Neural bases of action observation in dogs (*Canis lupus familiaris*) and humans

Magdalena Boch[1,2], Sabrina Karl[3], Isabella C. Wagner[1], Ludwig Huber[3]* & Claus Lamm[1]*

[1]Social, Cognitive and Affective Neuroscience Unit, Department of Cognition, Emotion, and Methods in Psychology, Faculty of Psychology, University of Vienna, Vienna, Austria ;[2] Department of Cognitive Biology, Faculty of Life Sciences, University of Vienna, Vienna, Austria; [3]Comparative Cognition, Messerli Research Institute, University of Veterinary Medicine Vienna, Medical University of Vienna and University of Vienna, Vienna, Austria; [4]Vienna Cognitive Science Hub, University of Vienna, Austria ; *These authors share senior authorship.

universität wien

Social, Cognitive and Affective Neuroscience Unit

BACKGROUND

Dog-human comparisons allow to study a potential convergence of the neural bases of action observation.

The **human brain evolved by adapting to changes in their complex social environment[1] which they have shared with dogs** since thousands of years[2].

Dogs and humans also share numerous **convergent skills**, such as (over-) imitation of other individuals' actions[3,4].

Humans and non-human primates engage **premotor, parietal, and sensorimotor regions during action observation**[5,6]

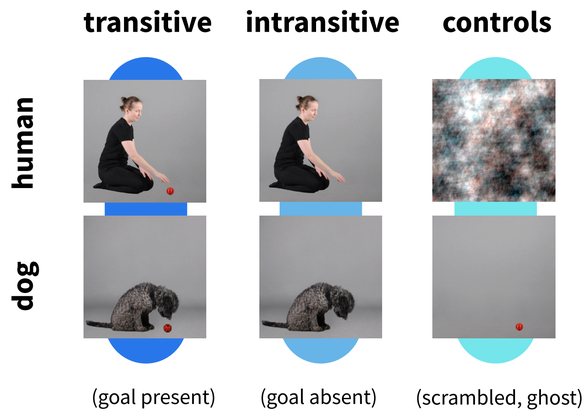
Do dogs possess an action observation network (AON) similar to primate species?

How do dogs and humans perceive conspecific vs. heterospecific actions?

STUDY DESIGN

N = 16 pet dogs (10♀)
Awake, unrestrained, trained[7]
Mean: 6.9 yrs (SD: 32)
75% hunting / herding breeds

N = 40 humans (22♀)
Mean: 23 yrs (SD: 2.6)

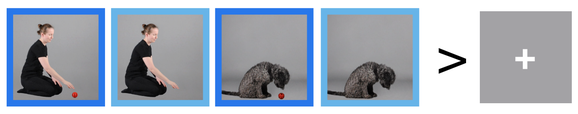


- Two 5-min task runs
- ~12s blocks (5 videos each)
- Action: picking up ball
- 2 human, 2 dog models
- Videos were created based on transitive action recording

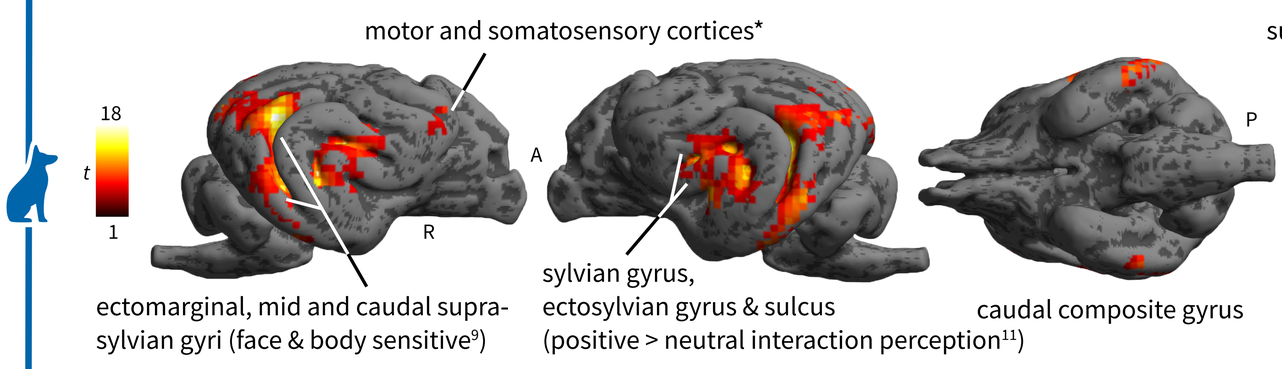
Dog imaging data was convolved with a tailored dog HRF[8] and human data with standard canonical human HRF. **Imaging parameters dogs**: multiband (MB)accelerated EPI sequence, TR/TE = 1000/38 ms, voxel size = 1.5 x 1.5 x 2 mm3, 24 axial slices, flip angle = 61°, interleaved; structural scan: MP-RAGE, TR/TE = 2100/3.13 ms, voxel size = 0.7 mm isotropic; **humans**: MB accelerated EPI sequence, TR/TE = 1200/34 ms, voxel size: 1.5 mm isotropic, flip angle = 66°, interleaved; structural scan: MP-RAGE, TR/TE = 2300/2.26 ms, voxel size: 0.9 mm isotropic

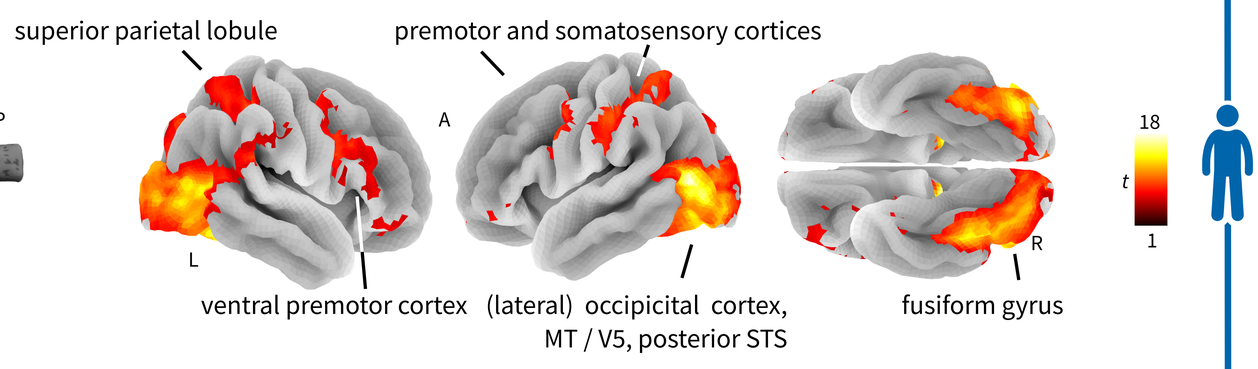
FIRST RESULTS

A Action observation > implicit baseline



As expected, activation in AON.





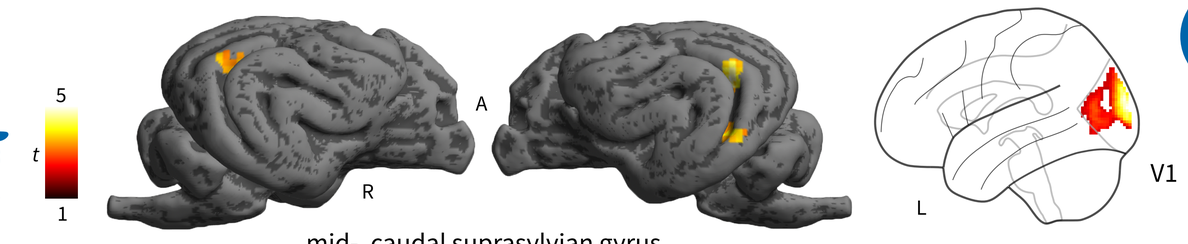
Same activation pattern for comparisons against ghost & scrambled (not shown).

Activation in temporal network beyond face- and body-sensitive areas and in motor and somatosensory cortex.

B Action (transitive, intransitive) x Agent (dog, human)

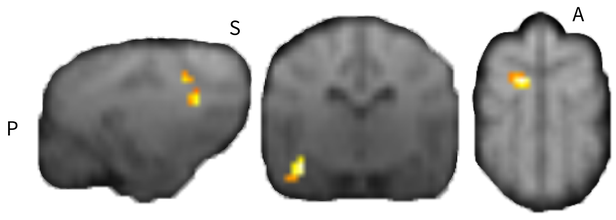
Greater activation in face- & body-sensitive regions[9].

Conspecific > heterospecific action



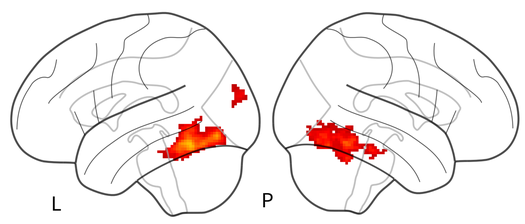
Greater activation in visual cortex.

Transitive < intransitive



Primary somatosensory cortex, amygdala, motor cortex

Transitive > intransitive

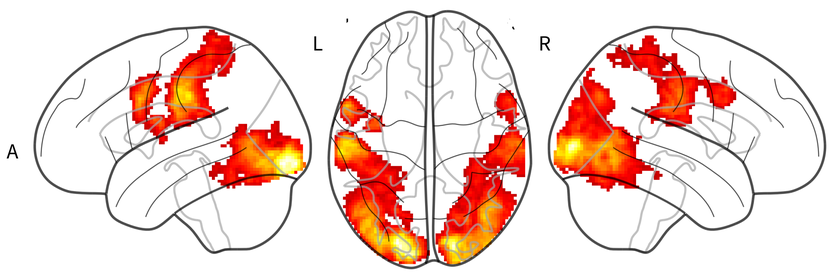


inferior temporal cortex (IT)

Greater activation for intransitive actions in dog somatomotor cortices - focus more on action with absence of toy?

Greater activation for transitive actions in human IT.

Conspecific < heterospecific action



Increased AON activation during dog action observation - stronger engagement due to lower familiarity[10]?

SUMMARY

Activation during action observation in somatomotor cortices and temporal regions beyond visual cortices of both species, but parietal activation exclusive to humans.

Greater activation for intransitive compared transitive actions in dog somatomotor cortices. In humans, differences only in visual cortices.

Stronger engagement of human AON during observation of dog compared to human actions. In dogs, increased activation only in higher-order visual areas for conspecific actions.

Images are accompanied with anatomical locations posterior (P), anterior (A), dorsal (D), ventral (V) , left (L) and right (R). Analysis A: one sample *t*-test, analysis B: contrasts from flexible factorial analysis. Display threshold: Cluster defining threshold: p < .005 / .001 (dogs/humans), probability threshold: p < .05 FWE corrected; * does not survive cluster correction; for analysis B (dogs), the cluster defining threshold was lowered to k = 20 voxels, because no voxels survived the significance threshold of k = 42 voxels.

References: [1]Dunbar et al., *Science*, 2007, [2]Bergström et al., *Science* 2020; [3]Huber et al., *Learn Behav* 2018, [4]Range et al., *Curr Biol* 2007, [5]Fabbri-Destro et al., *Physiology* 2008, [6]Hardwick et al., *Neurosci Biobehav Rev* 2018, [7]Karl et al. *Behav. Res. Methods* 2019, [8]Boch et al., *Neuroimage* 2021, [9]Boch et al., biorxiv; 2021, [10]Kilner et al., *Cogn. Proc.* 2007

magdalenaboch.com
@MagdalenaBoch

SCAN Unit
COGCOM PhD in Cognition and Communication
messerli Research Institute
vetmeduni vienna
oead Marietta Blau Grant
FWF W1262-B29
WWTF CS18-012