WebPage

Code

EUROPEAN CONFERENCE ON COMPUTER VISION

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NeuroPictor: Refining fMRI-to-Image Reconstruction via Multi-individual Pretraining and Multi-level Modulation

Jingyang Huo*, Yikai Wang*, Yun Wang*, Xuelin Qian, Chong Li, Yanwei Fu†, Jianfeng Feng
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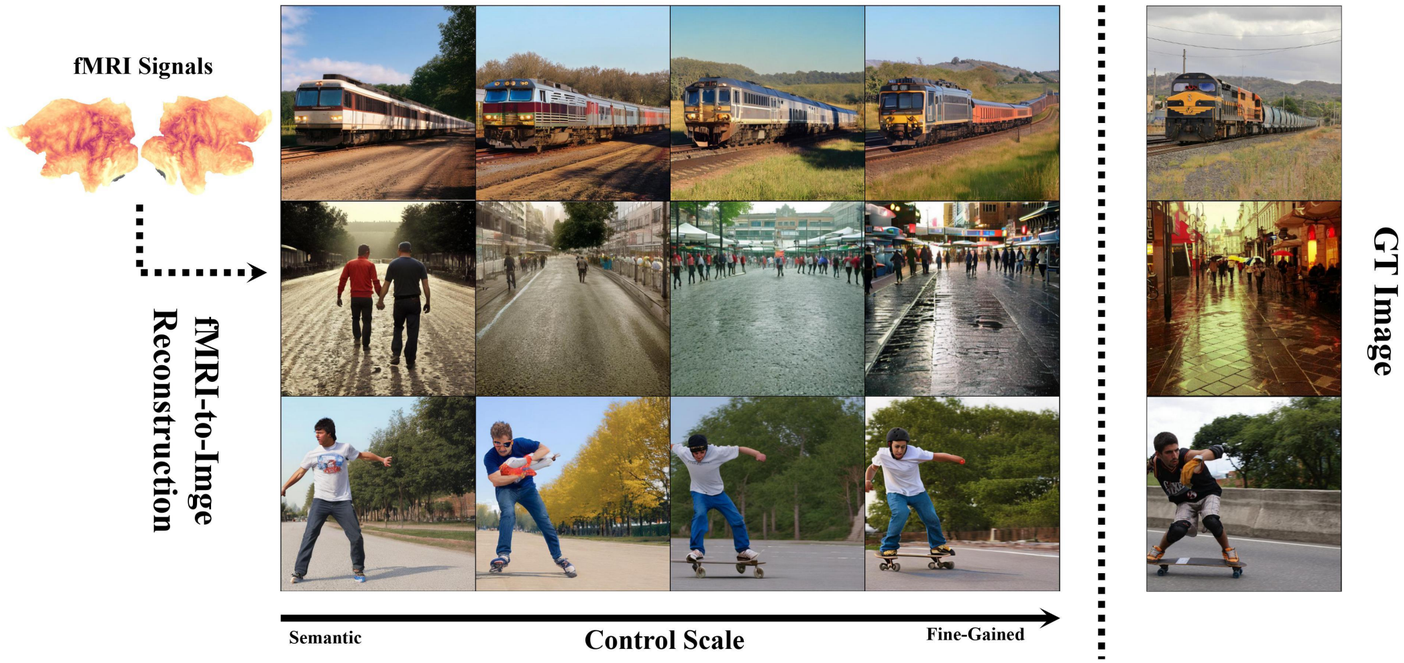
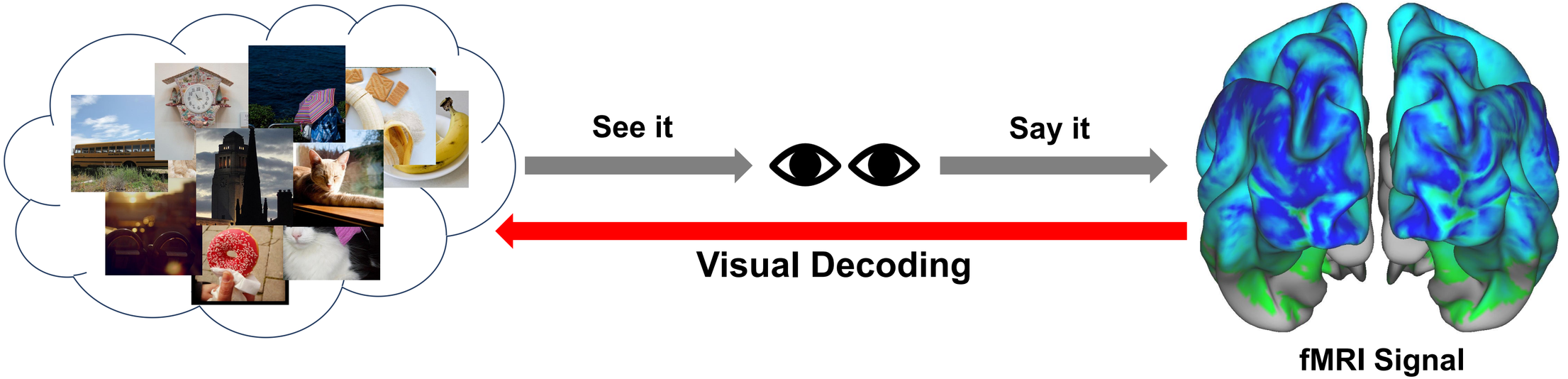


* Indicates equal contributions.

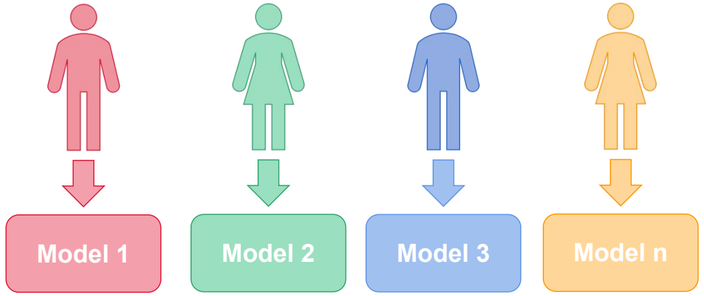
Task

Decoding visual stimuli perceived by humans using fMRI.



Motivation

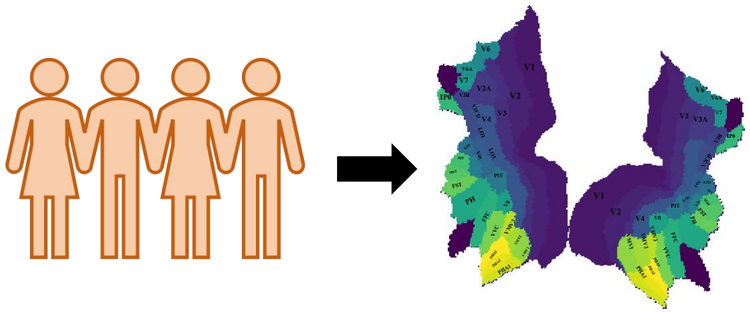
Previous



☒ **Individual-specific**

☒ **Data scarcity**

OURS



fsLR32K surface in **Group Space**

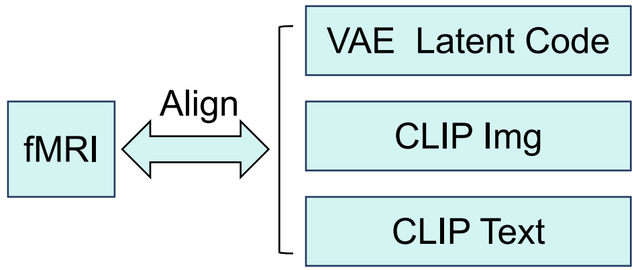
☑**Shared Representation**

☑**Data Scale** ↑

- UKB 40k subjects.
- NSD 67k fmri-image pairs.

Motivation

Previous



☒ **Information loss**
☒ **Error accumulation**
☒ **Partial feature capture**

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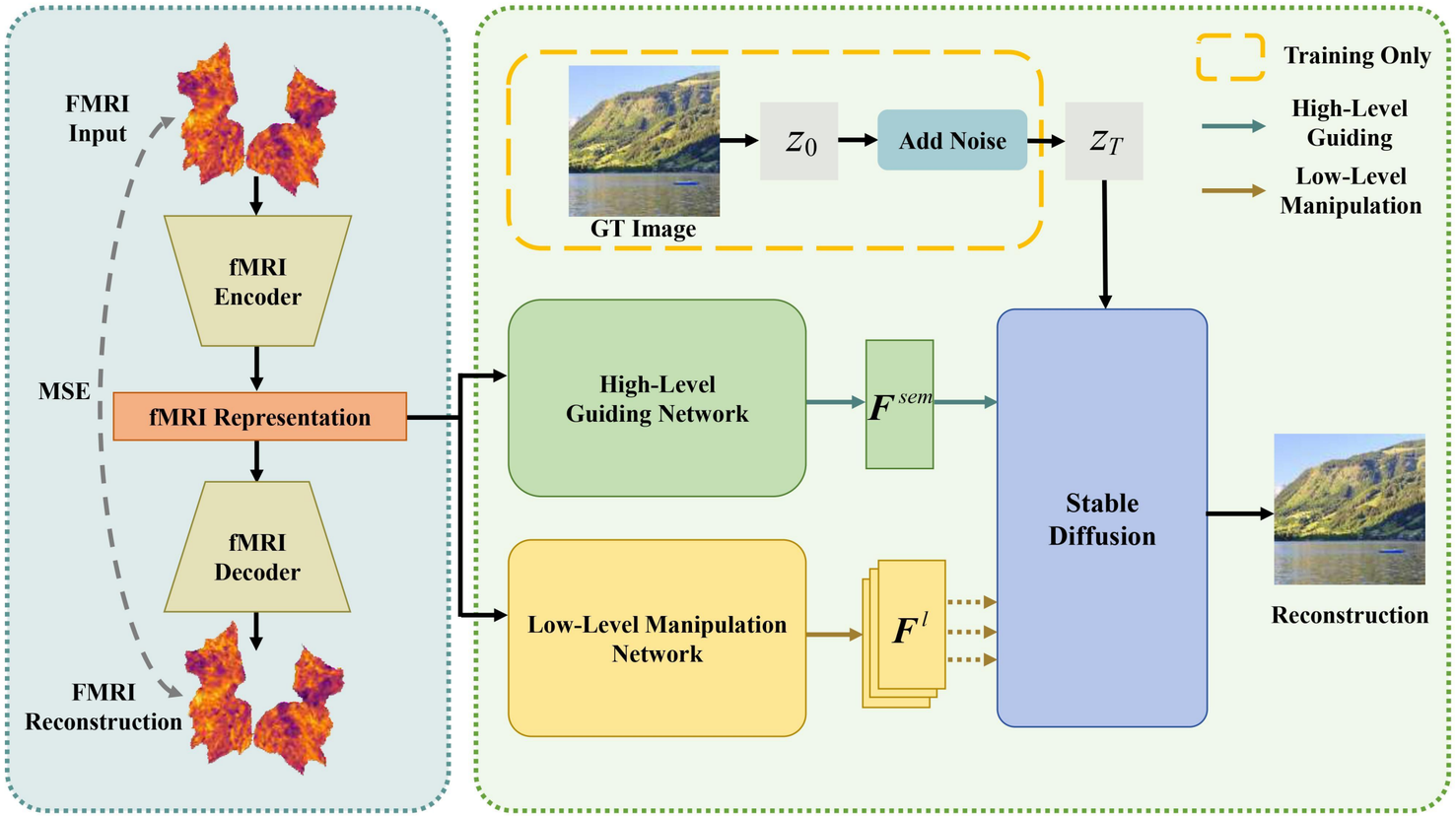
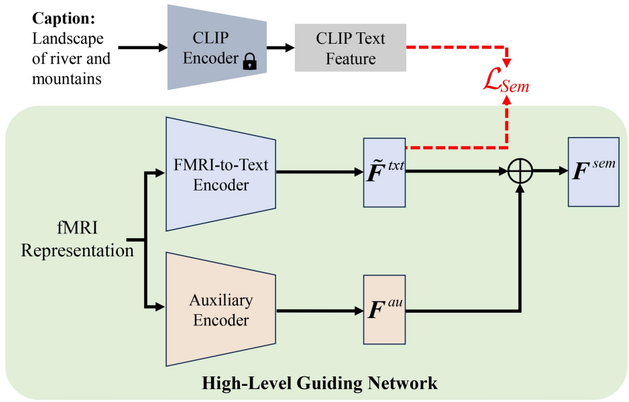
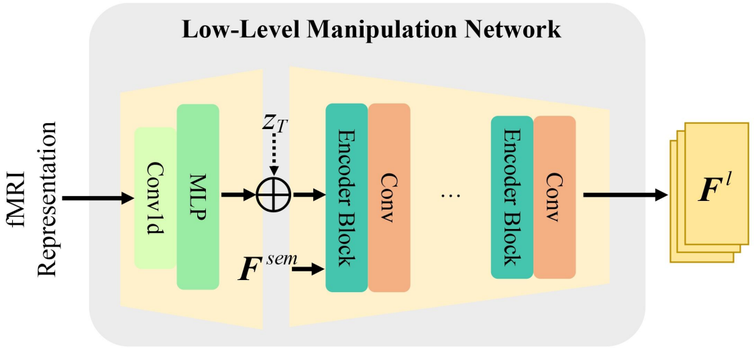
Model Design:

- Multi-level modulation.
- Incremental fine-tuning of generative models.
- Multi-individual pretraining.

Pipeline







i. Learn a universal latent fMRI space across multi-individuals via an auto-encoder, addressing the individual differences and data scarcity.
ii. fMRI-to-image multi-subject pre-training on 67k fMRI-image pairs.
iii. Perform single-subject refining using the same training strategy of step ii.

- Divide neural signal information into high-level and low-level guidance to supervise the diffusion generation process.

Main Results

Table 1: Quantitative comparison of within-subject brain decoding of our NeuroPictor and the previous state-of-the-art mothods on Natural Scenes Dataset.

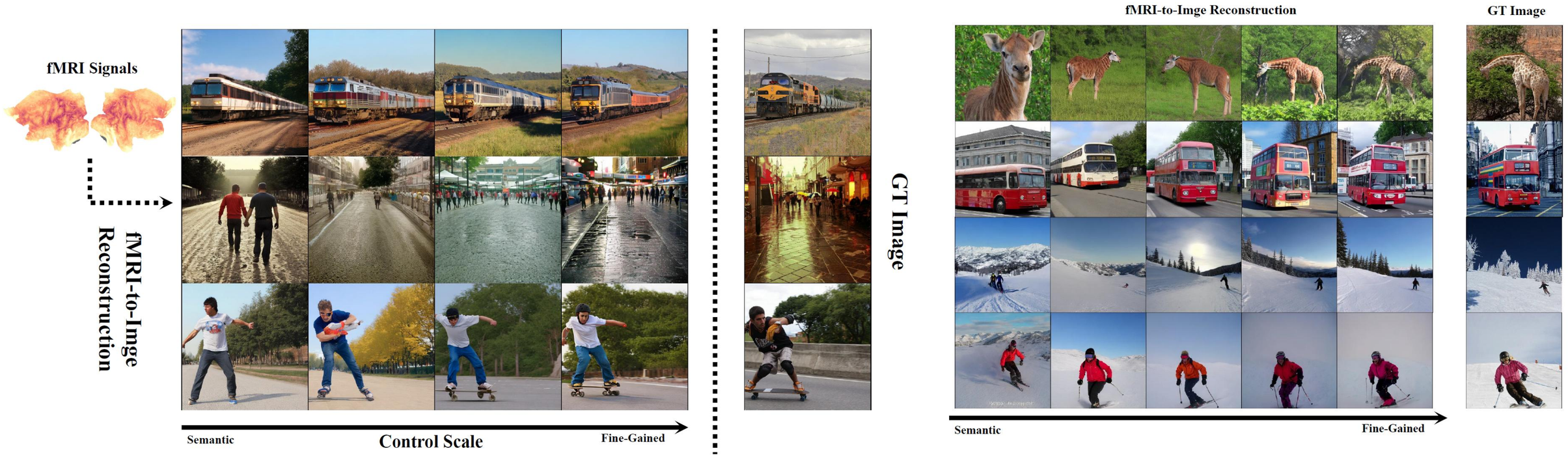
Method	Low-Level				High-Level			
	PixCorr ↑	SSIM ↑	AlexNet(2) ↑	AlexNet(5) ↑	Inception ↑	CLIP ↑	EffNet-B ↓	SwAV ↓
Lin et al. [22]	–	–	–	–	78.2%	–	–	–
Takagi... [41]	–	–	83.0%	83.0%	76.0%	77.0%	–	–
Gu et al. [16]	.150	.325	–	–	–	–	.862	.465
Brain-Cap [13]	**.353**	.327	89.0%	97.0%	84.0%	90.0%	–	–
Brain-Diff [27]	.254	.356	94.2%	96.2%	87.2%	91.5%	.775	.423
MindEye [36]	.309	.323	94.7%	97.8%	93.8%	**94.1%**	.645	.367
NeuroPictor (w/o ft)	.141	.349	91.4%	95.7%	88.3%	88.9%	.722	.417
NeuroPictor	.229	**.375**	**96.5%**	**98.4%**	**94.5%**	93.3%	**.639**	**.350**

Main Results

Restore the **underlying details** of visual stimuli.

Visualization

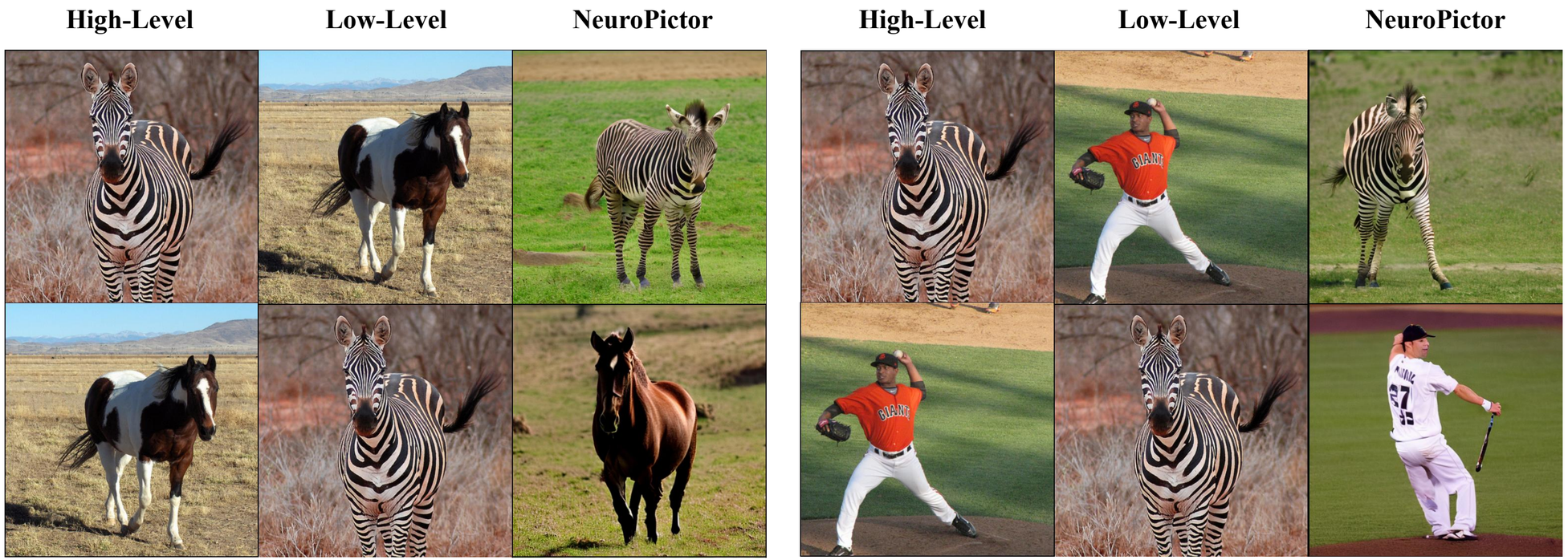
Interpolating the control scale transitions the reconstructed image from **semantic consistency** to **fine-grained control**.



NeuroPictor achieves precise control over decoding low-level structures from fMRI signals while preserving high-level semantics. The decoded images progress from reconstructing visual stimulus solely from high-level semantics to both high-level semantics and low-level structures as the influence increases from left to right.

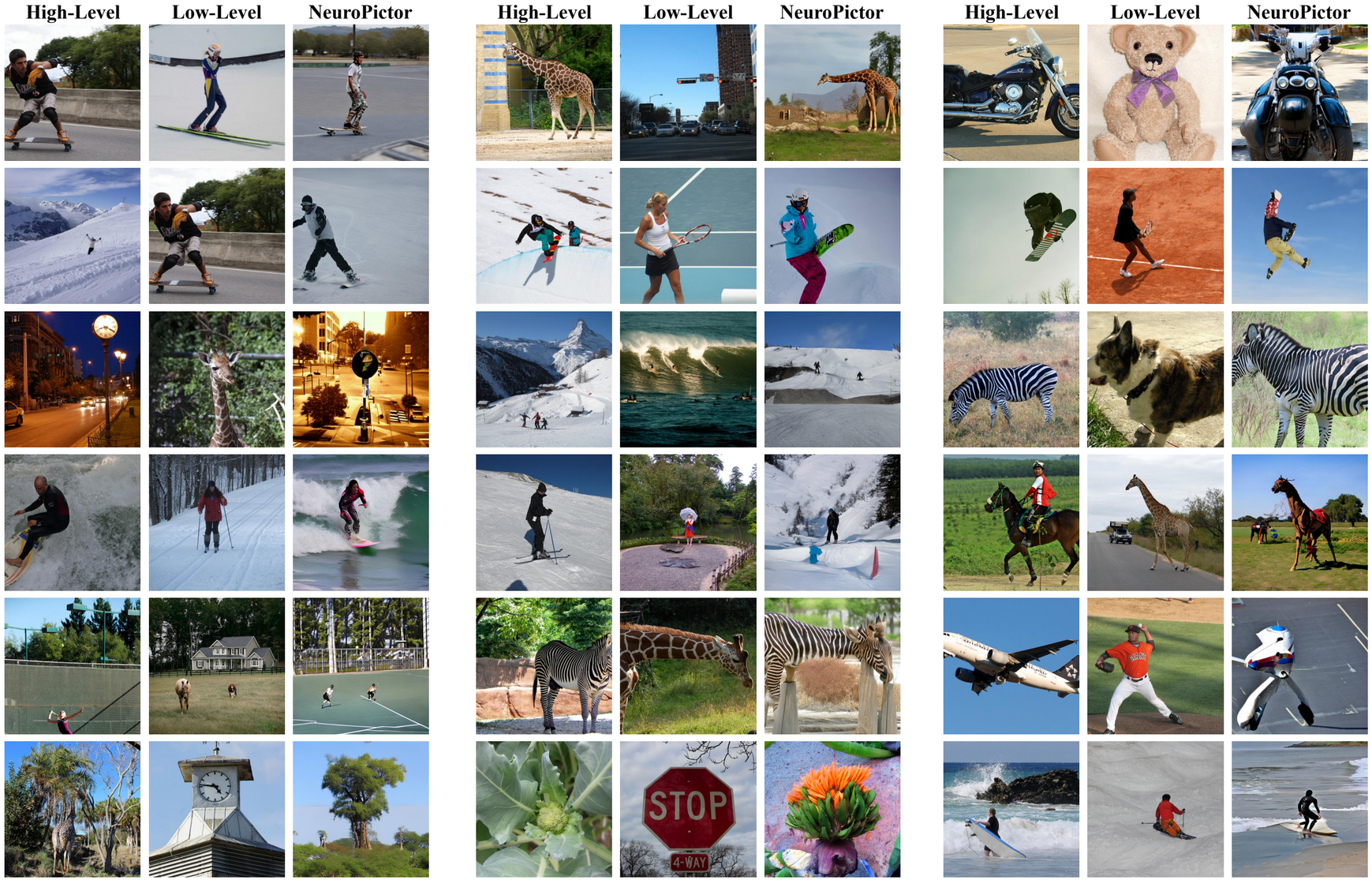
Visualization

Swap high-level fMRI features to manipulate image semantics while maintaining structural consistency.

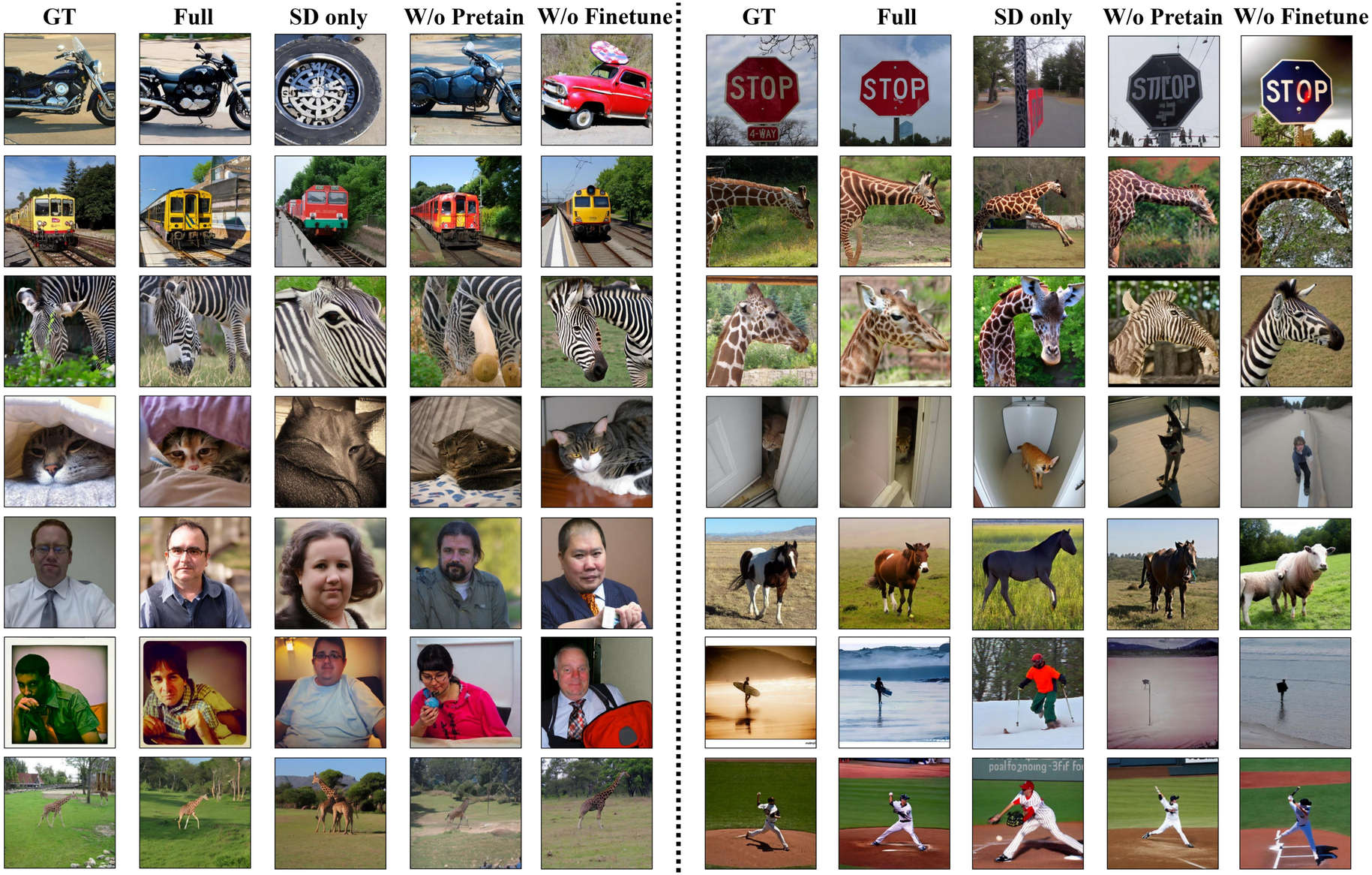


Visualization

Mismatched high-level and low-level features from different fMRI sources.



Ablation Study



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Thank you!

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