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Paper is not enough: Crowdsourcing the T1 mapping common ground via the ISMRM reproducibility challenge

*Mathieu Boudreau[1,2], *Agah Karakuzu[1,2], Julien Cohen-Adad[1,3,4,5], Ecem Bozkurt[6], Madeline Carr[7,8], Marco Castellaro[9], Luis Concha[10], Mariya Doneva[11], Seraina A. Dual[12], Alex Ensworth[13,14], Alexandru Foias[1], Véronique Fortier[15,16], Refaat E. Gabr[17], Guillaume Gilbert[18], Carri K. Glide-Hurst[19], Matthew Grech-Sollars[20,21], Siyuan Hu[22], Oscar Jalnefjord[23,24], Jorge Jovicich[25], Kübra Keskin[6], Peter Koken[11], Anastasia Kolokotronis[13,26], Simran Kukran[27,28], Nam. G. Lee[6], Ives R. Levesque[13,29], Bochao Li[6], Dan Ma[22], Burkhard Mädler[30], Nyasha Maforo[31,32], Jamie Near[33,34], Erick Pasaye[35], Alonso Ramirez-Manzanares[35], Ben Statton[36], Christian Stehning[30], Stefano Tambalo[25], Ye Tian[6], Chenyang Wang[37], Kilian Weis[30], Niloufar Zakariaei[38], Shuo Zhang[30], Ziwei Zhao[6], Nikola Stikov[1,2,39]

* These authors contributed equally.

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Summary

We present the results of the ISMRM 2020 joint Reproducible Research and Quantitative MR study groups reproducibility challenge on T1 mapping in phantom and human brain. T1 mapping, a widely used quantitative MRI technique, exhibits inconsistent tissue-specific values across protocols, sites, and vendors. The challenge aimed to assess the reproducibility of a well-established inversion recovery T1 mapping technique, with acquisition details published solely as a PDF, on a standardized phantom and in human brains. Participants acquired T1 mapping data from MRIs of three manufacturers at 3T, resulting in 39 phantom datasets and 56 datasets from healthy human subjects. The T1 inter-submission variability was twice as high as the intra-submission variability in both phantoms and human brains, indicating that the acquisition details in the selected paper were insufficient to reproduce a quantitative MRI protocol. This study reports the inherent uncertainty in T1 measures across independent research groups, bringing us one step closer to a practical clinical baseline of T1 variations in vivo. This challenge resulted in the creation of a comprehensive open database of T1 mapping acquisitions, accessible at osf.io/ywc9g/, and an interactive dashboard for wider community access and engagement.

Figures

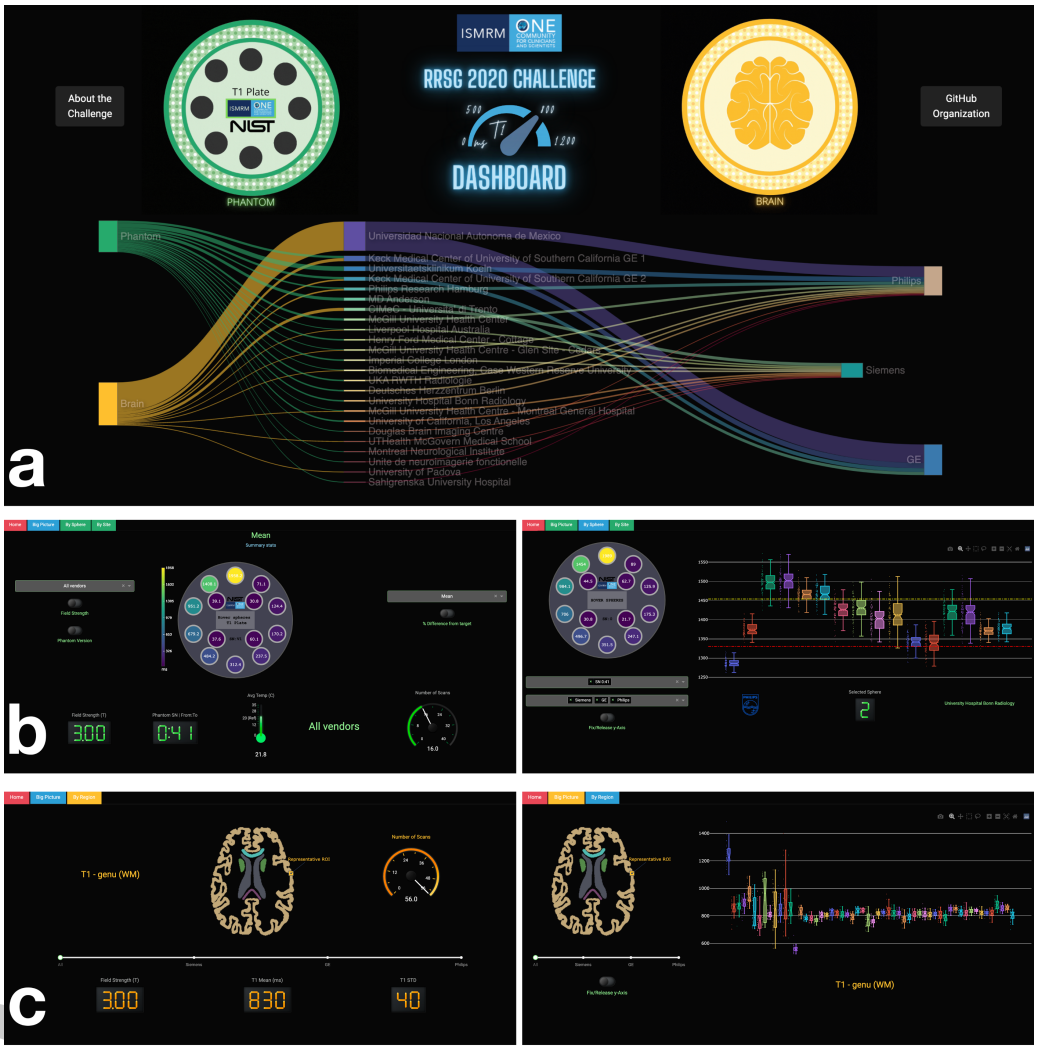

Figure 1: Dashboard. a) welcome page listing all the sites, the types of subject, and scanner, and the relationship between the three. Row b) shows two of the phantom dashboard tabs, and row c) shows two of the human data dashboard tabs Link: https://rrsg2020.db.neurolibre.org

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The authors thank the ISMRM Reproducible Research Study Group for conducting a code review of the code (Version 1) supplied in the Data Availability Statement. The scope of the code review covered only the code's ease of download, quality of documentation, and ability to run, but did not consider scientific accuracy or code efficiency.

Lastly, we acknowledge use of ChatGPT (v3), a generative language model, for accelerating manuscript preparation. The co-first authors employed ChatGPT in the initial draft for transforming bullet point sentences into paragraphs, proofreading for typos, and refining the academic tone. ChatGPT served exclusively as a writing aid, and was not used to create or interpret results.

NOTE

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References

DuPre, E., Holdgraf, C., Karakuzu, A., Tetrel, L., Bellec, P., Stikov, N., & Poline, J.-B. (2022). Beyond advertising: New infrastructures for publishing integrated research objects. *PLOS Computational Biology*, *18*(1), e1009651. https://doi.org/10.1371/journal.pcbi.1009651

Harding, R. J., Bermudez, P., Bernier, A., Beauvais, M., Bellec, P., Hill, S., Karakuzu, A., Knoppers, B. M., Pavlidis, P., Poline, J.-B., Roskams, J., Stikov, N., Stone, J., Strother, S., Consortium, C., & Evans, A. C. (2023). The Canadian Open Neuroscience Platform—An open science framework for the neuroscience community. *PLOS Computational Biology*, *19*(7), 1–14. https://doi.org/10.1371/journal.pcbi.1011230

Karakuzu, A., DuPre, E., Tetrel, L., Bermudez, P., Boudreau, M., Chin, M., Poline, J.-B., Das, S., Bellec, P., & Stikov, N. (2022). *NeuroLibre : A preprint server for full-fledged reproducible neuroscience*. OSF Preprints. https://doi.org/10.31219/osf.io/h89js

Affiliations

1 NeuroPoly Lab, Polytechnique Montréal, Montreal, Quebec, Canada **2** Montreal Heart Institute, Montreal, Quebec, Canada **3** Unité de Neuroimagerie Fonctionnelle (UNF), Centre de recherche de l'Institut Universitaire de Gériatrie de Montréal (CRIUGM), Montreal, Quebec, Canada **4** Mila - Quebec AI Institute, Montreal, QC, Canad **5** Centre de recherche du CHU Sainte-Justine, Université de Montréal, Montreal, QC, Canada **6** Magnetic Resonance Engineering Laboratory (MREL), University of Southern

California, Los Angeles, California, USA **7** Medical Physics, Ingham Institute for Applied Medical Research, Liverpool, Australia **8** Department of Medical Physics, Liverpool and Macarthur Cancer Therapy Centres, Liverpool, Australia **9** Department of Information Engineering, University of Padova, Padova, Italy **10** Institute of Neurobiology, Universidad Nacional Autónoma de México Campus Juriquilla, Querétaro, México **11** Philips Research Hamburg, Germany **12** Department of Radiology, Stanford University, Stanford, California, United States **13** Medical Physics Unit, McGill University, Montreal, Canada **14** University of British Columbia, Vancouver, Canada **15** Department of Medical Imaging, McGill University Health Centre, Montrea, Quebec, Canada **16** Department of Radiology, McGill University, Montreal, Quebec, Canada **17** Department of Diagnostic and Interventional Imaging, University of Texas Health Science Center at Houston, McGovern Medical School, Houston, Texas, USA **18** MR Clinical Science, Philips Canada, Mississauga, Ontario, Canada **19** Department of Human Oncology, University of Wisconsin-Madison, Madison, Wisconsin, USA **20** Centre for Medical Image Computing, Department of Computer Science, University College London, London, UK **21** Lysholm Department of Neuroradiology, National Hospital for Neurology and Neurosurgery, University College London Hospitals NHS Foundation Trust, London, UK **22** Department of Biomedical Engineering, Case Western Reserve University, Cleveland, Ohio, USA **23** Department of Medical Radiation Sciences, Institute of Clinical Sciences, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden **24** Biomedical Engineering, Sahlgrenska University Hospital, Gothenburg, Sweden **25** Center for Mind/Brain Sciences, University of Trento, Italy **26** Hopital Maisonneuve-Rosemont, Montreal, Canada **27** Bioengineering, Imperial College London, UK **28** Radiotherapy and Imaging, Insitute of Cancer Research, Imperial College London, UK **29** Research Institute of the McGill University Health Centre, Montreal, Canada **30** Clinical Science, Philips Healthcare, Germany **31** Department of Radiological Sciences, University of California Los Angeles, Los Angeles, CA, USA **32** Physics and Biology in Medicine IDP, University of California Los Angeles, Los Angeles, CA, USA **33** Douglas Brain Imaging Centre, Montreal, Canada **34** Sunnybrook Research Institute, Toronto, Canada **35** Computer Science Department, Centro de Investigación en Matemáticas, A.C., Guanajuato, México **36** Medical Research Council, London Institute of Medical Sciences, Imperial College London, London, United Kingdom **37** Department of Radiation Oncology - CNS Service, The University of Texas MD Anderson Cancer Center, Texas, USA **38** Department of Biomedical Engineering, University of British Columbia, British Columbia, Canada **39** Center for Advanced Interdisciplinary Research, Ss. Cyril and Methodius University, Skopje, North Macedonia