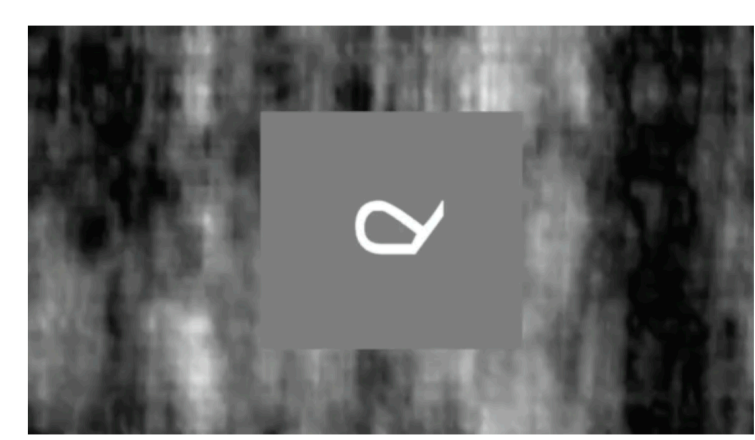
Sign Adaptation Stimuli



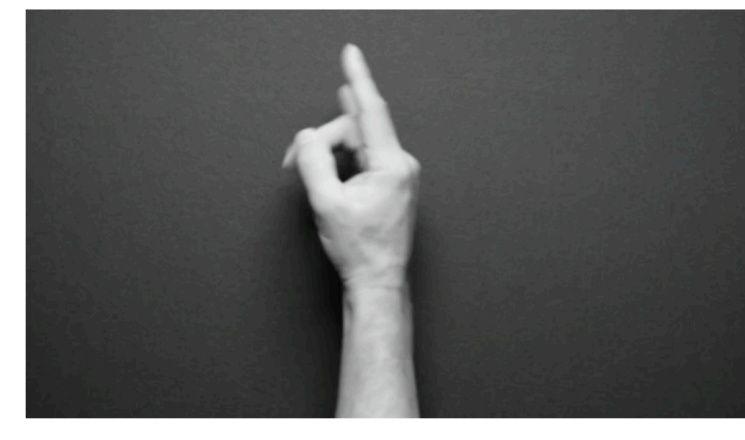
- Prior to scanning, deaf signers learned the association between each pictograph and pseudosign.
- Participants also learned to articulate the pseudosigns overtly or covertly, depending on the color of square cue.

Sign Adaptation Tasks

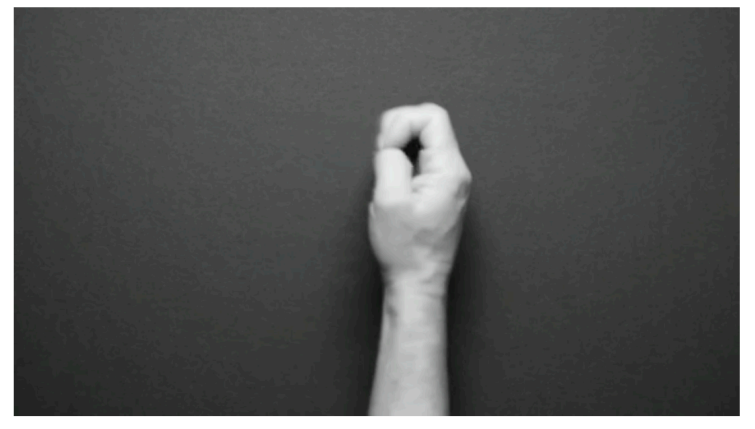
Overt Articulation



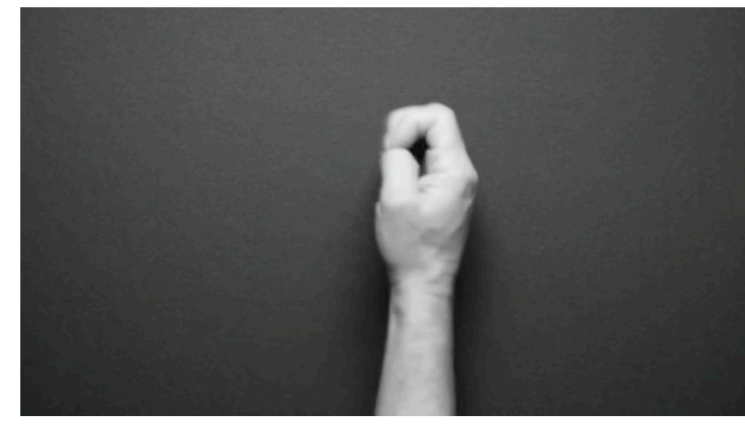
Probe



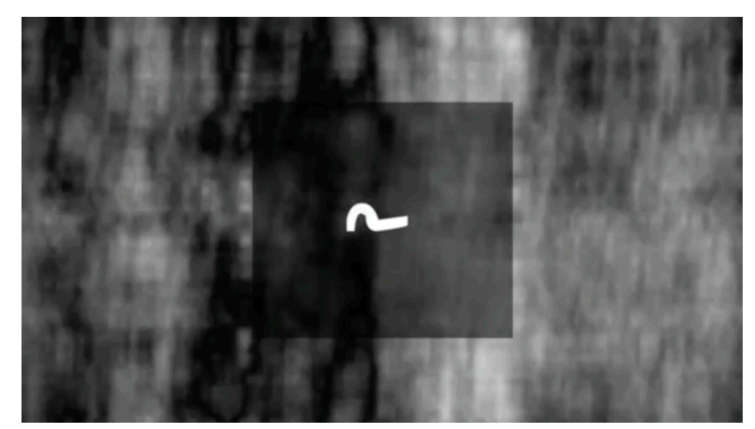
View pseudosign



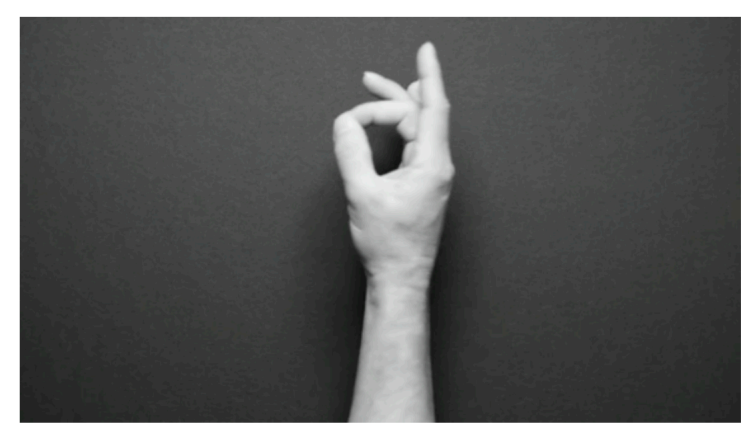
Probe



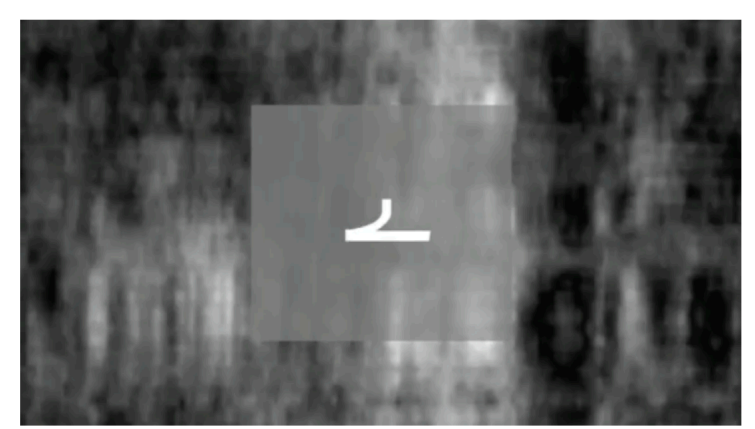
Covert Articulation



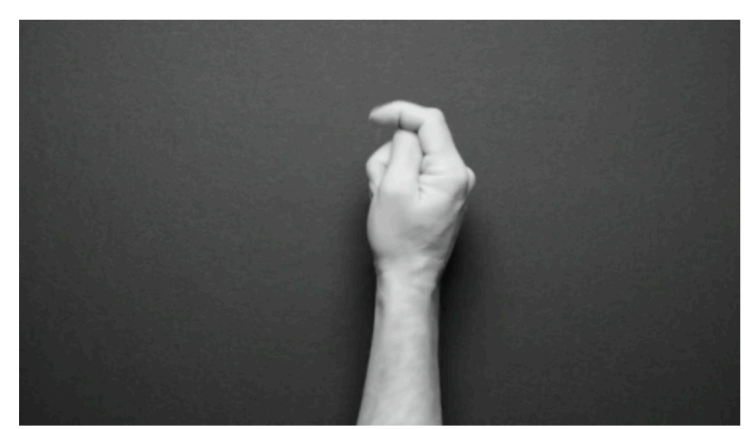
Probe



Imagine pseudosign



Probe

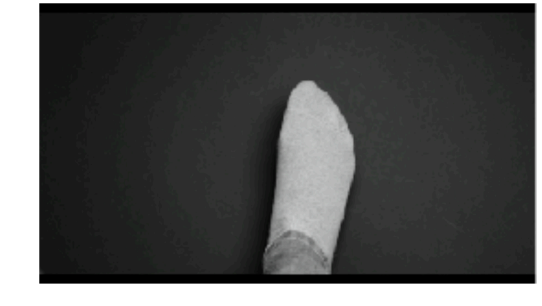
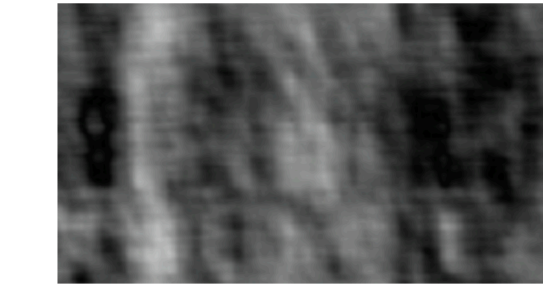


- The first video (adaptor) was always selected randomly from four categories: overt articulation, covert articulation, visual imagery, or visual presentation.
- The second probe was always a video of a pseudosign that was either the same pseudosign or a different pseudosign from the adaptor stimulus.

Localizer Tasks

Visual Response Localizer

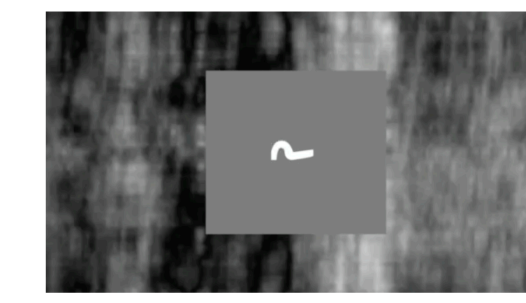
Task: View video clips



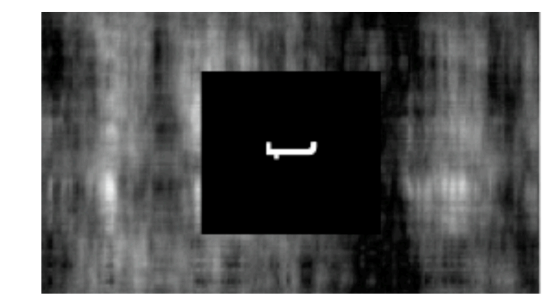
>>> Visual Area ROIs

Motor Response Localizer

Task: Produce pseudosign and foot movements



Hand movements



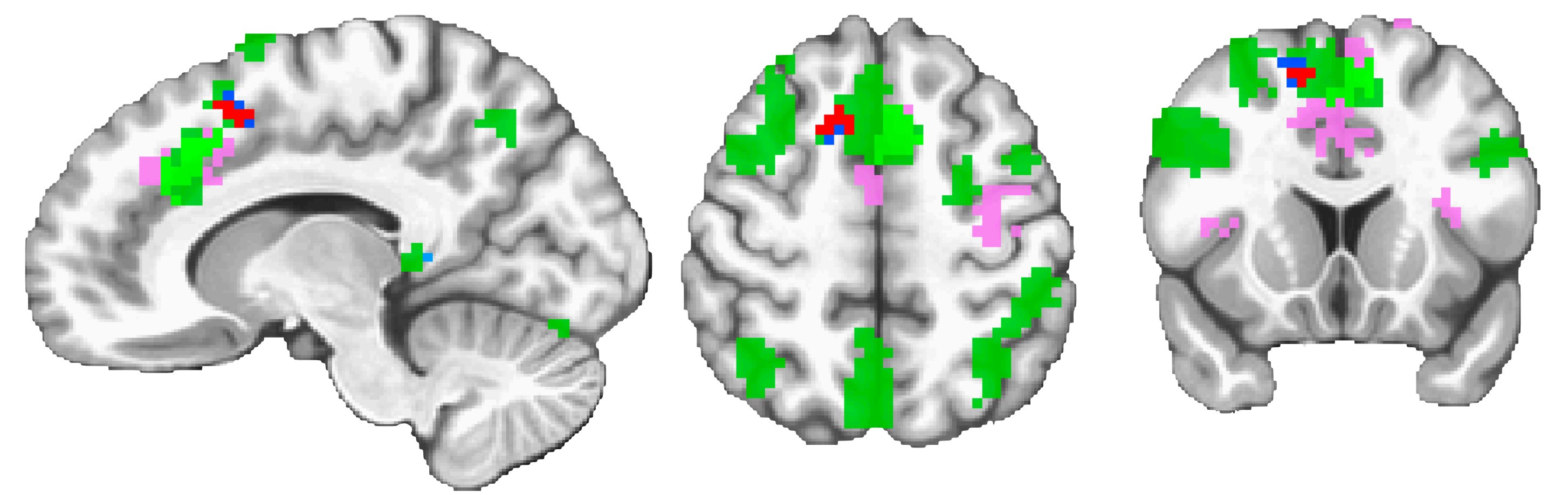
Foot movements

>>> Motor ROIs

- The localizer scans always followed the adaptation scans.
- The first localizer identified the cortical regions involved in viewing hand and foot motor actions (VIEW-LOC).
- The second localizer identified the regions involved in producing motor actions (PROD-LOC).

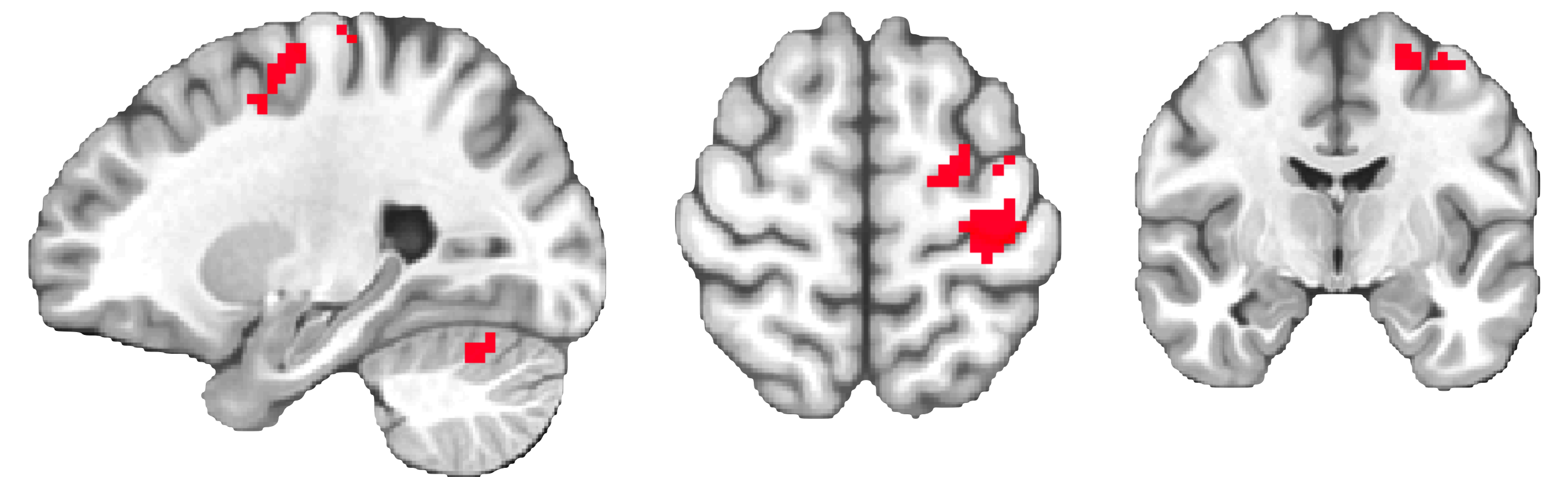
Results

A



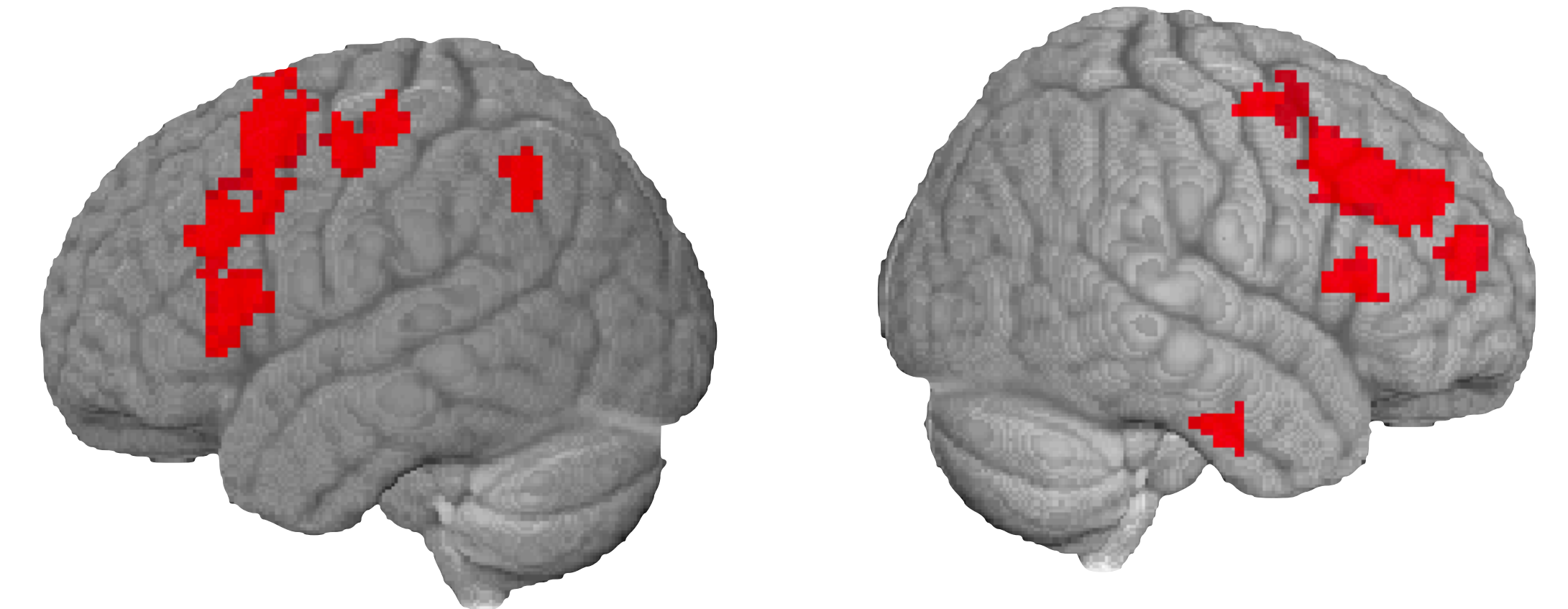
Overlap of neural activity during sign adaptation tasks. Green and pink are covert and overt articulations respectively. Lighter green = overlap of overt and covert articulations. Red = overlap of overt, covert articulation and visual imagery.

B



Brain regions active during the production of hand movements from the contrast of hand and foot motor response localizers.

C



Brain regions showing adaption effects for covert articulation.

Figure 1.

Conclusions

Surprisingly, the localizers did not reveal any overlap in the brain regions for viewing and producing pseudosigns.

The whole-brain analysis ($p = .01$) showed strong neural adaptation effects in the supplementary motor area (SMA) for both overt and covert articulation, and for visual imagery adaptors, but not for the visual adaptor **Figure 1A**.

SMA was also localized using the hand condition of the production localizer **Figure 1B**.

Moreover, the production localizer identified hand regions (precentral gyrus and middle frontal gyrus) that also overlapped with the clusters of adaptation effects for overt and covert articulation.

Of all adaptation effects observed, the ones from covert articulation were the strongest and most widespread **Figure 1C**.

Overall, our results reveal distinct patterns of neural adaptation for internally versus externally generated signing compared to those found for speech. We suggest that somatosensory feedback has a more pronounced influence than visual feedback on sign production.

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