Face, body and object representations in the dog and human brain

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BACKGROUND

- Humans and non-human primates: object responsive regions in **inferiotemporal cortex (IT)** and regions **specialized for face and body perception**[1].
- Representational similarity analyses (RSA) revealed matching **neural representations for animate vs. inanimate** and **face vs. body object categories**[2].
- But how did the (social) environment shape these neural bases? Dogs are long-standing close companions of humans[3]: this offers **insights into the convergent evolution**[4] of **object perception**.
- First study to investigate body perception: **systematic exploration of face–body and animate–inanimate object perception** in dogs & humans.

Do dogs and humans share similar neural underpinnings of face, body and everyday object processing?

STUDY DESIGN & ANALYSIS

- ***N*= 15 pet dogs** (♀: 11)
- Awake, unrestrained, trained[5]
- Mean: 7.8 years (*SD* = 2.23 years)
- 60% Border Collies

- ***N*= 40 humans** (♀: 22)
- Mean: 23 years (*SD* = 2.6 years)

- Two 5-min task runs
- 12 s blocks (à 5 images)
- Images are randomized across blocks
- 180 images and 6 trials per condition

UNIVARIATE ANALYSIS: Activation during object perception: animacy, faces, bodies, everyday objects

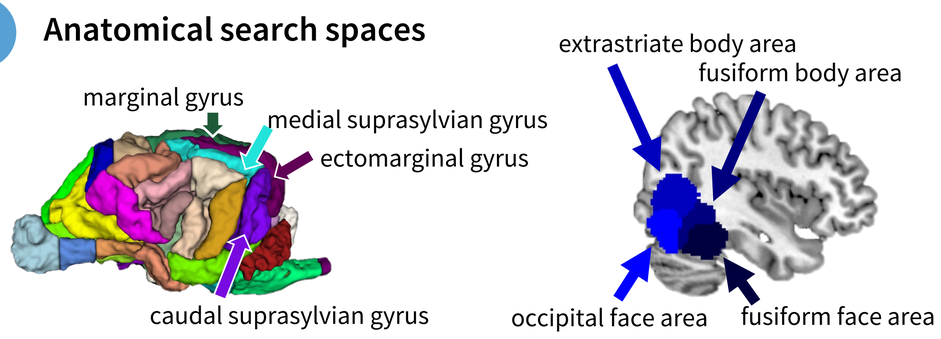
REPRESENTATIONAL SIMILARITY ANALYIS (RSA)[6]: Pattern similarity for animate objects, and conspecific bodies

Dog imaging data was convolved with a tailored dog HRF[7] 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 mm^3, 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

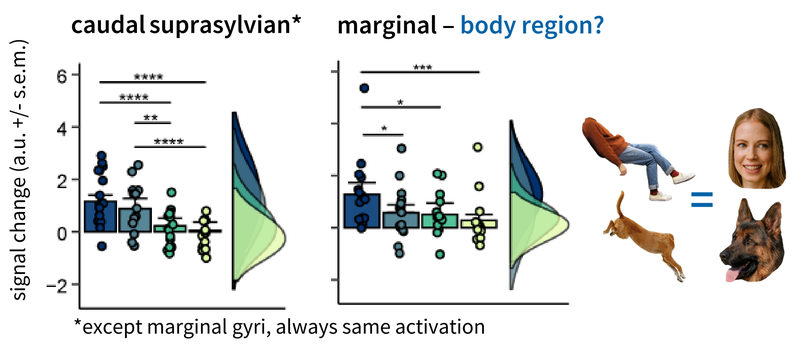
RESULTS

UNIVARIATE functional regions of interest (fROI) analysis*

A **Anatomical search spaces**



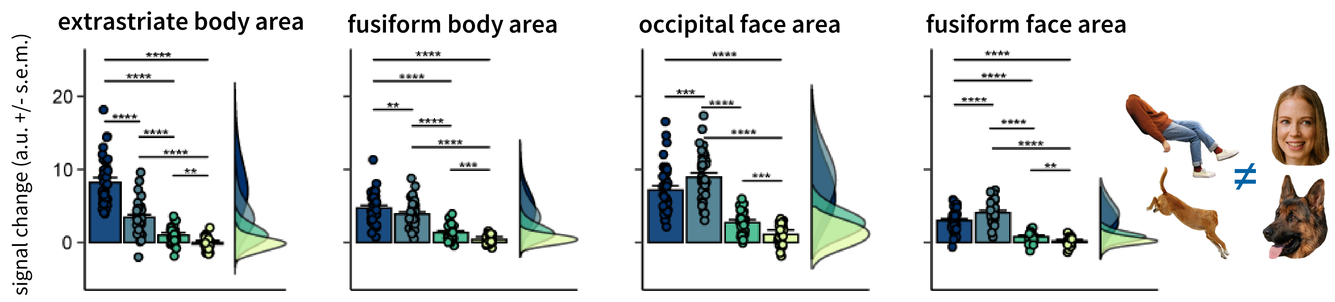
B **Dogs: primarily coding for animate stimuli** (data run 2)



*except marginal gyri, always same activation

Increased sensitivity for animate stimuli but not between faces and bodies, except marginal gyrus.

C **Humans: face and body sensitive regions** (data run 2)



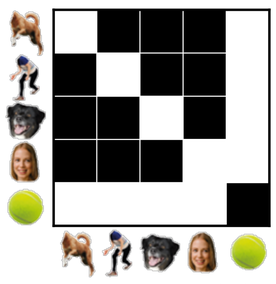
As expected, further **sub-division in face and body sensitive regions**.

bodies faces inanimate objects scrambled

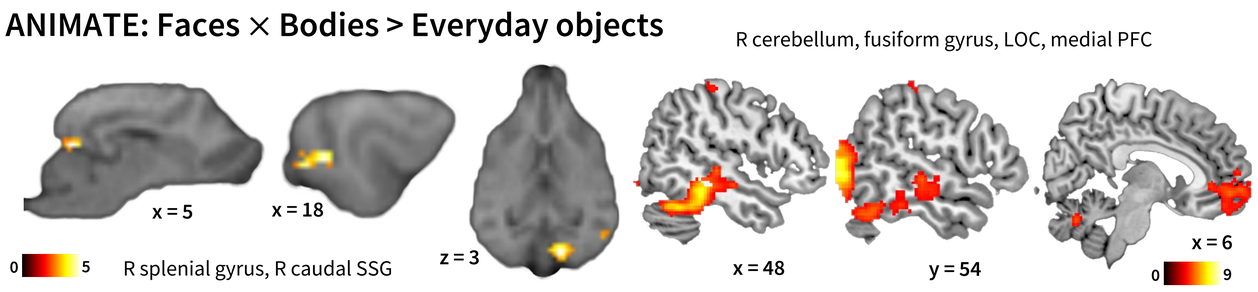
*individual fROIs were defined based on task run 1 within each bilateral search space (A) and defined based on the contrasts faces / bodies > inanimate objects.

REPRESENTATIONAL SIMILARITY ANALYSIS

D

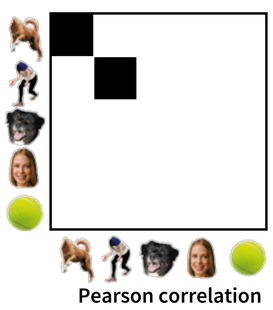


ANIMATE: Faces × Bodies > Everyday objects

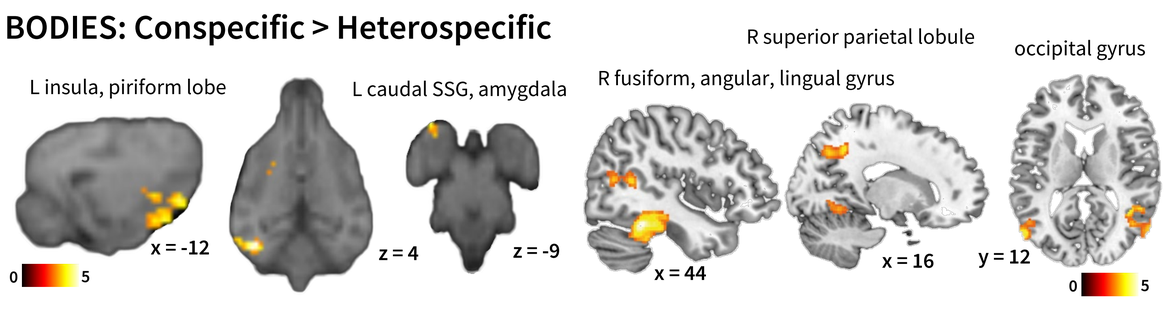


Shared neural representation of animate objects in visual regions.

E



BODIES: Conspecific > Heterospecific



Increased pattern similarity for conspecific bodies in body selective regions.
Dogs: consistent representation in **olfactory and limbic cortices for conspecific bodies**.

Areas of activation were determined using the canine breed-averaged t2w atlas[10] and labels from[11] for dogs and the Anatomy toolbox[12] and AAL[13] for humans. Images are accompanied with anatomical locations posterior (P), anterior (A), dorsal (D), ventral (V) , left (L) and right (R). Display threshold for univariate: Cluster defining threshold: $p < .005$ / .001 (dogs/humans), probability threshold: $p < .05$ FWE corrected; RSA: Cluster defining threshold: $p < .005$ probability threshold: $p < .05$ FWE corrected (dogs), and whole-brain FWE (humans) using SnPM.

CONCLUSION

- **Similar neural processes** during **animate vs. inanimate perception** in dogs and humans, a crucial socio-cognitive skill
- **Only humans:** additional sub-division into **distinct face- and body-sensitive brain regions**
- Insights into **differentially evolved sensory systems**

Convergent evolution of neural processes underlying animate vs. inanimate perception, but divergent neural face and body representations.

REFERENCES: [1]Tsao et al. 2009, *PNAS*; [2]Kriegeskorte et al., *Neuron* 2008; [3]Bergström et al., *Science* 2020; [4]Fitch et al., *Neuron* 2010; [5]Karl et al., *Behav. Res. Methods* 2019; [6]Kriegeskorte et al., *Front. Syst. Neurosci* 2008; [7]Boch et al., *Neuroimage* 2021; [9]Nitzsche; [9]Kanwisher et al., Philos. *Trans. R. Soc. Lond., B, Biol. Sci* 2006; [10]Peelen et al., *Nat. Rev. Neurosci.* 2007; [11]Czeibert et al., *Biol. Futur* 2019; [12]Eickhoff et al, *Neuroimage* 2005; [13]Tzourio-Mazoyer et al., *Neuroimage* 2002;

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