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Shared reorganization across sensory-deprived individuals reveals higher plasticity of visual cortex

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Background and Aims

- The characterisation of the sensory-deprived brain allows to understand **to what extent a sensory experience – or the lack of it – shapes the development** of brain functional organisation

- Because of the lack of a sensory modality since birth, deprived brain areas undergo a plastic reorganization and retain the ability to process non-preferred modalities

- It is unknown to what extent the type of the missing sensory input determines different **degrees of plastic reorganization** in the human brain

- Here we compared **congenitally blind and deaf individuals** to measure similarities and differences in hearing- and sight-dependent plastic changes

Experimental Paradigm

- Edited version of the action movie *101 Dalmatians* (duration: 54 min)
- Voice-over and subtitles to enrich the original movie screenplay
- 3T fMRI
- Typically-Developed (TD) and Sensory-Deprived (SD) participants (i.e. congenitally blind and congenitally deaf)

Audio-Video

TD, n=10

Audio

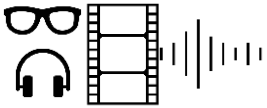
TD, n=10 SD (blind, n=10)

Video

TD, n=10 SD (deaf), n=10

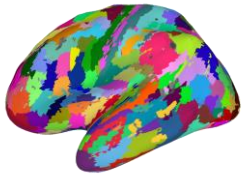
Methods - I

Audio-Video

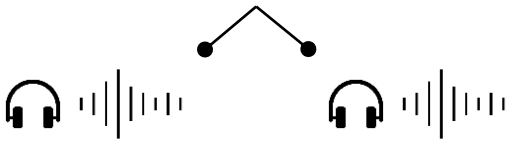


TD, n=10

Brain Parcellation



Audio

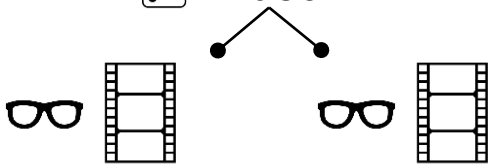


TD, n=10 SD (blind), n=10

Within-Group ISC **Within-Group ISC**

Differences in ISC

Video



TD, n=10 SD (deaf), n=10

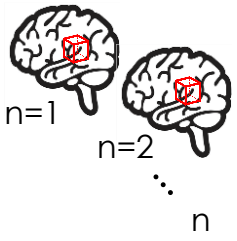
Within-Group ISC **Within-Group ISC**

Differences in ISC

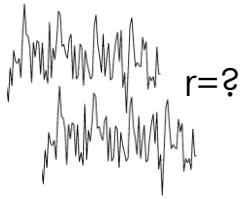
InterSubject Correlation (ISC)

Naturalistic Stimulation

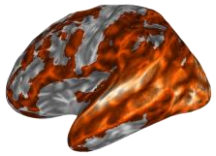
Partecipants



Temporal series



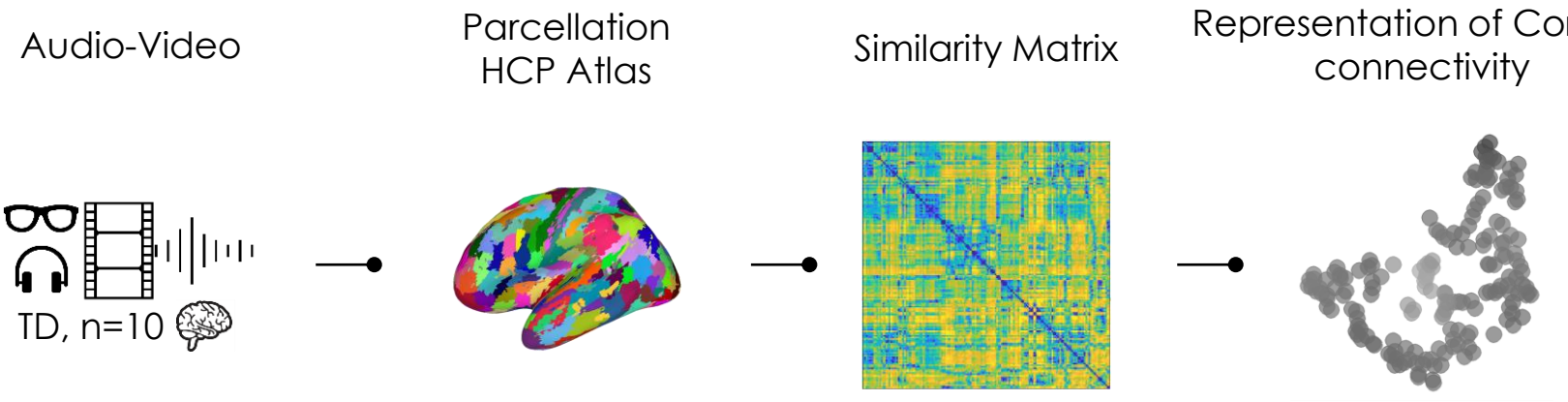
ISC Maps



Pearson's r

Methods - II

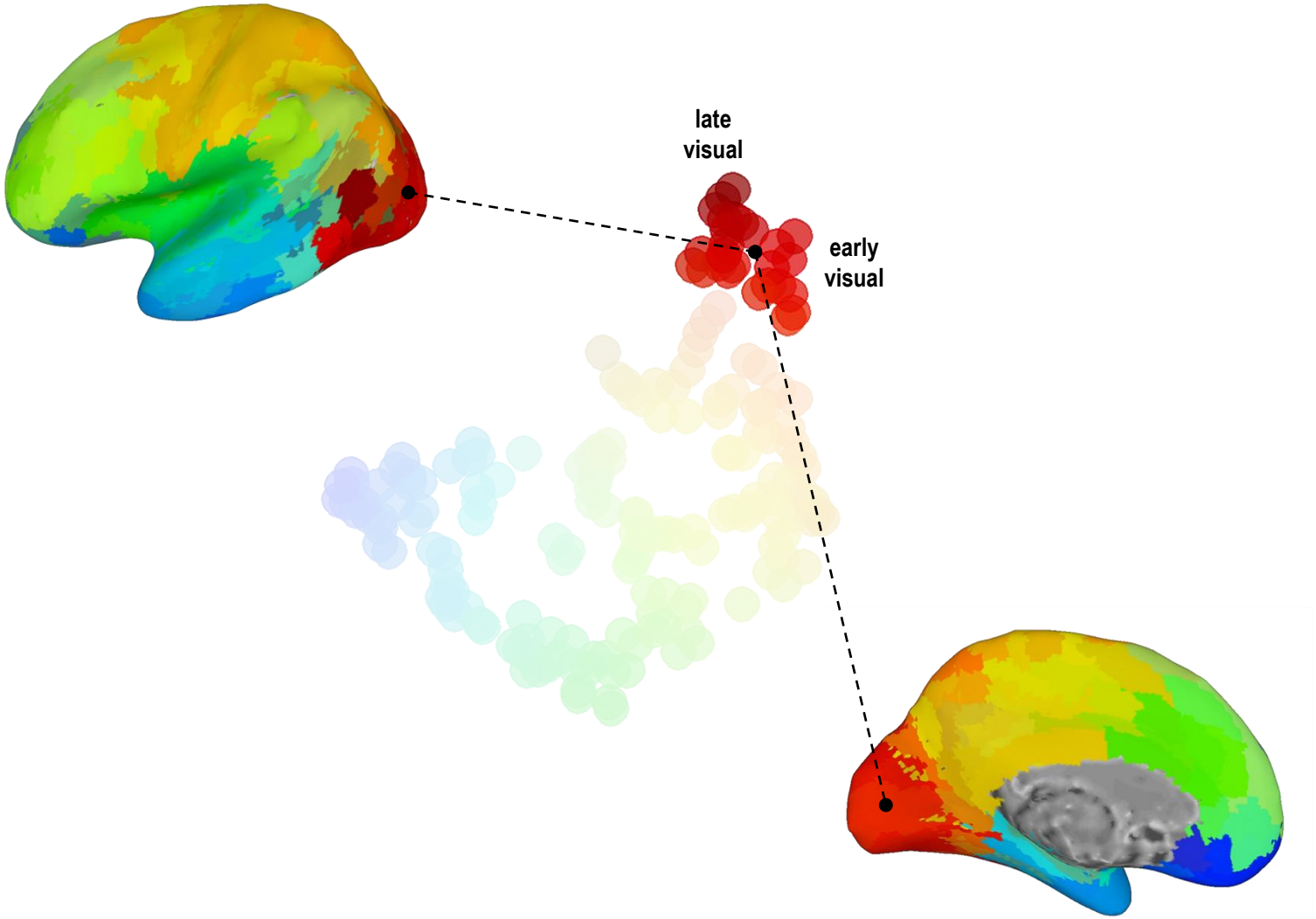
Macroscale organization and cortical gradients



- Reducing the dimensionality of voxels/vertices in few hundreds ROIs
- Measuring the connectivity between ROIs (or voxels/vertices) and embedding it in a lower dimensional manifold to uncover local functional similarities and global connectivity gradients
- Mapping our results on a 2D representation using the multisensory AV condition in TD participants

Glasser et al., 2016; Mesulam, 1998; Margulies et al., 2016

Macroscale organization and cortical gradients



Mesulam, 1998; Margulies et al., 2016

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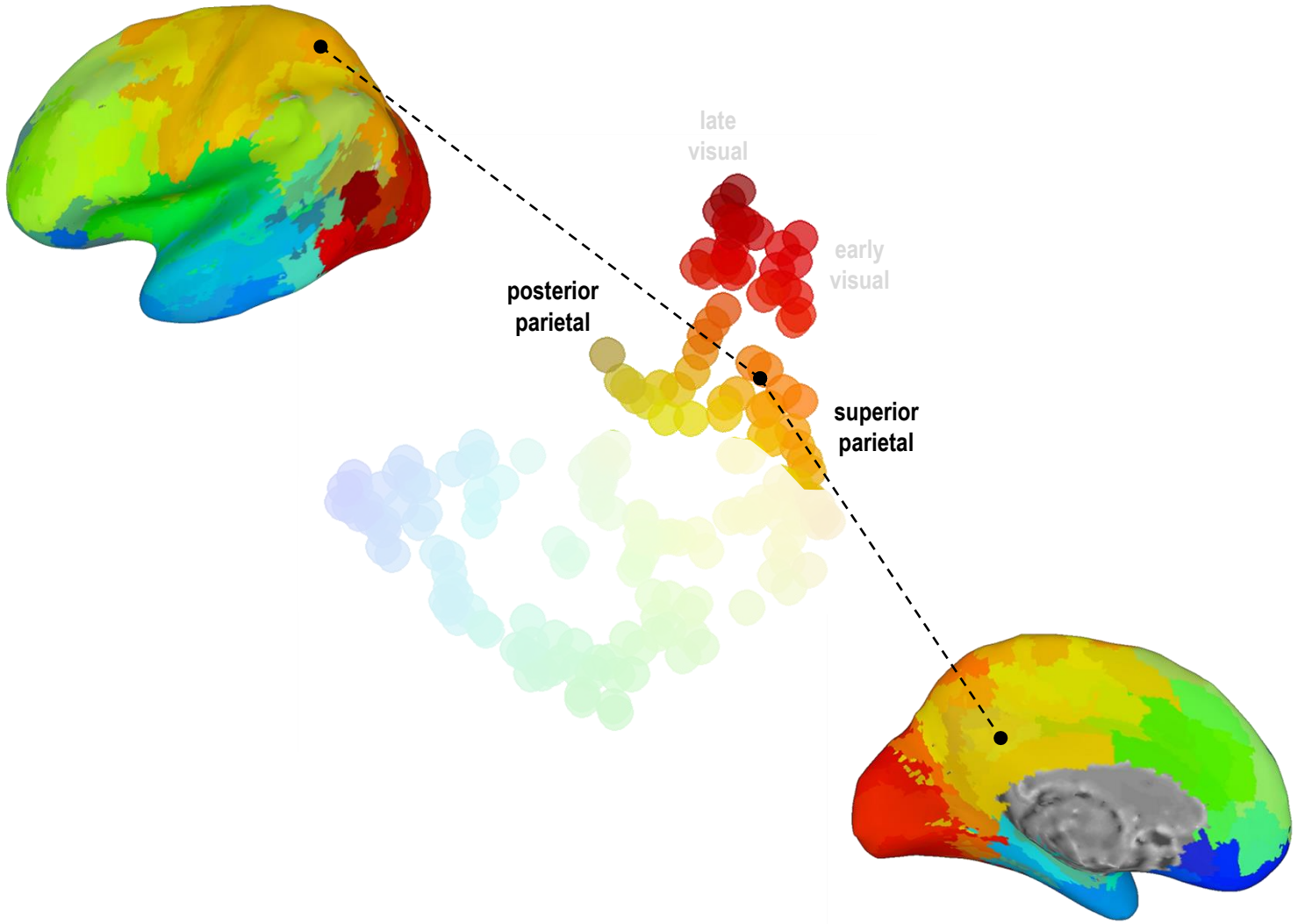
Macroscale organization and cortical gradients



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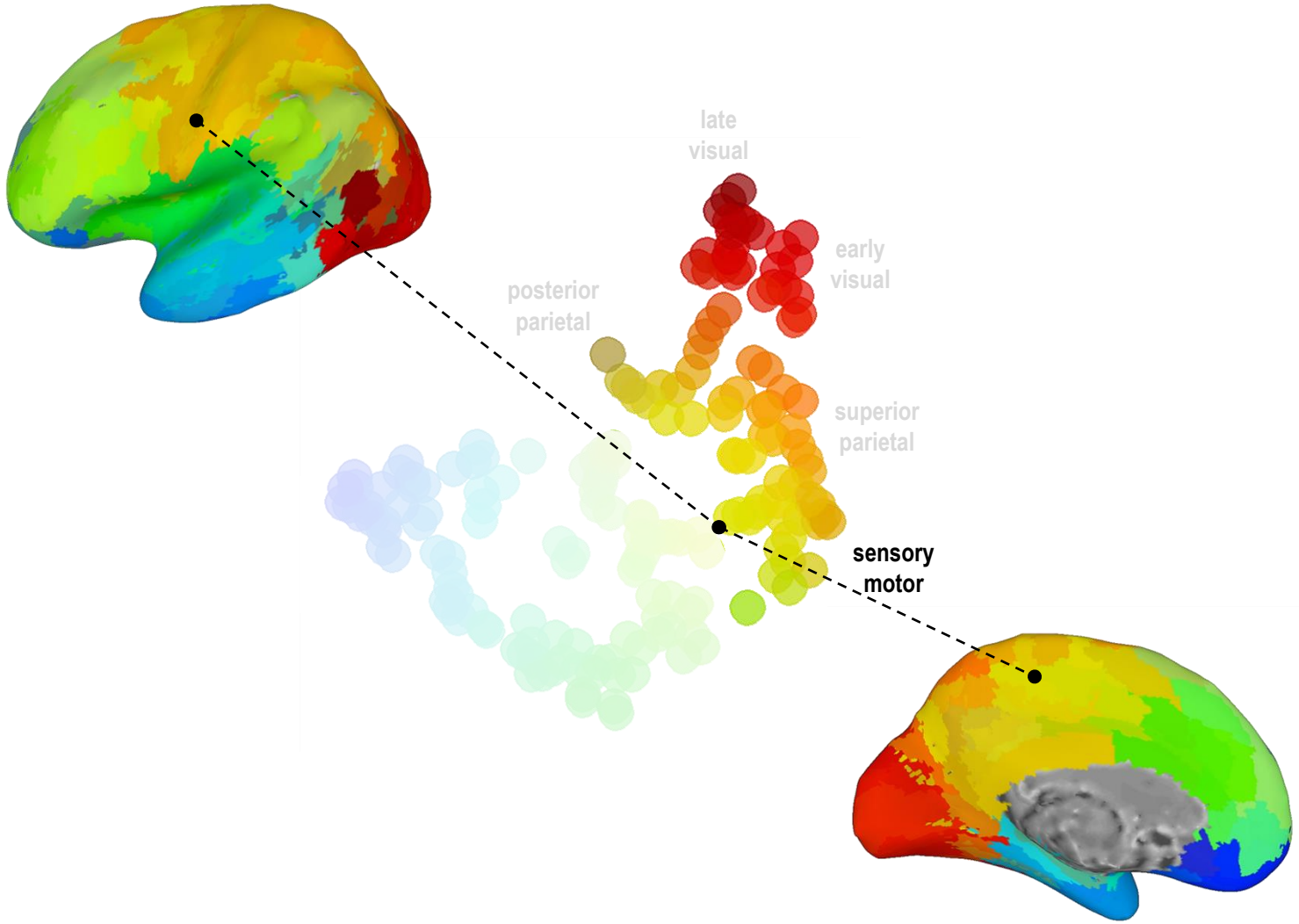
Macroscale organization and cortical gradients



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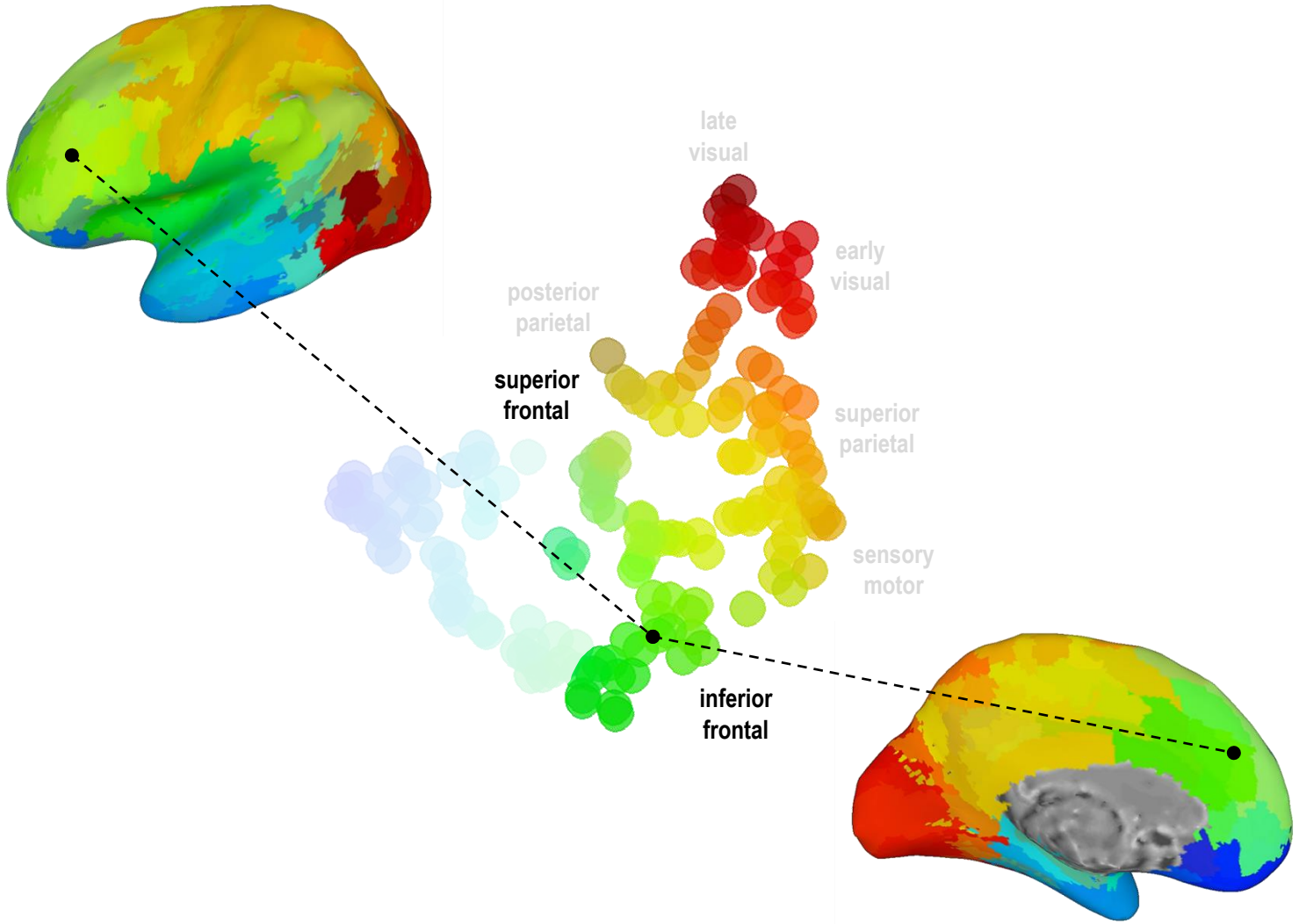

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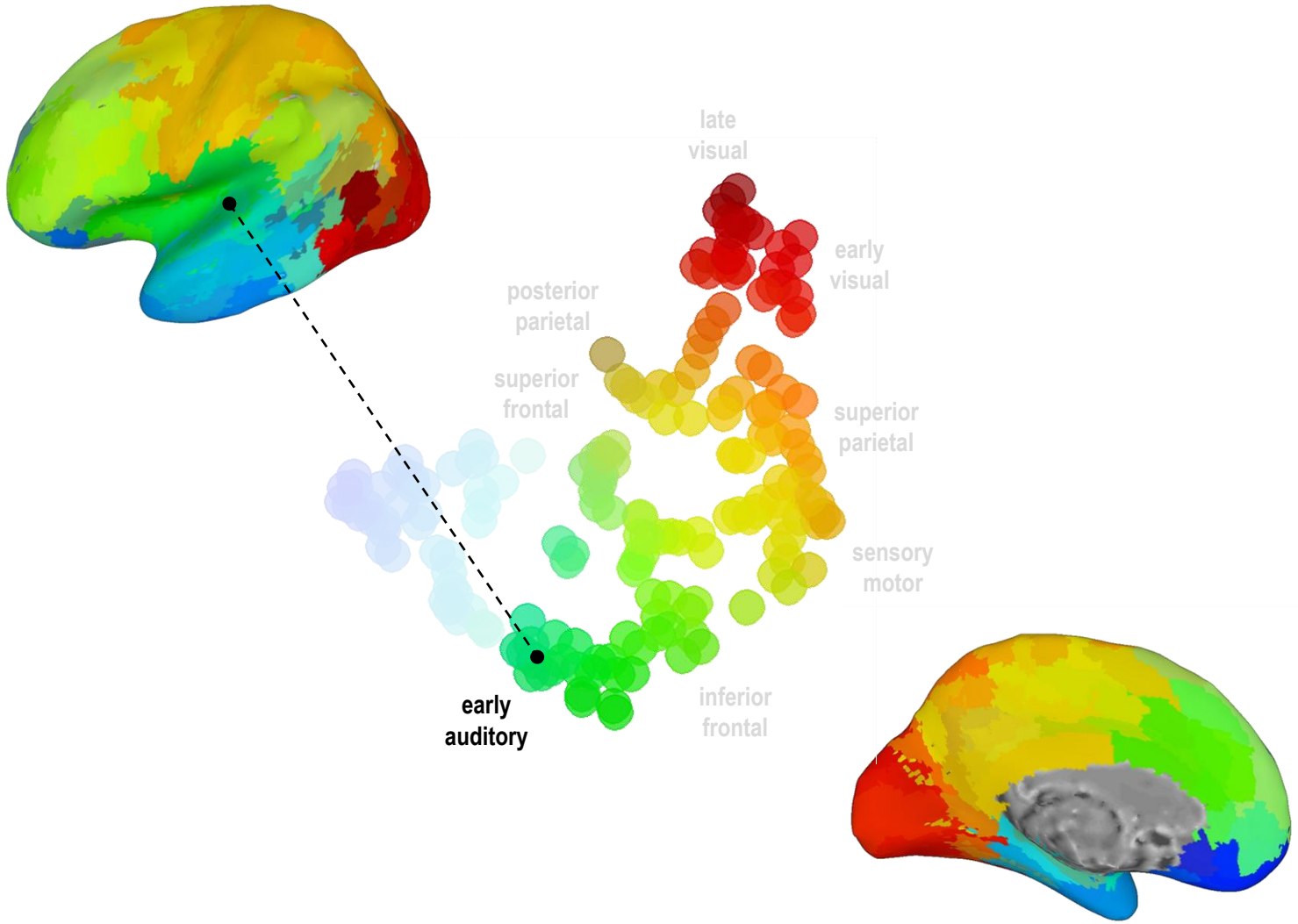
Macroscale organization and cortical gradients



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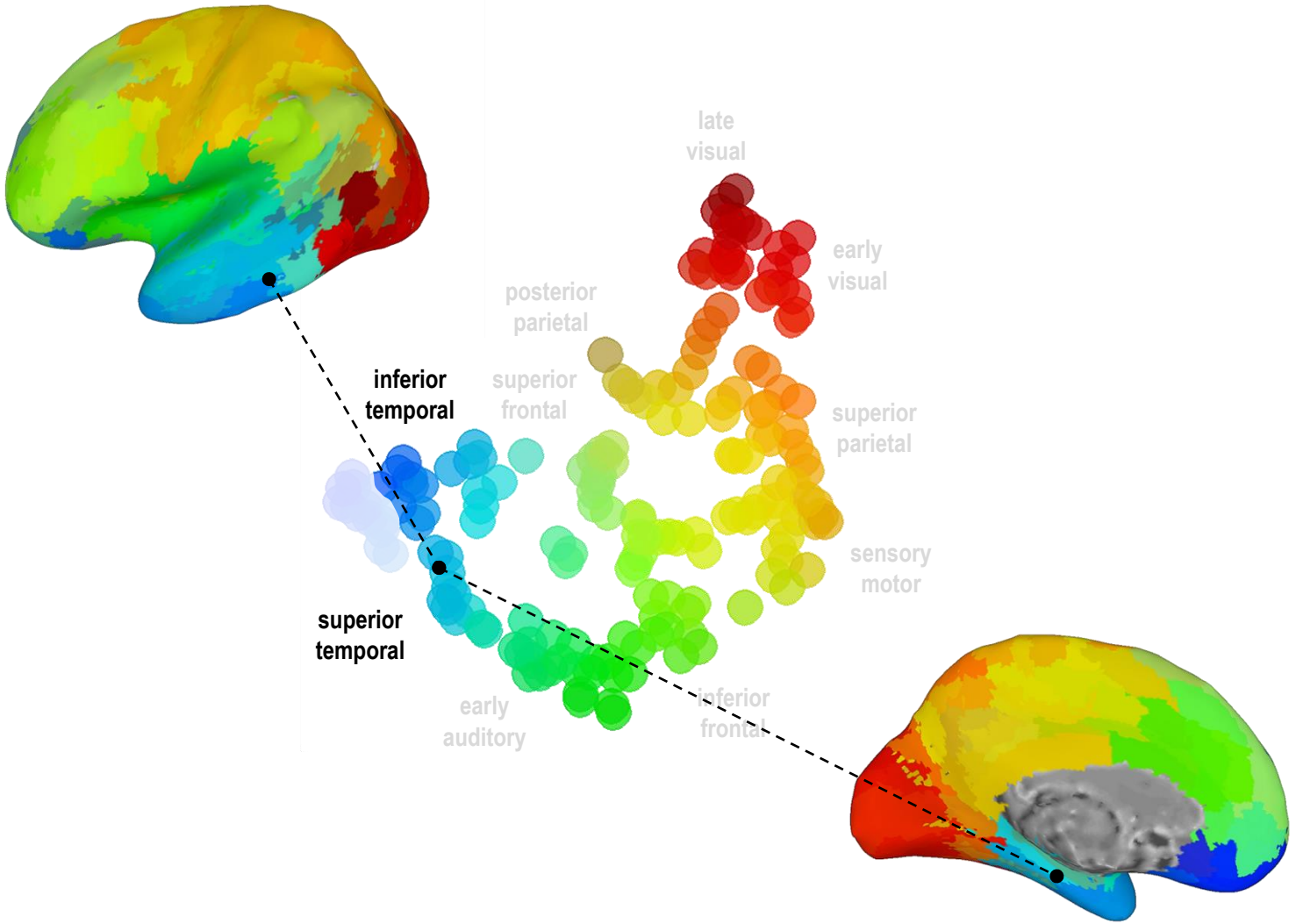

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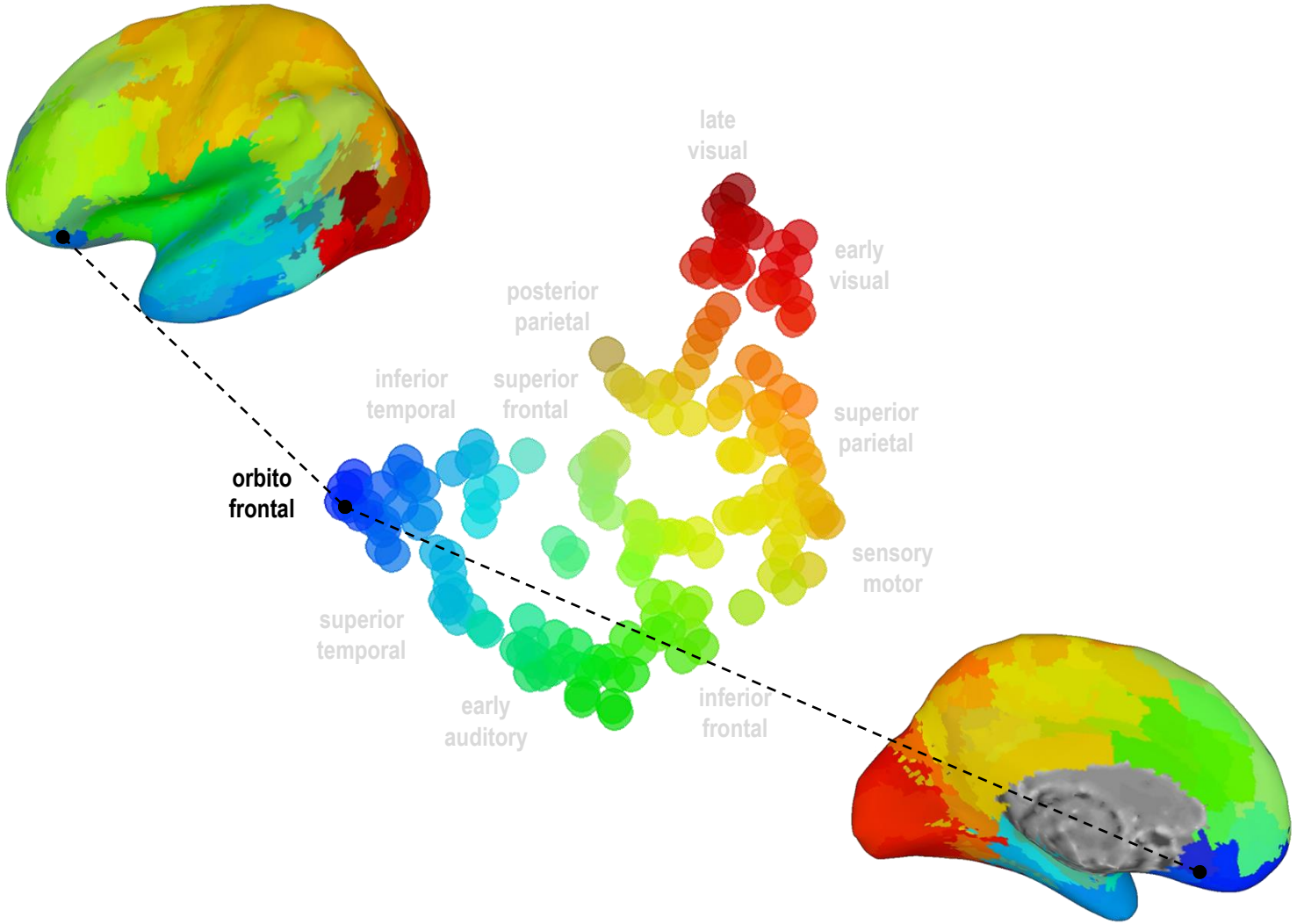
Macroscale organization and cortical gradients



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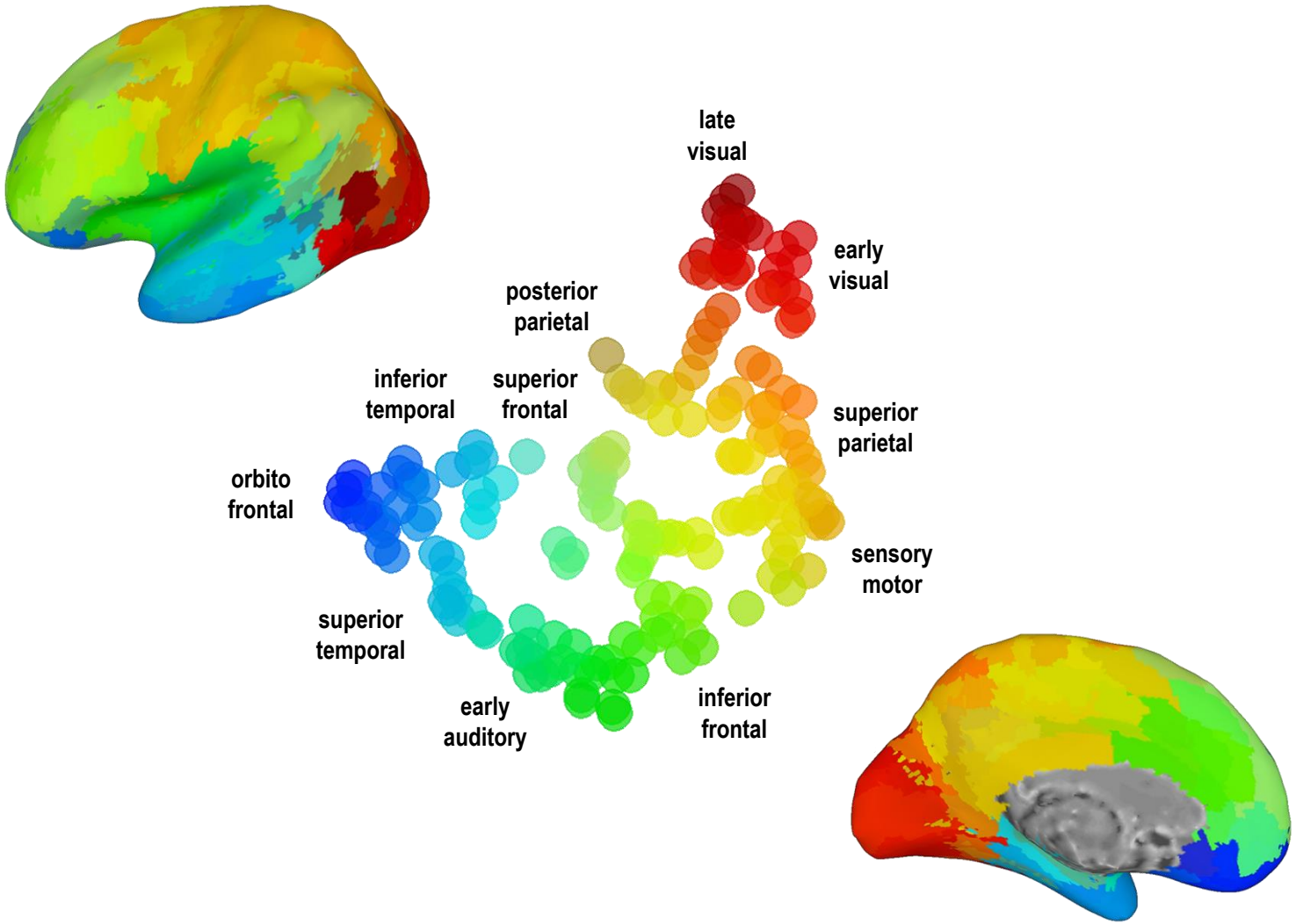
Macroscale organization and cortical gradients



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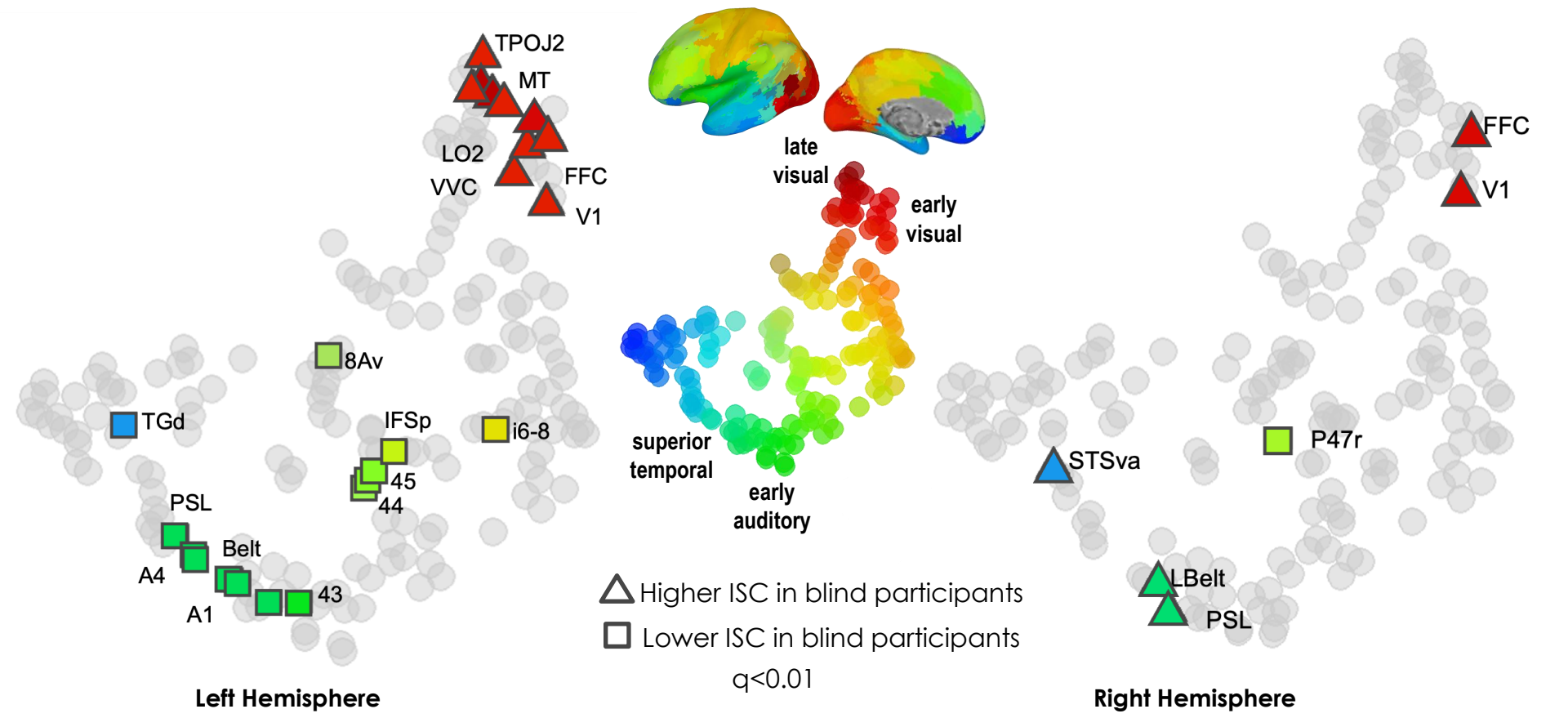
Results: Movie listening - Blind vs Audio TD



Blind individuals synchronize **occipital regions more than TD** participants. On the other hand, synchronization in **early auditory, superior temporal and frontal regions is lower** in blind than TD subjects

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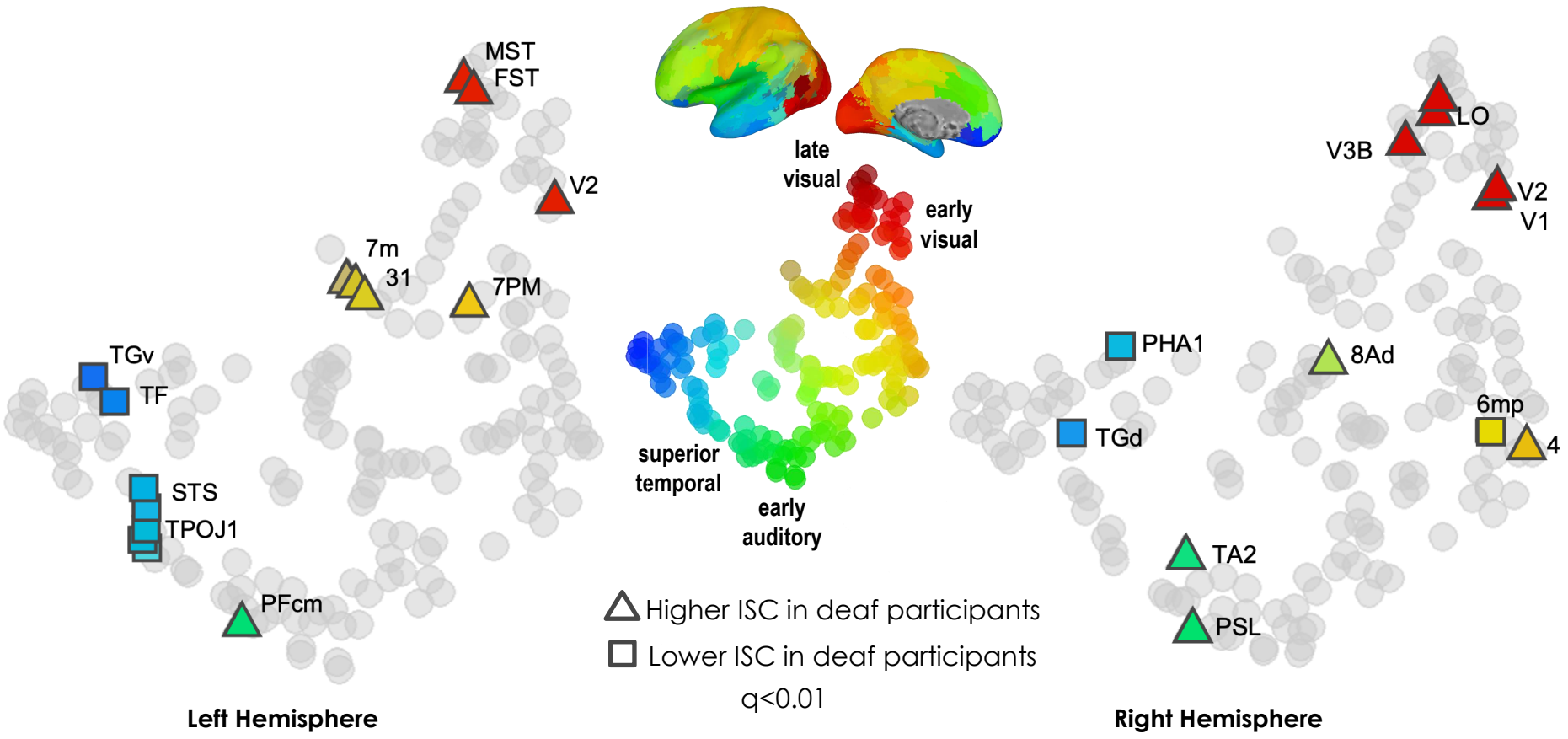
Results: Movie watching - Deaf vs Video TD



Deaf individuals synchronize **occipital and posterior parietal regions more than TD** participants in both hemispheres. Conversely, TD subjects are more synchronized in **superior temporal regions**. No differences in early auditory cortices.

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Summary & Conclusions

- **Occipital regions** showed **greater synchronization** in both congenital visual and auditory deprivation relative to typical development, thus suggesting that "visual" areas are reliably involved in stimulus processing regardless of the deprived sensory modality

- From a **functional perspective**, this finding recalls the hypothesis that the modulation of activity in occipital areas may have a causal role in cognition in humans (e.g., Roelfsema and de Lange)

- From an **ontogenetic perspective**, this finding is consistent with research showing that sensitive periods for the visual system lag the auditory ones and, in general, with the evidence that the visual system expresses a more protracted functional refinement and maturation

Acknowledgments

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Dataset and Code: https://osf.io/j8x6h/

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