# Task-dependent recruitment of modality-specific and multimodal regions during conceptual processing

Philipp Kuhnke[1,2], Markus Kiefer[3], and Gesa Hartwigsen[1,2]

[1]*Lise Meitner Research Group 'Cognition and Plasticity', Max Planck Institute for Human Cognitive and Brain Sciences (MPI CBS), Leipzig, Germany;*
[2]*Research Group 'Modulation of Language Networks', Department of Neuropsychology, MPI CBS, Leipzig, Germany;*
[3]*Department of Psychiatry, Ulm University, Germany*

MAX-PLANCK-GESELLSCHAFT @FriedericiLab

MAX PLANCK INSTITUTE FOR HUMAN COGNITIVE AND BRAIN SCIENCES LEIPZIG

## Introduction

- **Conceptual knowledge** (e.g. about objects in the world) underlies many cognitive abilities, such as word comprehension
- Concepts are (at least partly) composed of **perceptual and motor features** represented in **modality-specific perceptual-motor brain regions** [1]
- In addition, **multimodal "convergence zones"** integrate modality-specific representations into increasingly abstract representations [2,3]
- **Unclear** to what extent retrieval of perceptual-motor features & recruitment of modality-specific regions **depend on task demands**

**Research question:**

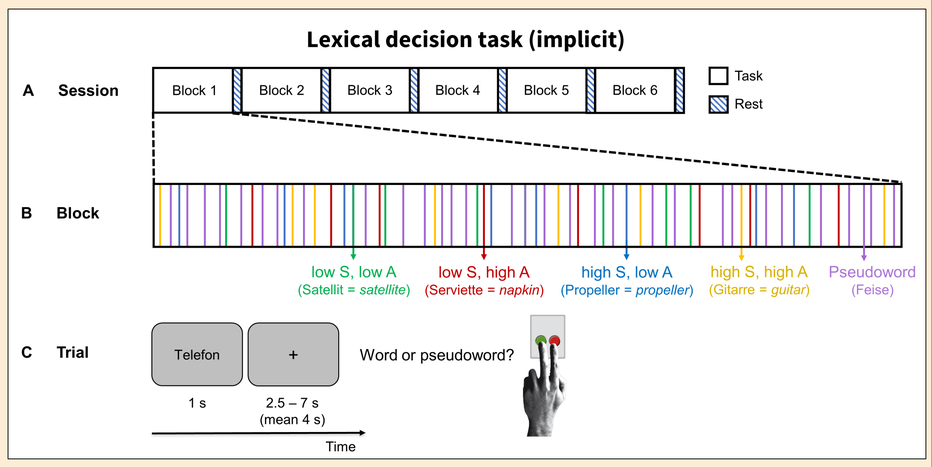
To what extent does retrieval of sound and action features & recruitment of auditory and motor regions depend on task?

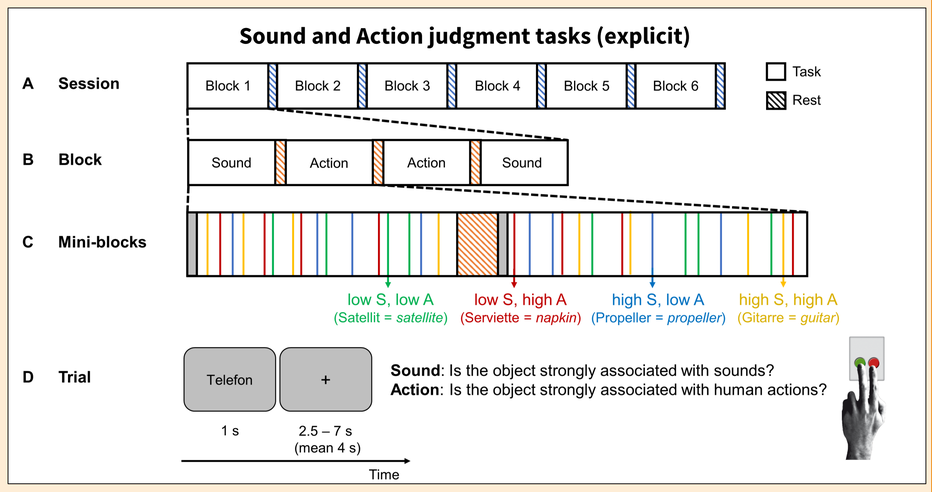
## Methods

### Stimuli

| | | Action: low | | Action: high | |
|---|---|---|---|---|---|
| Sound: low | | low S, low A | | low S, high A | |
| | | *Satellit (satellite)* | 48 | *Serviette (napkin)* | 48 |
| Sound: high | | high S, low A | | high S, high A | |
| | | *Propeller (propeller)* | 48 | *Gitarre (guitar)* | 48 |

- **40 participants** (healthy, right-handed, 18-35 years)
- **event-related fMRI**
- 3T scanner (32-channel head coil)
- dual-GE EPI sequence (TR = 2 s; TE = 12/33 ms; 2.5 $mm^3$ voxels; 90 axial slices)
- Localizers for motor (hand movements) & auditory (sound perception) regions
- **Analysis**: whole-brain random-effects group analysis (SPM12)
- **Threshold**: voxel-wise FDR q < 0.05 (extent > 20 voxels)




## Results

**Action feature retrieval** (high > low action words)

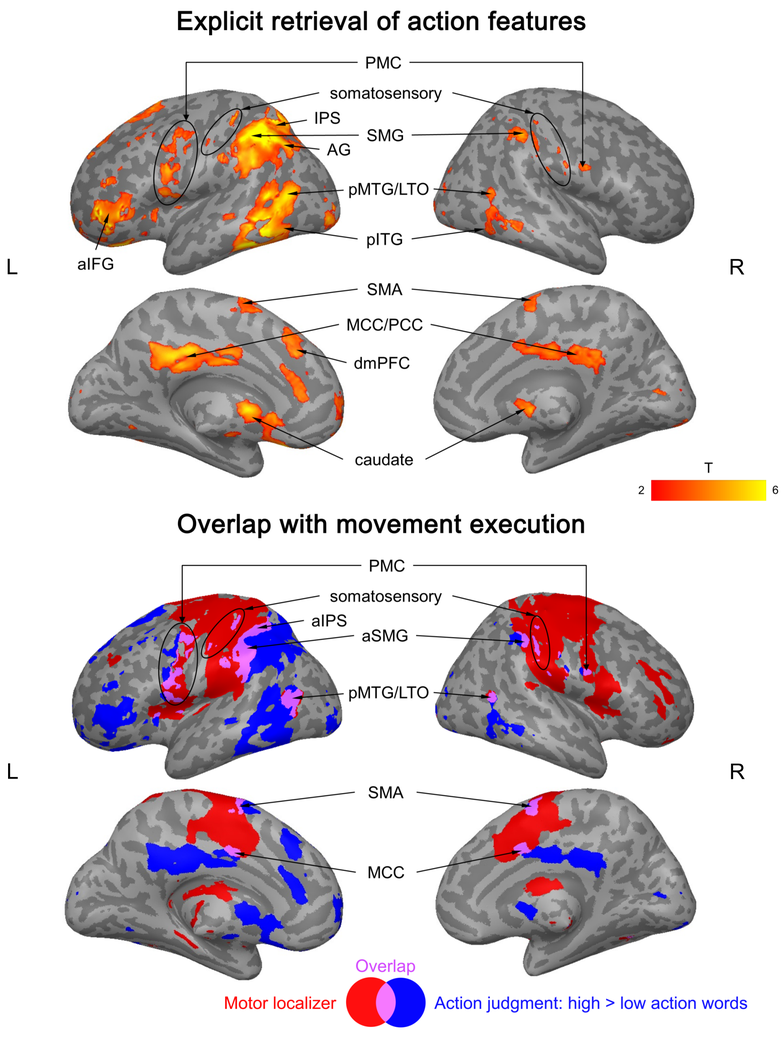
- Lexical decisions: no significant activations
- Sound judgments: no significant activations
- Action judgments:

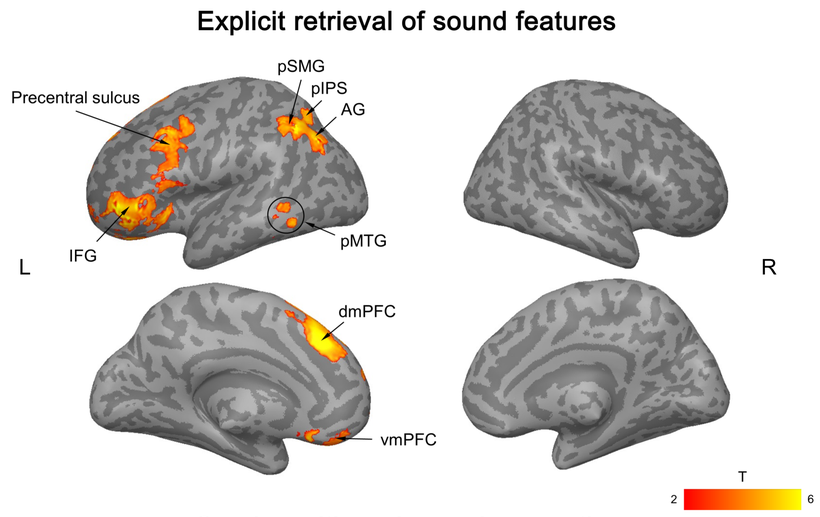
**Sound feature retrieval** (high > low sound words)

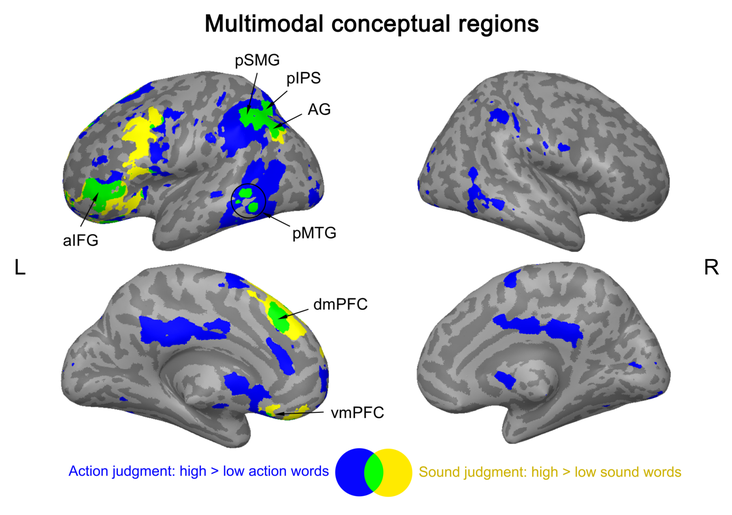
- Lexical decisions: no significant activations
- Action judgments: no significant activations
- Sound judgments:

**Multimodal conceptual regions:**

Engaged both during the explicit retrieval of action & sound features

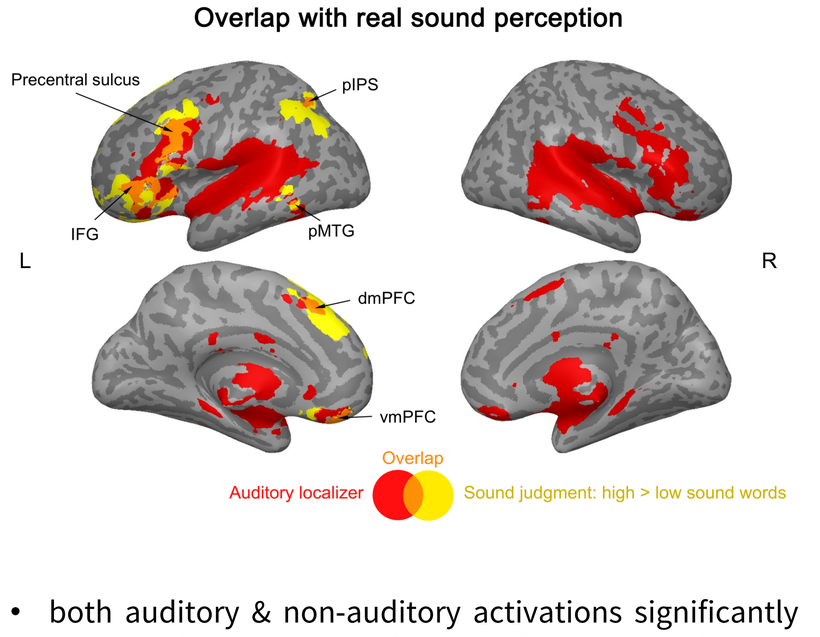


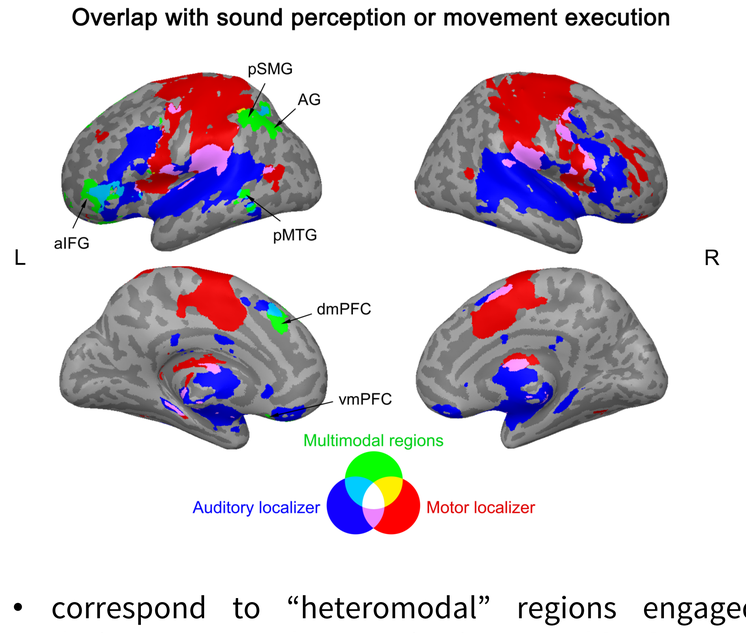










**Interaction analyses:**

- both motor & non-motor activations significantly stronger during action judgments than other tasks
- both auditory & non-auditory activations significantly stronger during sound judgments than other tasks
- correspond to "heteromodal" regions engaged during conceptual processing in general [2,3]

## Discussion

- Retrieval of sound & action features of concepts involves both **(1) modality-specific perceptual-motor regions** and **(2) higher-level regions** outside modality-specific systems
- Many of the **higher-level regions** were engaged in the retrieval of both sound and action features, indicating that they **are multimodal**
- Retrieval of perceptual-motor features is strongly **task-dependent**
  - Significant activations for sound or action feature **selectively when task-relevant**
  - Significantly **stronger activity** for a specific feature when task-relevant (vs. other tasks)
  - **Both modality-specific & multimodal regions** show a task-dependent response to individual perceptual-motor features

→ Conceptual processing relies on a **flexible, multilevel architecture** grounded in the perceptual-motor systems

## References

[1] Kiefer, M., & Pulvermüller, F., 2012. Conceptual representations in mind and brain: Theoretical developments, current evidence and future directions. Cortex 48, 805–825. doi:10.1016/j.cortex.2011.04.006

[2] Binder, J.R., & Desai, R.H., 2011. The neurobiology of semantic memory. Trends Cogn. Sci. 15, 527–536. doi:10.1016/j.tics.2011.10.001

[3] Binder, J.R., Desai, R.H., Graves, W.W., & Conant, L.L., 2009. Where Is the Semantic System? A Critical Review and Meta-Analysis of 120 Functional Neuroimaging Studies. Cereb. Cortex 19, 2767–2796. doi:10.1093/cercor/bhp055

## Contact

**Philipp Kuhnke**
PhD student
Lise Meitner Research Group 'Cognition and Plasticity', Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

*kuhnke@cbs.mpg.de* @PhilKuhnke