How input modality and visual experience affect the neural encoding of categorical knowledge

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Introduction

It has been proposed that some convergence regions in the brain represent concepts independently from the sensory input [(1,2)].

Aim 1: *Investigate which regions implement categorical processing in an amodal, multimodal or sensory related fashion in sighted adults [(3,4)].*

Categorical responses to non-visual stimulation were observed in the ventral occipito-temporal cortex (VOTC) of congenitally blind [(5,6,7)], suggesting that VOTC might be among the modality-independent regions[(8,9)]. However, overlapping categorical response profile between blind and sighted might be underpinned by distinct representational formats.

Aim 2: *Understand how visual deprivation impacts on the categorical processing.*

Materials and Method

PARTICIPANTS:

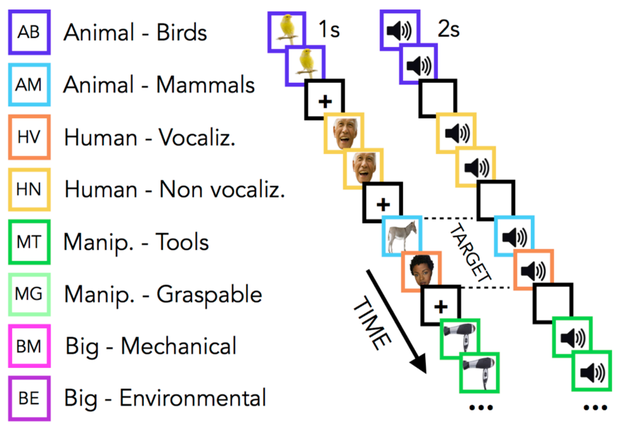
- 17 early blind – auditory exp. (EBa)
- 17 sighted – auditory exp. (SCa)
- 16 sighted – visual exp. (SCv)

MULTIVARIATE DATA ANALYSES:

- Multivoxel pattern analysis (MVPA)
- Representational similarity analysis (RSA)

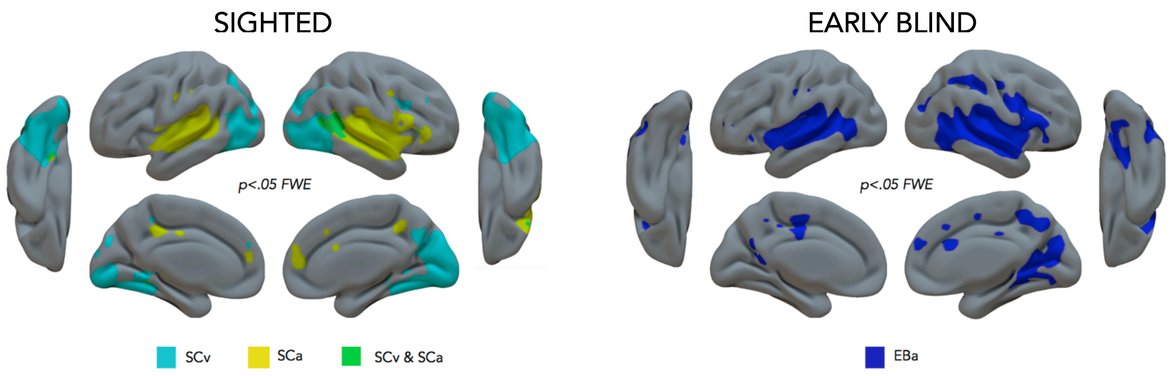
24 STIMULI (acoustical & visual format)

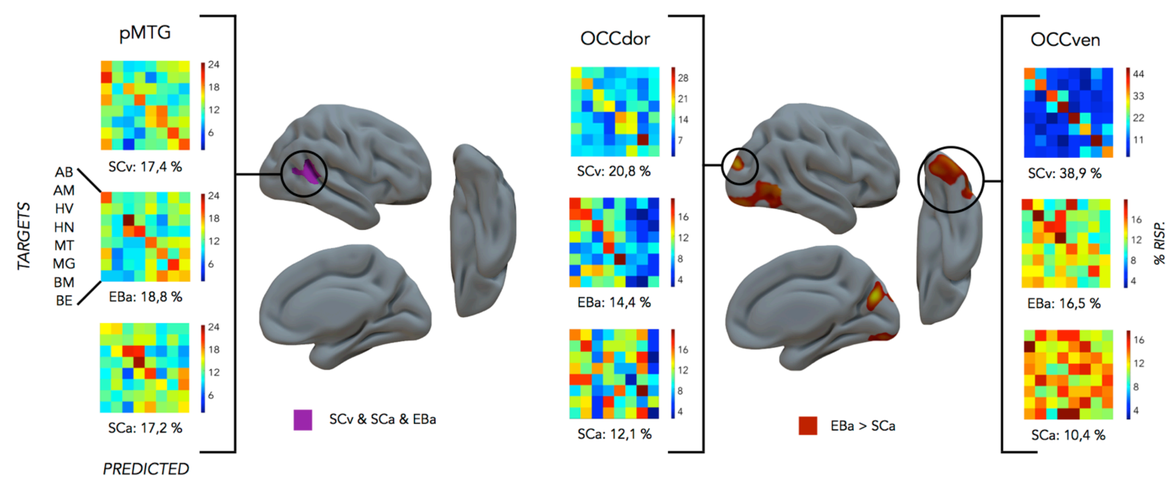
2 fMRI experiments (auditory & visual)



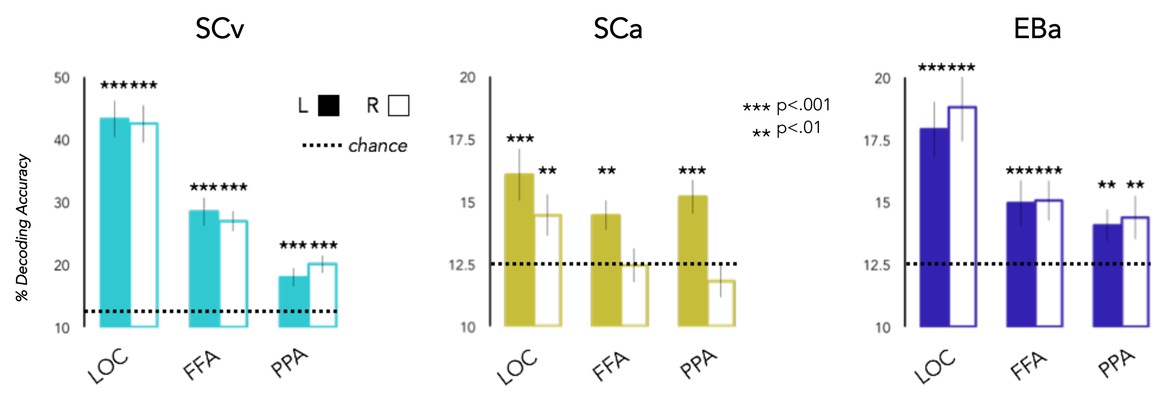
Results

MVPA SEARCHLIGHT

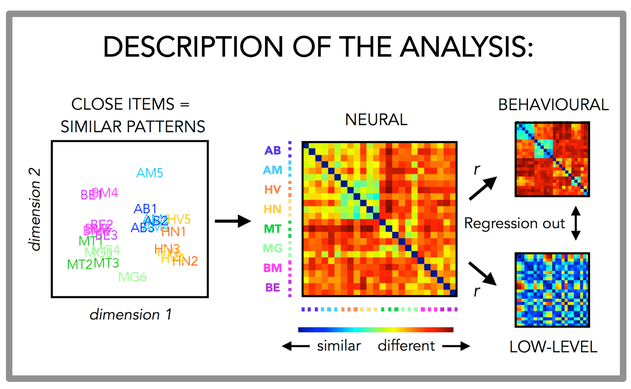


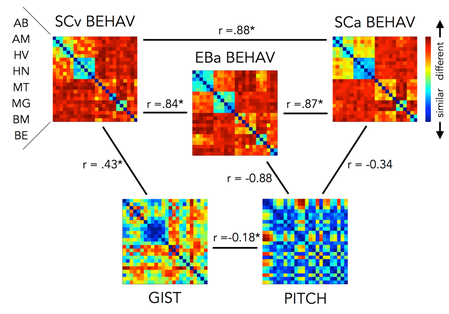


MVPA in VOTC ROIs

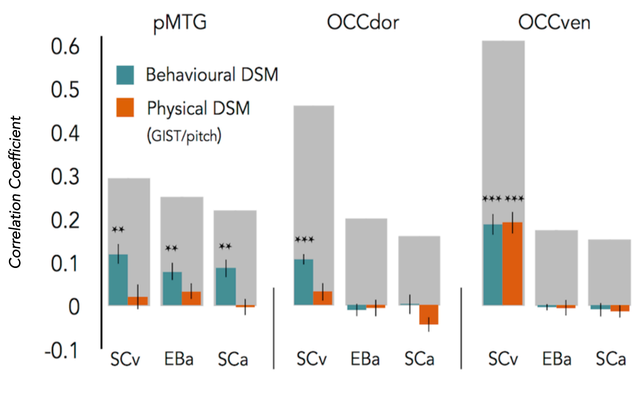


CLASSICAL RSA

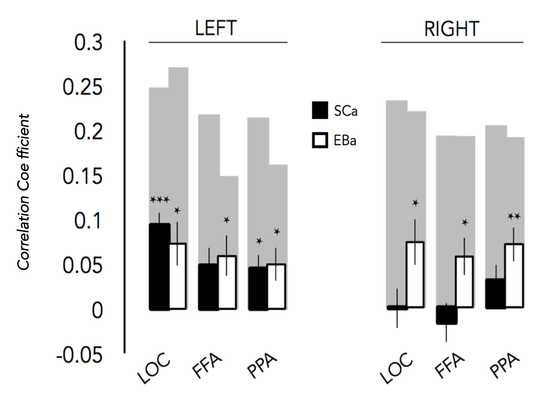




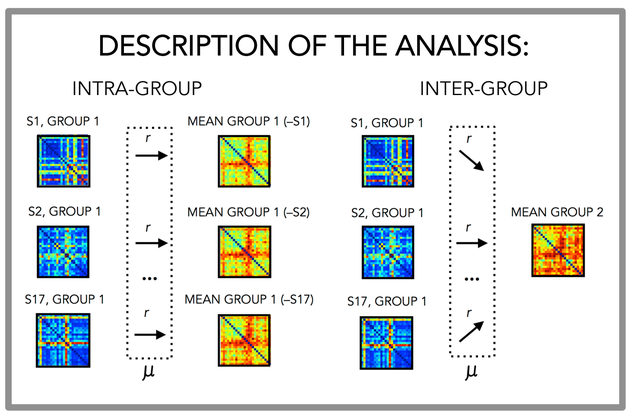
RSA with EXTERNAL MODELS

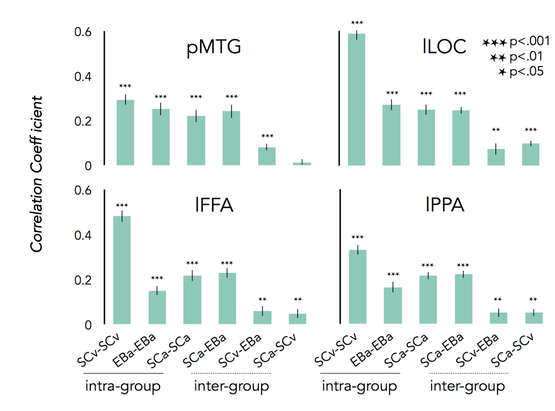


RSA with DSMs from SCv



CROSS RSA





Discussion

- Right pMTG decodes different categories of non-linguistic stimuli **independently of the input modality and visual experience**. However, it maintains separated the representation from different modalities, revealing a **multimodal** rather than an amodal nature.
- An extended portion of the **right occipital cortex** shows **functional reorganization** via **crossmodal plasticity in blind** compared to sighted individuals.
- VOTC shows **distinct functional profiles** according to the hemispheric side:
  - **Right VOTC**: sensory-related visual region in sighted that shows functional reorganization following early visual deprivation;
  - **Left VOTC**: involvement in the acoustical categorization processing at the same degree in sighted and blind people (maybe due to enhanced connection with language system?)

References

1. Mahon, B. Z., & Caramazza, A. (2009). Concepts and categories: A cognitive neuropsychological perspective. Annual review of psychology, 60, 27-51.
2. Fairhall, S. L., & Caramazza, A. (2013). Brain regions that represent amodal conceptual knowledge. Journal of Neuroscience, 33(25), 10552-10558.
3. Devereux, B. J., Clarke, A., Marouchos, A., & Tyler, L. K. (2013). Representational similarity analysis reveals commonalities and differences in the semantic processing of words and objects. Journal of Neuroscience, 33(48), 18906-18916.
4. Amedi, A., Raz, N., Azulay, H., Malach, R., & Zohary, E. (2010). Cortical activity during tactile exploration of objects in blind and sighted humans. Restorative neurology and neuroscience, 28(2), 143-156.
5. van den Hurk, J., Van Baelen, M., & de Beeck, H. P. O. (2017). Development of visual category selectivity in ventral visual cortex does not require visual experience. Proceedings of the National Academy of Sciences, 201612862.
6. Pietrini, P., Furey, M. L., Ricciardi, E., Gobbini, M. I., Wu, W. H. C., Cohen, L., ... & Haxby, J. V. (2004). Beyond sensory images: Object-based representation in the human ventral pathway. Proceedings of the National Academy of Sciences of the United States of America, 101(15), 5658-5663.
7. Dormal, G., Pelland, M., Rezk, M., Yakobov, E., Lepore, F., & Collignon, O. (2017). Functional Preference For Object Sounds But Not For Voices In The Occipito-Temporal Cortex Of Early Blind Individuals. bioRxiv, 143776.
8. Bi, Y., Wang, X., & Caramazza, A. (2016). Object domain and modality in the ventral visual pathway. Trends in cognitive sciences, 20(4), 282-290.
9. He, C., Peelen, M. V., Han, Z., Lin, N., Caramazza, A., & Bi, Y. (2013). Selectivity for large nonmanipulable objects in scene-selective visual cortex does not require visual experience. Neuroimage, 79, 1-9.

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