Impact of deep learning reconstruction on the accuracy of automated hippocampal subfield segmentation in high-resolution T2-weighted turbo spin echo imaging

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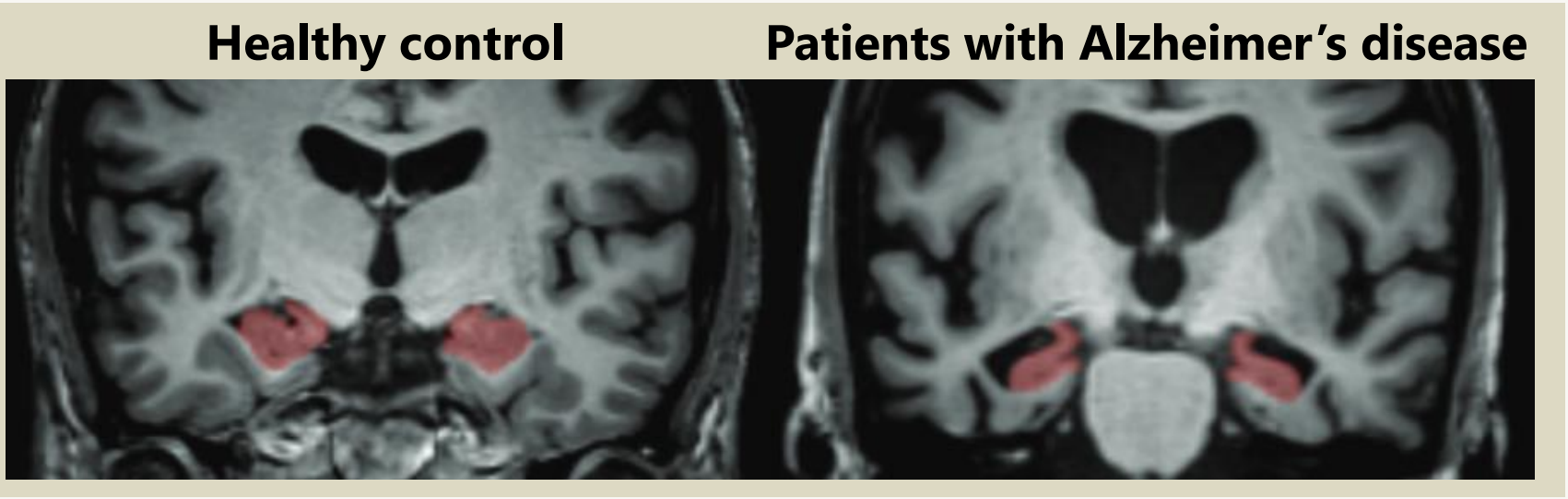
Hippocampus

- Major site of neuronal loss in neuropsychiatric disorders

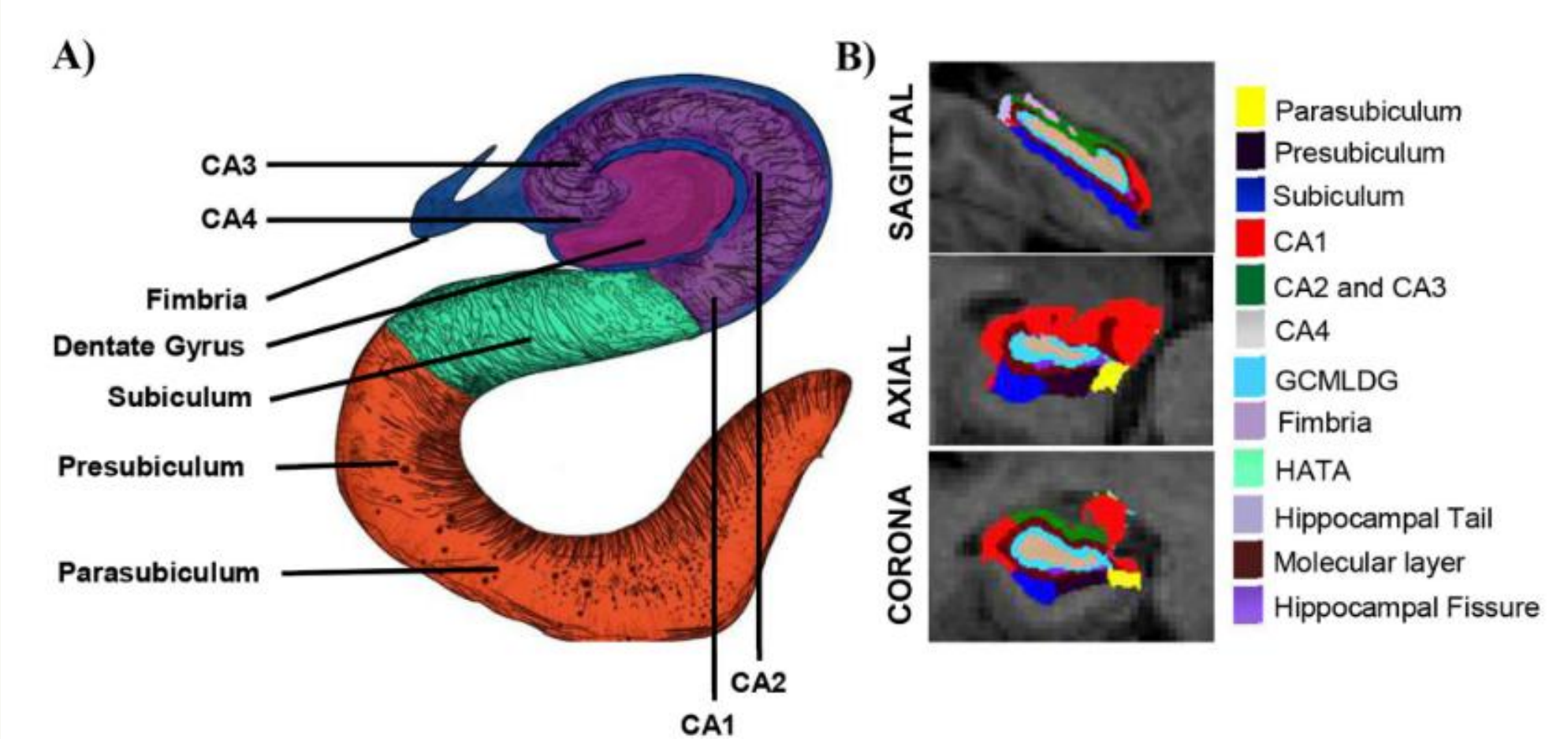


Teipel S, et al. Lancet Neurol. 2015

- Hippocampal subfield evaluation
  - More sensitive for early Alzheimer's disease than whole atrophy*
  - Demonstrates high disease specificity**

* Apostolova LG, et al. Neurobiology of Aging. 2010
** Blanken AE, et al. NeuroImage: Clinical. 2017

Automated segmentation of high-resolution T2WI



Kannappan B, et al. PLoS One. 2022

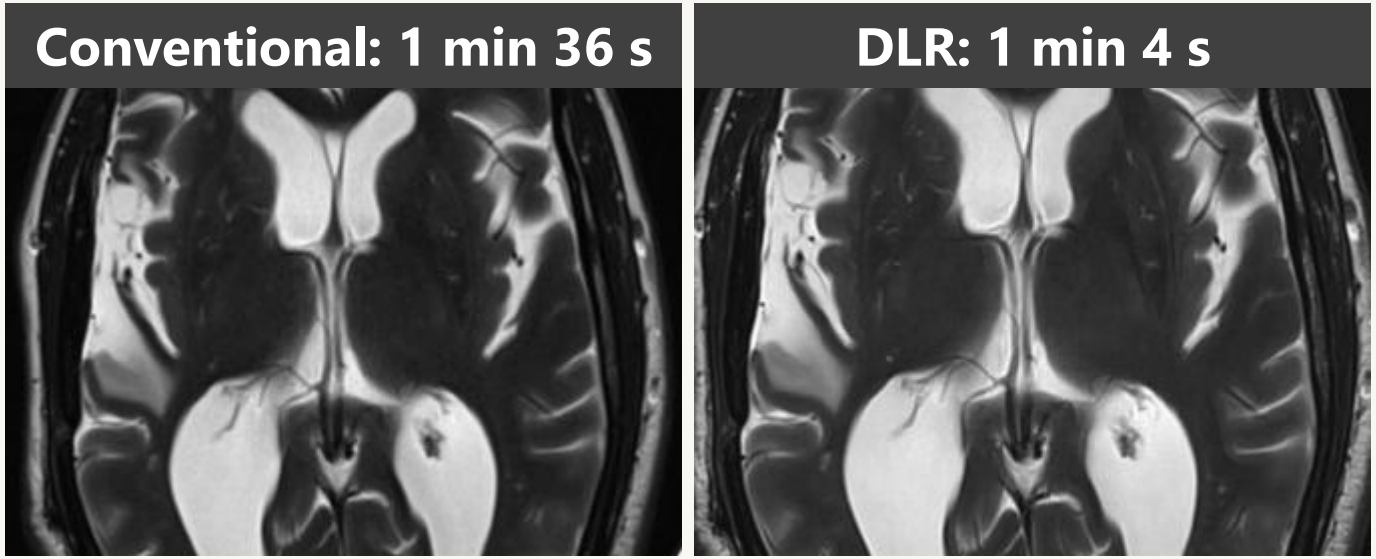
High-quality images require long acquisition times

Deep learning reconstruction (DLR)

- **Deep Resolve Boost**
  - Reduces noise caused by high acceleration factors
- **Deep Resolve Sharp**
  - Enables high-resolution imaging via deep learning

Reduce acquisition time while maintaining image quality

Lyo SK, et al. Radiol Adv. 2025



Impact on hippocampal subfield segmentation is unclear

Purpose

To evaluate whether accurate
hippocampal subfield segmentation can be maintained
using deep learning reconstruction,
even with reduced acquisition time.

Equipment and Subjects

- Subjects
  - **10 healthy volunteers (Total: 20 bilateral hippocampi)**

    7 males, 3 females; mean age, 29.8 ± 6.5 years (range: 23–47 years)
- MRI system
  - MAGNETOM Vida 3.0 T (Siemens Healthineers, Germany)
  - 20-channel head/neck coil

Imaging sequence

Parameters	3D T1WI	2D T2WI			
Acquisition plane	Sagittal	Coronal			
TR/TE (ms)	2300/2.98	8020/50			
Matrix (phase × frequency)	240 × 256	448 × 448			
Field of view (mm)	256	175			
Slice thickness (mm)	1	2			
Flip angle (degrees)	9	122			
Acceleration factor (GRAPPA)	2	**2**	**2**	**3**	**4**
DLR setting*	off	**off**	**on**		
Acquisition time (min:s)	5:21	**4:17**	**4:17**	**2:56**	**2:24**

*Deep Resolve Boost (medium) and Sharp (on)

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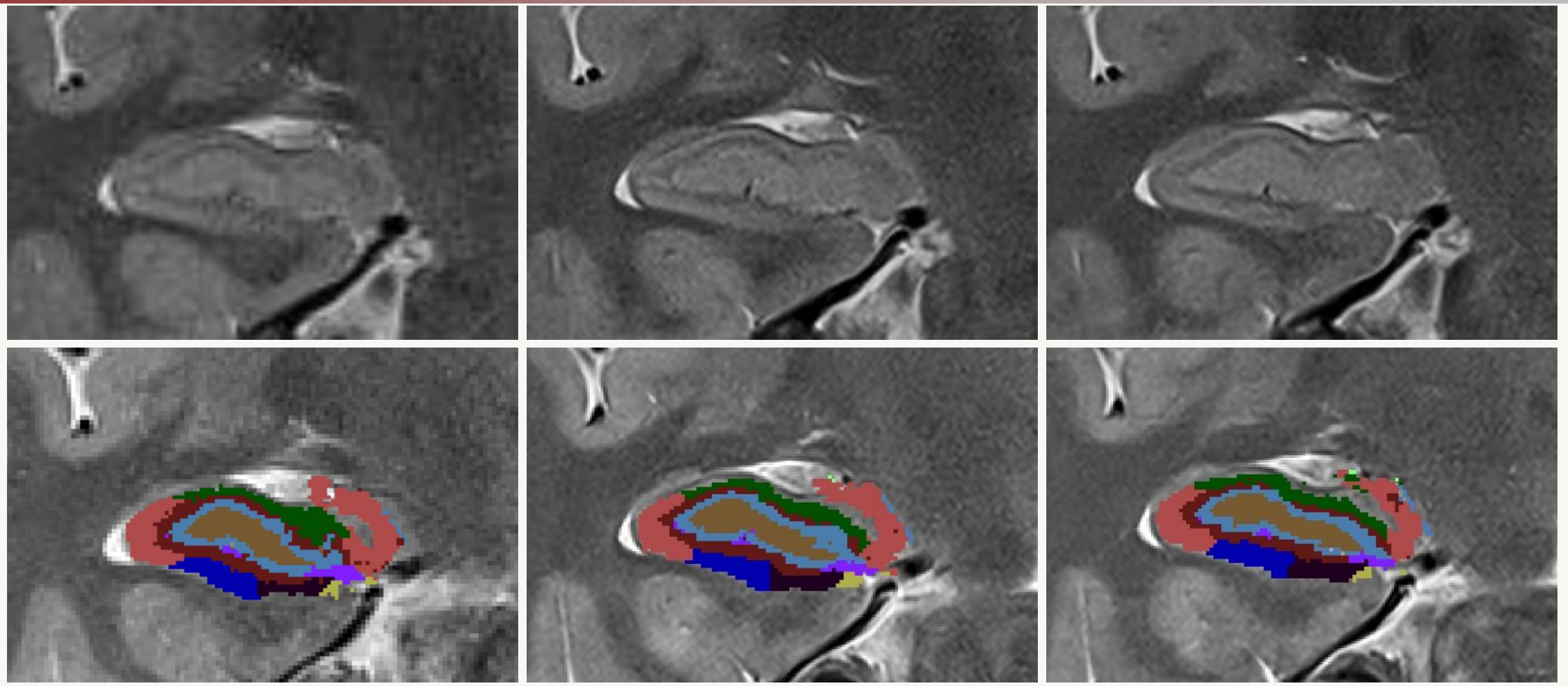
*Deep Resolve Boost (medium) and Sharp (on)

Analysis methods

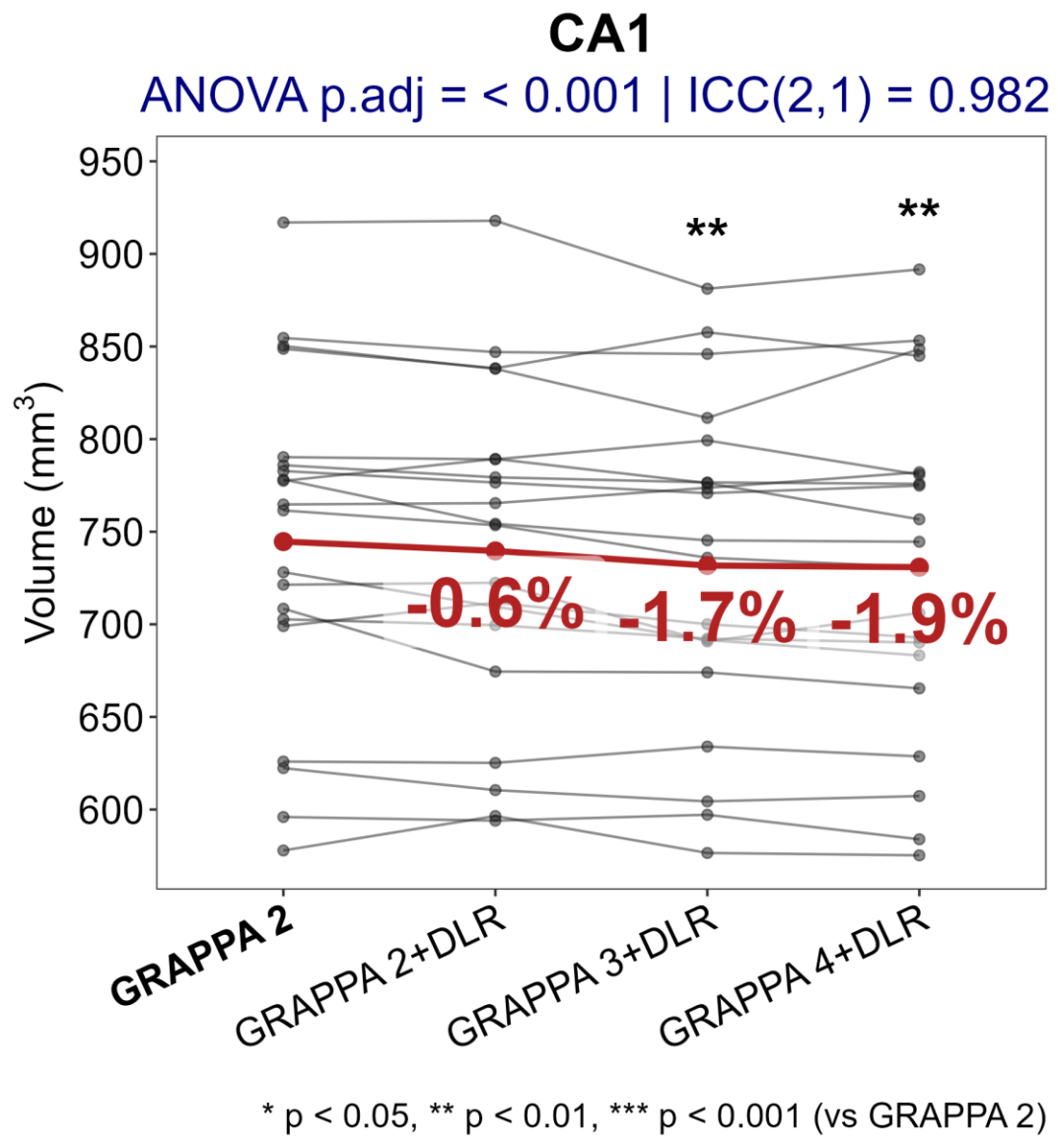
- Hippocampal segmentation using FreeSurfer (version 7.4.1)
  - CA1, CA3, DG+CA4, Subiculum, Tail and Whole hippocampal
- Statistical analysis (R version 4.4.0)
  - Comparison of volume differences
    - Assessment of volume change rate
    - Paired t-test (Holm correction)
  - Evaluation of Reliability: ICC (2,1), Bland-Altman analysis

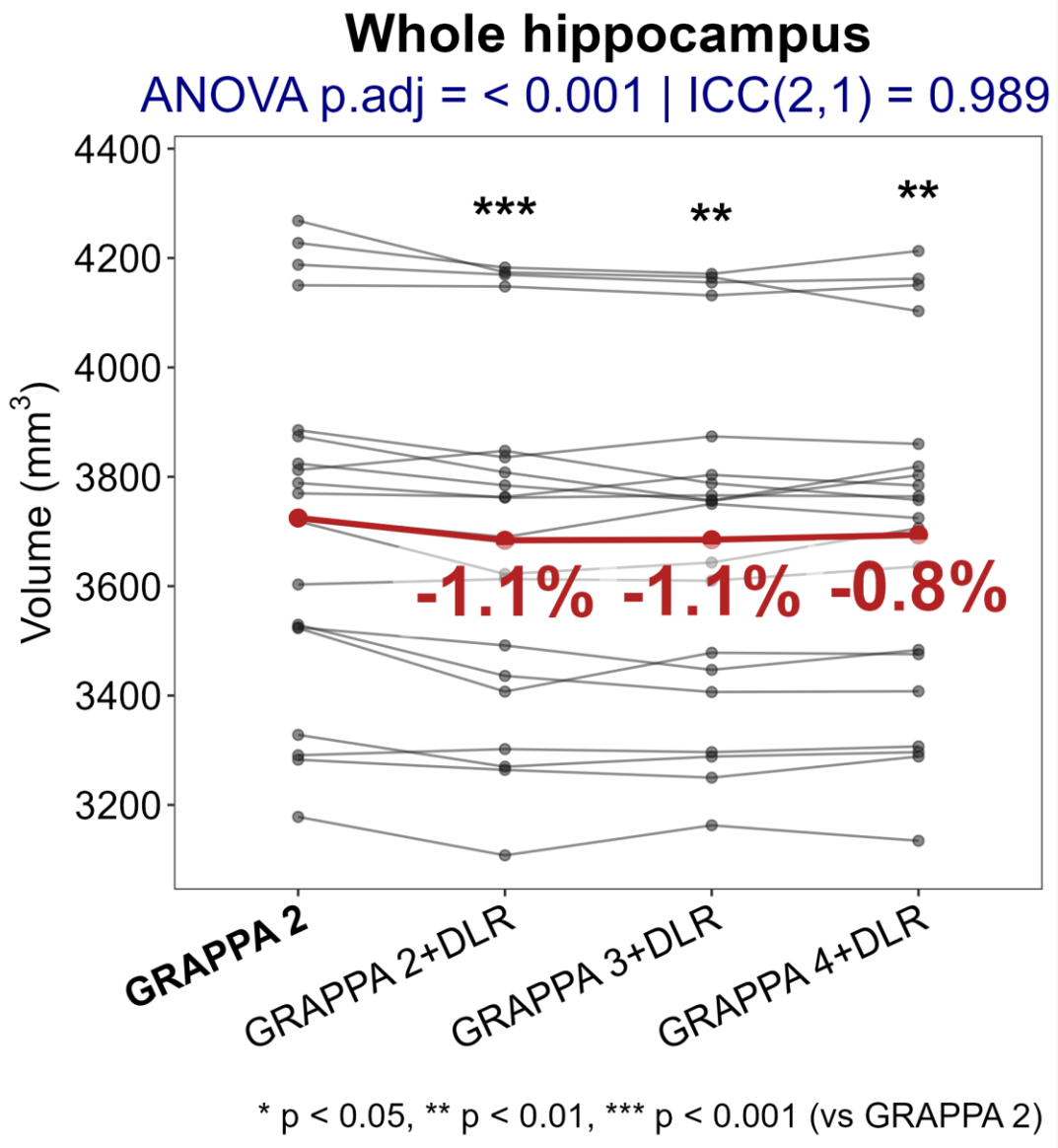
Acquired images



GRAPPA 2	GRAPPA 3+DLR	GRAPPA 4+DLR
4:17	**2:56**	**2:24**

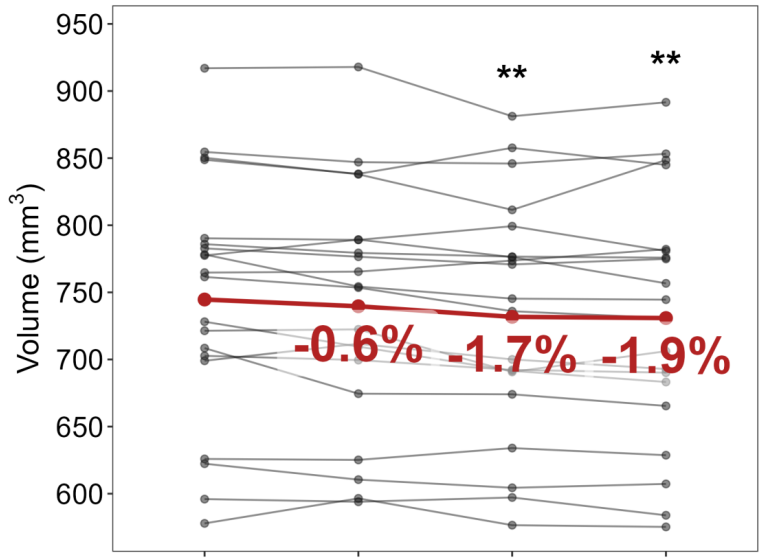
Results of volume change rates





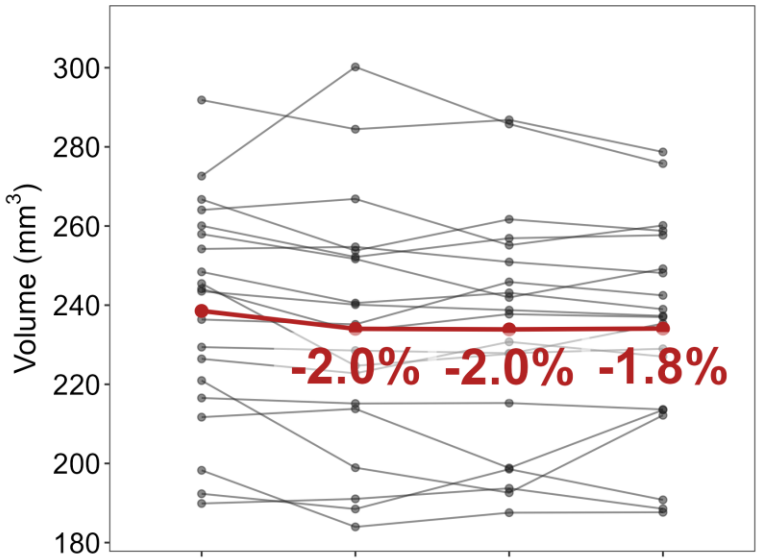
CA1

ANOVA p.adj = < 0.001 | ICC(2,1) = 0.982



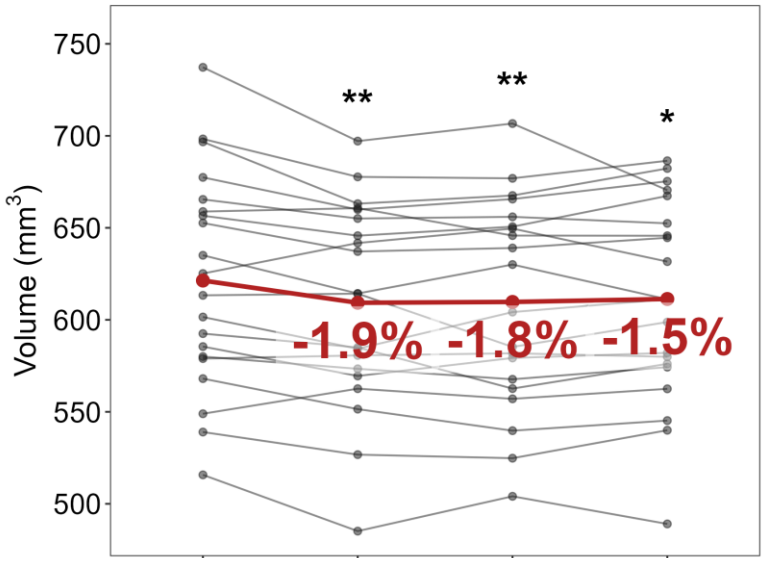
CA3

ANOVA p.adj = 0.112 | ICC(2,1) = 0.955



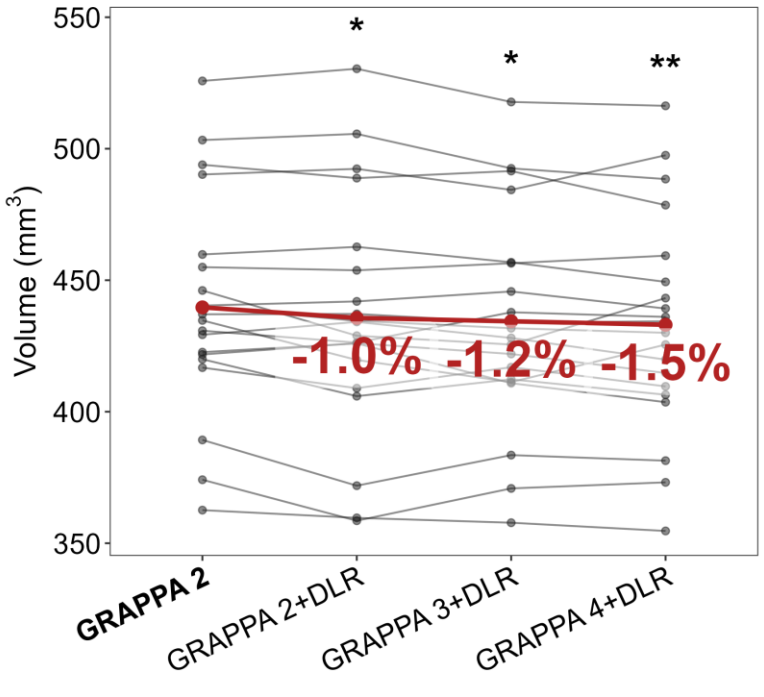
DG+CA4

ANOVA p.adj = 0.004 | ICC(2,1) = 0.959



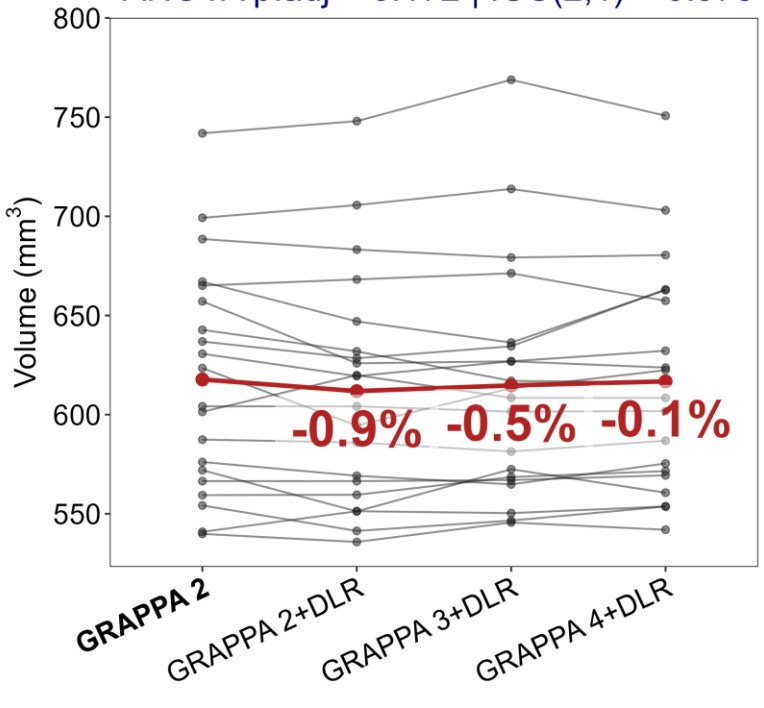
Subiculum

ANOVA p.adj = 0.018 | ICC(2,1) = 0.977



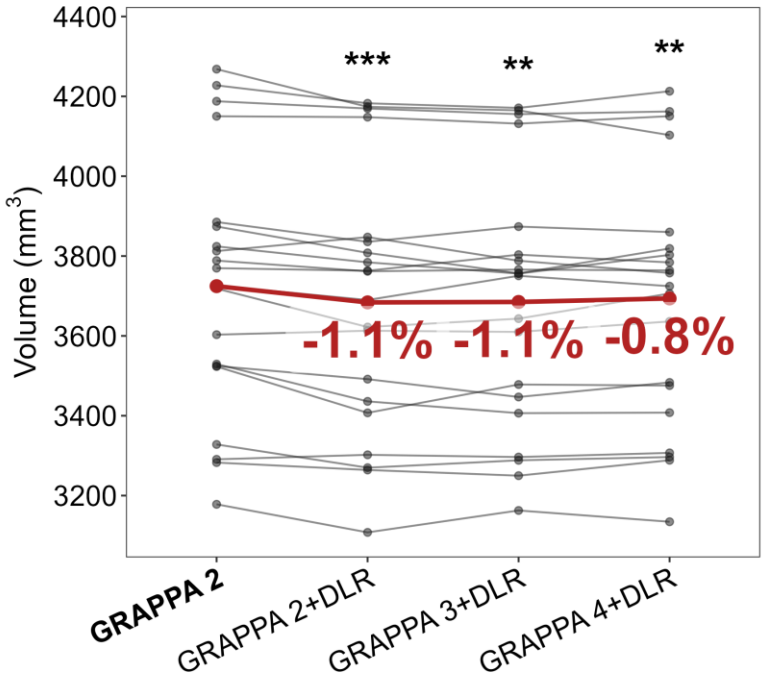
Hippocampal Tail

ANOVA p.adj = 0.172 | ICC(2,1) = 0.975

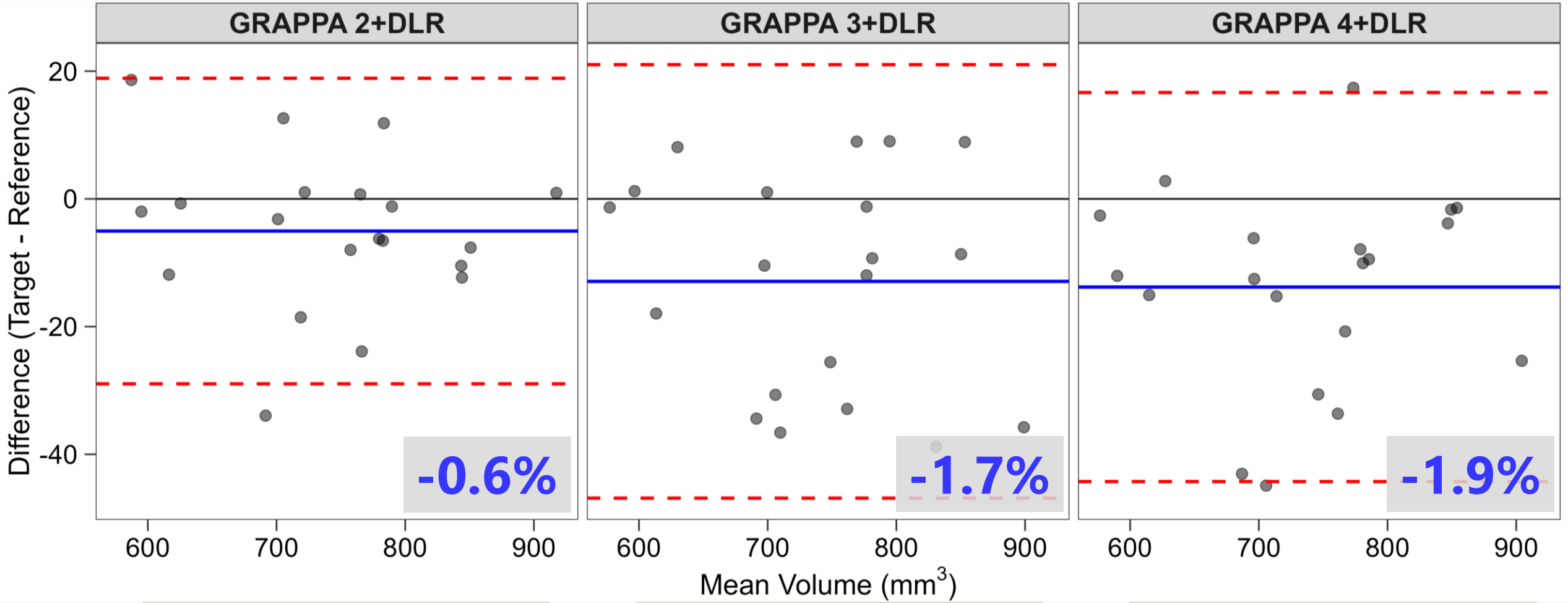


Whole hippocampus

ANOVA p.adj = < 0.001 | ICC(2,1) = 0.989

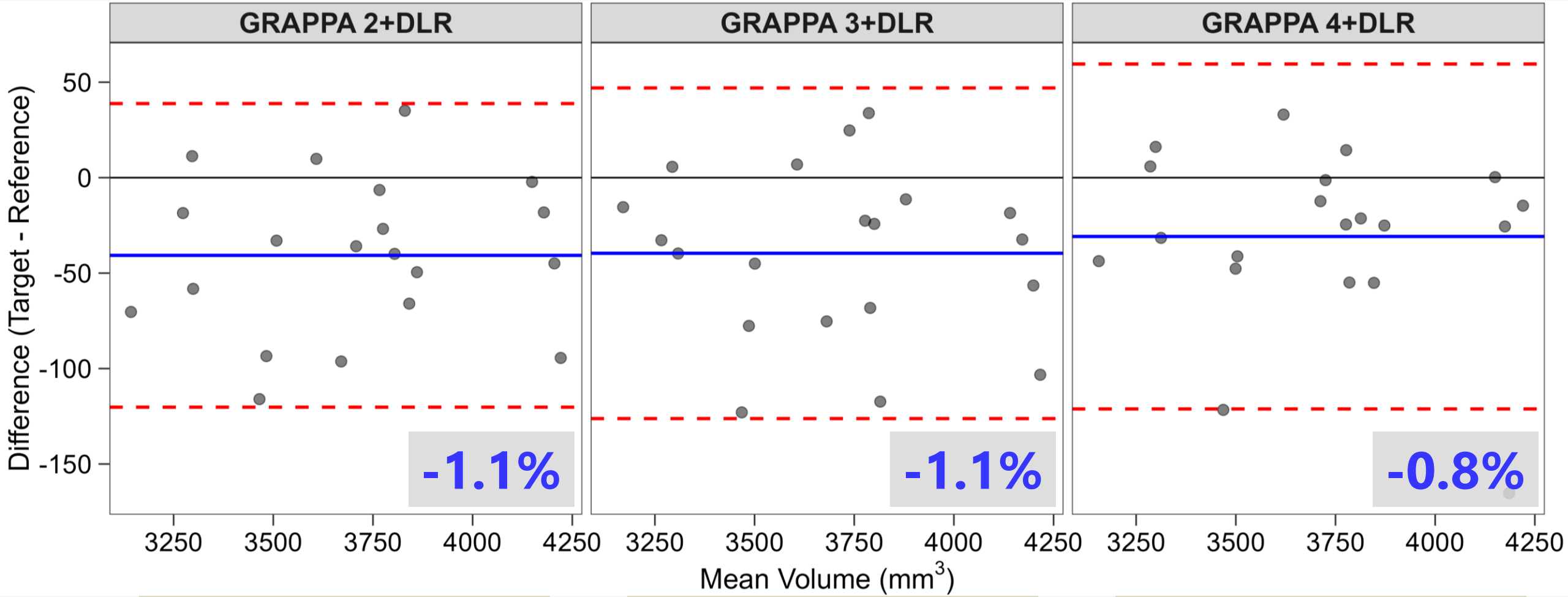


Bland-Altman analysis (CA1)



GRAPPA 2+DLR	GRAPPA 3+DLR	GRAPPA 4+DLR
Bias [95% LoA] (mm^3)	Bias [95% LoA] (mm^3)	Bias [95% LoA] (mm^3)
-5.0 [-29.0, 18.9]	**-12.9** [-46.9, 21.0]	**-13.8** [-44.3, 16.7]

Bland-Altman analysis (Whole hippocampus)



GRAPPA 2+DLR	GRAPPA 3+DLR	GRAPPA 4+DLR
Bias [95% LoA] (mm^3)	Bias [95% LoA] (mm^3)	Bias [95% LoA] (mm^3)
-40.7 [-120.2, 38.8]	**-39.6** [-126.2, 47.0]	**-30.8** [-121.2, 59.5]

Discussion

- Volume change rates
  - **~2% reduction** in CA1, DG+CA4, Subiculum, and whole hippocampus
  - **ICC > 0.90** for each subfield across different acceleration factors

  High reproducibility despite high acceleration factors

- Is this 2% change acceptable?
  - Longitudinal reproducibility error in FreeSurfer: **~5%***
  - Hippocampal atrophy in Alzheimer's disease can reach up to **34.2%****

* Brown EM, et al. NeuroImage. 2020
** Blanken AE, et al. NeuroImage: Clinical. 2017

Statistically significant, but clinically insignificant

Discussion

- Volume reduction trends with DLR
  - Advanced **denoising** and **high-resolution** processing Deep Resolve Boost and Deep Resolve Sharp

  Exclusion of "pseudo-structures" caused by noise

- Clinical impact of accelerated imaging
  - Scan time reduction (GRAPPA 4): 4 min 17 s to **2 min 24 s**

  Shorter scan time: Better feasibility and less motion artifact

Approximately 45% scan time reduction is possible via DLR

Conclusion

Hippocampal subfield segmentation
using DLR-processed images maintains
high segmentation accuracy,
even when acquisition time is **reduced by 45%**.