Predicting Dopamine D1 PET Radiotracer From D2 Using Deep Generative Model

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Backgrounds

- Positron Emission Tomography (PET) is essential for measuring metabolic processes, molecular interactions, and physiological functions of the brain.
- PET imaging relies on radiotracers which selectively bind to specific neurotransmitter receptors or proteins, enabling targeted investigations.
- The use of radiotracers involves ionizing radiation exposure, which limits the feasibility of using multiple tracers in the same individuals.
- Deep generative models, such as GANs (Generative Adversarial Networks), effectively model complex data distributions, enabling the generation of realistic images that closely match the target data's characteristics.

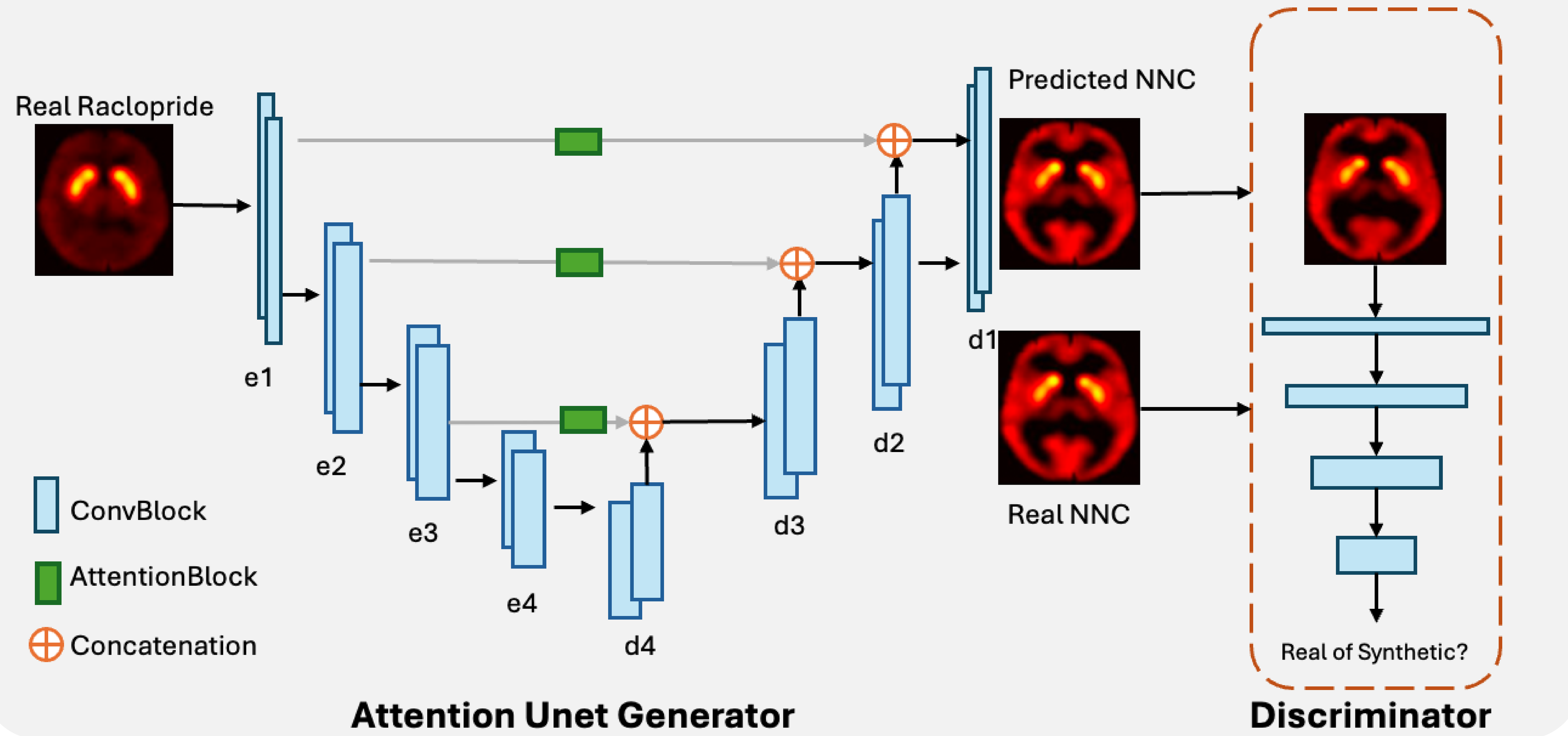
Materials and Methods

This study introduces an advanced deep learning approach using a U-Net-based Generative Adversarial Network (U-GAN) to predict [11C]NNC-112 PET images from resting-state [11C]Raclopride PET images. A total of 79 paired participants (31 females) underwent both dynamic [11C]NNC-112 and [11C]Raclopride scans. The model's performance was evaluated using 5-fold cross-validation. To assess ROI-based prediction accuracy, we analyzed the averaged bias and correlation plots across various brain regions of interest (ROIs) and networks.

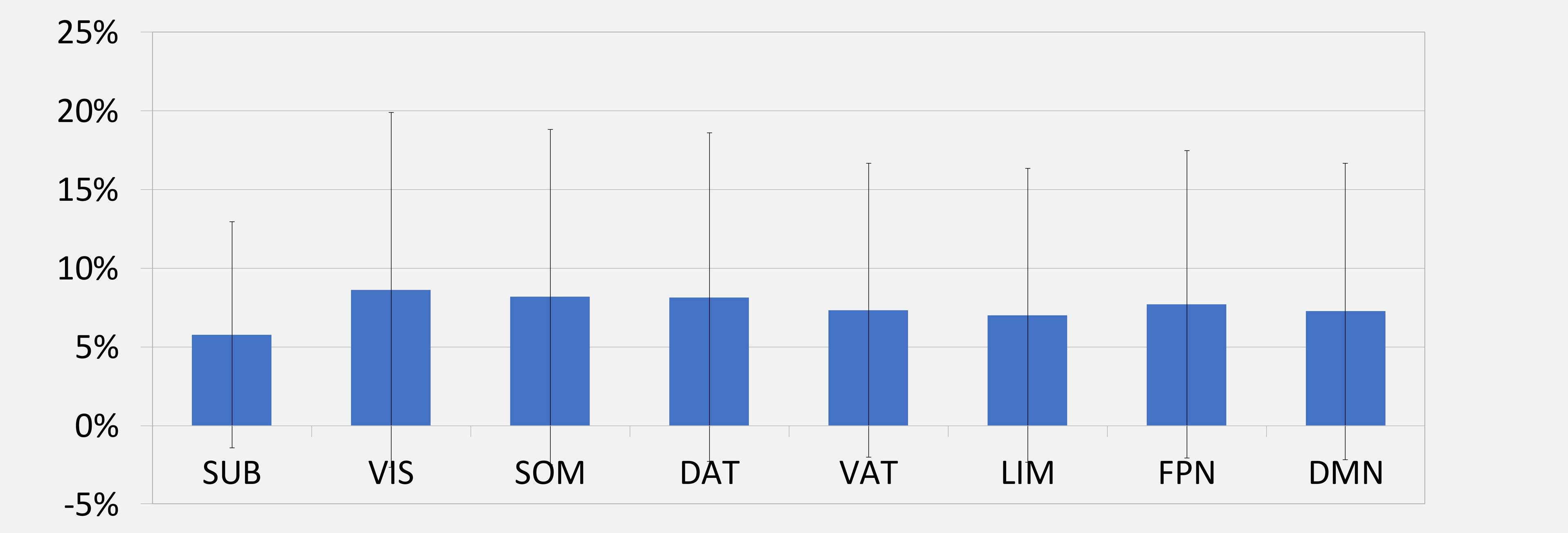
Demographics and clinal diagnosis of the dataset

Characteristics	Dataset (n = 79)
Age, mean (SD) [range], years	41.4 (11.5)
Sex (Male: Female)	48:31
BMI	27.7 (5.1)
Diagnosis (CN:OUD)	37:42

Architecture of the Unet-based Generative Adversarial Network (U-GAN)



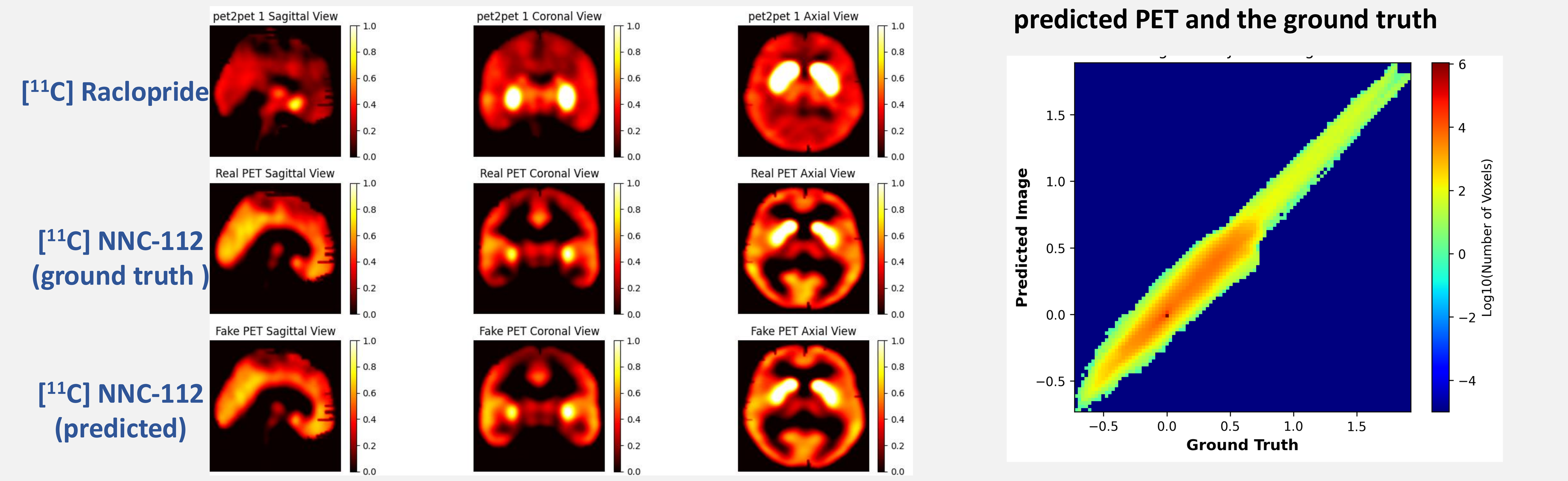
Result 1: Averaged biases of the predicted PET images



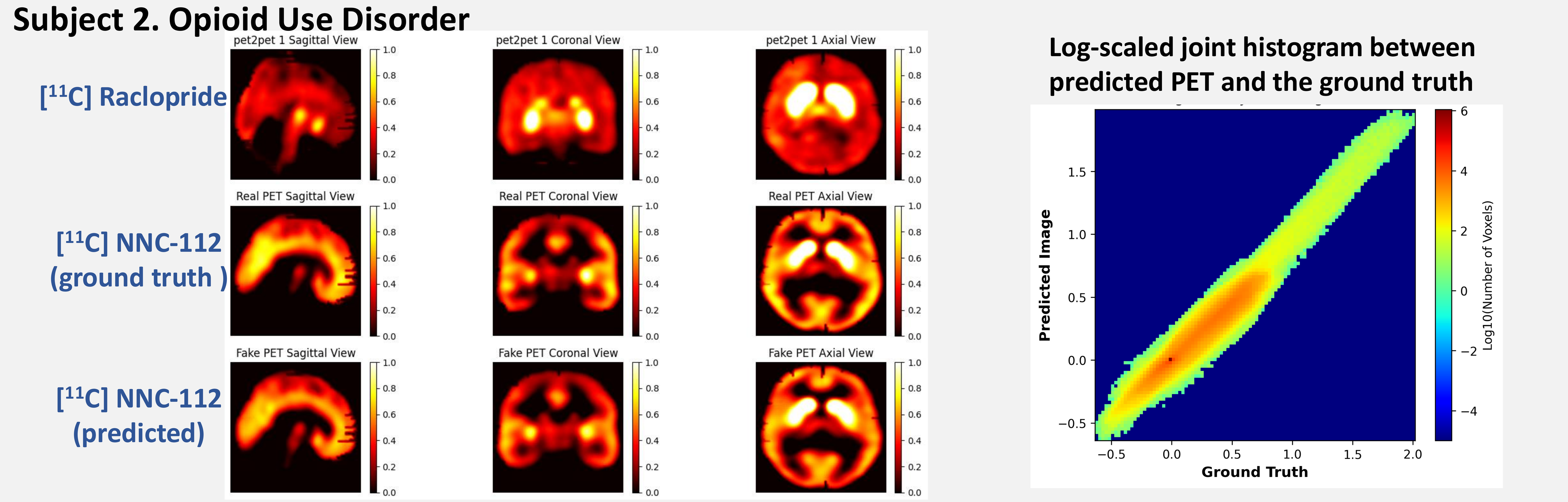
SUB: subcortical; VIS: visual; SOM: somatomotor; DAT: dorsal attention;
VAT: ventral attention; LIM: limbic; FPN: frontalparietal; DMN: default mode network

Result 2: Representative predicted results of deep generative model

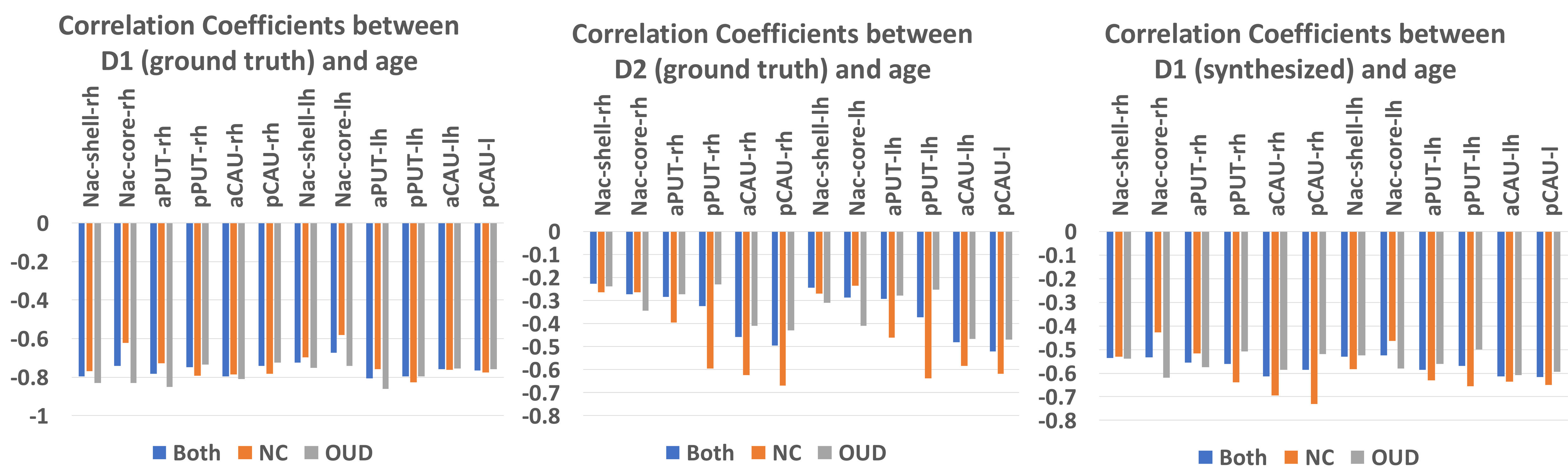
Subject 1. Normal Control



Subject 2. Opioid Use Disorder



Result 3: Dopamine - Age correlation analysis using predicted PET



The predicted D1 PET images could uncover relationships not observable in the original D2 PET images

Conclusions

To the best of our knowledge, this study is the first to synthesize D1 radiotracer ([11C]NNC-112) PET images from D2 radiotracer ([11C] Raclopride) PET images, demonstrating the feasibility of this approach with promising prediction accuracy. Furthermore, downstream correlation analysis revealed that the predicted D1 PET images could uncover relationships not observable in the original D2 PET image, highlighting the potential of deep generative model for PET image synthesis and clinical applications.

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