

Seeing Speech

Probing the cerebral mechanisms of Cued Speech perception

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Introduction

Cued Speech (CS) is a system that disambiguates lipreading when talking to deaf people.

In practice, the locutor talks normally in the spoken language (e.g. French) while making a hand gesture for each syllable. The combination of lip movements for the consonant and for the vowel, the position of the hand and the shape of the hand permits a full and non-ambiguous visual understanding of speech in the absence of sound.

~ 20 studies now suggest that exposure to CS improves general linguistic abilities in a deaf community characterized by a low average level of literacy (Gardiner-Walsh et al., 2020, Trezek, 2017).

By contrast, only a few studies have assessed the mechanisms of CS perception (Bayard et al., 2014, Hage, C., & Leybaert, 2005, Aparicio et al., 2017).

The present MRI study aims at identifying (i) the cerebral regions involved in Cued Speech perception in expert and non-expert users, (ii) the multiple codes under which CS may be represented across the brain, and (iii) the possible impact of CS mastery on the organization of the visual cortex.

Results from the first experiment, exploring (i), are presented here.

Population

60 healthy volunteers recruited for this study

19 Prelingually and severely/profoundly Deaf CS users (no cochlear implants in the MRI)

21 Hearing CS users (mostly trained in professional CS production)

20 hearing CS naïve Controls

Materials and Methods

Experiment I – Presentation of sentences in full or degraded CS: (1) Sentences in full CS (hand and mouth movements) with sound, (2) Silent sentences in full CS, (3) Silent sentences in lip-reading only, (4) Silent sentences with only the gestural part of CS, (5) Silent lists of meaningless pseudowords in full CS and (6) Rest baseline with a fixation cross.

Experiment II – Presentation of static images belonging to 5 visual object categories: faces, bodies, French words, houses and tools.

Experiment III – Repeated presentation of 16 silent CS syllables resulting from the combination of 2 hand positions x 2 hand shapes x 2 points of articulation (lip-reading of consonant) x 2 values of vocalic rounding (lip-reading of vowel).
Analysis: Binary decoding of each of these 4 CS features to identify the regions that encode the corresponding phonological distinction, at the whole-brain level and in chosen ROIs.

Additional data – Diffusion Tensor Imaging (DTI) and Resting state fMRI

References and affiliations

Aparicio, M., Peigneux, P., Charlier, B., Balériaux, D., Kavec, M., & Leybaert, J. (2017). *Frontiers in Psychology*, 8, 426.

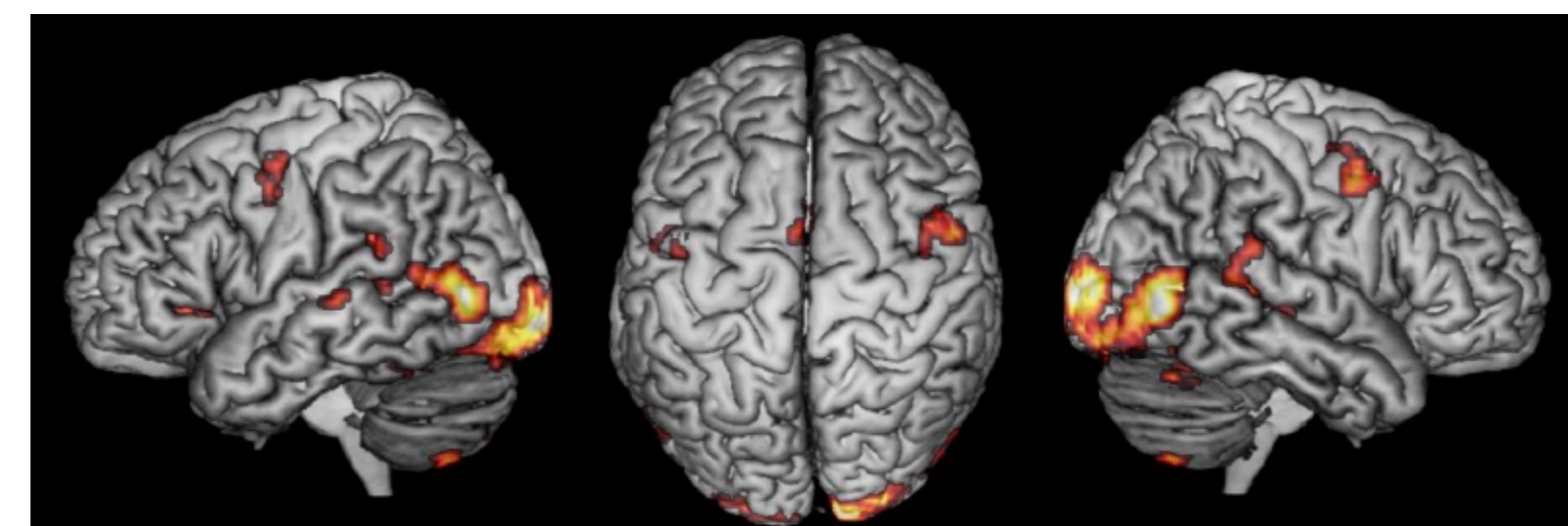
Bayard, C., Colin, C., & Leybaert, J. (2014). *Frontiers in Psychology*, 5, 416.

Gardiner-Walsh, S. J., Giese, K., & Walsh, T. P. (2020). *Deafness & Education International*, 0, 1-22.

Hage, C., & Leybaert, J. (2005). Oxford University Press.

Trezek, B. J. (2017). *The Journal of Deaf Studies and Deaf Education*, 22(4), 349-364.

Results – Full Cued Speech perception (Exp I)



Conjunction of activations in the 3 groups for the Silent CS > baseline

Still some differences between groups:

- Increased activation in the Hearing and Control groups relative to the Deaf in the right occipital lobe
- Parts of the Bilateral Dorsal Attentional Network (FEF and IPS) overactivated in the Hearing group (Probably reflects the spatial attention and effort involved in CS decoding, in individuals mostly trained in professional CS production)

Silent Cued Speech All three groups activate a large set of regions:

- As expected: Large set of common activations in all groups in low-level areas, including in visual areas
- More surprising: Also common activations in language areas, despite differences in CS expertise

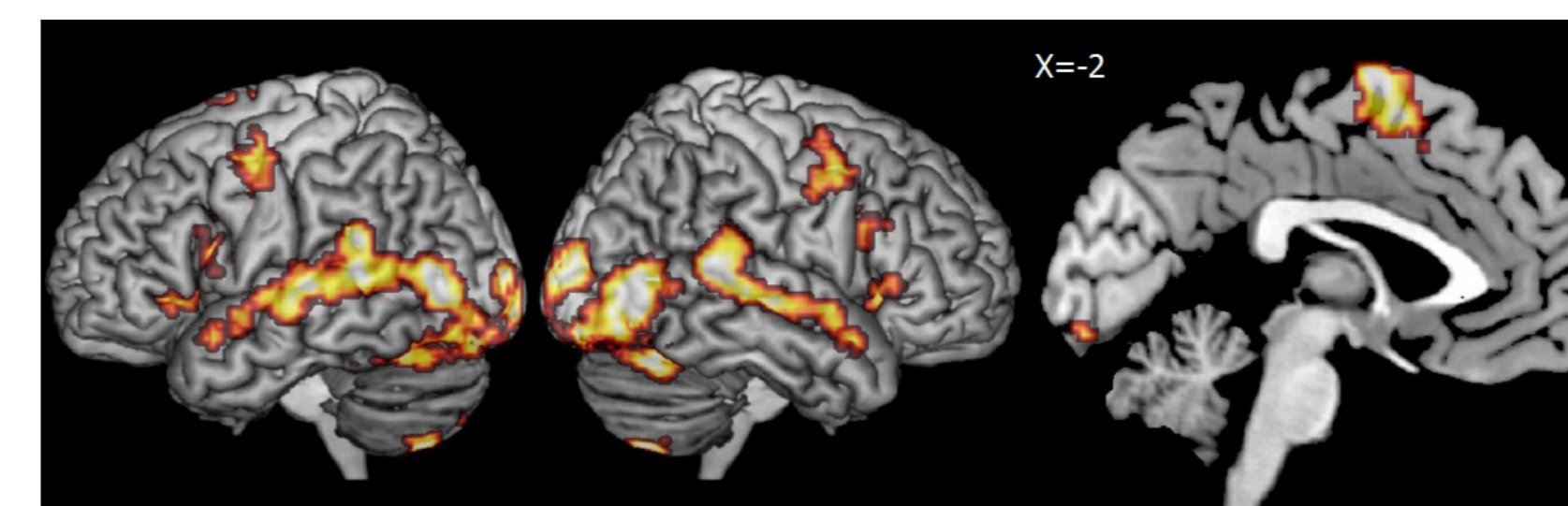
Results – Isolated Lip-reading perception (Exp I)

Isolated lip-reading Many common activations for the 3 groups, in visual and motor but also in language areas

Only one difference between groups: Stronger activation in Deaf participants in the bilateral pSTS/STG

Expected as all groups can read lips to some extent: Explains why CS yields shared activation of language areas across the three groups, including Controls

Results – Isolated Gestures perception (Exp I)



Activations by Gestures > baseline in Deaf participants

Isolated gestures Common activations between the groups mostly limited to visual areas

In Deaf participants only, isolated hand gestures are sufficient to activate language areas

Suggests that gestures may play a more prominent role than in the original conception of CS, where they are seen as a mere complement to lip-reading