Portraits versus landscapes: Neural responses to the aesthetic appreciation of visual artworks

Poster-ID: 1922

ISTBI 复旦大学类脑智能科学与技术研究院
Institute of Science and Technology for Brain-Inspired Intelligence

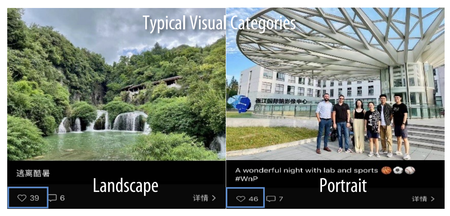
Xinyu Liang, Kaixiang Zhuang, Yun Wang, Peixin Yang, Jianfeng Feng, **Deniz Vatansever**

Institute of Science and Technology for Brain-Inspired Intelligence, Fudan University, Shanghai, China

xinyu_liang@fudan.edu.cn
@betory9178

1 Introduction

- Visual arts play a vital role in the shared history of mankind. Apart from cultural idiosyncrasies in style and form, two common objects that often appear in visual artworks are human portraits and scenes of landscapes[1].
- In modern visual arts and social media, faces and places most frequently appear as the central visual stimuli, influencing popular preferences and subsequent user decisions on aesthetic appeal.



- As such, the prevailing "aesthetic triad" model proposes that aesthetic appeal arises from the processing and interactions of category-specific meaning–knowledge, emotion–valuation, and sensory–motor systems[1].
- However, the distinct roles and reciprocal interactions of these systems in the aesthetic appreciation of visual arts requires further investigation.
- Specifically, neural responses[2] within the ventral visual pathway to viewing visual artworks with "Portraits and Landscapes", and their potential interaction with the emotion-valuation system remains unclear[3].
- To this end, we designed a 7T fMRI experiment to investigate the neural underpinnings of visual aesthetics using visual artworks.

Research Objective

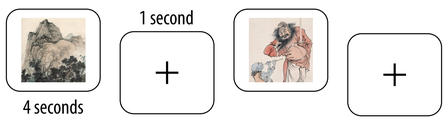
The primary goal of our study was to investigate the neural mechanisms underlying the aesthetic appreciation of visual artworks using ultra-high field 7T fMRI.

2 Materials and Methods

Experimental Paradigm: Art Recognition Task

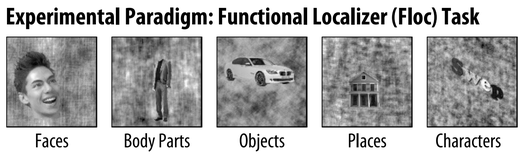
Chinese watercolor paintings from four separate artists
Two categories: 12 portraits and 12 landscapes for each artist

"Focus on the art images and think about how aesthetically pleasing you find them."



Event-related design[4]
Four experimental task runs
96 paintings in each run
(48 portraits and 48 landscapes)

Experimental Paradigm: Functional Localizer (Floc) Task



Four experimental task runs
Oddball task[5]
Five semantic categories

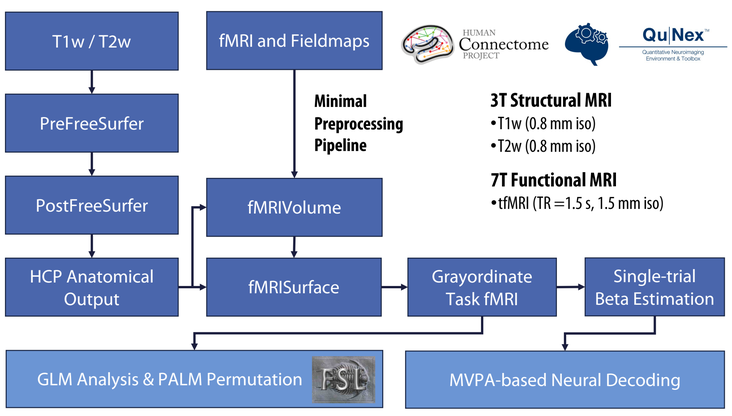
Data Collection: 34 Healthy Participants

Age = 23.21 ± 2.41 years; F/M ratio = 22/12

Behavioral Assessments

- Semantic similarity judgement: Multi-Arrangement Task[6] (MAT)
- Aesthetic appeal rating: Art Appreciation Task (AAT)

Neuroimaging Preprocessing and Analysis Pipelines



Traditional GLM Analysis

- Neuroimaging data was minimally preprocessed using HCP pipelines (Qunex[7]) and statistically modelled after 100s high pass filtering and smoothing with a 6 mm FWHM kernel in grayordinate (fsLR 32k) space.
- We focused on the comparison of the two visual categories (Portraits versus Landscapes) and their parametric modulation by the participants' subjective ratings of aesthetic appeal (FSL FEAT routines).
- Statistical significance: non-parametric permutation (5,000 times) with FDR correction via PALM (FDRp < .05).

MVPA-based Neural Decoding

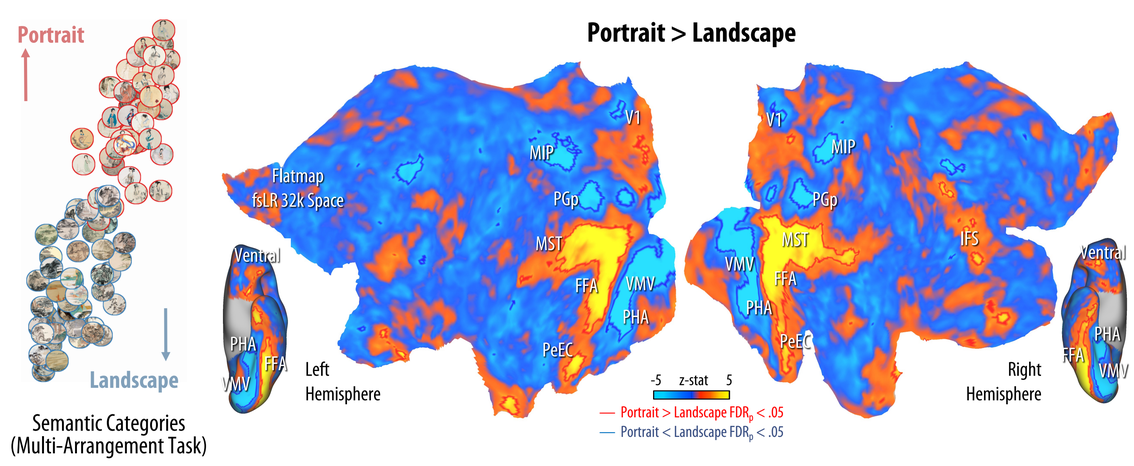
- Single-trial beta estimates (TypeD) were extracted using GLMsingle[8], averaged across runs (4mm smoothing).
- All paintings were divided into quartile grades based on the PCA decomposition of art appreciation ratings.
- Using CANlab core functions[9] two whole-brain multivariate machine-learning analyses (SVR, C = 1) were performed, in which individual beta maps (one per grade for each subject) were used as features.
- 10 repeats of 10-fold cross-validation was employed to evaluate decoding performance.
- Significance of feature weights: 10,000 times bootstrap with FDR correction (FDRp < .05).

Acknowledgements

This study was funded by a grant from the National Natural Science Foundation of China (No. 31950410541) awarded to DV, and a China Postdoctoral Science Foundation award (2021M700853) provided to XL. In addition, we thank Feng Zhou and Benjamin Becker for their help and suggestions on the neural decoding methods.

3 Results

Category-specific behavioral and neural responses to viewing visual artworks



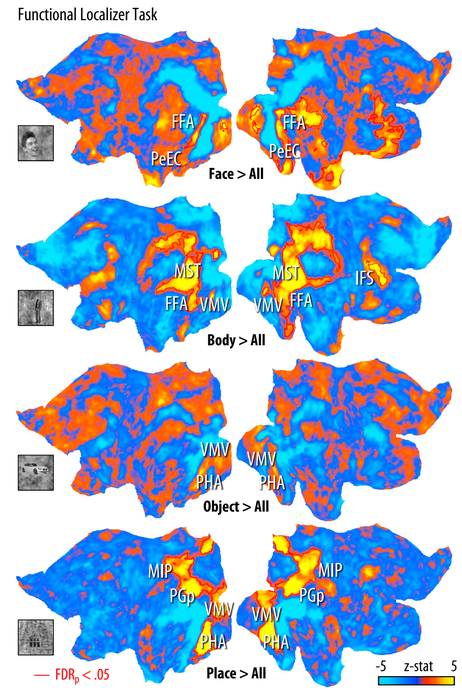
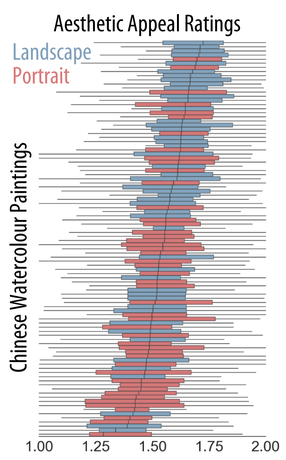
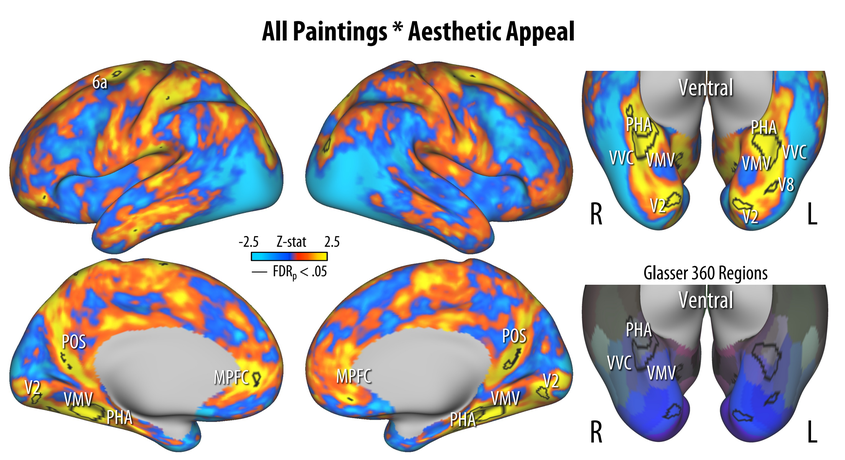


Figure 1. Category-specific neural responses to viewing visual artworks. Multidimensional scaling of semantic similarity judgments from the Multi-Arrangement Task validated a priori categorisation of stimuli into "Portraits and Landscapes", the contrast of which showed strong category-specific neural responses within the ventral visual pathway during Art Recognition Task. In comparison to the Functional Localiser Task, the Portrait > Landscape contrast showed greater activation within the face-specific and body-specific visual cortices (FFA, MST and PeEC). The reverse contrast, however, was associated with greater activity in regions that selectively responded to places and everyday objects (e.g. PHA, MIP and VMV) (5,000 times permutation with FDR correction) (V1: Primary visual area, MIP: Medial intraparietal area, FFA: Fusiform face area, MST: Medial superior temporal area, PeEC: Perirhinal entorhinal cortex, PHA: Parahippocampal area, VMV: Ventral medial visual area, and IFS: Inferior frontal gyrus).

Parametric modulation of neural responses to viewing artworks by aesthetic appeal





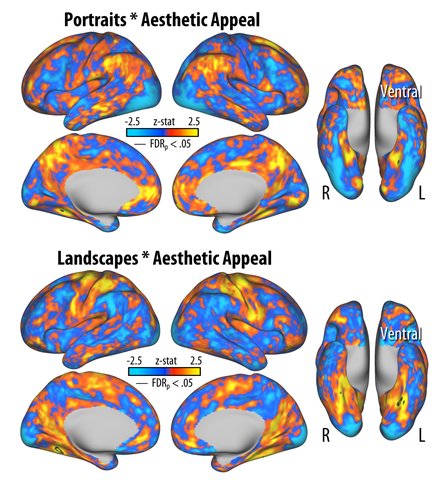
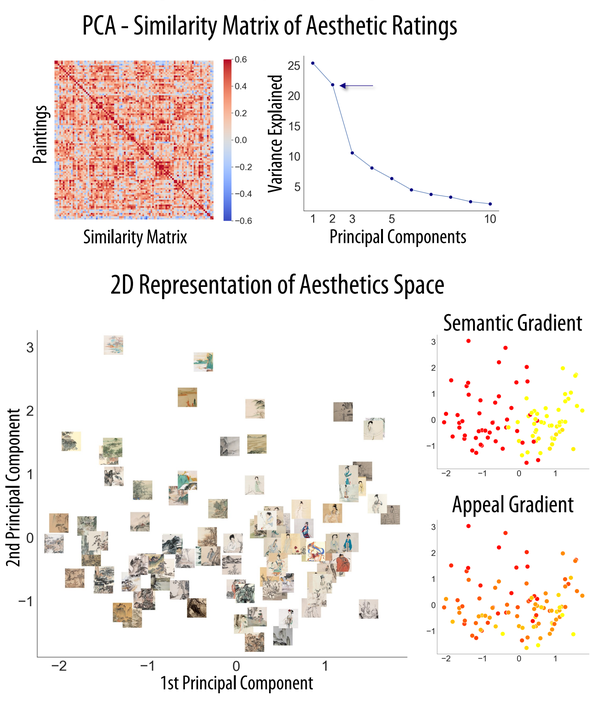


Figure 2. Parametric modulation of neural responses to viewing visual artworks by aesthetic appeal. We used average aesthetic appeal ratings as parametric modulators. With greater aesthetic appeal, the results revealed greater domain general responses within the core default mode network regions (MPFC) and the ventral visual pathway (V8, VMV and PHA). The largest significant cluster was situated at the border of category-specific ventral visual regions. The domain specific modulation for each category was only found in the left ventral medial occipital region. (MPFC: Medial prefrontal cortex, 6a: Area 6 anterior, POS: Parieto-occipital sulcus, V2: Secondary visual area, V8: Eighth visual area, and VVC: Ventral visual complex).

Neural decoding of dual principal gradients in the behavioral appreciation of visual art



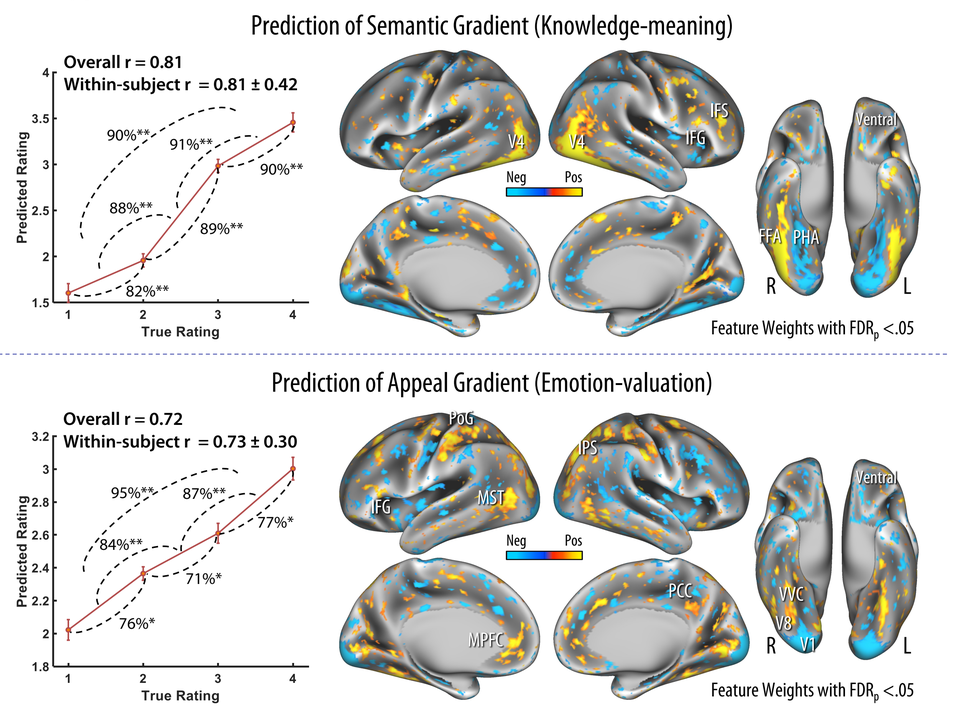
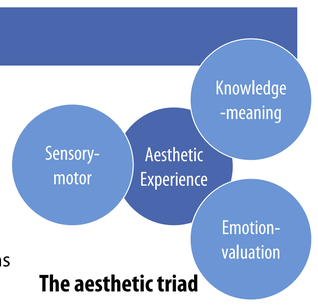


Figure 3. Neural decoding of dual principal gradients in aesthetic appreciation. We observed a significant difference in appeal ratings between landscapes and portraits (t = 2.64, p = .01). To decompose independent elements of aesthetic appeal, we utilized PCA to extract the first two principal components (25% and 22% variance explained, respectively) from the similarity matrix of appeal ratings. We verified the first component as semantic gradient representing knowledge-meaning information by correlating it with the dominant component (explained 86% variances) derived from MAT (r = .80, p < .001). The second component was validated as the appeal gradient, showing high correlation with average aesthetic ratings of paintings (r = .49, p < .001). We revealed two dissociable neural systems that could significantly predict ratings across these two gradients: one consisted with category-specific visual regions (FFA, PHA and V4), and another that encompassed intermediate zones between FFA and PHA, somatosensory area, and emotion-valuation related regions (MPFC, PCC). Significant vertices were identified through 10,000 times bootstrap with FDR correction. (PoG: Postcentral gyrus, IPS: Intraparietal sulcus, PCC: Posterior cingulate cortex, and V4: Forth visual area).

4 Conclusions

- Our results indicated both domain general and category-specific neural responses to viewing visual artworks that were modulated by aesthetic appeal, mainly located in the MPFC and ventral visual pathway.
- Using MVPA-based neural decoding, we identified two dissociable neural systems in the appreciation of visual artworks, corresponding to knowledge-meaning and emotion-valuation domains respectively.
- Collectively, our findings provide vital evidence for the neural mechanisms underlying aesthetic appreciation of visual artworks.



References

[1] Chatterjee (2014), 'Neuroaesthetics', Trends in Cognitive Sciences.
[2] Kanwisher (2010), 'Functional specificity in the human brain: A window into the functional architecture of the mind', Proceedings of the National Academy of Sciences, USA.
[3] Iigaya (2020), 'Progress and Promise in Neuroaesthetics', Neuron.
[4] Allen (2021), 'A massive 7T fMRI dataset to bridge cognitive neuroscience and artificial intelligence', Nature Neuroscience.
[5] Stigliani (2015), 'Temporal Processing Capacity in High-Level Visual Cortex Is Domain Specific', Journal of Neuroscience.
[6] Mur (2013), 'Human Object-Similarity Judgments Reflect and Transcend the Primate-IT Object Representation', Frontiers in Psychology.
[7] Ji (2023), 'QuNex – An Integrative Platform for Reproducible Neuroimaging Analytics', Frontiers in Neuroinformatics.
[8] Prince (2022), 'Improving the accuracy of single-trial fMRI response estimates using GLMsingle', elife.
[9] Kohoutová (2020), 'Toward a unified framework for interpreting machine-learning models in neuroimaging', Nature Protocols.