Supplementary Information

pyMEAL: A Multi-Encoder Augmentation-Aware Learning for Robust and Generalizable Medical Image Translation

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Table S1: Predefined test data: Summary of statistical analysis across methods for rotate, crop, intensity, and flip augmentations.

Section	Comparison	Metric	Test Used	p-value	Significant?
Group-wise Tests					
Group-wise (Rotate)	All Methods	PSNR	Kruskal-Wallis	**0.0000**	Yes
Group-wise (Rotate)	All Methods	SSIM	Kruskal-Wallis	**0.0000**	Yes
Group-wise (Crop)	All Methods	PSNR	Kruskal-Wallis	**0.0000**	Yes
Group-wise (Crop)	All Methods	SSIM	Kruskal-Wallis	**0.0000**	Yes
Group-wise (Intensity)	All Methods	PSNR	Kruskal-Wallis	**3.05e-09**	Yes
Group-wise (Intensity)	All Methods	SSIM	Kruskal-Wallis	**8.28e-09**	Yes
Group-wise (Flip)	All Methods	PSNR	Kruskal-Wallis	**0.0000**	Yes
Dunn's Test (PSNR and SSIM)					
Dunn's (Rotate)	BD vs CC	PSNR	Dunn (Bonferroni)	**1.79e-09**	Yes
	BD vs FL	PSNR	Dunn (Bonferroni)	**7.00e-08**	Yes
	BD vs NA	PSNR	Dunn (Bonferroni)	**1.07e-11**	Yes
	BD vs TA	PSNR	Dunn (Bonferroni)	**1.03e-06**	Yes
	CC vs FL	PSNR	Dunn (Bonferroni)	1.0000	No
	BD vs CC	SSIM	Dunn (Bonferroni)	**1.10e-04**	Yes
	BD vs FL	SSIM	Dunn (Bonferroni)	**3.02e-11**	Yes
	BD vs NA	SSIM	Dunn (Bonferroni)	**1.51e-03**	Yes
	BD vs TA	SSIM	Dunn (Bonferroni)	**9.25e-20**	Yes
Dunn's (Crop)	BD vs CC	PSNR	Dunn (Bonferroni)	**9.03e-12**	Yes
	BD vs FL	PSNR	Dunn (Bonferroni)	**1.96e-12**	Yes
	BD vs NA	PSNR	Dunn (Bonferroni)	**2.80e-09**	Yes
	BD vs TA	PSNR	Dunn (Bonferroni)	**2.45e-03**	Yes
	CC vs FL	PSNR	Dunn (Bonferroni)	1.0000	No
	BD vs CC	SSIM	Dunn (Bonferroni)	**7.61e-05**	Yes
	BD vs FL	SSIM	Dunn (Bonferroni)	**3.67e-14**	Yes
	BD vs NA	SSIM	Dunn (Bonferroni)	**3.64e-03**	Yes
	BD vs TA	SSIM	Dunn (Bonferroni)	**1.58e-16**	Yes
Dunn's (Intensity)	BD vs FL	PSNR	Dunn (Bonferroni)	**6.99e-05**	Yes
	BD vs TA	PSNR	Dunn (Bonferroni)	**3.54e-08**	Yes
	NA vs FL	PSNR	Dunn (Bonferroni)	**0.0126**	Yes
	NA vs TA	PSNR	Dunn (Bonferroni)	**3.56e-05**	Yes
	BD vs FL	SSIM	Dunn (Bonferroni)	**1.08e-05**	Yes
	BD vs TA	SSIM	Dunn (Bonferroni)	**1.48e-05**	Yes
	FL vs NA	SSIM	Dunn (Bonferroni)	**0.00096**	Yes
Dunn's (Flip)	BD vs CC	PSNR	Dunn (Bonferroni)	**1.58e-08**	Yes
	BD vs FL	PSNR	Dunn (Bonferroni)	**4.07e-08**	Yes
	BD vs NA	PSNR	Dunn (Bonferroni)	**8.52e-09**	Yes
	BD vs TA	PSNR	Dunn (Bonferroni)	**7.31e-14**	Yes
Mean Scores (Side-by-side PSNR and SSIM)					
Augmentation	**Method**	**Metric**	**PSNR**	**SSIM**	–
Rotate	BD	–	**24.452**	**0.806**	
	TA	–	17.482	0.380	
	FL	–	17.407	0.425	
	CC	–	17.338	0.460	
	NA	–	17.223	0.465	
Crop	BD	–	**24.463**	**0.806**	
	TA	–	15.411	0.248	
	FL	–	14.965	0.254	
	NA	–	15.169	0.290	
	CC	–	15.111	0.283	
Intensity	BD	–	**21.210**	**0.611**	
	NA	–	20.590	0.582	
	CC	–	20.054	0.577	
	FL	–	19.327	0.475	
	TA	–	18.824	0.474	
Flip	BD	–	**23.021**	**0.733**	
	FL	–	15.564	0.339	
	CC	–	15.540	0.338	
	NA	–	15.523	0.337	
	TA	–	15.248	0.308	

Validation with unseen test data

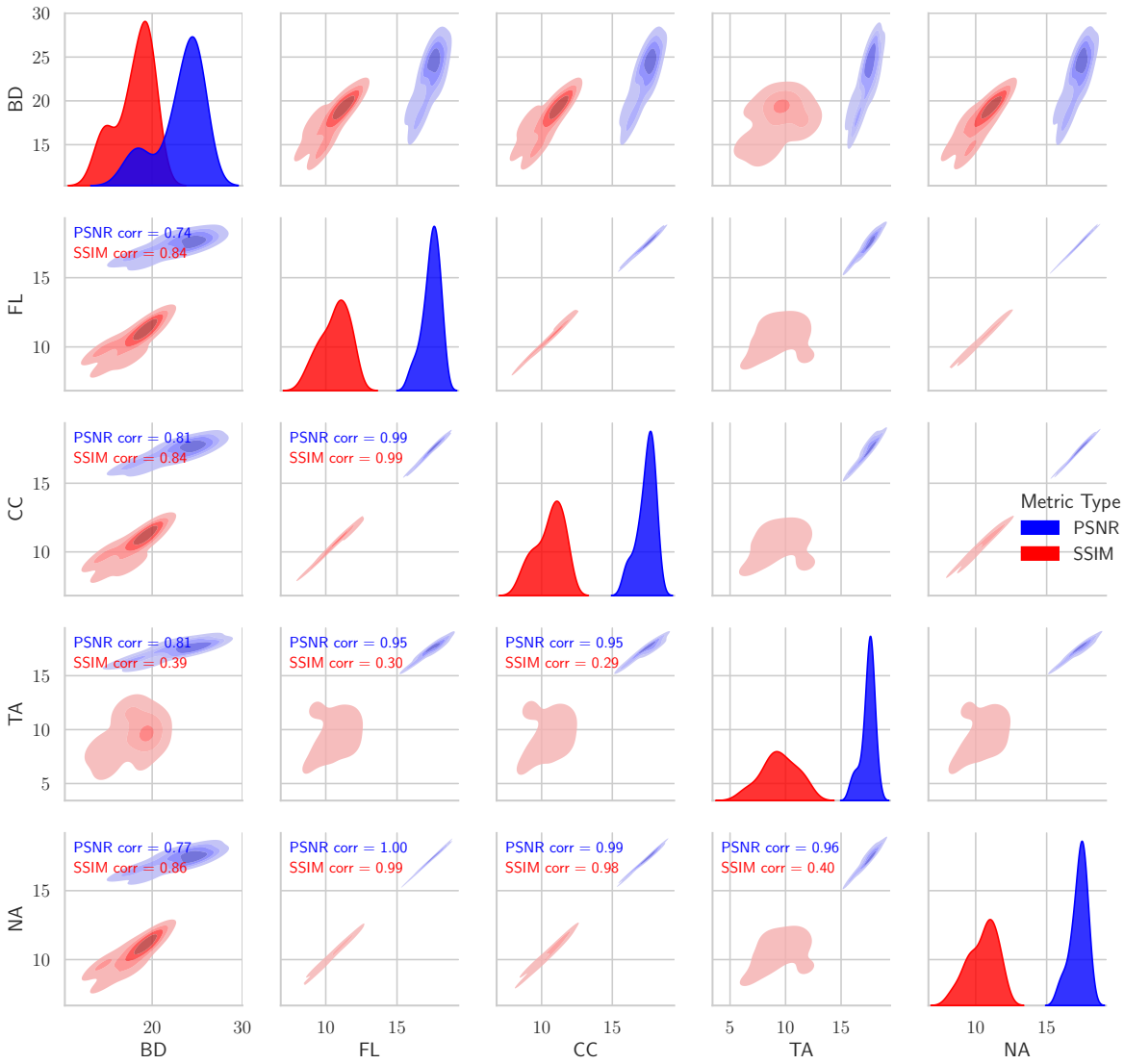

Figure S1: Pairwise comparison of PSNR and SSIM across reconstruction methods under rotation augmentation with unseen test data

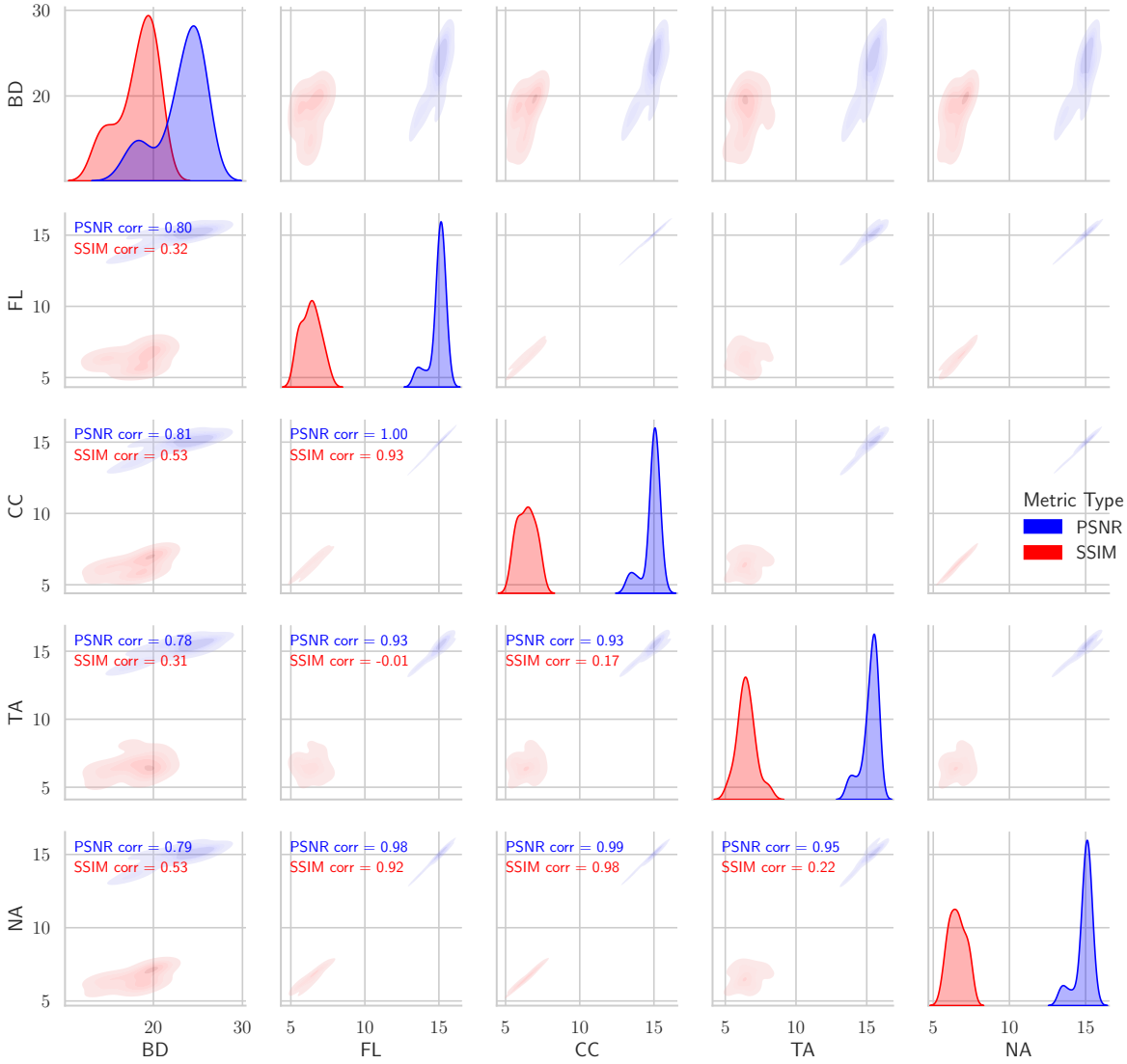

Figure S2:Pairwise comparison of PSNR and SSIM across reconstruction methods under crop augmentation with unseen test data

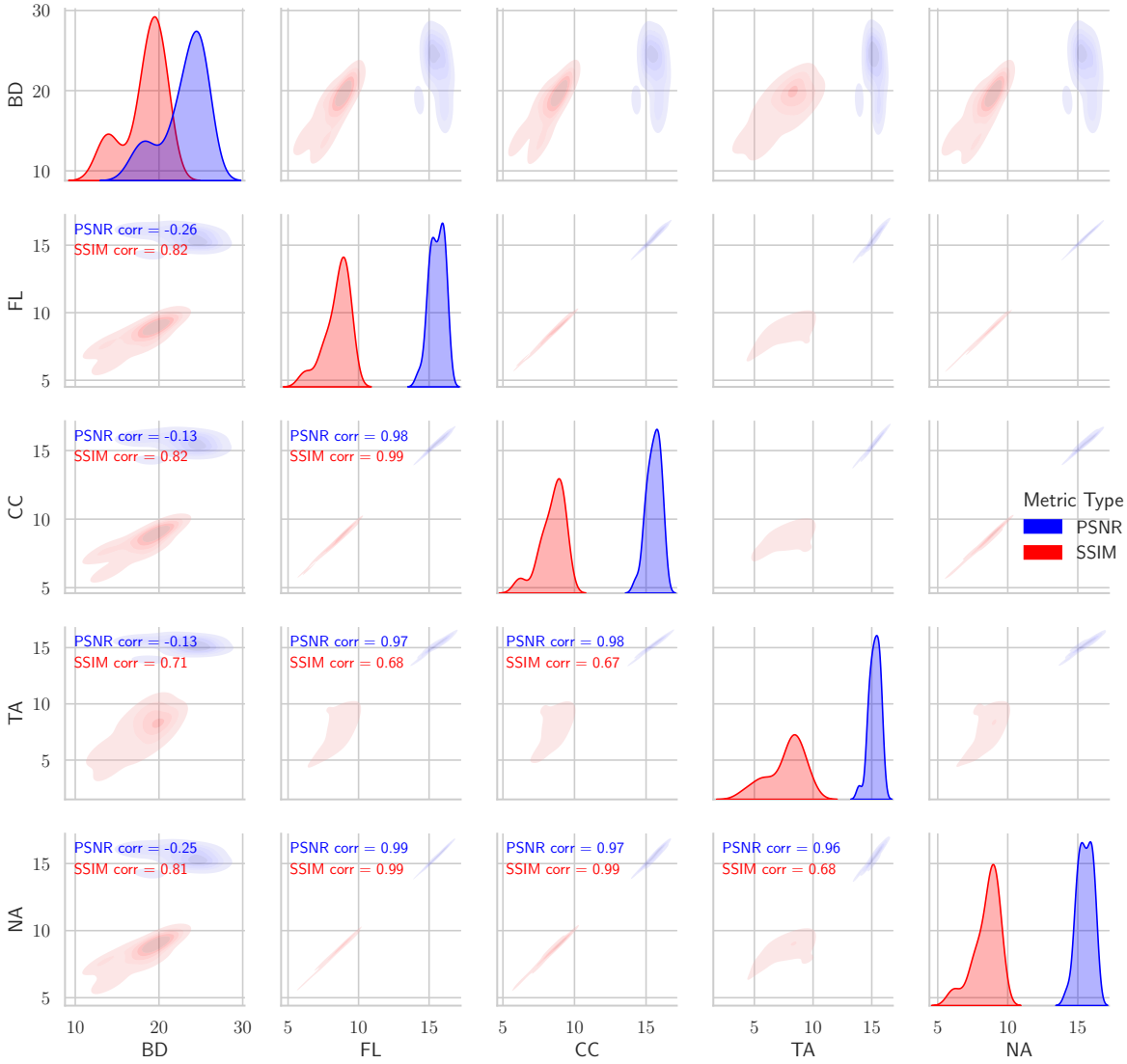

Figure S3: Pairwise comparison of PSNR and SSIM across reconstruction methods under flip augmentation with unseen test data

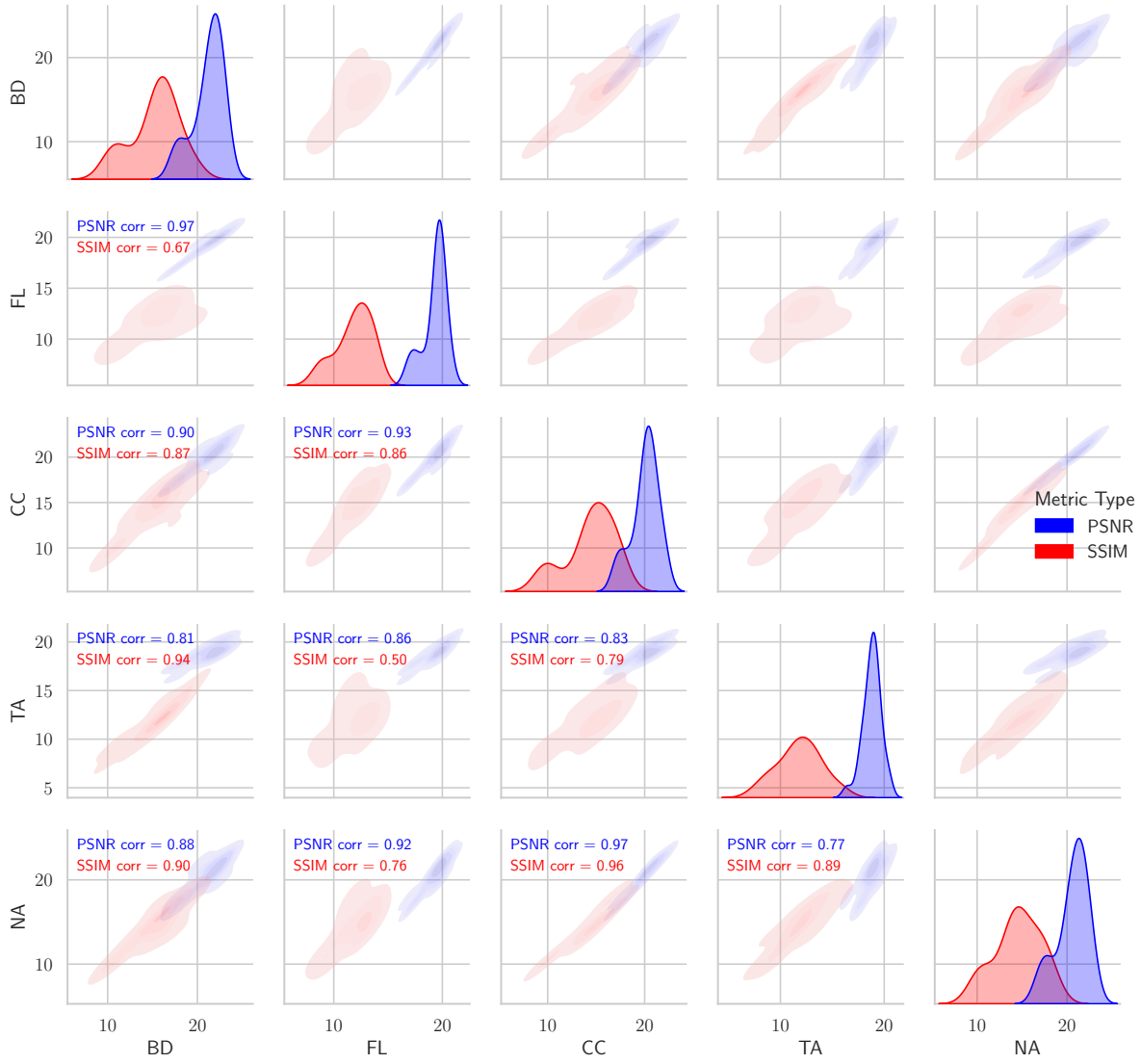

Figure S4: Pairwise comparison of PSNR and SSIM across reconstruction methods under intensity augmentation with unseen test data

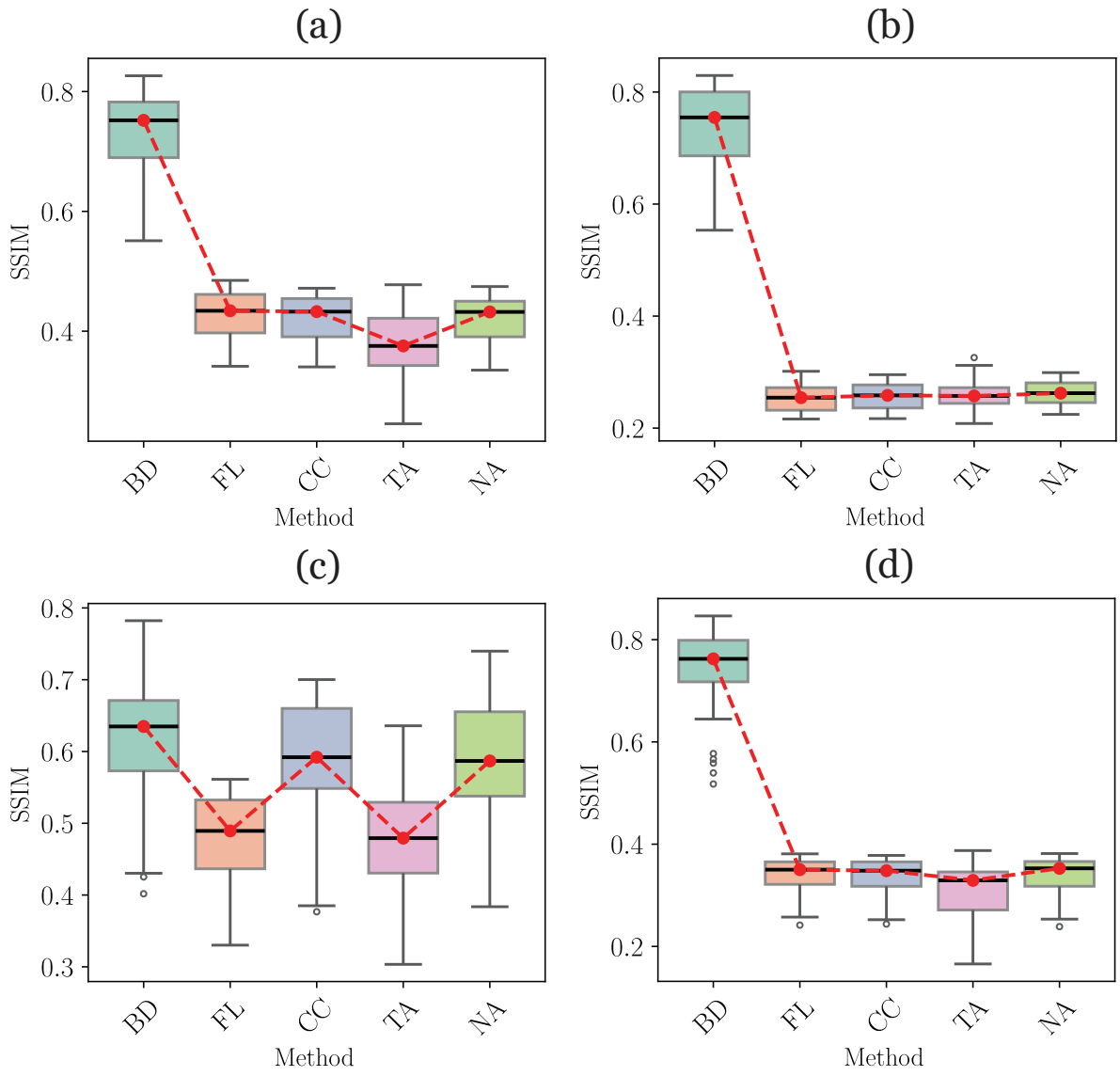

Figure S5: Boxplot showing SSIM distributions for five methods (BD, FL, CC, TA, NA) evaluated on unseen test data under (a) rotation (b) crop (c) flip and (d) intensity augmentation

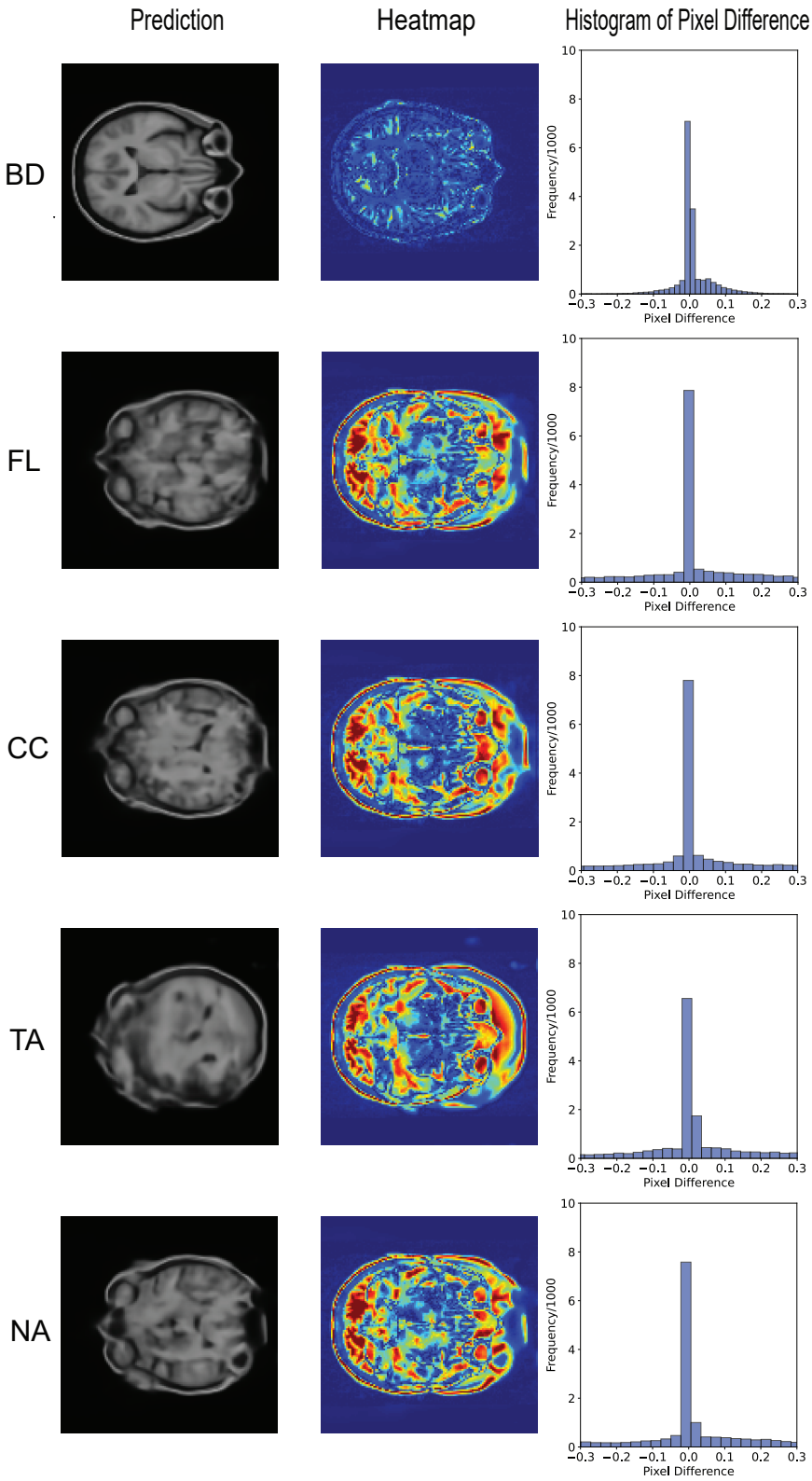

Figure S6: Pixel-wise reconstruction error analysis under flip augmentation (unseen test data) using heatmaps and histograms.

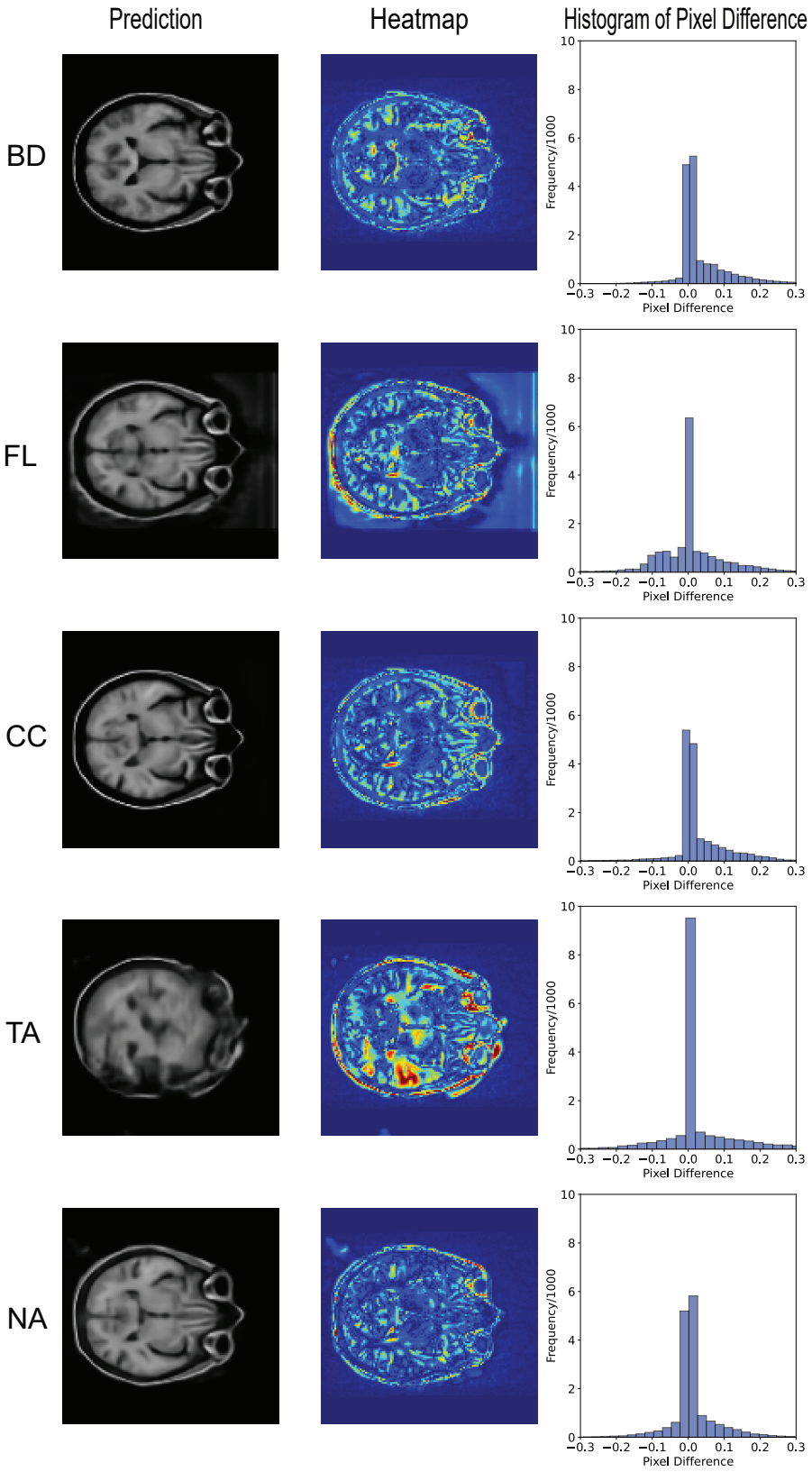

Figure S7: Pixel-wise reconstruction error analysis under intensity augmentation (unseen test data) using heatmaps and histograms.

Validation with testing data

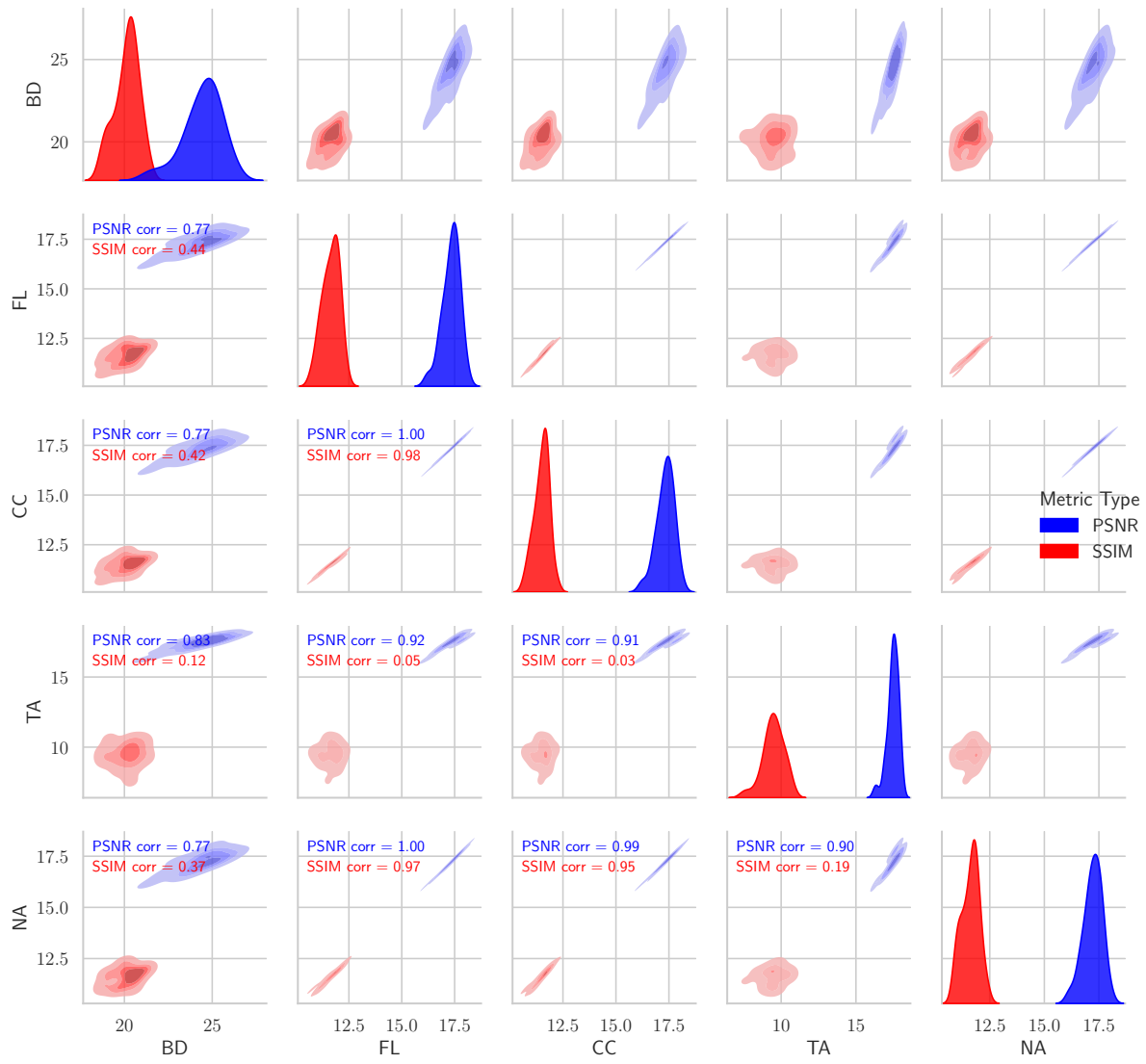

Figure S8: Pairwise comparison of PSNR and SSIM across reconstruction methods under rotation augmentation with predefined test data

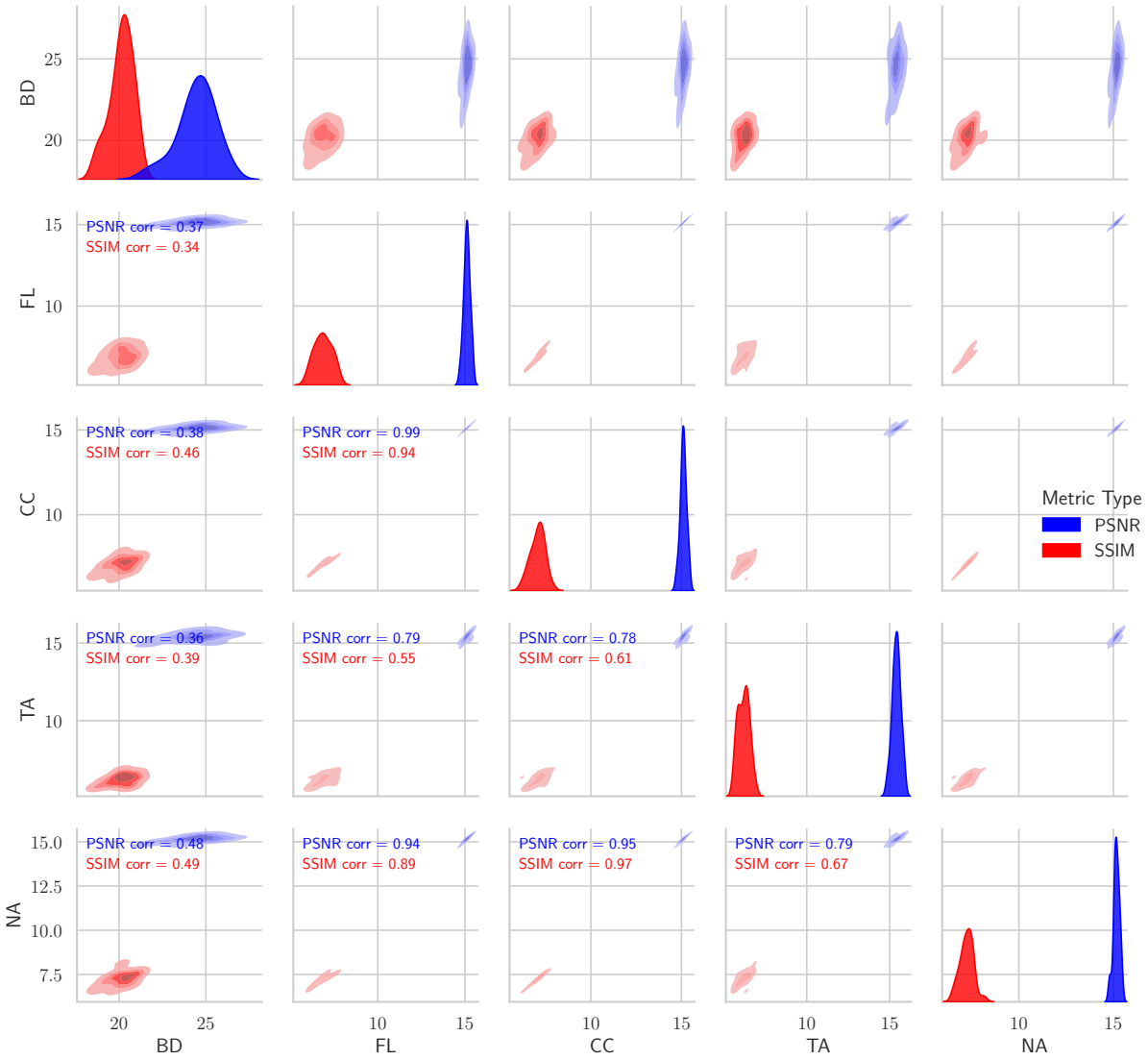

Figure S9: Pairwise comparison of PSNR and SSIM across reconstruction methods under crop augmentation with predefined test data

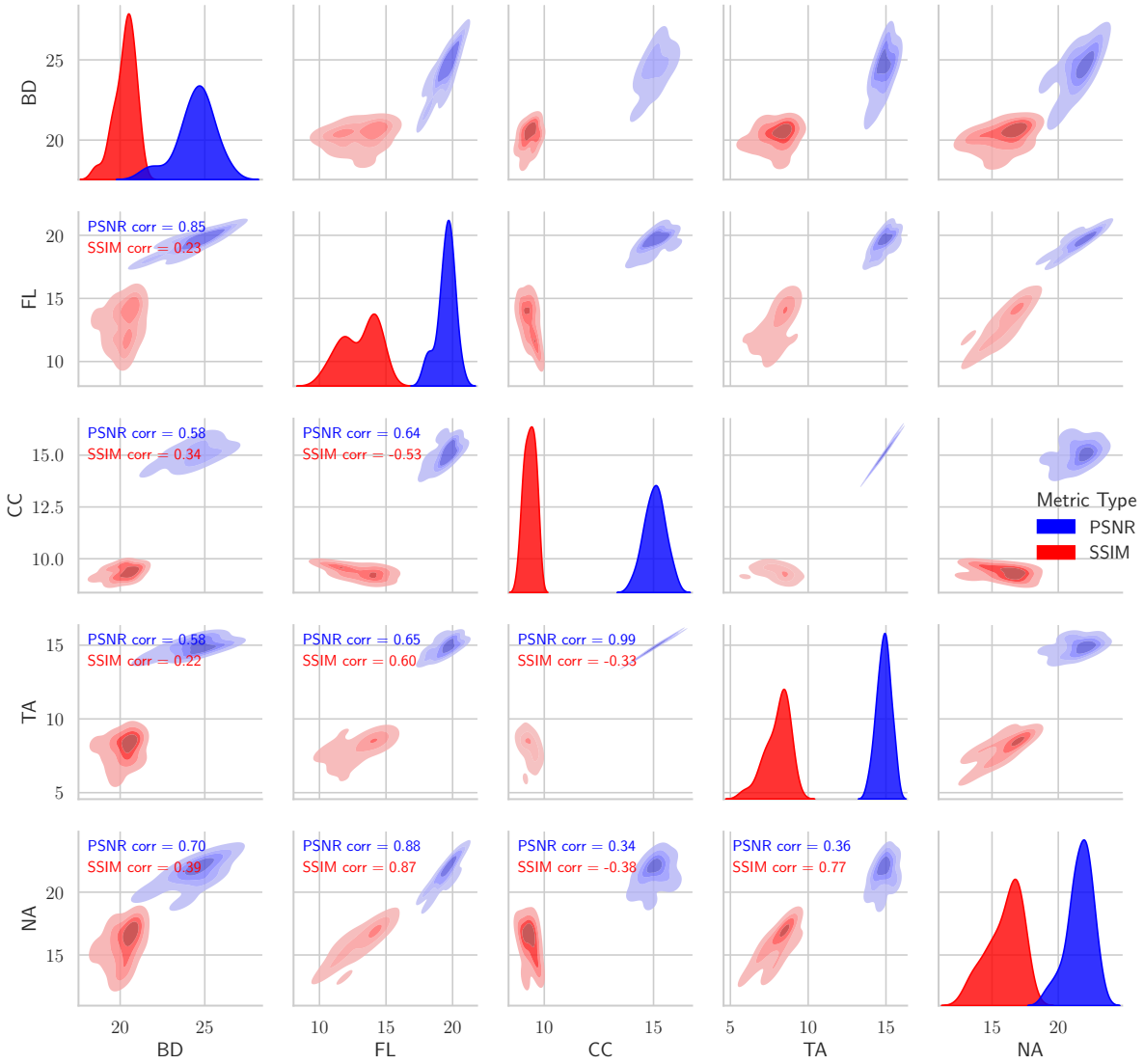

Figure S10: Pairwise comparison of PSNR and SSIM across reconstruction methods under flip augmentation with predefined test data

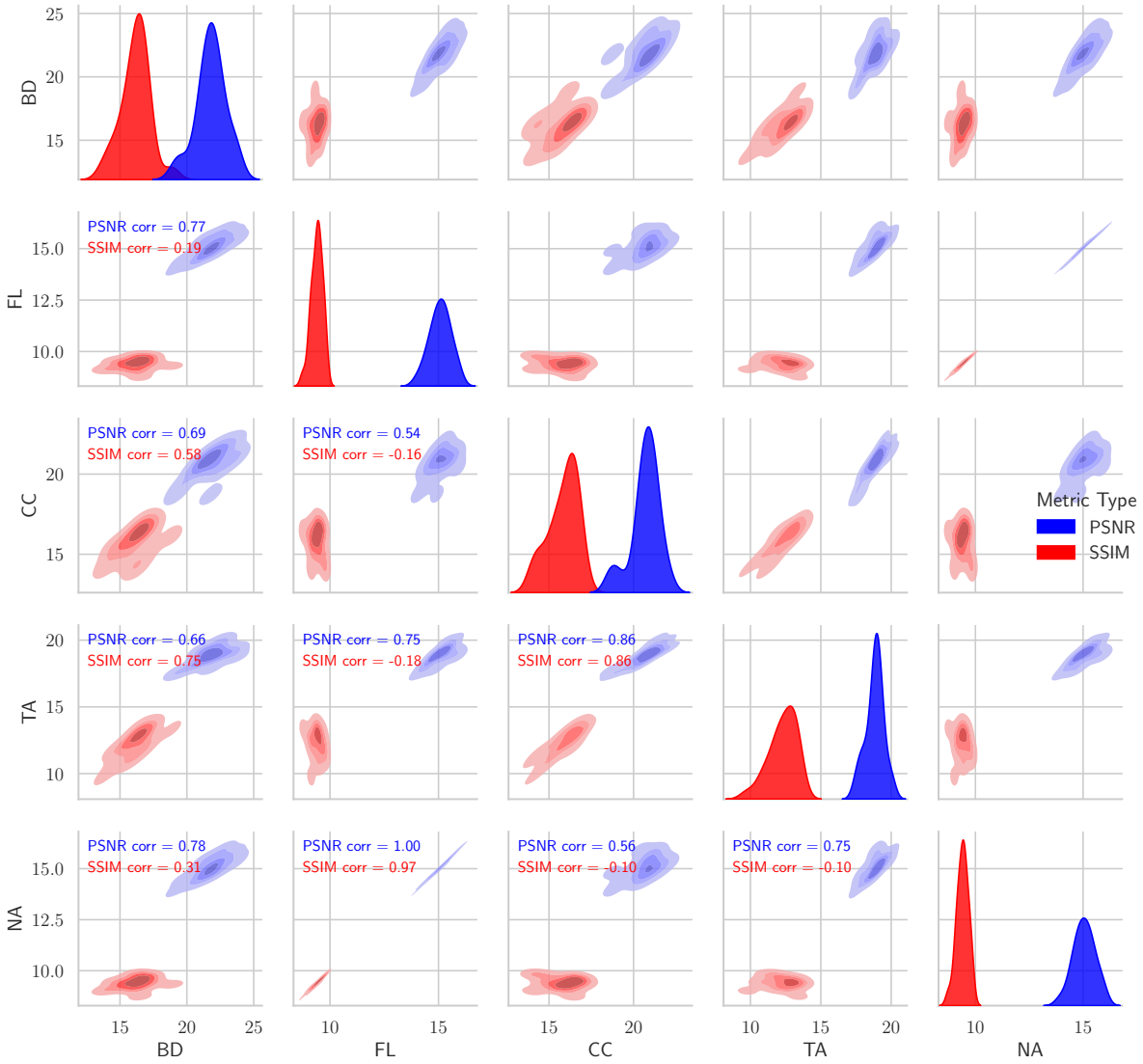

Figure S11: Pairwise comparison of PSNR and SSIM across reconstruction methods under intensity augmentation with predefined test data

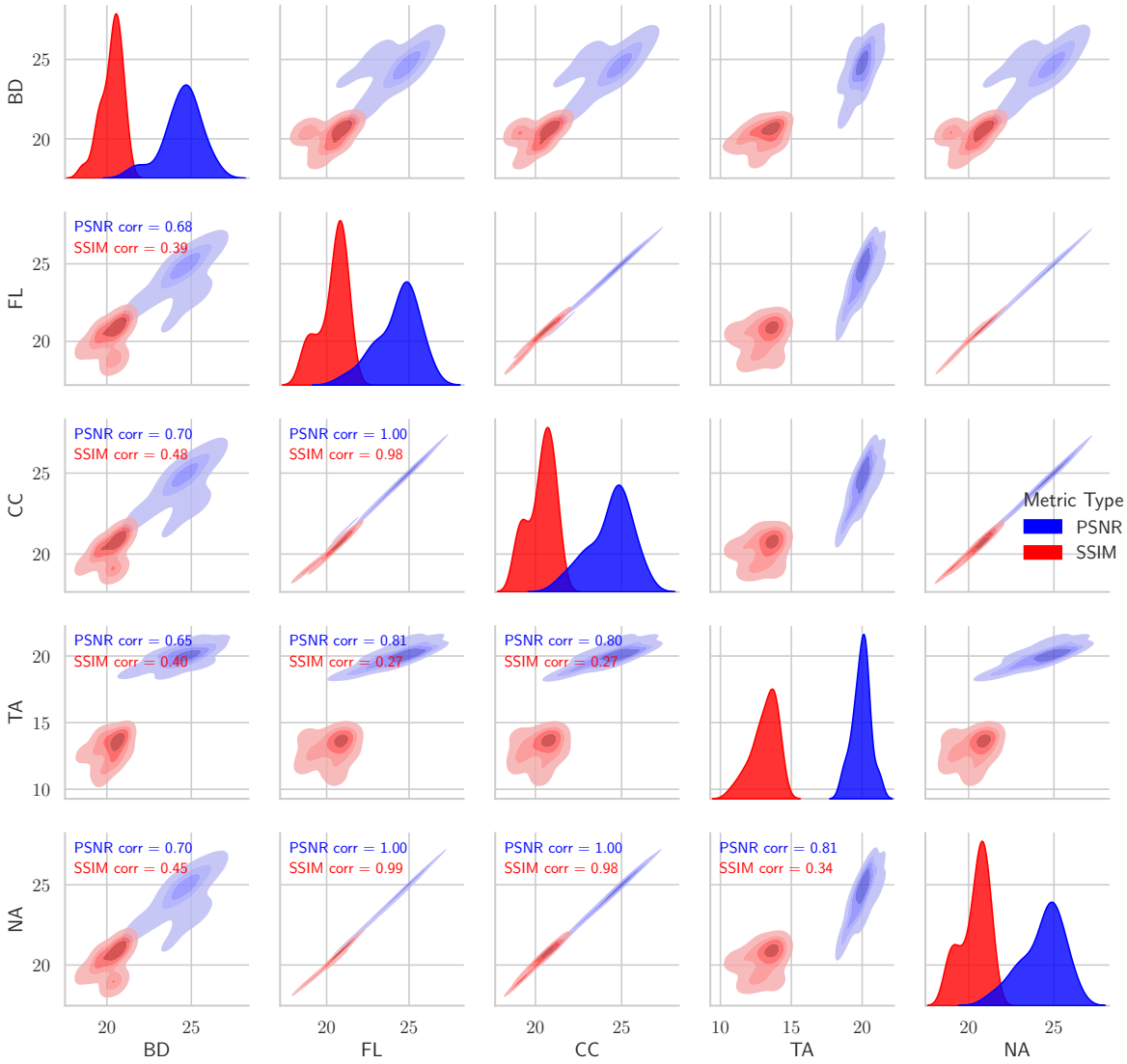

Figure S12: Pairwise comparison of PSNR and SSIM across reconstruction methods under no-augmentation with predefined test data

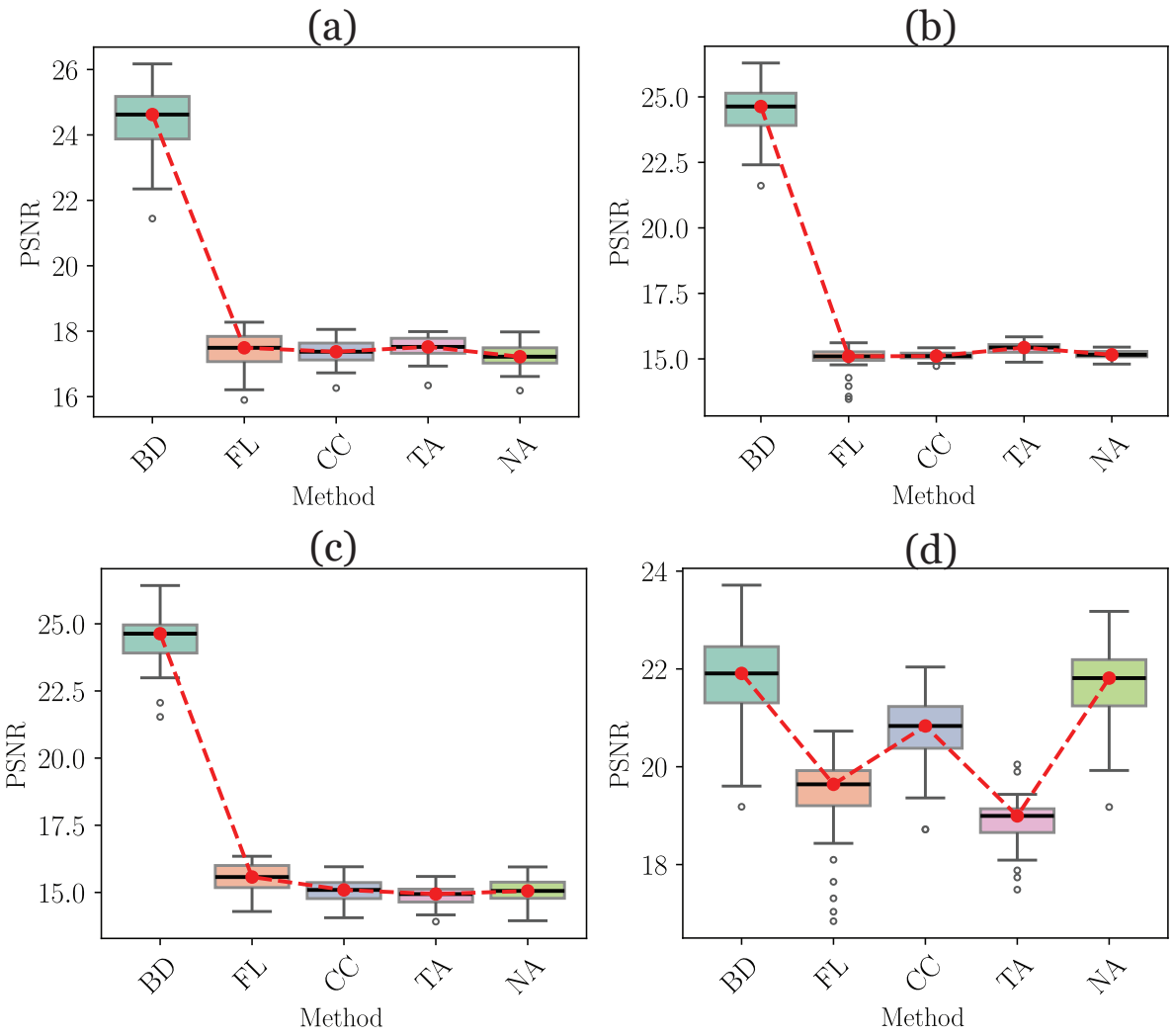

Figure S13: Boxplot showing PSNR distributions for five methods (BD, FL, CC, TA, NA) evaluated on predefined test data under (a) rotation (b) crop (c) flip and (d) intensity augmentation

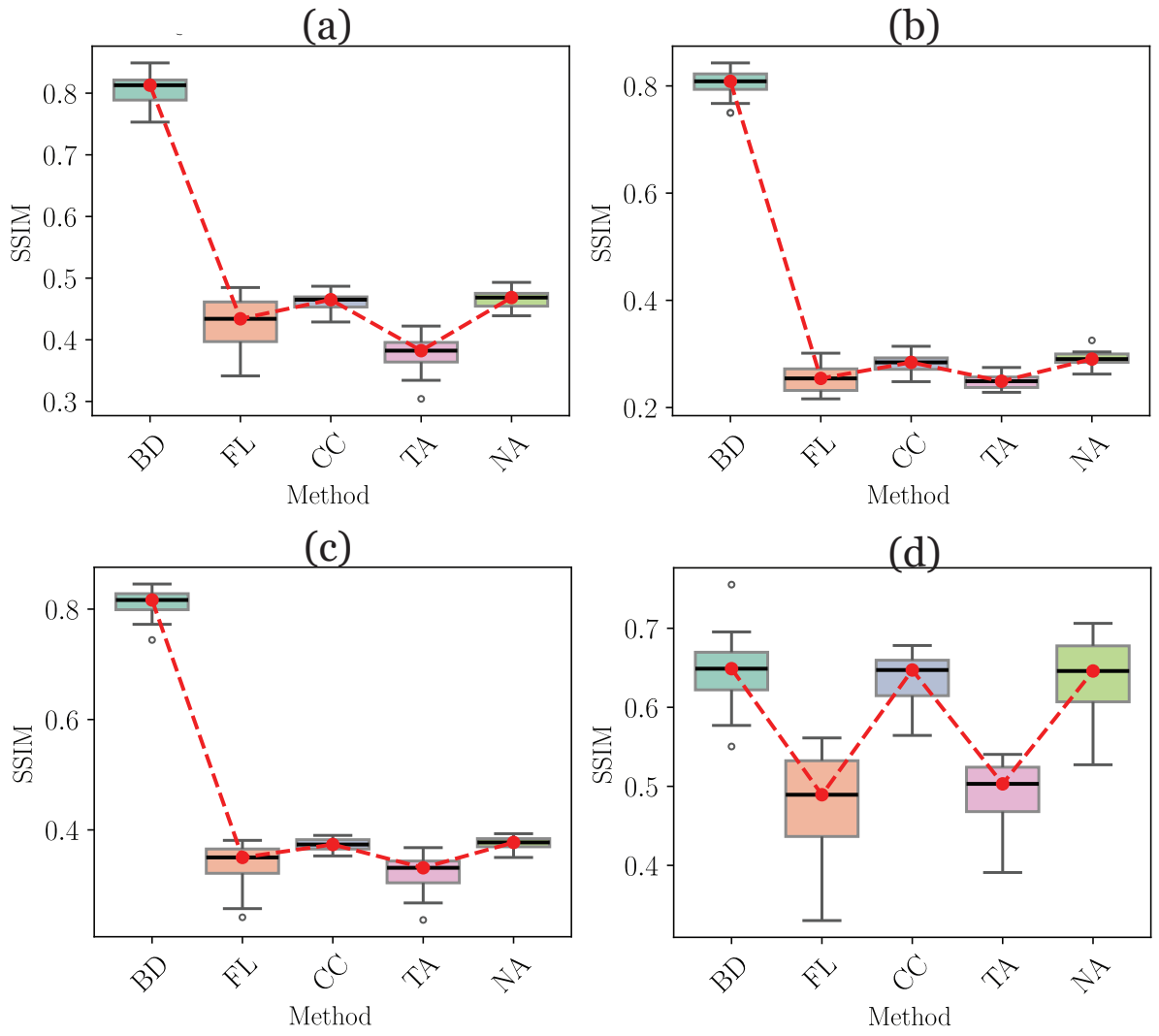

Figure S14: Boxplot showing SSIM distributions for five methods (BD, FL, CC, TA, NA) evaluated on predefined test data under (a) rotation (b) crop (c) flip and (d) intensity augmentation

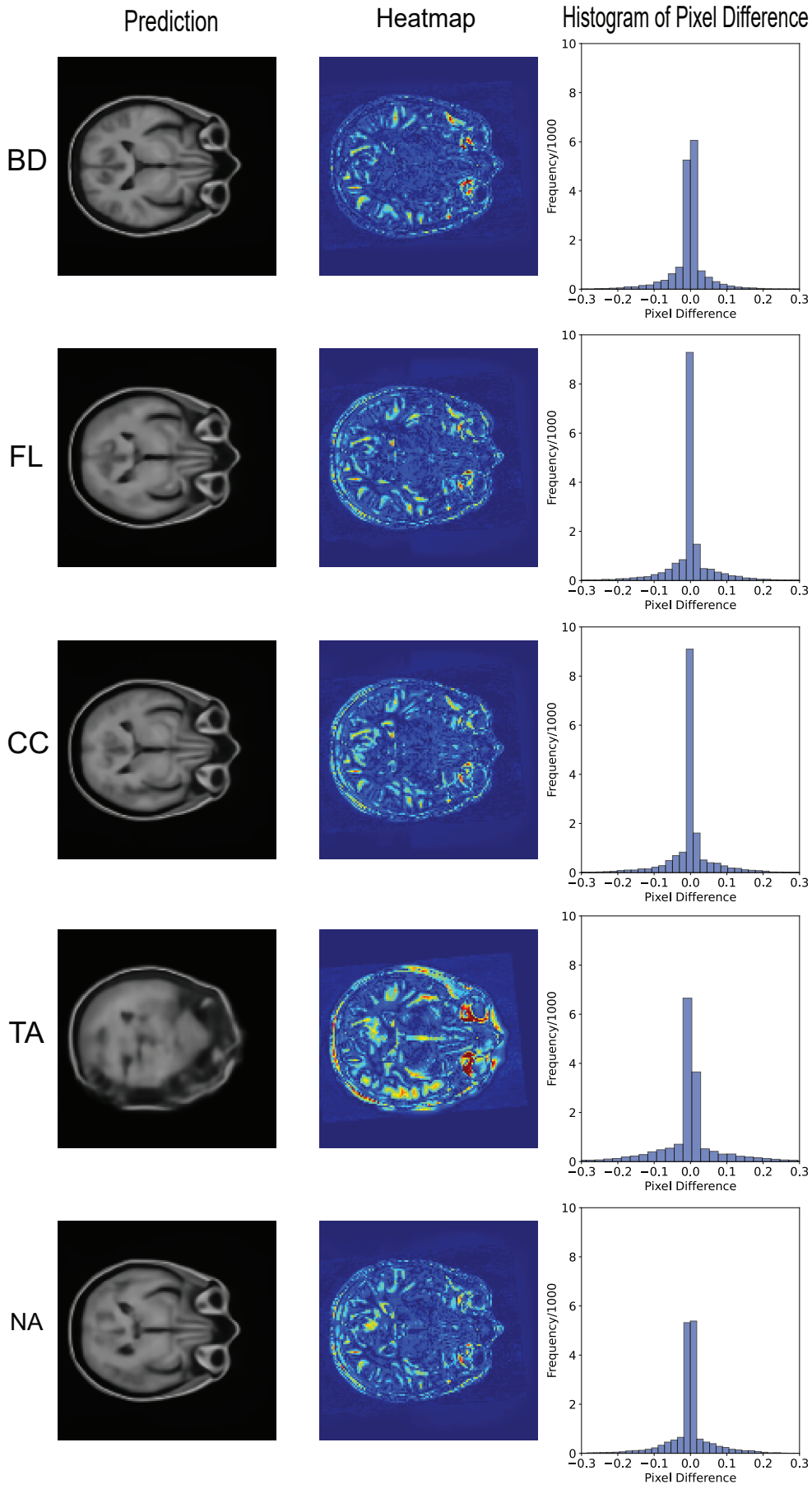

Figure S15: Pixel-wise reconstruction error analysis under no-augmentation (predefined test data) using heatmaps and histograms

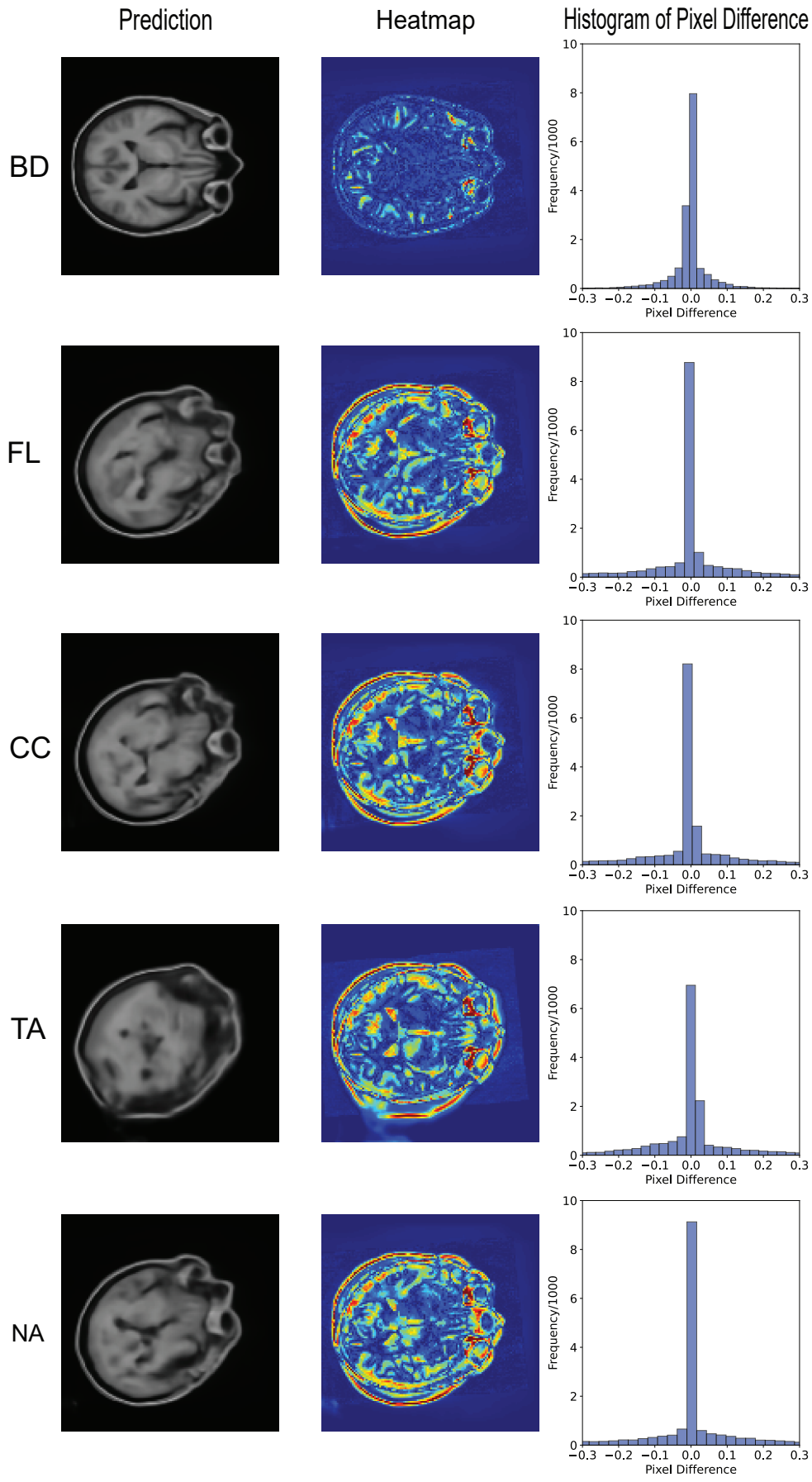

Figure S16: Pixel-wise reconstruction error analysis under rotation augmentation (predefined test data) using heatmaps and histograms

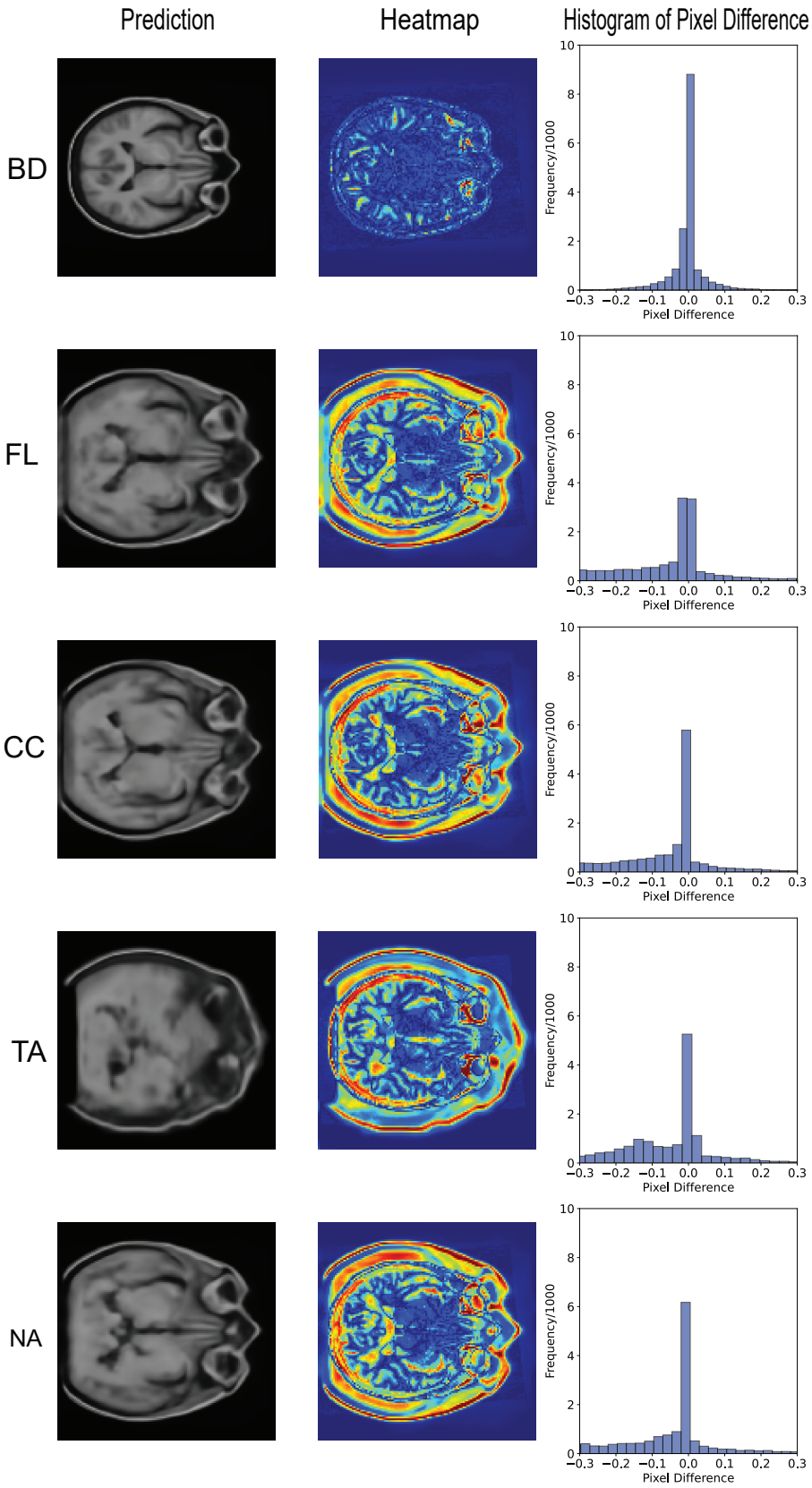

Figure S17: Pixel-wise reconstruction error analysis under crop augmentation (predefined test data) using heatmaps and histograms

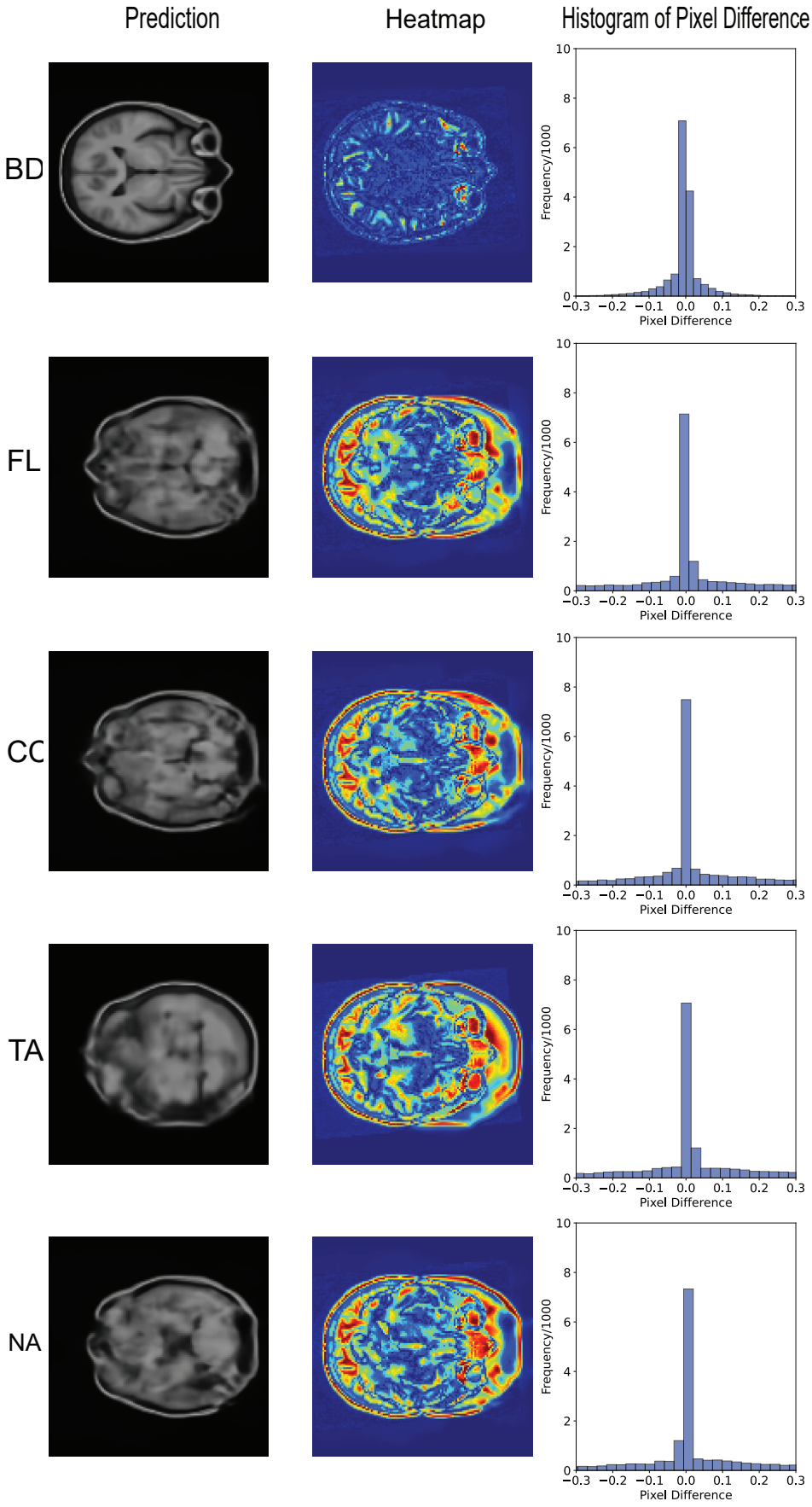

Figure S18: Pixel-wise reconstruction error analysis under flip augmentation (predefined test data) using heatmaps and histograms

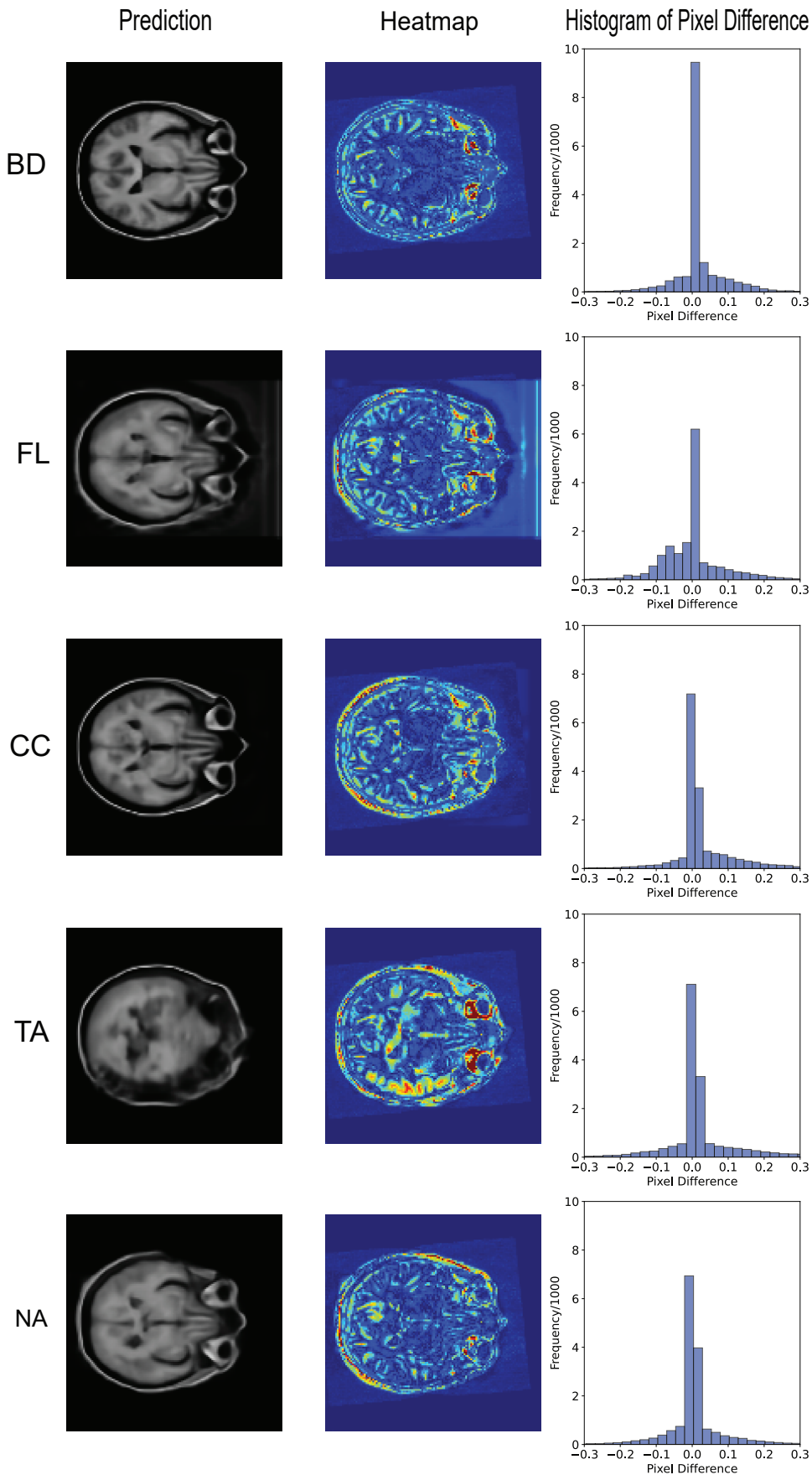

Figure S19: Pixel-wise reconstruction error analysis under intensity augmentation (predefined test data) using heatmaps and histograms