Speech in the mirror? Neurobiological correlates of self-speech perception
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Self-awareness and self-recognition during action observation may partly result from a functional matching between action and perception systems. This perception-action interaction is thought to enhance the integration between sensory inputs and our own sensory-motor knowledge.

We present a combined EEG and fMRI study that examines the impact of self-knowledge on multisensory integration mechanisms during auditory, visual and audio-visual speech perception. Our working hypothesis was that hearing and/or viewing oneself talk might facilitate the bimodal integration process and activate sensory-motor plans to a greater degree than does observing others.

**METHODS**

- **Subjects:** 18 healthy adults, right-handed native English speakers.

- **Procedure:**
  - **Averaged EEG:**
    - Each subject generated 64 electrodes of EEG data recorded according to the 10-20 international system with an analog bandwidth of 0.01 to 100 Hz. Subjects were seated in a comfortable, quiet environment with their eyes closed. The EEG signals were amplified by a BrainAmp active EEG amplifier (Brain Products, Germany) and recorded using a BrainScan II software (Brain Products, Germany) with a sampling rate of 1000 Hz. The EEG signals were band-pass filtered between 0.01 and 100 Hz. The EEG signals were rectified and low-pass filtered at 20 Hz. The signals were referenced to an average reference. The signals were stored on a disk for further analysis.
  - **Auditory and visual stimuli:**
    - The stimulus were 3-s speech segments of the speaker's own voice. The speech segments were filtered to match the natural frequency range of the auditory and visual modalities. The speech segments were presented at the participant's subjective level of comfort. The speech segments were presented in a randomized order. The duration of each speech segment was 3 seconds. The speech segments were presented once per condition.
  - **fMRI data acquisition:**
    - The fMRI data were acquired using a 3-Tesla MR scanner (Siemens, Germany) with a standard head coil. The imaging sequence was a T2-weighted gradient-echo echo-planar imaging (EPI) sequence. The EPI sequence was designed to cover the whole brain with a resolution of 3 mm x 3 mm x 3 mm. The EPI sequence was designed to cover the whole brain with a resolution of 3 mm x 3 mm x 3 mm. The EPI sequence was designed to cover the whole brain with a resolution of 3 mm x 3 mm x 3 mm.

**RESULTS**

- **Modality results:**
  - **Auditory regions:** stronger activity for the auditory condition than the visual only condition.
  - **Visual regions:** stronger activity for the visual condition than for the auditory only condition.
  - **Greater Activity of the dorsal part of the premotor cortex for visual stimuli (no activation for the auditory only condition).**

- **Self effect:**
  - Stronger activity of the cerebellum, the parahippocampal gyrus and the left inferior frontal gyrus (pars opercularis).
  - Small effect but well test more subjects.

- **Main Effect of Self (F contrast, p < .001 unc):**
  - Visual self: increased activity in the visual associative cortex.
  - Auditory self: increased activity in the auditory cortex.

- **Self x Noise Interaction (F contrast, p < .001 unc):**
  - Increased activity in the visual associative cortex.

- **Self x Modality Interaction (F contrast, p < .001 unc):**
  - Increased activity in the cerebellum, parahippocampal gyrus and left P2 (pars opercularis).

**DISCUSSION**

1. **a)** In line with previous studies on multimodal speech perception = integration mechanisms of auditory and visual speech signals.

2. **b)** A visual processing advantage when the perceptual situation involves our own speech production.

3. **Global coherent activations of the single effects during auditory, visual and audio-visual speech perception.

4. **hearing and/or viewing oneself talk increased activation in the left posterior inferior frontal gyrus (pars opercularis) and cerebellum.**

- These regions are generally responsible for predicting sensory outcomes of action generation.

Altogether, these results suggest that viewing our own utterances leads to a temporal facilitation of auditory and visual speech integration and processing afferent and efferent signals in sensory-motor areas gives rise to self-awareness during speech perception.