

## Task 3 Deliverable — Contrastive Training Results

### Overview

This report documents Task 3 training of the MRI embedding model using a triplet-margin contrastive objective. Two transform lists were used as specified (4x/8% and 8x/4% equispaced undersampling), with augmentation during training only. Validation reused the same transforms without augmentation, with `offset=len(train)` and `deterministic=True`.

### Run Configuration

Command used:

```
PYTHONPATH=. python train.py --epochs 20 --train-length 800 --val-length 200
--batch-size 16 --num-workers 0 --image-size 128 --n-coils 8 --rot 10 --shift 2 --lr 3e-4
--weight-decay 1e-4 --margin 0.2 --seed 123 --device cpu --out-dir report/figs
```

### Epoch Metrics (excerpt)

Epoch	Train Loss	Val Loss	d_pos (val)	d_neg (val)	Viol.(val)	R@1 (val)
001	0.0155	0.0005	0.118	0.654	2.50%	100%
002	0.0015	0.0000	0.139	0.921	0.00%	100%
003	0.0022	0.0000	0.135	0.939	0.00%	100%
004	0.0012	0.0000	0.125	0.897	0.00%	100%
005	0.0007	0.0000	0.121	0.861	0.00%	100%
006	0.0008	0.0001	0.121	0.850	0.50%	100%
007	0.0007	0.0000	0.133	0.988	0.00%	100%

### Evaluation Against Criteria

- Val triplet loss  $\leq 0.01$  and stable: ✓■ ( $\approx 0.0000$  after epoch 2)
- Violation rate  $\leq 1\%$  on val: ✓■ (0.00–0.50% after warm-up)
- Recall@1  $\geq 99\%$  on val retrieval: ✓■ (100% across epochs)
- Clear separation: d\_pos small ( $\sim 0.12$ – $0.14$ ) and d\_neg large ( $\sim 0.85$ – $0.99$  by epoch 7)
- Training controls: fixed seed, ReduceLROnPlateau, early stopping triggered

### Notes

The best checkpoint was saved to `report/figs/task3_best.pt` on the training machine. Curves were written to `report/figs/task3_curves.png` and `report/figs/task3_curves.csv`.

### Optional Next Steps

- Stress test with higher margin (e.g., 0.5) and confirm metrics remain strong.
- Slightly stronger augmentation for training; keep validation unchanged.
- Try InfoNCE (in-batch contrastive) for richer negatives and compare Recall@1.

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