Magnetic Resonance in Medicine

HIGHLIGHTS

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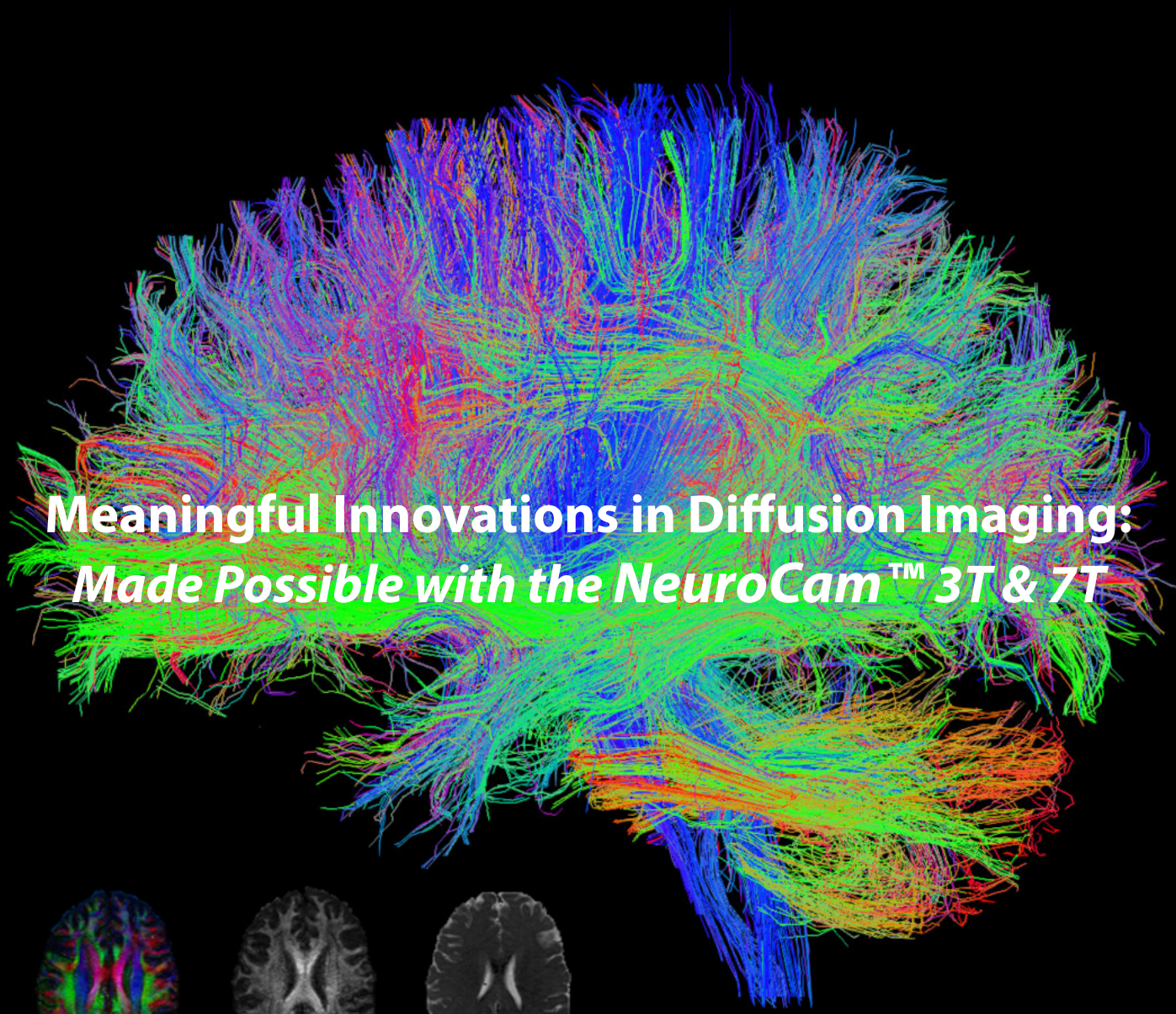

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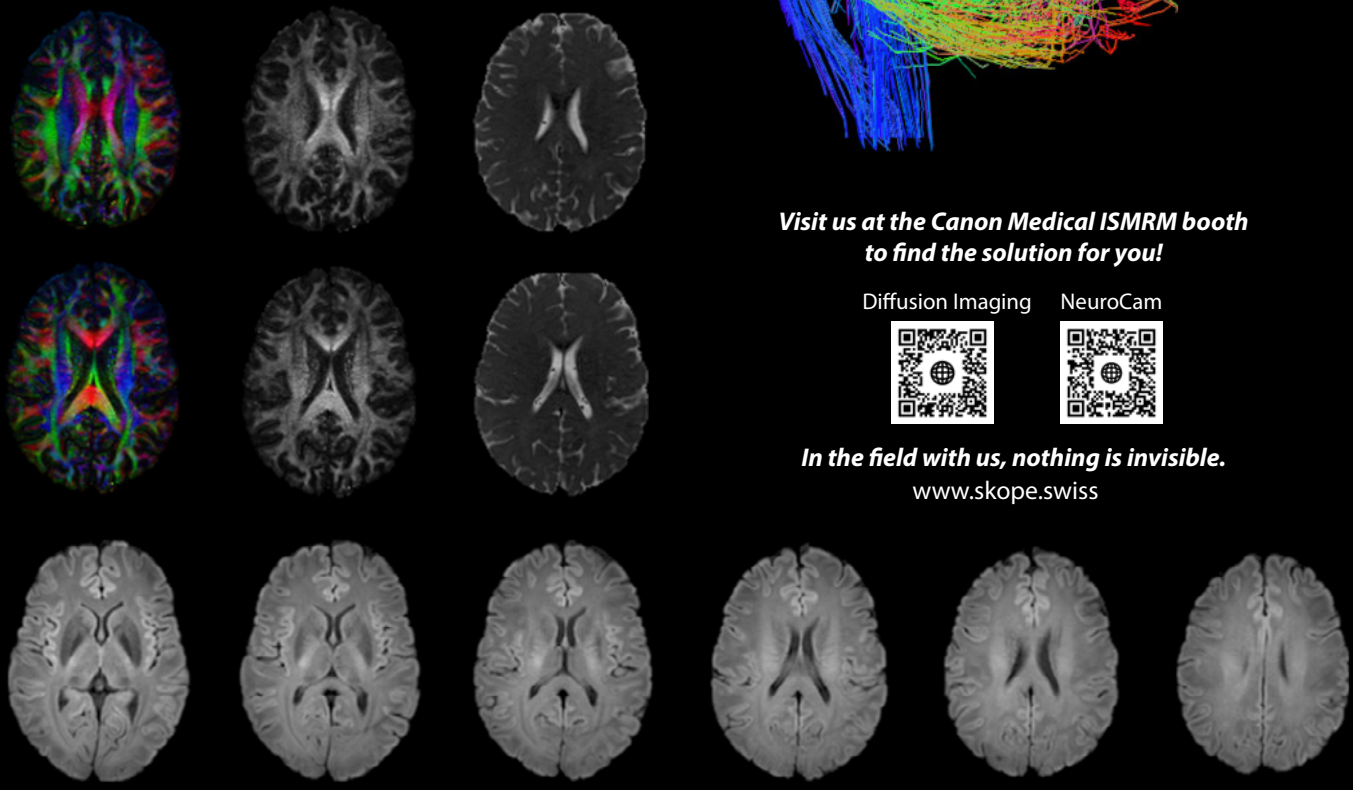

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Welcome to 2023's *Magnetic Resonance in Medicine Highlights*

Back in December 2022, when I started brainstorming with Peter Jezzard and the rest of the MRM Highlights team, it was extremely easy to draft a rich table of contents for this 8th issue, full of intriguing topics and names that could engage readers once again. It was so easy that, honestly, my brain rested on its laurels. Then my work and family commitments got in the way, and suddenly it was my son's birthday, at the end of February, and I couldn't find the time to send invitations to the people that we wanted to interview, not to mention starting the search for volunteer contributors. But here's a couple of things that saved my day: first, within ISMRM I found friends, true friends, in the last seven years, who wouldn't hesitate to help me even with the shortest notice; second, this Society holds so many gems, such intriguing and inspiring stories deserving to be told, that each piece you will read almost wrote itself. So before illustrating the main contents, let me thank Dr. Laura Bortolotti, my partner in crime, amazing deputy editor, the kind of person everyone should have in their life; Dr. Mathieu Boudreau, the true soul of MRM Highlights, who keeps it going and growing in a *seemingly* effortless way, supported by the Quebec Bioimaging Network and the Canadian Open Neuroscience Platform; last, but never least, Peter Jezzard, our Editor-in-Chief, so professional and kind, always supportive, never daunting.

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Now without further ado, please dive into the pages and get to know the exciting new initiatives, such as how ISMRM is starting to broaden the reach of MRI education and training in the Global South, read about our wonderful Executive Director, Roberta Kravitz, our President Scott Reeder, find advertisements describing our member-initiated activities, and take a look at what happened in the very same city, Toronto, twenty years ago.

And if you have learned to know and love MRM Highlights, you'll be happy to see that Q&As are also back, this year "embellished" by reproducible research insights.

We are also delighted to continue showcasing the amazing early-career talent in our Society, both present and from Toronto 2003.

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Together with Mathieu Boudreau, Editor of the MRM Highlights Digital Content, and Peter Jezzard, MRM Editor-In-Chief, we want to thank our volunteer collaborators, the ISMRM Central Office, and the team at Wiley who have all helped this magazine to see the light of day. We hope you enjoy reading it as much as we enjoyed making it!

Maria Eugenia Caligiuri
MRM Highlights Magazine Editor

JUNE 2023 | VOLUME EIGHT

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ISMRM Inclusion Working Group

Who are we?

We are a free and open network of ISMRM members with our main goals to:

- Amplify the voices of ISMRM members who identify as belonging to one or more underrepresented groups to promote advances in inclusion practices;
- Develop initiatives and workshops to recommend to the ISMRM Board of Trustees and Annual Meeting Program Chairs for action; and
- Welcome everyone interested in promoting Equity, Diversity, and Inclusion (EDI), irrespective of how they personally identify.

What are we doing at the Annual Meeting?

Our first goal is to launch an **EDI Kiosk** at this year's ISMRM in Toronto. This kiosk will provide a contact point for resources within the community and an area for discussion on how to improve inclusivity at ISMRM, which will be available throughout the conference. We will then relay your ideas to the Board of Trustees and Program Chairs.

What is the future of the group?

The Inclusion Working Group aims to support future Program Chairs in facilitating inclusion strategies at upcoming annual meetings, and provide actions points from the ISMRM membership. We will meet every 2-3 months, with increasing frequency around the annual meeting, to discuss your ideas. We are excited to support **you**, be it through helping organize a "Secret Session", suggesting accessibility improvements, or increasing awareness of a particular topic. We aim to partner with Study Groups and Chapters to produce exciting community content too.

I'm not sure I have time…

That's okay! Feel free to be as involved as possible, but we hope you can join at least one meeting per year to get your voice heard.

How can you get involved?

We are looking for volunteers! If you would like to support the kiosk, learn more or join our group, please get in touch here: **edi@ismrm.org**

Helping everyone, everywhere in the world benefit from advances in MRI technology

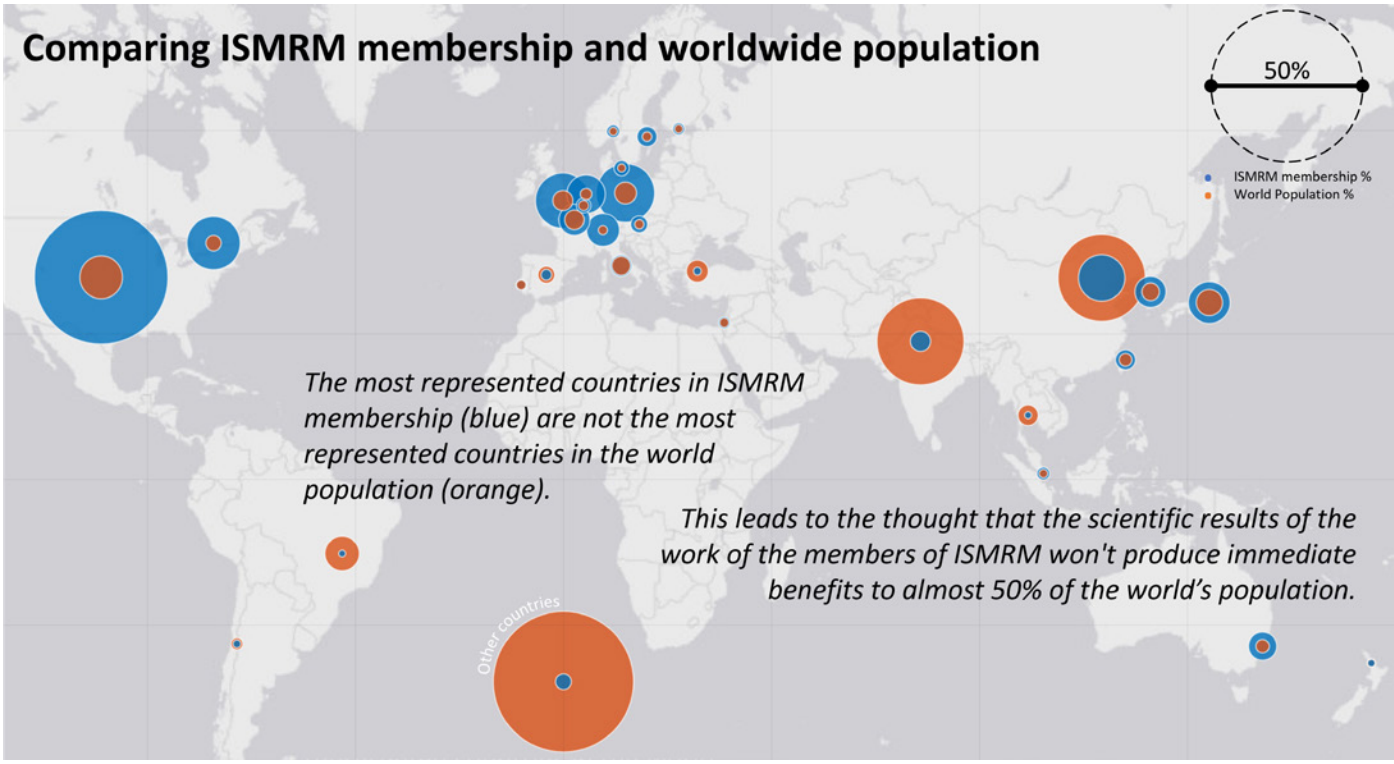
INTERVIEW BY **LAURA BORTOLOTTI, MARIA EUGENIA CALIGIURI**

Prof. Derek Jones, Director of CUBRIC (Cardiff University Brain Research Imaging Centre, in Cardiff, Wales UK) and MRI legend, is currently Vice-President of ISMRM, which means he will become President at the Business Meeting in Toronto. In this interview, he tells us about the newest, most exciting initiative from our Society's leadership: an unprecedented effort to improve the accessibility of MR hardware, education and knowledge on a global basis, starting with Africa.

Dr. Udunna Anazodo, Assistant Professor in the Department of Neurology and Neurosurgery, and also a member of the Neuroimaging and Neuroinformatics research group at The Neuro, in Montreal, also gives an overview of the events that eventually led to the birth of the ISMRM African Chapter.

MRMH: Had you ever been to Africa before undertaking this new adventure?

Derek: Yes, I was lucky enough to first go to Kenya when I won a TV competition as a teenager. I'd been to Egypt as a student, and South Africa on honeymoon, but I never would have imagined that I'd come back one day in any official capacity, helping our Society to democratise MRI.



Only 7% of the world's population lives in North America (blue) but represents 49% of the ISMRM's membership (Sources: MRM Highlights Magazine – Volume 5, https://worldpopulationreview.com/). This leads to the thought that the scientific results of the work of half of the members of ISMRM will produce immediate benefits to less than 10% of the world's population.

The birth of the African ISMRM Chapter (Cape Town 2023); From the left: Johnes Obungoloch (Mbarara University, Uganda) Godwin Ogbole (University of Ibadan, Nigeria); Derek Jones (CUBRIC, Cardiff University, UK/ ISMRM Vice President); Ernesta Meintjes (University of Cape Town, South Africa); Udunna Anazodo (McGill University, Canada); Scott Reeder (University of Wisconsin, USA/ ISMRM President); Roberta Kravitz (Executive Director, ISMRM); Leon van Rensburg (University of the Western Cape, South Africa); Anne-Marie Kahrovic (Associate Executive Director, ISMRM).

MRMH: How did it all start?
Derek: I remember it well. It was about 7 am on the 9th May in London, and I was attending the 31st ISMRM Annual Meeting. In the ISMRM's EDI forum "Axes of Inclusion", I heard Prof. Udunna Anazodo and Prof. Godwin Ogbole discussing magnetic resonance in Africa and what they felt was needed. I was struck by a comment that it wasn't more MRI hardware that African countries needed to progress in the field.

MRMH: What else do they need then?
Derek: The speakers emphasised the importance of proper training in order to effectively utilise machinery, particularly in the medical field. A lack of structured training programs has led to a scarcity of trained personnel in Africa, causing a 'brain drain' as talented individuals seek education and opportunities abroad, often never returning. This has created a cycle of fewer experts and training centres, perpetuating the problem. However, they also shared their dream of having skilled personnel, teachers, and experts in Africa to exchange knowledge with local users.

I was totally captivated by what they were saying. This is definitely a complex issue, but we're a Society of around 8000 members who can pull together to help out. For the next few mornings at breakfast in the hotel, I eagerly recounted the forum and how we could help with early-risers like Andrew Webb, a crucial founder of CAMERA (https://www.cameramriafrica.org/) and Jim Pipe, a former President and AMPC Chair, and I was grateful for their patience and willingness to hear me out as we discussed potential solutions.

MRMH: What's the matter?
Derek: The ISMRM community is acutely aware that the geographical distribution of its membership is heavily skewed towards North America and Europe, which make up the majority of what is often referred to as 'The Global North'. Access to MR hardware and MR education across the globe is similarly imbalanced, meaning that a significant proportion of the world's population continues to miss out.

I guess this bias might influence the implicit assumptions our members make when considering new MR projects. These might have a significant impact on where, and how, these ideas are tested, and the speed at which new solutions and discoveries can be applied for the benefit of the global population.

As an aside, I love the anecdote that Andrew Webb shared with me. Andrew had designed a portable low field MRI scanner in Leiden in the Netherlands and then went to Uganda to collaborate with engineers in Mbarara. They soon discovered that the soil in Mbarara has a much higher percentage of iron ore than the local soil in Leiden! Who knew soil could be so 'attractive'?

We've got to approach our work with a global perspective and consider its implications and benefits for all communities, not just those in our immediate vicinity. To quote Udunna at the first EDI Forum at the Annual Meeting in 2019, "MRI is W.E.I.R.D." (i.e., found mostly in Western, Educated, Industrialised, Rich and Democratic countries).

MRMH: So you want to maintain one part of MRI's weirdness? Just the "D" and go W.I.L.D. (Working In-Unison, Leading to Democratization)?
Derek: Ha! I love that! But to go truly W.I.L.D, we need a full Society effort and we need people driving the initiative from within Africa. This is one of the main reasons I went to Cape Town in January, to join a roundtable discussion about the formation of an African Chapter of the ISMRM.

Prof. Udunna Anazodo flew in from Montreal, Prof. Johnes Obungoloch from Mbarara, Uganda, Prof. Godwin Ogbole flew from Nigeria, and 'locals' Prof. Leon van Rensburg from the University of the Western Cape and Prof Ernesta Meintjes from the University of Cape Town, joined Roberta Kravitz (our Executive Director), Anne-Marie Kahrovic (our Associate Executive Director), and Scott Reeder (our current President) for a very productive roundtable discussion about bringing the African ISMRM Chapter to fruition, with Johnes Obungoloch as the Chair (I pronounce my last name the same way Johnes pronounces his first name, or is it vice-versa?). The Cape Town meeting was successful and, to conclude, the Toronto Annual Meeting will be the first one for the African ISMRM Chapter!

MRMH: You may not be among the first proponents of the African Chapter, but you are definitely a protagonist of what comes next. Can you tell us more?
Derek: You're right. I definitely shouldn't take any credit for the African Chapter. The process for that started way before I got involved. But, when I agreed to go on the ballot as President, I said I wanted to put the

"I" into 'ISMRM' and make the Society truly international. This means starting with the Annual Meeting.

While the formation of the African Chapter is going to build community and strength across Africa, we need to get more people from the Global South participating in our Annual Meeting, contributing new perspectives and benefiting from, and contributing to, the excellent educational content of the meeting.

Going back to that EDI Forum in London, it was humbling to recognize the privilege that attending the Annual Scientific Meeting represents for only a small handful of Africans, who often face significant obstacles in accessing opportunities for education and career advancement. Flying to the other side of the world is a luxury that puts our Annual Meeting quite literally out of reach. Yet, participating fully in an international community of MR users offers tangible benefits beyond the warm feeling of belonging to something larger. Unfortunately, in regions such as Africa, parts of Asia, and South America, this level of engagement was not occurring. So it was time for a change.

MRMH: So what did you do?

Derek: I was keen to see what could be done to make our annual meeting more accessible and to expand our membership, and this led to a 'two-pronged' attack.

First, as you'll have seen in the 'twin blogs' from Scott Reeder and me back in April, we're going to be holding our first ever Annual Meeting in Africa, in Cape Town in 2026! The founders of the African Chapter have confirmed that this will massively increase accessibility for people in Africa. We visited the conference centre during our visit in January, and it's a beautiful facility in a stunningly beautiful location. I know the entire membership is going to love going there.

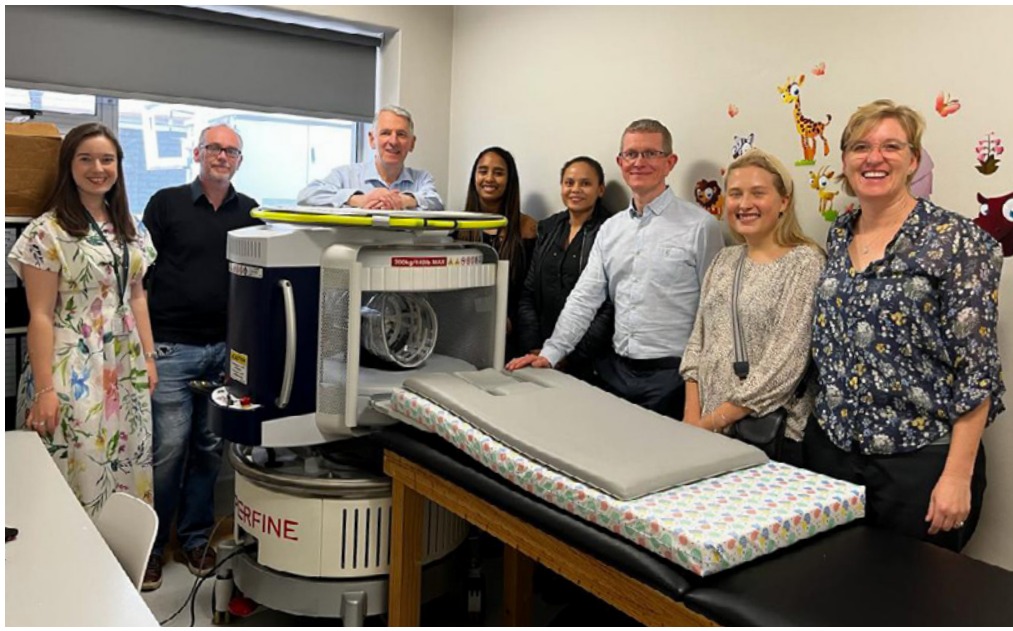
But 2026 is a long way off, and I'm impatient. So I'm even more excited that the Bill and Melinda Gates Foundation (BMGF) agreed to enter into a Strategic Partnership with the ISMRM for a multi-phase approach to democratizing MRI. Under the 'UNITY' programme, BMGF are already very active in Africa (as well as Pakistan, India and Bangladesh), in supporting the use of low-field MRI to understand the first 1000 days of life. While we were in Cape Town, we visited our colleagues in 'CUBIC' who are using both low-field and high-field (3T) MRI to study development. Back to the Partnership. In Phase 1, the BMGF are going to fully sponsor a diverse group of 100 people, who come from all across Africa, working in different domains (such as: radiologists, radiographers, physicists, and engineers), and balanced across genders and senior and junior status, to come to our Annual Meeting for the first time in Toronto this June. We will welcome them at the Newbie Reception on the Saturday night, where each will be paired with a mentor for the duration of the meeting and the following year. We'll then have a full-day meeting after the ISMRM to hear from our invitees, getting advice on the next phase in democratising MRI.

MRMH: How do you put the plan to "democratise MRI" into action?

Derek: Well that leads nicely into Phase 2. It would be so easy to sit in my office chair in Cardiff and say "I know what's best there", but that's obviously not true. We needed to hear the voices and the opinions of those with 'the lived experience' of working in Africa, and this could only be done by visiting the countries involved. So in April, I formed part of an "Africa tour" comprising ISMRM members and BMGF staff, visiting 5 sites in 3 countries over 2 weeks, visiting existing MRI sites and meeting groups in Blantyre and Zomba (Malawi), Kampala and Mbarara (Uganda), Kisumu (Kenya) with the team going on to Accra and Kintampo (Ghana), and this has helped us put plans in place for after Toronto.

MRMH: What will happen after Toronto then?

Derek: A second thing was said in the EDI forum in London: "It is not effective to take somebody out of a country and pop them in a different context to be trained. What would be really effective is to provide training and support in situ", and that's what will keep us busy in the coming year! We have set the challenge to break the barriers that prevent us so far to provide training, knowledge exchange and education in situ.



UNITY (Ultra-Low field Neuroimaging In The Young) researchers meeting up at the Cape Universities Body Imaging Centre (CUBIC), Groote Schuur Hospital, Cape Town in January; the UNITY project, funded by the Bill and Melinda Gates Foundation, aims to validate and develop Low Field MRI as a portable tool to provide early diagnosis on child neurodevelopment and to assess the neurodevelopmental outcome of therapeutic interventions in LMICs. From the left: Jessica Ringshaw (CUBIC, Cape Town); Daniel Alexander (UCL, UK); Steve Williams (Kings College London, UK); Simone Williams (CUBIC, Cape Town), Reese Samuels (CUBIC, Cape Town); Derek Jones (Cardiff University, UK); Layla Bradford (CUBIC, Cape Town); and Kirsty Donald (CUBIC, Cape Town).

That's where Phase 2 comes in. With support from BMGF, in the next year we're going to pilot some 'Knowledge Exchange Fellowships'. These will support people from the sites we visited in Africa in April to spend time training in high income settings, but CRITICALLY – they will also support our members from HIC settings to spend time in Africa, at those sites, exchanging knowledge and helping to improve MRI, whether it's the hardware, data acquisition, image processing or interpretation.

Working closely with BMGF, and following the Fellowship pilots in 2023/2024, I hope to announce the next phase in our journey at the 32nd ISMRM Annual meeting in Singapore 2024 - stay tuned!!

Administering this is going to take some work, but I'm part of a fellowship of truly motivated people including Roberta Kravitz (Executive Director of the ISMRM Central Office), Scott Reeder (current ISMRM President) and Anne-Marie Kahrovic (Associate Executive Director of the ISMRM Central Office). We've got excellent leadership and experience from the African ISMRM Chapter, a Partnership with the Bill and Melinda Gates Foundation, and a commitment from the ISMRM Central Office to help administer the Fellowship scheme. But we will need more help – and this is where the volunteerism of the members of the ISMRM Society that we know and love will come to the fore!

We strongly believe that this is just the first step for the ISMRM community. Our hope is not only to have created momentum in Africa, but to have established a blueprint of a model that can be applied to democratize MRI technology in other parts of the world. As the President for only a year, I recognize that I can only do so much. However, my ambition is to inspire and motivate others to think about what can be done in other parts of the world, including Latin America and Southeast Asia. This is my vision, and I am confident that through our collective efforts we can make a significant impact in increasing access to MRI technology worldwide.

MRMH: A final message from the incoming President to the ISMRM members:

Derek: We're an amazing Society. The ISMRM thrives on people's ideas and time for volunteering, and that's what makes our Society flourish and evolve year after year. To anybody who is reading the interview, and who has an idea but is unsure about proposing it, I would say: you're completely encouraged to get in touch with me to discuss it! I can't guarantee to be able to implement and support every proposal, but I'm always ready to listen. ■

The birth of African Chapter of ISMRM

BY **UDUNNA ANAZODO**

Genesis: The Long Road to a Chapter

In 2018, the ISMRM signaled its commitment to foster a more inclusive scientific society by establishing the Equity Task Force (later Equity, Diversity and Inclusion Ad Hoc Committee), led by Dr. Elizabeth Morris. At that time, Africa, with 49 members, represented 0.05% of the overall membership. Of the 49 members, only 19 held an active status and only 4 were Full or Associate Members, and, with the exception of South Africa, none were from Sub-Saharan Africa. Thus, among over 9000 clinicians, physicists, engineers, biochemists, and technologists from all over the world, only 4 members from Africa were eligible to participate in ISMRM committees or to be nominated for the Society's distinguished awards – Gold Medal and Fellow of the Society.

To close this longstanding gap, Dr. Udunna Anazodo and Dr. Johnes Obungoloch met at the 2019 ISMRM Annual Meeting in Montreal, Canada, and carved a path towards establishing the African Chapter of the ISMRM to promote inclusion of MRI professionals from Africa in the ISMRM and to provide opportunities for collaboration. First, the Consortium for Advancement of MRI Education and Research in Africa (CAMERA) was established in October 2019 as a working group of the European Society for Magnetic Resonance in Medicine and Biology (ESMRMB) to identify barriers to inclusion, improve MRI training, and build a network of MRI users in the region. Over the next four years, CAMERA mapped out a framework for breakthrough inclusion of Africa in the global MRI community following an in-depth needs assessment study and built a network of over 300 African MRI clinicians, physicists, engineers, computer scientists, and technologists.

Leveraging funding awarded to the CAMERA Network in 2022 from the Chan Zuckerberg Initiative (CZI) to support an inaugural Chapter's activities, and the increased commitment of the ISMRM leadership to achieving excellence in MRI through inclusive representation, Dr. Udunna Anazodo and Dr. Johnes Obungoloch along with Dr. Godwin Ogbole and Dr. Edward Nganga, backed by an active network of African MRI users, initiated a petition for the African Chapter of the ISMRM. The rest as they say is history.

Numbers: The Power of Tenacity

The African Chapter of the ISMRM represents tenacity in the face of complex challenges. It stands as a testament of the capacity to mobilize a global scientific community to effect transformative change in the scientific society. To establish a regional Chapter at ISMRM, a petition from at least 25 active ISMRM members, 15 of whom must be either Full or Associate Members, is required. The annual membership cost, too prohibitive for even an average radiologist in Arica to afford, posed a fundamental barrier to the formation of the Chapter. In 2022, ISMRM awarded 1-year Associate Membership Stipends to at least 21 MRI professionals based in Africa, increasing the number of active members in the region to 40. This financial assistance to attend the 2022 Annual Meeting exemplified the pragmatic approach discussed at the 2019 Annual Meeting equity events, where demonstratable actions at the Society level provides access to underrepresented groups to participate in meetings and leads to long-term equity improvements at ISMRM. The inaugural executive committee of the African Chapter consists largely of members who benefited from the stipend.

Assistance to establish the Chapter also came from individuals at

ISMRM Members at the 2022 CAMERA Network Meeting following the 2022 ISMRM Annual Meeting in London UK. Sitting L to R: Rita Nunes, Farouk Dako, Iris Asllani. Standing L to R: Matteo Figini, Henk Jan Mutsaerts, Andrew Webb, Abiodun Fatade, Udunna Anazodo, Zahra Hosseini, Paulien Moyaert, Regina Chinwe Onwuchekwa, Patricia Figueiredo and Rebecca Dewey. Virtual: Ernesta Meintjes, Godwin Ogbole, Abderrazek Zeraii, Marcello Alecci. Not pictured: Daniel Alexander.

ISMRM and ESMRMB who participated in symposia/meetings/webinars advocating for improved access to MRI in Africa and raised awareness of Africa's inclusivity to funding agencies, vendor partners, and the MRI community at large. These champions include Prof. Andrew Webb and Prof. Marion Smits, Past-Presidents of ESMRMB who offered a platform to jumpstart the Chapter through establishment of a network. Dr. Iris Asllani who organized events at ISMRM, co-wrote grants and continues to push for training MRI opportunities in Africa. Prof. Vikas Gulani, who ensured active vendor participation in ISMRM advocacy events. These vendors have continued to maintain active engagement with MRI researchers in the region. Within the region, Dr. Abiodun Fatade, a consultant radiologist, Managing Director of Crestview Radiology, Nigeria, and the Treasurer of the Inaugural Executive Committee of the African Chapter, is one of the strongest advocates for MRI in Africa. Dr. Fatade ushered a large network of MRI radiologists to the global MRI community and financially supports several local MRI events and capacity building initiatives in Africa. Other regional leaders in MRI research and training on the continent, Dr. Ernesta Meinjtes and Prof. Ntobeko Ntusi, provided indispensable insights in navigating the MRI research and clinical practice landscape in Africa. With her long-standing expertise in running a successful MRI research facility in Africa, the Chapter is privileged to have Dr Meintjes as the Vice Chair of the Inaugural Executive Committee. The Iberian Chapter of ISMRM was instrumental in drafting the petition for the African Chapter and their Chair, Prof. Rita Nunes, provided valuable feedback to bylaws.

The Chapter by and large reflects the collaborative effort of several ISMRM members who have supported and continue to support MRI in Africa (Figure 1 above). Without underestimating the multi-faceted challenges the African researchers continue to face, this is an exciting time for MRI education and research in Africa with the ISMRM Chapter providing a seed that will flourish in the years to come. ■

Have a look at the MRI projects ongoing in Africa

https://www.cameramriafrica.org/
https://www.gatesfoundation.org/about/committed-grants/2022/10/inv-047888

Further Reading

https://www.ismrm.org/19/program_files/EDI.htm

https://www.ismrm.org/press/, July 17 2018

https://www.cameramriafrica.org/

https://chanzuckerberg.com/imaging/strengthening-mri-education-research-in-african-countries/

https://worldpopulationreview.com/

http://re-design.dimiter.eu/?p=969 (Don't use global south term - here why!)

"A Framework for Advancing Sustainable MRI Access in Africa", NMR in Biomedicine, Volume36, Issue3, March 2023, https://doi.org/10.1002/nbm.4846

"AI-driven portable MRI provides quick and cost-effective option for neuroimaging", https://www.centreforbrainhealth.ca/news/ai-driven-portable-mri-provides-quick-and-cost-effective-option-for-neuroimaging/

Resonate: Reflections and Recommendations on Implicit Biases within the ISMRM. J. Magn. Reson. Imaging 2019, 1–3. https://doi.org/10.1002/jmri.26593.

Resonate: Reaching Excellence Through Equity, Diversity, and Inclusion in ISMRM. J. Magn. Reson. Imaging 2021, 53 (5), 1608–1611. https://doi.org/10.1002/jmri.27476.

Building a Global Power of Experience in Diagnostic Imaging – Lessons from Africa's COVD-19 Response. Siemens Healthineers MAGNETOM Flash 2022, 82(3), 10-17. siemens-healthineers.com/magnetom-world

COVER STORY

Roberta Kravitz: Living and Learning with ISMRM

INTERVIEW BY **LAURA BORTOLOTTI** AND **MARIA EUGENIA CALIGIURI**

Roberta Kravitz has been working for the ISMRM since 1992, and this year's meeting in Toronto will be her 31st. Following the Toronto meeting, she will be stepping down from the role of Executive Director after 18 years of service, but she's not done yet! Read below!

Roberta Kravitz

MRMH: How long have you been part of ISMRM?

Roberta: I have been working full-time for ISMRM since 1995, though I worked as a contract worker for the Annual Meeting from 1992 to 1995. When my children were small, I had my own company providing support for court reporters/stenographers. The Executive Director at that time, in 1992, asked me to go to Berlin to assist the predecessor Society, the SMRM, with its committee meetings. I leapt at the chance to get out of the house for a couple of days, speak with adults and travel (not to mention repossess the TV remote control). What surprised me was that as soon as I stepped into the ICC Berlin, the convention centre, I knew I had found my vocation, association management. I worked for the SMRM at its Annual Meeting for a couple of years on a contract basis before coming on full time in 1995. It took a couple of years because my husband and I lived in Los Angeles and the Central Office was in Berkeley. Remote working was not a reasonable option with the technologies of the nineties. But finally at the repeated invitation of Jane Tiemann, my predecessor Executive Director, I finally was able to accept her offer, and we moved back to Northern California.

MRMH: What happened after you accepted the job?

Roberta: The Society was still quite young, with the staff numbering around seven or eight. I started at the front desk, becoming sort of a "jack of all trades." There were a lot of opportunities, and Jane Tiemann, the Executive Director, was so supportive and open-minded to new ways of doing things. Back then we had five study groups as opposed to the 34 study groups we have today. The annual meeting took 75% of our time because everything was so manual, where today the Annual Meeting takes about 45 to 50% of our time, and we now are able to organize five to ten workshops a year along with several webinars monthly, in addition to other initiatives.

As technology marched on, we were able to streamline processes, and I was able to take on new roles. I was the Director of IT at one point, along with Director of Study Groups and Director of Meetings before becoming the Executive Director when Jane retired. From the beginning it all felt innovative and exciting, pushed forward by a membership that was so committed to its organization. I have always loved that as scientists and clinicians you allow yourself to take risks, even if you fail every now and then. You take the lessons learned and you move on. This has been inspirational to me. I try to mirror this when making important decisions, because taking calculated risks can be so rewarding.

MRMH: Can you give us an example?

Roberta: The introduction of electronic abstract submission was a complete disaster in 2001. The company we worked with at the time were overwhelmed by our members, who brought down their system leading into the abstract deadline given the amount of activity. The next year they withdrew from their contract, and we had to regroup. But we knew we were on the right path, and we started working with Mira (the company ISMRM still works with, editor's note). It took about three years to refine and stabilize the process. But this was a calculated risk. . . We knew it was not going to be easy transitioning to electronic submission, and the fact that we were willing to take that risk was actually applauded by the membership despite their frustration with the transition.

MRMH: How do you deal with such important choices?

Roberta in Berlin in 2006

Roberta: I had the pleasure of experiencing a talk by Bill Clinton at RSNA, where he said that for every decision he made as Governor of Arkansas, President of the United States and CEO of his own Foundation, he asked himself three questions: One, does it take us into the future? Two, is it sustainable? And, three, does it bring others up around us? These questions can be applied to both one's personal life as well as business life, and they have been instrumental in my own decision-making for the ISMRM.

MRMH: Tell us about ISMRM Central Office: where is it located? How many people work there?

Roberta: The ISMRM Central Office was originally located in Berkeley, at the entrance of the University of California. Before the merger of the SMRM and SMRI in 1994, the SMRM was in Berkeley, and after the merger, when the SMRI Chicago office closed, the merged organization stayed on in Berkeley. In 2015, we moved the office about a half an hour inland to Concord, in the East Bay. The move was a win-win situation – we saved a significant amount of money in rent and parking for the Society, and we cut the commuting time for the staff. While at times I miss being in Berkeley near the University, the fact that the ISMRM membership consists of nearly one-half trainees keeps that academic atmosphere alive for all of us at the Central Office.

As for the staff, we have 15 full-time employees. Similar societies have double the staff, but we have always managed well the peaks and valleys of the deadline-driven work of this organization, not only through the use of technology, but through providing temporary support for the staff at peak times.

MRMH: How did the Central Office work when you first joined? How did it evolve in the following years?

Roberta: When I started, we used MS-DOS, and though we had the option to use Windows, nobody wanted to use it. When we transitioned from a FoxPro database that resided in MS-DOS to a Windows-based database, the mantra in the office was "Change is good" as most struggled with the new operating system at first.

Roberta and her husband, John, while he acknowledges he's married to a V.I.P.!

For years everything was printed and manually handled. We had to mail blueline abstract forms to the members in August so they could write and send in their abstracts by the deadline in November. Just mailing those forms was almost a full-time job.

When we had the abstract deadline, we would shut the office down for three or four days. Each of the seven people working at the office had their assigned responsibilities. It was a real team effort. For example, our bookkeeper would check all the opened packages to make sure there were no abstracts stuck inside. A couple of us would put numbers on stipend applications, matching them to corresponding abstracts. Others would blind the abstracts, photocopy them, and package them to send to a company that recorded them in a spreadsheet and prepared the blinded abstracts for the review. And while that was all happening, members were knocking at the door to drop off more abstracts.

The conference books used to be printed, and the last few years we printed those books, members were carrying 15 to 20 pounds of books at the Annual Meeting. And to get those books to the meeting, if the meeting was outside North America, the books would be shipped on pallets by boat two or three months in advance.

MRMH: Wow, all of this sounds unbelievable these days…

Roberta: Yes, and I hope you get the idea of the amount of work we had to manage by hand back then. This is where technology has really helped. Being able to utilize web-based technology, as well as other tools, has allowed the staff to take on other duties and expand the activities of the Society.

We're always looking for the next thing that's going to save us time. When we learned that we could mail merge correspondence, that reduced the time to complete projects requiring a week down to an hour or two. I was worried for a while that introducing new technology in the office came with the price of losing something, but that has proven not true. What it has done is expand our capacity to do new things.

MRMH: Were there other significant changes in the Society?

Roberta: The ISMRM has always been committed to its internationalism, but it was a fairly big decision to introduce Asia in the rotation of the countries hosting the Annual Meeting. It was a learning opportunity for the Central Office and leadership, because conference centres work differently across countries and continents. For example, North America sees the convention centre as an incentive for the business that will benefit the city from the event. In other parts of the world, the centres are independent profit centres. Asia is more like Europe than North America. Members see the same meeting going around the world, but the Central Office has to translate it to fit the location, as well as make it work financially without fluctuating registration rates every year to cover expenses. We have to be flexible and adaptable and forward thinking. In addition, there are cultural differences, and we

Roberta in Kyoto, working to build the 2004 ISMRM Annual Meeting

Roberta in Cambodia, in 2016, after the Annual Meeting in Singapore

are constantly educating staff and vendors so that we consistently respect those differences. Introducing Asia into the rotation was challenging because of the variability it presented; however, it also was the most satisfying because it was an opportunity to learn and to successfully meet the challenges presented.

MRMH: There is no doubt that going virtual was the latest challenge you faced.

Roberta: Yes, but we all knew that sooner or later this would happen and actually have been preparing for it since 2004, with the introduction of recording sessions and providing access following the meeting. The pandemic, of course, provided a big push to a hybrid model. But as I said before, we learn from you to throw something out in the middle of the table, tear it apart, work through it, and then put it back together in a new way. Staff is working hard to improve the virtual format and to make it sustainable. Hybrid is here to stay; however, I don't believe any of us know exactly what the final format will look like. We are exploring and working through all the possibilities, though.

MRMH: What are the things that remained unchanged, instead?

Roberta: Volunteerism. I am always awed by the membership's willingness to put in hours of work for no pay, reviewing hundreds of scientific abstracts, dozens of journal manuscripts, serving on extremely active committees and flying around the world to talk at a two-day educational workshop. This membership breathes commitment into its work, embracing this community as an integral part of the MR community. This has never changed. The membership has always made our jobs challenging and fun.

MRMH: Tell us more about the "behind the scenes" of Annual Meeting construction! What are your timelines and deadlines, as organisers, compared to the ones of us researchers?

Roberta: Well, your deadlines are our deadlines, and for every one of your deadlines, we have a whole series of other deadlines leading up to that. For example, members will have the Annual Meeting abstract deadline in November, but there are a series of internal deadlines starting in August to be ready for abstract deadline. For example, not only do we need to set the system up, making any modifications requested by the Annual Meeting Program Committee, we also have to test the system and ensure that everything is running smoothly. We also have to send out a call for abstract reviewers, vetting those lists of over 1000 volunteers to ensure the Program Chair has all the information he/she needs to assign abstracts. And the stipend deadline is the same as the abstract deadline, so behind the scenes, since membership is required for stipend application, we have hundreds of membership applications coming in, along with hundreds of emails from trainees with questions about their applications.
And there is so much more going on at the same time with awards programs, print ad deadlines for our journals, regular communications, marketing, workshop organization, webinars, to name just a few. And there are always issues. You can have rules and regulations, you can have all these things automated, but there will always be exceptions with which we must deal.

So again, your deadlines are our deadlines, but there is a whole lot of work to support those deadlines.

MRMH: So we really need to thank you, Roberta, and the rest of the Central Office, for our smooth-running Society! Is there anything else you would like to share with our readers?

Roberta: In November, at the Board of Trustees meeting, I announced that I am going to step down from the position of Executive Director in July. Anne-Marie Kahrovic, my Associate Executive Director, will take over as the interim Executive Director at that time. But I am not going away completely as I will be working as a part-time project manager for an exciting new project initiated by Derek Jones, who will assume the role of ISMRM President in Toronto. (Read Derek Jones' interview in this issue to find out more!, editor's note).

I have always felt like the luckiest person to have a job that has challenged me and allowed me to push my boundaries and grow. After a particularly big mistake I made a number of years ago, I wrote a past Board president that "I lived, and I learned." He wrote back the following, which I still keep in front of me, "There are those who can say one or the other, but few who can say both. Good job." That is our membership – challenging and demanding yet collaborative and supportive. I am so grateful to have had the opportunity to serve this community. ■

Shizhe He: the youngest ISMRM presenter of all time!

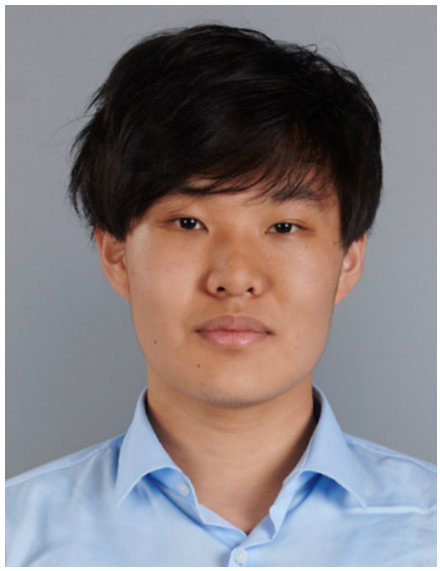
INTERVIEW BY **KERSTIN HAMMERNIK**

MRMH: Can you briefly introduce yourself?
Shizhe: My name is Shizhe and I'm a first-year student at Stanford University studying computer science with a particular interest in artificial intelligence/machine learning and how it intersects with other fields such as medicine. I am passionate about the potential of AI to not only advance industries, but to make a positive impact on society as a whole.

MRMH: Can you tell us about the program for high school students to work at a research lab at TUM?
Shizhe: In the program I was enrolled in, the TUMKolleg, 15 high school students per year are given the chance to go through an independent experimental track through the German A-levels, the Abitur. The students get the possibility to take part in selected university courses and to be involved in research projects carried out at the TUM faculties on Wednesday every week.

MRMH: Can you tell us about your experiences participating in a research lab at university?
Shizhe: As part of the TUMKolleg program, I had the opportunity to search for and apply for a specific lab/area I was interested in. I personally conducted research on deep learning for undersampled MRI reconstruction. Specifically, I worked on the impact of data shift for MRI reconstruction applied on static 1.5T and 3T brain/knee data from the fastMRI dataset, and on possible architecture(s) for dynamic (2D + time) cardiac 7T MRI data from Berlin. I've also had the opportunity to attend conferences and networking events with my mentor, Dr. Kerstin Hammernik.

Being my first formal research project, my time conducting research at the lab for AI in Medicine and Healthcare led by Prof. Daniel Rueckert marks an important milestone and beginning in the early stages of my life, forming me and my future. This was a truly unique, invaluable experience, from which many of my interests and experiences now have emerged. Coming in without any previous experience or knowledge of the usage of AI in medicine, the lab was welcoming and patient in introducing me to the intriguing world of academic research and scientific conferences. I had a very positive experience throughout my time in the lab, which was defined by patient guidance, continuous encouragement, and inspiring insights.



Shizhe He

> *I am passionate about the potential of AI to not only advance industries, but to make a positive impact on society as a whole.*

MRMH: Your project led to a power pitch at ISMRM 2022. Can you tell us about your experiences with your first conference?
Shizhe: Unfortunately, ISMRM 2022 conflicted with my German final exams, the Abitur, due to which I had to attend ISMRM 2022 virtually. However, Kerstin "led me around the conference" virtually on her laptop and it was truly inspiring to see all the brilliant minds and their projects in MRI technology and research.

MRMH: What are your current and future plans? Do you plan to stay in the field of AI in Medicine?
Shizhe: Currently, I am a first-year undergraduate student at Stanford pursuing studies in Computer Science (Artificial Intelligence) and Psychology. Currently, I am very interested in the intersection between AI and different fields of application. Considering my extensive experience with specifically MRI reconstruction, I am currently pursuing further research in the usage of learning-based approaches in the field of MRI as well as different applications in Medicine and Healthcare. In the future, I would like to transition to and explore different applications of AI.

MRMH: If you have anything else you would like to share, please feel free to formulate your own questions!
Shizhe: Thank you so much for reaching out and featuring me in the magazine "Magnetic Resonance in Medicine Highlights"! It is an honor for me to represent the younger group of researchers that were part of the ISMRM conference!

There are countless individuals without which my research and growth could not have been possible. In particular, I would like to express my gratitude towards my thesis advisor Dr. Kerstin Hammernik, Dr. Veronika Zimmer, Prof. Daniel Rückert, Dr. Christoph Aigner, Mrs. Katrin Lison, Dr. Ralf Laupitz, Mr. Markus Stöckle, and my family. ■

A BLAST FROM THE PAST

Moving mountains

How to plan, reschedule, and run a successful annual meeting despite an epidemic

INTERVIEW BY **MARIA EUGENIA CALIGIURI**

Richard "Dick" L. Ehman, M.D., is Professor of Radiology and "Blanche R. & Richard J. Erlanger" Professor of Medical Research at Mayo Clinic. **David John Lomas** is Emeritus Professor of Clinical MRI at the University of Cambridge and in the Department of Radiology of Addenbrooke's Hospital, Cambridge. Dick and David were respectively President and Program Chair of the 2003 Annual Meeting, which was held in Toronto, despite the SARS epidemic of 20 years ago threatening its cancellation. In this interview, we asked them to tell us how they managed to keep things going and successfully run the Meeting, just a few months later than planned.

Richard "Dick" L. Ehman

MRMH: Thank you both for accepting to take us along this memory lane. Having experienced the COVID pandemic, we can all now understand the struggle of dealing with a global infectious disease emergency, which makes the story of the Toronto ISMRM meeting - exactly 20 years ago - particularly interesting. Can you give us some background on what was going on back then?

Dick: It was a challenging time, and just recollecting the events and reviewing the old material reminded David and me about how intense the experience was! I called that period the "April Surprise", because everything basically unfolded in that month of 2003. I became President of ISMRM at the Honolulu meeting in 2002 and held that role until the end of the Toronto meeting. The executive committee included Past President Chris Boesch, Vice-President Mike Moseley, Vice-President Elect Walter Kucharczyk, Secretary of the Board David Miller, and Treasurer Roxanne Deslauriers. And then of course, David (Lomas, editor's note), who was my choice to be Program Chair for the meeting, and had agreed to take this role in 2001. I had known him for a long time and I was sure he was going to do a fantastic job. And of course, among the key people involved in this story, there was Jane Tiemann, Executive Director of ISMRM at the time, along with Roberta Kravitz, who was Director of Meetings at that time and who transitioned to ISMRM Executive Director three years later.

MRMH: You mentioned that it was an "April Surprise". When was the annual meeting originally planned?

Dick: It was planned from May 10th to 16th 2003, but things started to change at the beginning of April. I'm going to turn it over to David, to tell something about the scale of the event, and what was different and new about that meeting.

> *There were still people writing that we were doing it all completely wrong. But I'm pleased to say in the end, we weren't.*
>
> –David J Lomas

David John Lomas

David: The first meeting of theScientific Program Committee (SPC–now called the Annual Meeting Program Committeee–AMPC) that I chaired was held in Honolulu in July 2002. Back then we had 27 members, almost half the actual current AMPC composition, 27 was already quite challenging to handle! We had agreed on the structure of the meeting for Toronto, planned the Plenaries, and introduced several new ideas, like the transition to electronic submission, and having Wi-Fi at the meeting, instead of desktop computers. In fact, we had both. All this seems a bit old-fashioned now, but of course,

back then it wasn't at all! Everybody used to carry around three huge program books with all the details of the abstracts, and this was going to be the first year without the printed versions (you might have seen them on some of the old members' shelves!) This was of course mildly controversial..

MRMH: How many attendees were you expecting?

David: In December 2002, abstract submissions came through. At the Board meeting in Chicago I reported a record number of submissions that year, 3513. So that was good news, and over Christmas, those submissions were allocated to reviewers. After the reviews, we were able to organize everything at the program construction meeting, which we held in Toronto, close to the site of the actual meeting. And just to give you some numbers, to give you a feel for the complexity of the meeting (it's very similar now I think), we had accepted 2735 submissions, which turned into 85 oral sessions, nine parallel session tracks in the morning and the afternoon, with other things interspersed. There were 1797 posters and 122 poster sessions. On top of that, we had the plenaries and the categorical courses. It was a pretty busy meeting, as it still is. Putting all these things together required a lot of work, but by March 2003, we had finalized the program for May and we were preparing the abstract CDs, because we put all the abstracts on a CD instead of printing them. By the end of March, the schedule was online and we were all set.

MRMH: Here comes April, then…

Dick: Yep. So things were looking really good, until around March 23, the Central Office started getting inquiries from members of the Society who were planning to attend the meeting and were concerned because they were reading about this strange disease that was affecting people in Asia, but now had this isolated cluster appearing in Toronto. Our membership is not shy, so people started to share widely divergent but always strongly held views on how the leadership should handle the situation (chuckles).

MRMH: How did the SARS epidemic evolve?

Dick: The first case was seen in China in November of 2022, and then it spread to Hong Kong, Vietnam, and Singapore. The first case in North America was identified in Toronto on February 23, and it evolved as a cluster of cases confined at two hospitals, primarily involving people who had arrived from Asia, close family members of those people, and unfortunately, some of the health care workers who were taking care of those patients. But of course, nobody knew what was going to happen, and there was a lot of uncertainty/ I have to say that it was nothing like Covid, in that in the end there were a total of around 8500 cases around the world, but the fatality rate associated with SARS was 11%, a serious thing. Getting back to the story of our meeting, it's the end of March and these inquiries started coming in. I still keep those emails, I have them here, and I have to say it's exhausting to read through them, even after all these years! By the first of April (and here's why I called it April Surprise!), we were actually hearing rumors that we were going to cancel the meeting because of SARS, although we hadn't yet discussed that! Being a scientific organization, we were really paying attention to what major healthcare agencies like the World Health Organization and the CDC were advising. When I say we, I'm talking primarily about the Executive Committee of the Board, the people I mentioned before, the Central Office, and, in the end, also the Board of Trustees itself, because any major decisions regarding the Society involve the Board. But while articles in the New England Journal of Medicine were admitting that the disease situation was evolving so quickly that the journal couldn't keep pace, there were no foreign travel advisories from healthcare organizations related to Toronto.

> *The successful outcome of our 2003 annual meeting could not have been possible without the incredible assets of this Society: the talented and energetic staff of our Central Office, the commitment of the ISMRM board, and most importantly, the resilience and passion of the ISMRM community.*
>
> –Dick Ehman

MRMH: How did you deal with the inquiries that kept coming from the membership?

Dick: We initially sent a memo to the membership indicating that the meeting was still on. But just a few days later, on April 3rd, the American Association of Cancer Research canceled its meeting, which was scheduled to be held in Toronto just three days later; a meeting that would have had 15,000 attendees! So although there was still no official travel advisory, an organization four times larger than ours, with a lot of international attendees, took the major, controversial decision to cancel the meeting and move it later on that year, and to another city. That of course ratcheted up the pressure on us but still, for the next three weeks, there were no travel advisories, and the cases continued to be confined, with no evidence of community spread. So we kept monitoring things closely and updating the membership. Dr. Walter Kucharczyk, the Vice-President Elect, who lives in Toronto, even started issuing weekly on-the-ground reports to the members of the Society. Nonetheless, we were seeing escalating concerns, more and more letters from attendees saying that institutions wouldn't let them travel. Most of those letters were heartfelt and thoughtful. Others were crazy! In any case, all the uncertainty was resolved on April 23rd, when the WHO issued a travel advisory against non-essential travel to Toronto. Therefore, on that very day, the Executive Committee and the Board voted to postpone the meeting. We then let all of the members know about this in a note I can share with you, and we had lots of messages, many supportive but many concerned about this decision to reschedule.

And on the 26th, we made another controversial decision, to reschedule in Toronto.

We considered rescheduling to a different city, but the logistical and liability issues made that virtually impossible. The next day, April 27th, Roberta Kravitz, Jane Tienmann and I flew to Toronto, and met with the local city leadership to make things work. The city representatives were extremely grateful that we were not abandoning Toronto and were hugely valuable in helping us to manage the many issues involving hotels and the venues. We identified July as a possible period to reschedule (not without further controversies!), and on April 30th we announced the official dates to the membership: July 10th-16th. And on that very date, the World Health Organization lifted its travel advice. On. That. Day.

MRMH: Just one month, all these events one after the other, it must have been an emotional roller coaster! But I believe another challenging part starts now: rescheduling the scientific content.

David: As soon as we heard , on the 24th of April, that the meeting was going to be deferred. I wrote to all the SPC members saying: "please start to look straightaway for alternative speakers, because people will drop out. And we're going to have a problem here, putting the whole program back together again". So I gave them an immediate heads up . But I told them to not email me back straight away if someone declined, but rather start to look for valid substitutes first. This is because in SPC/AMPC meetings, what you do is you select themes, and create sessions around a particular theme that received the best set of abstracts. So it's not so easy to rearrange things if presenters drop out from this or that session, you can't just plug in any abstract into an existing session, you have to try and match them up, or remake a session completely.

So with the new dates, we contacted everyone involved, asked if they could still attend the meeting, and if they were prepared to still talk or present or chair a session. We also swiftly produced an FAQ for the membership to tell people what was going to happen, and how we would manage it.

The month of May was a pretty hectic time. Each evening after work I'd spend hours dealing with emails about issues related to the meeting. There were still people emailing in that we were doing it all completely wrong. But I'm pleased to say in the end it's clear, we weren't! I think the most impressive thing is that over 90% of the people who were going to present at the meeting, including the plenary speakers, said they would still come on the new meeting dates in July, which was pretty amazing. In the end only 16 invited speakers withdrew, resulting in the loss of some morning categoricals talks and 2 plenaries. We had 64 oral presenters pull out, and the bad news was they were spread across 51 different sessions! As I said, rearranging sessions is not straightforward, and with the help of Jane Tiemann and the Central Office we patched up these sessions, sending spreadsheets back and forth to each other through the whole of May. I actually discovered I still have those spreadsheets in an old folder! And we managed to recruit missing moderators fairly easily. So by the end of May, after a lot of emails, and a lot of evening work, we had confirmed the program and put it back together. And I really want to acknowledge Bob Goldstein, who with Roberta Kravitz and Jane Tiemann, really sorted out the background paperwork.

MRMH: Among all these issues, were there any pleasant surprises?

INTERNATIONAL SOCIETY FOR ISMRM MAGNETIC RESONANCE IN MEDICINE

April 24, 2003

Dear ISMRM Colleagues:

I regret that recent events have compelled the ISMRM Board to postpone the Eleventh Annual Meeting and Exhibition of our Society in Toronto, which was scheduled to start on May 10, 2003.

Alternative dates are being urgently evaluated and further information will soon be provided through updates on the ISMRM website and by e-mail.

The Executive Committee has been watching the severe acute respiratory syndrome (SARS) situation in Toronto very closely over the last several weeks. As a scientific organization, the Society has relied on the recommendations of authoritative bodies such as the Centers for Disease Control (CDC) and the World Health Organization (WHO).

On April 23, WHO issued an advisory: http://www.who.int/csr/don/2003_04_23/en/, officially discouraging nonessential international travel to Toronto. The Executive Committee and the Board concluded that in view of this recommendation it is prudent to defer the annual meeting to a later date.

Decisions regarding the annual meeting are being made with careful consideration of the following:

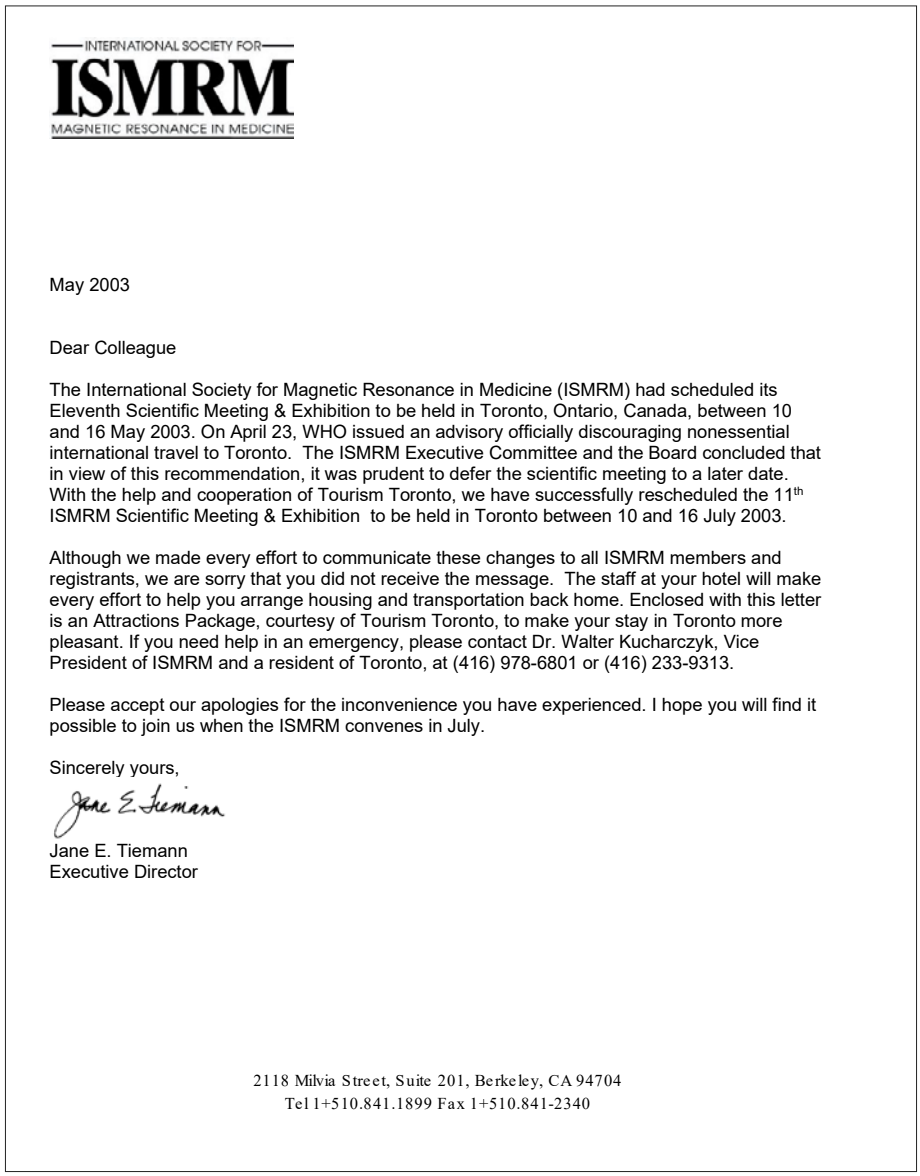
- The safety and health of the *attendees, exhibitors, and staff* at our Annual Meeting
- The public health issues concerning spread of the SARS virus worldwide
- The *scientific, educational,* and *humanitarian* importance of our Annual Meeting
- The financial and intellectual investments made by our *attendees* and *exhibitors* in order to participate in the Annual Meeting
- The investment that our *members* have made through the ISMRM in order to hold the Annual Meeting

Please check the ISMRM website and e-mail messages in the coming days for important information, including procedures for rebooking or obtaining refunds of registration and hotel deposits. Details for the rescheduled meeting will be provided as soon as possible, in order to provide more options for holders of airline tickets.

I would like to thank the members of the Scientific Program Committee and Education Committees, who, with the support of the central office, designed a truly outstanding Eleventh Annual Meeting. We also owe a debt of gratitude to the faculty of our educational courses, our plenary speakers, and our scientific presenters, who will all be contacted individually regarding the deferred meeting plans, as soon as they become available.

Richard L. Ehman
President

The note Dick sent to the membership right after the decision to postpone the meeting.



INTERNATIONAL SOCIETY FOR
ISMRM
MAGNETIC RESONANCE IN MEDICINE

May 2003

Dear Colleague

The International Society for Magnetic Resonance in Medicine (ISMRM) had scheduled its Eleventh Scientific Meeting & Exhibition to be held in Toronto, Ontario, Canada, between 10 and 16 May 2003. On April 23, WHO issued an advisory officially discouraging nonessential international travel to Toronto. The ISMRM Executive Committee and the Board concluded that in view of this recommendation, it was prudent to defer the scientific meeting to a later date. With the help and cooperation of Tourism Toronto, we have successfully rescheduled the 11th ISMRM Scientific Meeting & Exhibition to be held in Toronto between 10 and 16 July 2003.

Although we made every effort to communicate these changes to all ISMRM members and registrants, we are sorry that you did not receive the message. The staff at your hotel will make every effort to help you arrange housing and transportation back home. Enclosed with this letter is an Attractions Package, courtesy of Tourism Toronto, to make your stay in Toronto more pleasant. If you need help in an emergency, please contact Dr. Walter Kucharczyk, Vice President of ISMRM and a resident of Toronto, at (416) 978-6801 or (416) 233-9313.

Please accept our apologies for the inconvenience you have experienced. I hope you will find it possible to join us when the ISMRM convenes in July.

Sincerely yours,

Jane E. Tiemann

Jane E. Tiemann
Executive Director

2118 Milvia Street, Suite 201, Berkeley, CA 94704
Tel 1+510.841.1899 Fax 1+510.841-2340

Unfortunately, it did not reach everyone…

David: On the social side, Toronto was so pleased to get us back that when we looked at the social events, they offered to provide music for the opening event, as well as an extra bar, which of course went down well! Another interesting novelty that came up as a consequence of delaying were late-breaking sessions at the meeting which we used as a means of filling any gaps or late dropouts. The idea was that members could submit only truly recent work; you couldn't do something which was old and rehashed.

MRMH: What happened next?

David: After we finalized the program, at the end of May, things were pretty stable. After that, we still had some issues, for example with the airlines, some of them were refusing to refund or reschedule flights attendees had previously booked. We needed a direct intervention from the local authorities to soften them up! But then anxiety came back, as a second wave of SARS arrived. And what's interesting, if you look at the epidemiology curves in that time, is that the WHO advisory was introduced as the first wave ended, and they rescinded the advisory as the second wave started. So the advisory was completely in the wrong place. Luckily, it all faded away by the time we reached the 10th of July, and really, thanks to all the staff, the leadership, all the different committees, the meeting was a great success. We had over 3000 attendees, slightly less than Honolulu in 2002, which had about 3500, but more than Denver, which was just a couple of years before. And we built a good relationship with Toronto, this year must be the third or fourth time we've been back with the Annual Meeting, not least because we supported them in 2003.

Dick: In the end, the revenue from the meeting was good, about a little over a million dollars versus 1.3M, which was planned. And we still spent $330,000 on student stipends, which was just an incredible result, because it meant students were attending nonetheless.

MRMH: What did you learn from that experience?

Dick: Throughout that time, we felt that it was important to take into account multiple factors in decision making. We placed a high priority on the safety and health of our attendees, our exhibitors, and our staff. As an international organization, we had to consider the potential public health consequences of an event which would bring people together from all over the world, and then have them return home. And we had to take into account the importance of our Annual Meeting and the value of its scientific, educational, and humanitarian contributions to the world. It wasn't just a social event. And finally, we had to take into account the major financial and intellectual investments that our membership had made in this meeting, by submitting their science and booking travel. We were determined to take all these factors into account, rather than basing our decisions on one aspect only.

We did our best to communicate extensively with our membership and to be transparent as we faced these decisions. As a physician, I think that one of the most challenging aspects in medicine is dealing with uncertainty, and that is also true in science and indeed in any enterprise. Finally, I'll just say that the successful outcome of our 2003 Annual Meeting could not have been possible without the incredible assets of this Society: the talented and energetic staff of our Central Office, the commitment of the ISMRM Board, and most importantly, the resilience and passion of the ISMRM community. ■

Repeat it with me

MR research, like many other research fields, has the potential to suffer from lack of reproducibility

BY **SOPHIE SCHAUMAN AND LAURA BORTOLOTTI**

Last year in London, the ISMRM launched its first Reproducibility Challenge in 2022, Repeat it with Me, which aimed to promote transparency, reproducibility, and collaborations in the MR research community. The Challenge was chosen among other proposals that came from members of the Society (so look up for future calls, if you're interested in proposing a Challenge!)

Why reproducibility matters

In the context of MR research, reproducibility can refer to different things, including that the same research method should produce the same results when it is repeated on different subjects, different scanners, different sites, and when using different implementations of the same method. Guaranteeing reproducibility in MR research enhances the reliability of study results and allows us to make informed decisions in terms of how reliably a method might be translated into medical practice or medical research, as well as how to build on the findings to expand MRI research itself. Therefore, it is crucial to ensure that the findings presented in our community and at our conferences are robust and reliable.

The Challenge

The Repeat it with Me Challenge aimed to encourage and evaluate reproducible MR research by challenging participants to assess the reproducibility of abstracts presented at ISMRM Annual Meetings. Any abstract presented at any Annual Meeting was eligible for the challenge, any topic, any year. Additionally, replication attempts that focused on any aspect of the abstract (methods, results, or conclusions) were allowed to enter the challenge.

To participate in the challenge, researchers formed teams with members from two or more labs. The teams consisted of two halves: the original authors and the reproducers. The reason the original authors were included in the team was that an ISMRM abstract can not be expected to provide all the necessary details needed for reproduction, due to the short format. The original authors assisted the reproducers in defining how the replication was going to be designed. A natural outcome of the challenge format was thus also to forge new collaborations.

The teams were required to pre-register their replication attempts. This involved specifying the criteria for a successful replication, outlining anticipated communication between sub-teams, and determining the approach for analysis. The reproducer sub-team then performed the replication study with as little involvement from the original author sub-team as possible. At the end of the study, the sub-teams reconnected to evaluate the reproduction.

> *"Everyone should be encouraged to go through the process at least once during their PhD to help them understand what is required to reproduce their results in the future!"*

Each submission (pre-registration and end-of-study evaluation) was then judged by at least three judges (a mixture of people with expertise in reproducibility and the topic of the reproduction study) based on "openness" (e.g. shared protocols, data, code, etc.), "completeness" (how well was the original and replication study described, how much additional information was required beyond the abstract/presentation to attempt successful replication), "success in replication and soundness of conclusion" (if the authors claim the replication was a success, do they have sufficient evidence for that claim and vice versa?), and "secondary outcomes" (e.g. the replication study was submitted/accepted as an abstract for ISMRM 2023 or similar meetings, the results were published, or new open tools were developed and shared).

The Teams

Eight teams pre-registered for the 2022-2023 ISMRM Reproducibility Challenge, two more abstracts were offered on the official Challenge Forum but didn't find a reproducer half (yet!!). The teams attempted to reproduce the findings from abstracts of different topics, all presented at previous ISMRM Annual Meetings. However, many of the teams struggled with issues commonly associated with irreproducible research, such as insufficient instructions on how to run code or perform certain analyses. Despite these challenges, all teams were able to provide valuable insights into the reproducibility of MRI research, and several were even able to replicate their chosen abstracts successfully. These aspects will be discussed more during the "ISMRM Challenge session" on Tuesday 6th June.

Overall, the Challenge highlighted the importance of transparency and open communication in ensuring that MRI research becomes reproducible. It also demonstrated that by working together and sharing knowledge and resources, researchers can overcome many of the obstacles that stand in the way of reproducible research.

The organisers of the challenge hope that it will inspire more collaboration and open science practices within the field of MRI research and beyond as the Challenge has been confirmed to run again for 2023-2024! Look out for interesting ISMRM presentations in your field to find your half for the challenge!

By participating in the Reproducibility Challenge, you'll be contributing to a more

The Teams participating in the ISMRM Challenge 2023

ISMRM 2022 #3283
"Average Liver"
DIFFUSION

ISMRM 2022 #1700
"MReplicators"
RECONSTRUCTION

ISMRM 2022 #2810
"FAULTY GRADIENT FIXERS"
TRAJECTORY

ISMRM 2021 #0790
"RECOMPOSE"
Susceptibility Weighted Imaging

ISMRM 2021 #1570
"Open source MR fingerprinting"
Quantitative MRI

ISMRM 2022 #8064
"The ASL Challenge Reproduction Project"
PERFUSION

ISMRM 2022 #1783
"UTE 31P 3D Rosette MRSI Reproducibility Team"
CARDIAC

The **winner** will be announced on
Tuesday 6th June,
Session "ISMRM Challenge" 08:15 - 10:15 EDT,
Room: 716A/B

Are you willing to participate into the initiative in 2024?

Looking to whom is supporting reproducibility in research and have chat about that!

PRESIDENTIAL INTERVIEW

ISMRM President Scott Reeder

INTERVIEW BY **MARIA GUIDI**

Scott Reeder, MD, PhD is Professor, Vice Chair of Research and Chief of MRI in the Department of Radiology at the University of Wisconsin, Madison. After his undergraduate degree in Engineering Physics at Queen's University in Kingston, Ontario, he moved to Johns Hopkins, Baltimore, where he got his Master's and Doctorate in Biomedical Engineering and completed his medical studies.

Scott Reeder

A love story that began at the seaside

MRMH: You have been Program Chair for the successful ISMRM meeting in 2017 in Honolulu. What other experiences do you have with ISMRM?

Scott: I like the word successful! Thank you. Yes, it was great fun. What other experiences have I had? I've been a member of the Society since 1993 when it was the predecessor Society, SMRM. My first meeting was in New York when I was a graduate student and I've been involved with the Society almost every year since, as an attendee, then as a speaker, and then I've been on a number of different committees, such as the Education Committee, and the Board prior to my role with the AMPC. Definitely a highlight was being Program Chair, which was a lot of work, but a whole lot of fun as well.

MRMH: Do you remember the first abstract you sent to ISMRM?

Scott: I do. I had two abstracts at the 1993 meeting, both about cardiac MRI. We were doing tagged cardiac MRI and studying the best ways to do tagging. I wrote an abstract on optimizing the image contrast between normal myocardium and tagged myocardium.

MRMH: What got you in the field of MRI?

Scott: Oh boy, this is long and complicated! I'll try to keep it simple. My undergraduate degree is from Canada in Engineering Physics, and I was very interested in physics and engineering in general, but I had never heard of MRI. I was looking at graduate school programs in aeronautical engineering, nuclear fusion engineering, and something I'd never heard of before, called biomedical engineering. After I finished my undergraduate degree, I went on a windsurfing trip with some friends of mine to South Carolina, we drove down all the way from Canada. On the way down we stopped in Baltimore, and I had a chance to visit this place I'd never heard of before – Johns Hopkins. I was introduced to the biomedical engineering program there and I met with my future supervisor who showed me my very first MR image, something I've never seen before. Later that week, sitting on the beach, I decided I'd rather get into medical imaging than building warplanes or nuclear reactors. I got into the master's program and I fell in love with the elegance and the complexity. I also met a number of physician scientists and decided that I also wanted to work with patients. This led me into a career as a physician-scientist, working with both physics and clinical MRI, and the rest is history.

MRMH: What is the achievement you are most proud of?

Scott: I'm proud of several achievements, but what I'm most proud of are the mentees and students that have gone on to succeed in their goals and dreams. To feel that I have some role in either encouraging or guiding or helping these young people to be successful is by far the most gratifying part of my career.

> *I give a lot of advice to young scientists and physicians, but if I were to pick one thing, I would tell them to have fun. If you're not having fun, then the rest of it really doesn't matter.*

MRMH: What advice would you give to young scientists?

Scott: I give a lot of advice to young scientists and physicians, but if I were to pick one thing, I would tell them to have fun. If you're not having fun, then the rest of it really doesn't matter. Sure, it's important to choose something that's important, something that you're good at and you're passionate about. But at the end of the day if your work is boring it will be tedious and not worthwhile. So, make sure that you really enjoy what you're doing.

Dr Reeder's family, including his wife, Jean Brittain, PhD, FISMRM and their son, Jack.

Toronto 2023: so nice to be back (in so many ways)

MRMH: This year's ISMRM is the first one after the pandemic where all scientific sessions will be in person. There will be virtual attendees who can view sessions only. What do you think about that?

Scott: This is a great question. There have been a lot of ongoing discussions behind the scenes and this is a complicated multifactorial challenge the ISMRM has had to face, similar to what the whole world is still grappling with, with regards to hybrid work. It was a complex decision, and it was mostly driven by the survey that we did with the membership, which overwhelmingly wanted an in-person meeting. There was also a lot of concern from the membership about keeping the costs down, and it's a lot more expensive to put on a fully interactive hybrid meeting than it is to have an in-person meeting with streaming. While we will have virtual attendance in Toronto, presentations will be given in person. Through careful planning we're very fortunate that we've actually been able to reduce both registration and membership fees. Sustainability was another important consideration - the central location of Toronto relative to our membership will minimize air travel and other factors that impact our carbon footprint. It took a lot of effort and conversation to come to this decision but I think it's a good decision and one that we'll continue to evaluate moving forward for future meetings.

MRMH: How did you evaluate the sustainability of the meeting?

Scott: We are in the process of developing a sustainability program. There is a strong focus on site selection as a way of reducing the carbon footprint and there's some terrific work done by Christof Böhm, who has been working with the Central Office to create a carbon footprint calculator for potential meeting locations with regards to air travel. Air travel is by far the biggest contributor to our carbon footprint; there are other considerations that we are also looking into, but that's the first one that we want to focus on.

MRMH: I think there is more to say about Toronto…

Scott: Yes, the other piece about Toronto that I think is important to remember is that our first meeting in Toronto was in 2003, and was initially postponed by several months because of the first SARS pandemic!! As a result of the ISMRM coming back to Toronto in July of that year, we've developed an excellent working relationship with the city. This will be our fourth meeting in Toronto and is a result of a collaborative relationship built during the first SARS pandemic. I find it very gratifying and somewhat metaphorical that we're coming back to Toronto as the SARS-CoV-2 pandemic fades into the past. It's also special for me as a Canadian to hold the meeting in Canada.

MRMH: What about ISMRM and inclusivity?

Scott: Inclusivity and diversity are high priorities and really launched in earnest probably before or around the time of the Singapore meeting in 2016, led by Mark Griswold (our recently elected Vice President-elect!). There have been tremendous efforts by the AMPC over the years to consider all dimensions of diversity, including gender, MD vs PhD, geography, stages of career, and so on. Not just the old men from North America, but rather a really broad sampling of our membership. I was very proud to have continued that tradition for the Hawaii meeting and the subsequent AMPC chairs have really done a wonderful job, including Niv Agarwal for the upcoming meeting in Toronto. Those who have been on the AMPC in recent years know that diversity weighs heavily on the choice of speakers and the choice of moderators. More recently there's been an increasing emphasis on our junior members, which I'm pleased to see since they are the future of our Society. I think we are doing well in this area, and I am so proud of what Niv Agarwal and the AMPC have accomplished this year. The program in Toronto is going to be outstanding.

The future is bright, but easy it is not

MRMH: What are the biggest challenges that the MR community is facing globally?

Scott: Sustainability and how we address this existential threat is one of the biggest challenges we face. What part should we play in that? We need sustainable solutions, not just

Fishing is one of Dr. Reeder's past times, shown here is a northern pike caught in northern Saskatchewan.

Dr Reeder and his family in late 2019 on the South Island of New Zealand on the Tasman Glacier near Mt Cook.

for our Annual Meeting but, perhaps more importantly, we must address the carbon footprint of MR in general. In addition to materials and power consumption, the physical footprint of MR is evolving, and costs need to come down. Another major priority for the Society is to find creative solutions that bring MR to the rest of the world. MR is largely limited to developed countries, both for research and clinical care, and the vast majority of the world has no access to MR. Based on our international mission, the depth and diversity of talent that we have (scientists, engineers, physicians) we need to get serious about how we bring MR to the Global South. This is a high priority for the Society and considerable effort is already underway to launch new initiatives to address this long-term vision.

MRMH: And within the community?

Scott: First of all, we're getting to a more mature stage with machine learning and artificial intelligence, which have revolutionized the way we do MR. Financial pressures also continue to mount. Another challenge is dwindling clinician engagement with the Society. This is largely related to the emergence of other sub-specialty clinical societies, and the pressure that our clinical members are facing because they have limited time to attend meetings. One of the most important characteristics of ISMRM is the unique mix of clinicians, scientists and engineers. Without that, we will lose the "special sauce" of what makes ISMRM so great. It is for this reason that I appointed an ad hoc Clinician Engagement committee who are working on recommendations to address this existential threat to the identity of the ISMRM. I will present their recommendations at the Annual Meeting in June.

MRMH: How do you see the future of ISMRM in general?

Scott: I wish I had a crystal ball and could tell the future, but I am extraordinarily optimistic. Wearing both my engineering and clinician hats, I am firmly convinced that MRI and NMR are here to stay for both scientific discovery and clinical care. The field certainly is maturing, but we continue to witness great discoveries and new developments every day. I am excited to see how MR continues to evolve!

MRMH: Anything else you'd like to tell the community?

Scott: It's been truly an honor and a privilege to serve the community in this role, and I feel very fortunate to have this opportunity. I'd like to thank all of the members for their support! ■

Dr Reeder at the ISMRM Annual Meeting in Honolulu, Hawaii, where he was chair of the AMPC

LOOKING BACK

ISMRM's 2003 I.I. Rabi Young Investigator Award winner

INTERVIEW BY **KATHERINE BLANTER**

Michael Markl, PhD, won the 2003 I.I. Rabi Young Investigator Award for his paper titled Flow Effects in Balanced Steady State Free Precession Imaging. He completed his PhD in Physics at the University of Freiburg, Germany (2000), and has been a faculty member at Northwestern University since 2011. He served as the Director of Cardiovascular Imaging Research and led cardiovascular MR research in the Center for Translational Imaging and is now the Vice Chair of Research at the Department of Radiology at Northwestern University.

MRMH: How did you get into MRI and specifically flow imaging and cardiac MRI?
Michael: Great question. So I got into MRI when I did my masters degree at the University of Freiburg in Germany. This was when I was studying physics and thinking about my thesis project. I was initially thinking of going into elementary particle physics, but then I heard about a friend who was doing this interesting medical imaging with MRI. It was something I never really heard about, but it sounded intriguing to me to do a thesis at the intersection of medicine and physics, so I talked to him and he introduced me to his supervisor, Jurgen Hennig, who directed the research group in Freiburg. He took me on as a masters student then and that lead to a PhD in the same group. And that's where I got involved with MRI. I started out with cardiac imaging, not so much with flow imaging, looking at cardiac function and tissue. Flow imaging came a bit later when I did my post doc at Stanford right after my PhD.

MRMH: Were you sure you could succeed when starting the project?
Michael: The project that won the YIA was about some fundamental signal theory and concepts in balanced SSFP imaging, which is often used for cardiac imaging, or is related to how flow impacts the imaging. This was something that wasn't going to be a planned project. It was more something that was going to be an experiment with a controlled phantom and running SSFP images. We saw some really strange artifacts that we didn't understand. This led us to think that there must be something in the SSFP underlying signal that we were just not capturing. This led to a series of other experiments until we finally understood this effect. This is what the award was about. So, this wasn't really a planned project, since I was working on balanced SFFP imaging as a technique for improved cardiac imaging. But then we just stumbled on this interesting effect in some of the images and looked further. This led to it becoming a real project, and essentially an abstract for the ISMRM which later won the award and became a paper.

MRMH: Sounds like a happy accident then?
Michael: It is. It is one of those interesting things where you find something you don't expect or don't understand. Those are often the most interesting times in research, when you expect something and the experiment or the MRI scan shows the exact opposite.

MRMH: What was it like to win the YIA in 2003?
Michael: That was fantastic obviously. I was still very early in my career, just in the second year of my postdoc. It was a very important moment in my career because it really is a very well-recognized award in the community that is given out by the ISMRM. It was a great honor to be selected for this award and it was a very important part of my CV going forward when I applied for faculty positions.

MRMH: Did winning the Rabi Award influence your career?
Michael: I do think so, since it's always the whole package when you look at a candidate or a person for a faculty position. I also think it was important to see that the work was recognized by the community and peers. In that sense the award was very important.

MRMH: Do you have any advice for early career researchers who are currently in the same position you were in 2003?
Michael: Of course, you have to work hard, but the key message is to not be discouraged if an experiment doesn't work out. Research is an iterative process where you have to keep at it and keep constantly improving. And then you find these interesting effects or results of experiments that help you develop a deeper understanding of MRI. That makes it such an interesting field. I think that there are constantly unanswered questions that you can explore. So it is really about the curiosity and continuous investigation. The other thing that I think is important is that you have to like what you do, and you have to be passionate about it, otherwise you probably won't be that successful. So, I think my advice would be that you should try to find a topic, a group, and a supervisor where you feel appreciated, but also where you're passionate about your research and you like to come to the lab every single day, are curious, and are looking forward to the next experiment. ■

2023 ISMRM Young Investigator Award Finalists

EDITED BY **MARIA CELESTE BONACCI**

This year, the Society nominated eight finalists for its Young Investigator Awards (YIA), and the winners will be announced at the Annual Meeting. The W.S. Moore Award, for a paper published in JMRI, is given for original clinical research, whereas the I.I. Rabi Award, for a paper published in MRM, is given for original basic science research. Additionally, this year there will be a new 'Prince-Meaney' YIA for translational research. As usual, we have an outstanding group of finalists, and we have the pleasure of showcasing them here in the Highlights magazine.

Rachel Eddy

Rachel Eddy

W. S. Moore YIA Finalist

I am a post-doctoral fellow at the University of British Columbia in Vancouver, Canada. I am interested in the opportunity for imaging tools to improve the detection, monitoring and measurement of lung disease towards improving outcomes for these patients. My research is focused on developing and applying novel pulmonary imaging and data science tools to provide a deep understanding of lung disease and ways to use imaging to guide lung disease interventions. As an electrical and biomedical engineer, I was fascinated by the ability to non-invasively visualize and measure internal organs using medical imaging. I was further intrigued by the technical challenges associated with MRI of the lungs and the unique ability of hyperpolarized gas MRI for functional lung imaging to overcome these challenges, which drove me to pursue graduate studies in Medical Biophysics with Dr. Grace Parraga at Western University in London, Canada. My YIA paper is the culmination of my PhD training during which I used hyperpolarized noble gas MRI in combination with CT to explore spatial-temporal relationships of airway abnormalities in asthma. My results have contributed to a new understanding of asthma as a spatially and temporally persistent lung disease. In Vancouver, in collaboration with clinical colleagues, I have launched andam actively leading two new hyperpolarized 129Xe MRI research programs at dedicated adult and pediatric centers at the Centre for Heart Lung Innovation, St. Paul's Hospital and BC Children's Hospital, respectively. We continue to lead broad pulmonary MRI research programs with development and application of hyperpolarized 129Xe and 1H MRI methods for a range of lung conditions, towards better understanding of pulmonary pathophysiology and improved detection and monitoring of lung disease.

NOMINATED PAPER

"Pulmonary MRI and Cluster Analysis Help Identify Novel Asthma Phenotypes"

Asthma is a common chronic inflammatory lung disease with a range of underlying disease processes. Current clinical phenotypes are typically based on demographic, clinical and/or pathobiological characteristics, yet most do not show strong relationships with disease pathogenesis or treatment responses. New approaches are urgently needed to provide novel phenotypes that are consistent with the airway pathologies present in patients with asthma. Machine learning clustering methods have been increasingly employed to identify novel asthma phenotypes using clinical and computed tomography (CT) imaging measurements. Hyperpolarized 129Xe gas MRI has revealed spatially and temporally persistent ventilation abnormalities in patients with asthma that are sensitive to patient outcomes and treatment responses, so the incorporation of functional 129Xe MRI in cluster analyses has the potential to better describe airway pathologies and provides new information, complementary to CT measurements. Therefore, in this work we derived data-driven imaging phenotypic clusters of asthma using functional 129Xe MRI biomarkers in combination with structural CT airway biomarkers. We identified four MRI-CT clusters (or phenotypes) of asthma with distinct structural, functional and clinical characteristics that directly reflect airway pathologies in patients, including one novel cluster with severely abnormal 129Xe MRI ventilation that could only be differentiated by MRI measurements and not CT or pulmonary function test measurements. Alternatively, when asthma patients were stratified by clinical severity groups, there were no differences in demographic, pulmonary function test or imaging measurements between the

groups. Our results challenge currently used paradigms for asthma phenotyping and treatment decisions and have the potential to be used to better understand disease trajectories or discover novel treatments and genetic underpinnings of disease.

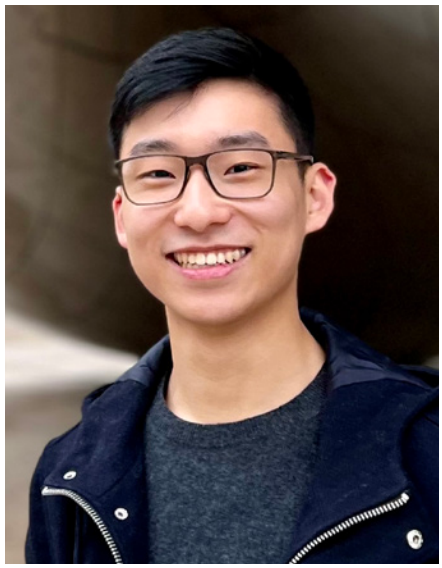
Philip Lee

W. S. Moore YIA Finalist

My name is Philip Lee and it is a great honor and privilege to be a finalist for this year's W.S. Moore Award. I deeply thank ISMRM, the selection committee, and my colleagues for this. I also congratulate my fellow finalists. Their work is of tremendous impact and deserves widespread recognition.

My journey into this field was unexpected. At the start of my PhD program in bioengineering at UC Berkeley and UCSF, I was poised to enter into the field of gene editing, but due to independent circumstances, none of my three research rotations had positions for me. Concerned about the future of my PhD program and the work I would be conducting, I asked my then-graduate advisor Professor Daniel Vigneron at UCSF if he had an available position. I made it clear to him that I had little to no background in biomedical imaging—which meant that I would have to learn everything from scratch—but he welcomed me with open arms and brought me into the warmest, most collaborative, and the most supportive research group of which I have ever been a part. So thank you, Dan. I would not be here today if it was not for your belief in me and your unshaking resolve to train young graduate students and to bring them to their full potential.

Ever since I began this work, I have been awestruck with the beautiful complexity that makes hyperpolarized carbon-13 magnetic resonance imaging the technology that it is. Against all odds—the laws of physics are unkind to non-proton imaging—it succeeds and it flourishes. It allows us to peer into the hidden yet unceasing and thriving metabolic processes occurring within our tissues. And from there, we understand disease and improve our treatment. I look forward to how as a researcher—and hopefully soon as a physician—we can collaboratively advance our understanding and imaging of metabolic processes in the human body to more effectively treat patients worldwide.



Philip Lee

NOMINATED PAPER

"Whole-Abdomen Metabolic Imaging of Healthy Volunteers Using Hyperpolarized [1-13C]pyruvate MRI"

Each imaging modality was developed to provide us with deeper and more sophisticated information concerning human anatomy and physiology. Not one modality is replaceable and all are necessary for the comprehensive care and treatment of patients. What hyperpolarized carbon-13 magnetic resonance imaging (HP 13C MRI) uniquely affords us is dynamic, quantitative imaging and characterization of in vivo metabolism, which is especially valuable in the context of response to therapy.

The most widely utilized molecule in HP 13C MRI is [1-13C]pyruvate. Pyruvate, a key molecule in cellular bioenergetics, can be metabolized by cells through two major pathways. Typically, healthy cells use pyruvate to produce acetyl-CoA, ultimately for oxidative phosphorylation and ATP production through the citric acid cycle. However, in cancerous cells, metabolic reprogramming known as the Warburg effect causes the upregulated conversion of pyruvate to lactate. Thus, there is the need for safe, non-invasive methods that can quantify the rate at which a given tissue (perhaps a suspicious lesion) metabolizes pyruvate through this second pathway. Such a method would allow researchers and clinicians to non-invasively assess response to drug therapies (whether a tissue still exhibits high levels of lactate production characteristic of cancer metabolism after treatment).

This unmet clinical need may be addressed by HP [1-13C]pyruvate MRI. Applications are not limited to cancer but can be extended to other metabolic diseases, such as non-alcoholic fatty liver disease (NAFLD). Yet, whole-abdomen imaging with HP 13C is challenging due to B0 and B1 inhomogeneities, respiratory motion, and broad spatial coverage. There is also little baseline data about healthy metabolism in abdominal organs.

With my colleagues at the Hyperpolarized MRI Technology Resource Center (HMTRC) at UCSF, we developed and describe in our nominated work a reliable imaging method to overcome these challenges, enabling metabolic imaging of the entire abdomen in a series of healthy volunteers. We present observed conversation rates of HP [1-13C] pyruvate to lactate and alanine in key organs such as the liver, kidneys, pancreas, and spleen. Methods established here set a firm foundation for investigating a broad spectrum of metabolic and neoplastic abnormalities in the liver.

Zengping Lin

W. S. Moore YIA Finalist

My journey into the wonder world of MR neuroimaging began with my participation in an Undergraduate Summer Camp at Shanghai Jiao Tong University in 2018. During the Summer Camp, I had opportunities to attend lectures and demos on multimodal MR imaging and its applications in the diagnosis of brain diseases. I was fascinated by the capability of MRI and the rich information that it can obtain noninvasively. The beautiful MR structural images, the colorful functional connectivity maps, and the mysterious metabolic maps that I was exposed to left a deep impression and made me want to know more.

Zengping Lin

My curiosity about multimodal neuroimaging drove me to graduate school in 2019. I am blessed to have an opportunity to pursue a master's degree under the guidance of Professor Yao Li at Shanghai Jiao Tong University. During my graduate studies, I was fortunate to have opportunities to collaborate with Professor Zhi-Pei Liang's group at the University of Illinois at Urbana-Champaign, Prof. Xin Yu at Case Western Reserve University, and Prof. Parashkev Nachev at University College London, and many talented students in Dr. Li's group. These interdisciplinary interactions were extremely beneficial to my graduate training and enabled me to successfully carry out an ambitious study on the spatial and temporal changes of MRSI signals in ischemic stroke. In the spatial domain, my study showed that metabolic changes captured by high-resolution MRSI could enhance the delineation of ischemic penumbra, while also offering a deeper understanding of regional vulnerability. In the temporal domain, my study found that neurometabolite concentrations within the ischemic lesion could vary over time, providing a reliable means of distinguishing ischemic stroke patients in the early and late hyperacute stages. My graduate thesis research has further enhanced my interest in metabolic imaging of brain diseases. Apart from MRSI, I also embarked on PET/MR research in 2022. My dream is to continue advancing in this exciting field with the goal of unraveling pathophysiological mechanisms of brain diseases to enable early diagnosis and better treatment and clinical management. Presently, I am working as a clinical collaboration scientist, collaborating with clinicians to identify the ideal application scenarios for MR and PET/MR. This endeavor has enabled me to interact with numerous doctors and patients on the front lines. The realization that my MRI knowledge and my work could potentially save lives is very fulfilling.

NOMINATED PAPER

"Predicting the Onset of Ischemic Stroke With Fast High-Resolution 3D MR Spectroscopic Imaging"

This study investigated the use of neurometabolite biomarkers (N-acetylaspartate (NAA), creatine, choline, and lactate) for characteristizing stroke infarcts and establishing the duration and extent of tissue damage, which is desired for effective management of stroke. It is well established that neurometabolite concentrations can indicate brain tissue injury progression over time as a consequence of pathologic cascade following ischemia. Proton MR spectroscopic imaging (1H-MRSI) provides noninvasive measurement of regional neurometabolite changes in stroke, including NAA for neuronal integrity, creatine for energy metabolism, choline for cell membrane turnover, and lactate for anaerobic glycolysis. In this study, we investigated the temporal evolution of neurometabolite concentrations in stroke lesions using a fast high-resolution MRSI technique known as SPICE (SPectroscopic Imaging by exploiting spatiospectral CorrElation). SPICE allows for rapid, high-resolution 3D neurometabolite mapping of nearly the entire brain in about 8 minutes, with nominal resolution of 2.0 × 3.0 × 3.0 mm. This imaging performance was achieved using several innovative data acquisition and processing features, which include: a) elimination of water and lipid suppression pulses, b) use of FID-based acquisition with ultrashort echo time (1.6 ms) and short repetition time (160 ms), c) variable-density sampling of the (k, t)-space, d) acquisition of navigators for tracking and correction of magnetic field drift and patient motion, and e) machine learning-based signal denoising. We studied 73 ischemic stroke patients, 25 of whom had follow-up scans, and grouped them into hyperacute, acute, and subacute categories, further divided into early and late hyperacute groups. We observed that NAA and creatine levels were significantly lower in subacute than in acute stroke. NAA levels were also lower in late than early hyperacute patients and were inversely related to time from symptom onset across both groups. These changes in neurometabolite levels enabled good differentiation between patients in early and late hyperacute time windows. Our study showed that high-resolution 3D MRSI could effectively assess the neurometabolite changes and discriminated early and late hyperacute stroke lesions. The results indicated fast high-resolution metabolic imaging might improve clinical management of stroke.

Taylor Froelich

I. I. Rabi YIA Finalist

My interest in MRI began at a very early age when my older brother was diagnosed with a rare heart condition that required long term care. Throughout my childhood, I remember him going back and forth to doctors who would hook him up to new equipment to monitor the progression of his condition. Over the years, I noticed the diagnostic tools kept getting smaller and more advanced yet still provided the same high-quality diagnostic information. However, we were fortunate to have access to such powerful tools to help my brother. Still today, access to high quality health care is not possible for many. Despite its importance, a large majority of the world's population cannot access MRI due to its overall high cost; thus, this powerful tool is typically relegated to the middle and upper classes in wealthy countries. This inequality creates a tremendous need for the development of new techniques and technology that can begin to address the challenges currently facing MRI.

In recent years, more groups have

Taylor Froelich

begun to explore possible options to address these inequalities, including developing radiofrequency (RF) encoding techniques and more complex reconstruction algorithms to compensate for non-ideal hardware. This variability in approaches is ultimately what led me to Professor Garwood's group at the Center for Magnetic Resonance Research. Here I have gained experience developing portable, mid- to high-field brain MRI technology. Initially, I began by developing a series of robust Bloch simulators to act as an analogue. This was a very powerful approach; being able to develop and test the feasibility of ideas in this manner prior to implementing them on a physical spectrometer. Building from this, I began to explore eliminating pulsed B0 gradients, in favor of different methods that utilized nonlinear RF gradients to perform spatial encoding. This work forms the foundation of my YIA project as it provided several unique advantages over conventional imaging techniques. While this approach shows great promise in reducing the cost of MRI scanners, there is still much to explore regarding the advantages of nonlinear gradient techniques. I plan to continue developing new RF-based encoding schemes and new reconstruction techniques that can better leverage nonlinear gradients.

NOMINATED PAPER

"Fast spin-echo approach for accelerated B1 gradient–based MRI"

The fast spin-echo approach for accelerated B1 gradient–based MRI is part of the class of radiofrequency imaging (RFI) techniques that have made a resurgence as an alternative to the traditional imaging methods that utilize conventional pulsed B0 gradients. The technique presented was developed from a frequency-modulated Rabi-encoded echo (FREE) approach that replaces traditional B0 gradients with a nonlinear B1+ field to perform spatial encoding. In its original implementation, the FREE technique suffered from prohibitive total scan times that limited its versatility; however, this work addresses this problem by employing techniques from traditional fast spin-echo sequences. The main innovation is the application of a train of relatively short frequency-modulated, adiabatic full-passage (AFP) pulses. The pulses within the train are modulated such that the phase of each resulting echo is augmented by a constant amount that is relative to its echo number and the AFPs used throughout the train. The resulting k-space filling order is rather unique in that there are large gaps in k-space, alternating in sign, that will ultimately be filled in by later acquisitions. Utilizing a train of AFPs leverages the pulses capability to invert any frequency within their bandwidth; thus, providing excellent robustness to resonance offsets effects that typically plague conventional RFI techniques.

Not only does this work improve on previous RFI techniques, it also represents an important step improving their clinical viability. This accelerated RFI technique has demonstrated the feasibility of eliminating one pulsed B0 gradient in a manner that could be easily extended to 2D/3D acquisition schemes without losing its resilience to imperfections. This resilience allows for this technique to not only be employed in a wider range of smaller, low-cost magnets that have a more inhomogeneous static B0 field, but also allows for the elimination of pulsed B0 gradient coils. This would drastically reduce the overall cost of MRI by eliminating the associated cost and required infrastructure of pulsed B0 gradients coils while also allowing for truly silent MRI.

Ruiqi Geng

I. I. Rabi YIA Finalist

My path to MRI was somewhat of a "random walk." My liberal arts education at Carleton College allowed me to explore such diverse disciplines as Ancient Roman literature and Physics. My career goal didn't take shape until my grandmother's passing from small-cell carcinoma made me aware of the urgent need for medical research, so I decided to use my physics education to help improve human health. My master's research in Dr. Fang-Fang Yin's lab at Duke University analyzing radiomic feature changes of lung tumors from radiation therapy helped me appreciate the critical role imaging, especially MRI, plays in patient care. That led me to pursue my PhD in Dr. Diego Hernando's Quantitative Imaging Methods Lab at the University of Wisconsin-Madison.

At UW-Madison, my research is focused on advancing quantitative, efficient MRI. I work on addressing motion-related artifacts from cardiovascular pulsation and respiration. Using novel diffusion waveform designs to address signal dropout and quantitative bias, I showed that previously observed variations in Apparent Diffusion Coefficient (ADC) along the pancreas are likely the result of cardiovascular-pulsation-related artifacts rather than a true tissue property. ADC repeatability of the abdomen substantially

Ruiqi Geng

improved using motion-robust methods developed by our group. I validated the combination of motion-robust and distortion-correction techniques in motion phantoms, healthy volunteers and patients with liver metastases. I also optimized motion-corrected averaging techniques to account for respiratory motion for free-breathing DWI. My YIA project focused on the development and validation of AI-based methods to improve MR imaging workflows by automating the prescription of MRI acquisitions in the liver. My interest in imaging science and AI was further developed during two internships at Genentech with Dr. Laura Bell and at Google with Dr. Cheng Chen.

I am grateful to my advisor Dr. Hernando and co-advisor Dr. Scott Reeder for their mentorship, and my science/clinical/industrial colleagues from Mechanical Engineering, Medical Physics, Radiology and Oncology departments at UW-Madison and from GE HealthCare for their amazing teamwork.

NOMINATED PAPER

"Motion-robust, blood-suppressed, reduced-distortion diffusion MRI of the liver"

Recent technical advances in abbreviated MRI protocols and motion-robust free-breathing quantitative MRI methods have the potential to enable MRI of the abdomen with enhanced efficiency. These methods open the door to single-button push MRI exams of the abdomen, which require automated prescription of liver images. Previous efforts relied on traditional image processing tools, with limited performance and validation. Reliable image prescription for the liver remains an unmet need. A team of medical physicists, engineers and radiologists at UW-Madison developed, evaluated, and implemented a novel AI-based fully automated prescription method for liver MRI.

The proposed approach is based on a convolutional neural network for object detection (YOLO), to detect the relevant structures (liver, torso, arms) in each localizer slice. 3D image prescription was obtained from the maximal coverage in each dimension. This method, which has been trained on 831 patient exams at UW-Madison, enables prescription of liver images with full liver coverage in any standard orientation (axial, sagittal, coronal). In 208 testing datasets, AI-based 3D axial prescription achieved an S/I shift of <2.3 cm compared to manual prescription for 99.5% of the test dataset, which means that adding narrow safety margins would ensure complete liver coverage in effectively all patients. Various training settings were also tested. The AI method performed well across patients, pathologies, and clinically relevant acquisition settings, and better in 3D axial prescription than radiologists' inter-reader reproducibility performance. In close collaboration with engineers at GE HealthCare, we successfully implemented the AI method on a clinical scanner and tested it prospectively on healthy volunteers. In this prospective evaluation, the AI method demonstrated robust performance across localizer sequences. Further optimization and evaluation of this method involving multi-center, multi-vendor datasets for retrospective and prospective validation are ongoing.

This method has the potential to enable automated, efficient, and reproducible image prescription for liver MRI and facilitate single-button push, free-breathing MRI exams with automated analysis and reporting.

Valerie Klein

I.I. Rabi YIA Finalist

Valerie Klein

I started working in the field of MRI during my graduate studies at Heidelberg University, Germany. Coming from a pure physics background, MRI fascinated me as an imaging technique combining a variety of scientific disciplines and facing many technical challenges.

In recent years, considerable efforts have been dedicated to developing high-performance gradient systems to boost the spatial and temporal image resolution. Despite impressive advances in technical performance, these new systems are heavily limited by unwanted physiological interactions with the patient's body. More specifically, the rapid switching of the gradient coils induces electric fields that can cause peripheral nerve stimulation (PNS) and potentially cardiac stimulation (CS). This, in turn, restricts imaging sequences relying on high gradient performance such as TSE, SSFP, EPI, or diffusion imaging.

My research aims at investigating the physical and physiological mechanisms underlying CS to understand and predict when and where CS could be induced in the human body. In fact, the IEC 60601-2-33 regulatory standard imposes limits on the switching speed of MRI gradient systems that are likely overly conservative. Unlike PNS, CS thresholds cannot be safely measured in human volunteers. To address this issue, I have developed a numerical model that can predict CS thresholds and locations in the heart for arbitrary gradient coil geometries and waveforms. The model combines electromagnetic simulations in detailed body models with electrophysiological modeling of the electrophysiological response of electrically excitable myocardial fibers. Ultimately, the goal of my research project is to obtain more accurate estimates of CS thresholds that ensure patient safety without unnecessarily restricting the usable image encoding performance.

Clearly, careful experimental validation of this CS model is critical for achieving this goal. Therefore, my mentors Prof. Lawrence Wald and Prof. Bastien Guerin at the Martinos Center for Biomedical Imaging in Boston and I recently measured CS thresholds in pigs – and I am excited that

this study has been chosen as a YIA finalist paper. Importantly, the porcine CS thresholds measured in this study agree well with predictions made using our CS modeling pipeline. I believe that our CS model can and will play an important role in choosing appropriate human safety limits for state-of-the-art MRI systems.

NOMINATED PAPER

"Measurement of magnetostimulation thresholds in the porcine heart"

The work reported in my YIA finalist paper presents the first in vivo measurement of cardiac magnetostimulation thresholds in pigs, the primary animal model for the human cardiovascular system. Our study adds critical data to the otherwise scarce body of literature that measured CS thresholds for time-varying magnetic fields.

We measured CS by discharging a large capacitor into a flat spiral coil positioned near the chest of ten healthy, anesthetized pigs. The amplitude of the pulses was increased incrementally until CS was observed on ECG, blood pressure, or peripheral oximetry traces. The average CS threshold measured in the animals was dB/dt=1.60±0.22 kT/s at heart center, a value that is 11-fold higher than the IEC CS dB/dt limit for the stimulus waveform used in the experiments.

Furthermore, we created individualized electromagnetic body models of the pigs used in the experimental study to model animal-specific electric fields induced by the capacitor discharges. To do so, the pigs were moved into a 3T MRI scanner to acquire whole-body fat-water-separated Dixon and CINE images immediately after the stimulation experiment. These images were segmented to create individualized body models reflecting the anatomy and posture of the animals under study.

For comparison with the measured thresholds, electric fields were simulated in a human body model placed in three commercial gradient systems. The maximum induced electric field in the human heart was 37-fold lower than the electric field in the porcine heart at the experimental threshold.

Our study therefore shows that current gradient systems are extremely unlikely to cause CS. Furthermore, our results indicate that the IEC cardiac safety limit for MRI gradient systems is conservative for the investigated stimulus waveform. Finally, simulations in the porcine-specific body models allow for a careful validation of the CS prediction model I have developed. A validated CS model will become a useful tool for informing appropriate safety limits that protect patients from CS without overly restricting gradient performance, a goal that I have recently been working towards with a sub-committee of the IEC.

Gian Franco Piredda

I. I. Rabi YIA Finalist

During my undergraduate studies at the Polytechnic University of Turin and the École Polytechnique Fédérale de Lausanne (EPFL), I had the chance to challenge myself in projects related to medical image processing, and I became fascinated by how research activity in this field can drastically improve disease diagnosis and patient follow-up. Motivated by this goal, in 2017 I started a PhD in quantitative MRI (qMRI) under the supervision of Prof. Jean-Philippe Thiran at EPFL and Dr Tobias Kober from Siemens Healthineers.

My PhD thesis was centered around increasing the value and promoting the practical utility of qMRI in clinical settings with a focus on brain relaxometry and myelin water imaging (MWI). More specifically, I worked on improving the brain coverage and accelerating the acquisition time of a sequence for MWI to foster the use of this quantitative technique. Moreover, I developed new methods to compute normative ranges of quantitative MR parameters (e.g., T1 and T2) in the brain and visualize deviations from such norms in accordance with requirements of the clinical workflow for single-patient analyses. As I am strongly enthusiastic to bring cutting-edge technology into clinical routine, various prototype packages of the developed methods were shared with clinical collaborators (including, among others, the University Hospital of Lausanne, the Charles University Hospital of Prague, the University Hospital Centre of Tours) and resulted in methodological spin-off research and clinical validation projects. The nominated paper for the YIA represents a continuation of these efforts. In collaboration with the Inselspital in Bern, we developed a method for single-patient comparison of qMRI maps at 7T and explored its potential in clinical applications. Currently, I continue to work on ultra-high filed imaging as an MR research scientist at Campus Biotech in Geneva, a facility hosting both a 3T and a clinical 7T scanner.

Gian Franco Piredda

NOMINATED PAPER

"Submillimeter T1 atlas for subject-specific abnormality detection at 7T"

Quantitative MRI (qMRI) allows moving from a relative MR contrast information susceptible to various confounding factors to – ideally – absolute measures of physical properties, thus providing the means to characterize tissues and gain insight into subtle microstructural changes caused by diseases. However, to fully exploit quantitative maps, normative values in healthy tissue are required, enabling the comparison of tissue properties from a single patient to those considered healthy.

In a previous study at 3T, we proposed a framework that enables voxel-wise comparison of brain qMRI maps to normative values

in a single-patient setting. The application of this method in subsequent studies has shown that quantitative T1 deviations from normative values are more correlated with patients' disability than conventional MRI-based metrics.

In this context, the improved SNR of high-resolution MR images acquired at 7T can add clinical value. Following this rationale, in this study we established a method for single-patient analysis of quantitative T1 values at 7T by building an atlas (0.6mm isotropic resolution) of normative T1 values from a healthy cohort. A method for single-subject comparisons was developed then by computing T1 z-scores. Such deviation maps were evaluated in patients with different neurological conditions scanned both at 3T and 7T.

One of the main findings of our work is represented by the possibility of detecting subtle T1 alterations that are not visible in conventional MRI contrasts. The detection of widespread global changes in normal-appearing brain tissue may allow a deeper understanding of disease pathophysiology and more precise assessment of tissue damage for both differential diagnosis and follow-up. Hence, I believe that atlas-based single-subject analysis represents a promising tool looking beyond the visible changes often reflecting only the "tip of the iceberg" of the underlying pathology.

Xingfeng Shao

I. I. Rabi YIA Finalist

I started MRI research and submitted my first abstract to ISMRM in 2013 when I was an undergraduate student. Since then, my passion for developing MRI techniques that have significant clinical impact has continued to grow, driving me to constantly explore new ideas and push the boundaries of what's possible in the field of MRI. I'm now a research Assistant Professor at the University of Southern California (USC) Stevens Neuroimaging and Informatics Institute. My research is focused on the technical development of novel neuroimaging methods, with a particular interest in arterial spin labeling (ASL). For the past five years, I have focused on developing and evaluating a diffusion

Xingfeng Shao

prepared pseudo-continuous arterial spin labeling (DP-pCASL) technique and modeling algorithm that quantifies the water exchange rate (kw) across the blood-brain barrier (BBB) without contrast. The BBB plays a vital role in protecting the central nervous system (CNS) from harmful substances such as plasma proteins and inorganic solutes. Water is an endogenous tracer with a small molecular weight, and its rapid exchange across the BBB is mediated by multiple transport mechanisms. Assessing BBB water exchange has the potential to provide a sensitive assessment of BBB dysfunction, especially in the early stages of disease progression. I believe sharing and collaboration are essential to scientific research. Our technique has been shared with over 40 research centers worldwide to study various neurological disorders and has been independently validated by pre-clinical studies and associated with aging, small vessel disease, APOE Σ4 genotype and amyloid PET, as well as CSF Aβ-42 in cognitive normal subjects. I feel privileged to work together with my ISMRM colleagues from different research groups with diverse approaches to non-invasively assess BBB function and integrity. Through innovative approaches and different ideas, we can gain a better understanding of BBB water exchange mechanisms and eventually broaden its clinical applications.

NOMINATED PAPER

"Quantification of Blood-Brain Barrier Water Exchange and Permeability with Multi-delay Diffusion Weighted pCASL"

While the DP-pCASL technique has been successfully applied in research studies, it has drawbacks of low spatial resolution and sensitivity, as well as the lack of the venous compartment in the model, which makes estimating the BBB permeability surface area-product (PSw) impossible. Simultaneously mapping BBB kw and PSw will provide a more comprehensive understanding of BBB function and integrity because they measure different aspects of BBB physiology. In this paper, we presented an innovative MR pulse sequence that integrates a motion-compensated diffusion weighting (MCDW) scheme, BIR-4 refocusing pulse and GRASE pCASL. This new pulse sequence was carefully designed and tested to ensure motion robustness and high image quality. Compared to the DP-pCASL, this embedded MCDW scheme does not increase TE or cause half signal loss, thus achieving 3-fold higher SNR and higher spatial resolution (3.5 mm^3 isotropic). This new technique allows us to acquire intravascular and extravascular ASL signals across a wide range of post-labeling delays (PLDs), providing opportunities for quantification of BBB water exchange kinetics using more rigorous mathematical models. In this study, we developed a 3-compartment single-pass approximation (SPA) modeling to capture the full dynamics of the labeled blood bolus passing through capillaries while exchanging into tissue space before flowing into venules. A comprehensive set of perfusion and permeability parameters including cerebral blood flow (CBF), capillary transit time (τc), capillary volume (Vc), kw and PSw were obtained from group-averaged data of 11 subjects. Finally, using information obtained from three-compartment SPA modeling, we developed a simple yet robust solution (LRL) for kw quantification, and PSw was calculated from long PLDs. The potential impact of this technique is high with the delivery of multifaceted novel capabilities for BBB imaging and the potential to identify biomarkers for treating neurological disorders that are related to the BBB. ■

Magnetic Moments & MRPub

5th Magnetic Moments Competition
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will deliver a live lay talk of their annual meeting
abstract and you are invited to the session!

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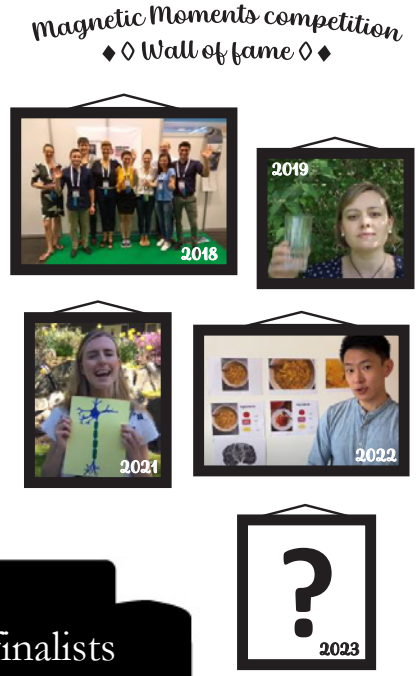
Be in the audience to score the finalists and help the judges to select the winner of the 2023 edition!



MR-pub Competition for Interactive Code

ISMRM ONE COMMUNITY FOR CLINICIANS AND SCIENTISTS

What is it?

MR-pub is a competition for interactive open-source code demos. It aims to facilitates code sharing in our community. Specifically, it draws submissions of interactive, easy-to-use, cool code demos. All the submitted code demos will be published online in the ISMRM's open-code hub, titled MR-pub: **https://ismrm.github.io/mrpub/**

Who can participate and how?

Any person who is willing to share a code demos that reproduces an abstract accepted to the ISMRM meeting can participate. The submission is done via an online google form. To find it, look out for announcements of the RRSG committee. Submitted code demos can be in any language – python, Matlab, Julia, C++ etc.

Efrat Shimron

Who organizes it?

The MR-Pub competition is organized by the ISMRM Reproducible Research Study Group (RRSG) committee. Specifically, the committee's trainee representative, Efrat Shimron, has organized it in 2021-2023.

Why participate? What topics can be included?

Code sharing is fun and increases exposure of your work! All the participants are invited to give power-pitch talks about their submissions in the RRSG business meeting during the ISMRM annual meeting.
Last year the submissions addressed broad topics, including open-access deep-learning software, vendor-neutral sequences, virtual scanners and methods for real-time shimming.

How can I see the open codes that were submitted?

Check out https://ismrm.github.io/mrpub/

The 2022 MR-pub competition organizers and winners.

Accurate free-water estimation in white matter from fast diffusion MRI acquisitions using the spherical means technique

INTERVIEW BY **MATHIEU BOUDREAU**

MRM HIGHLIGHTS' PICK

This first MRM Highlights Pick interview of 2022 is with **Antonio Tristán-Vega** and **Santiago Aja-Fernández,** researchers at the University of Valladolid in Spain. Their paper is entitled "Accurate free-water estimation in white matter from fast diffusion MRI acquisitions using the spherical means technique". We chose this paper because the authors demonstrated exemplary reproducible research practices. In particular, in the context of a larger software tool that they developed and manage (dMRI-Lab), they shared tools developed as part of this work.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM AT MRM.ISMRM.ORG

MRMH: Can you tell us a little about yourselves and your background?

Antonio: My background is in communications engineering. I did a PhD under the supervision of Santi (Santiago) and my research focus has always been medical imaging. I started off doing general image processing, like registration, filtering, and segmentation, but then I quickly moved on to diffusion MRI. I focus on mathematical modeling more than on clinical applications. I also do a lot of teaching at my university.

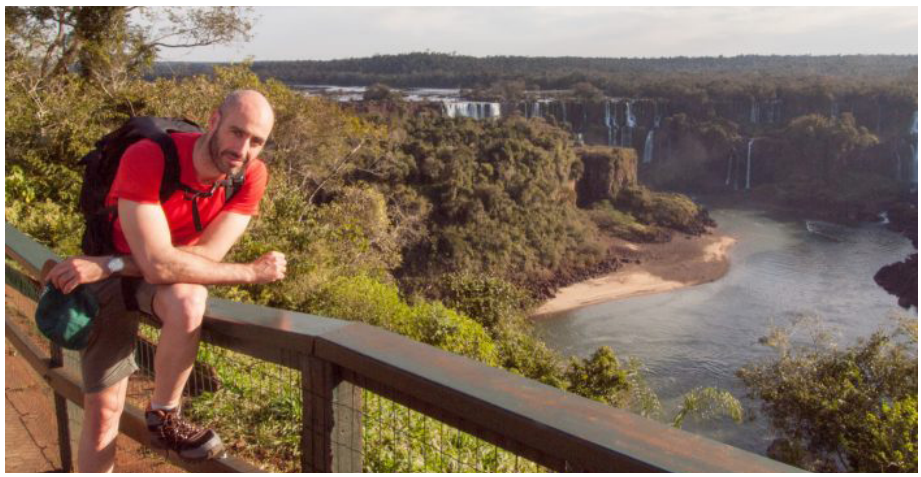
Santiago: I finished my PhD in 2003, and although my group back then was working with medical imaging, I was not involved in those projects. After my PhD, I started to focus on medical imaging, initially with ultrasound imaging, which is very hard to work with because you are dealing with analog data – we had to record the video output of the ultrasound scanner to get the images. I did my postdoc in Boston and that's where I started getting involved with diffusion MRI. I am now a professor at the Universidad de Valladolid.

MRMH: Before we jump into the paper, could you clarify what you mean by the "spherical means technique" referred to in the title of your paper?

Antonio: Basically, in diffusion imaging what you do is acquire images weighted by bipolar pulsed gradients along different spatial directions. The spherical means technique is a way of averaging the signals of all the orientations you acquired, prior to using the data in your analyses. This can be useful for certain applications because you not only improve the signal-to-noise ratio, but also dramatically reduce the number of degrees of freedom to be optimized, which can make these techniques more robust.

MRMH: Thanks! Could you give us a brief overview of your paper?

Antonio: The central motivation for this paper was data access, or rather the lack of it! Our aim was to extend the advantages of advanced diffusion imaging to the clinical practice setting, so that the clinical teams we work with can benefit from them. In practice, clinicians cannot spend several hours acquiring three different diffusion shells with hundreds of gradient directions and large b-values. Clinicians only have access to DTI-like data. So, the aim of this paper was to estimate the free water compartment using this type of data. Even though there are other methods that can do this, they typically depend on complex multi-shell data. Therefore, our idea was to estimate this particular parameter, the free water compartment, while using an acquisition



Antonio Tristán-Vega

Tristán-Vega, A, París, G, de Luis-García, R, Aja-Fernández, S. Accurate free-water estimation in white matter from fast diffusion MRI acquisitions using the spherical means technique. *Magn Reson Med.* 2021; 87: 1028– 1035. https://doi.org/10.1002/mrm.28997

https://blog.ismrm.org/2022/03/11/qa-with-antonio-tristan-vega-and-santiago-aja-fernandez/

https://blog.ismrm.org/2022/03/18/reproducible-research-insights-with-antonio-tristan-vega-and-santiago-aja-fernandez/

Santiago Aja-Fernández

protocol closer to diffusion tensor MRI. We developed a method that allows us to do this by adding only a few extra gradient directions at an intermediate b-value to our regular DTI MRI protocol. With this subtle change in the acquisition protocol, we are able to accurately estimate the free water compartment voxel-by-voxel, without spatial regularization. We compared this method with comparable ones, and found that, unlike the other methods, ours did not introduce a bias in the estimation of free water whenever you have crossing fibers in the brain.

Santiago: Yes, so to contextualize the problem, when we acquire diffusion clinical data, we also need to acquire T1, T2, resting-state signal, etc. So, we asked Antonio if we could minimize the extra acquisitions needed to estimate the free water, and through mathematical modeling he found that only six additional measurements at a b-value of 500 were all it took, and I think that's really great for the clinical community.

MRMH: Why is free water an important parameter?

Santiago: There are many brain diseases that are thought to be related to the water content in the brain and to neuroinflammation. For instance, through our investigation of migraine and headaches in collaboration with neurologists, we have come to believe that free water may play a role. There have also been studies of schizophrenia that have considered this aspect, and more recently we've been looking at whether patients with long-term effects of COVID might also have neuroinflammation.

Reproducible Research Insights with Antonio Tristán-Vega and Santiago Aja-Fernández

1. Why did you choose to share your code/data?

We feel that code sharing is a nice way to increase the visibility of our work. Traditionally, our research tends to focus on mathematical modeling of images, which often leads to complex conceptualizations/mathematical developments that end users cannot afford to implement themselves. Publishing our implementations gives our research outcomes the chance to be adopted (or at least tested) by a wider audience.

2. What is your lab or institutional policy on code/data sharing?

With regard to diffusion MRI processing, which is one of the main research lines developed at our lab, we are committed to integrating all the methods we develop into a continuously evolving MATLAB toolbox, which we keep publicly available.

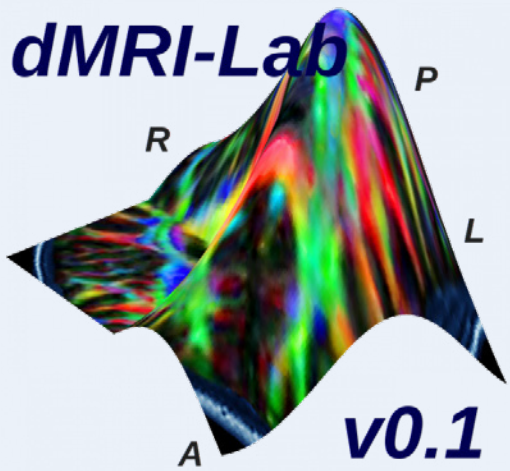
3. At what stage did you decide to share your code/data? Is there anything you wish you had known or done sooner?

The answer to this question is related to our reply to the first one. We realized that, quite often, researchers (especially those more interested in clinical applications of dMRI than in dMRI processing itself) adopt standard pipelines based more on the availability of handy software than on the actual suitability of the given methods for their specific problems. Despite having been, for years, in the habit of publishing small pieces of software that implemented the methods of a particular paper or conference communication, it was not until two years ago that we decided to put together all the software we had contributed over the past decade and publish a complete toolbox. We are aware that it is neither the only nor the best existing software for dMRI processing. However, it has the advantage of making all our research outcomes easily available to any interested researcher, without them needing to be big experts in either dMRI processing or software engineering.

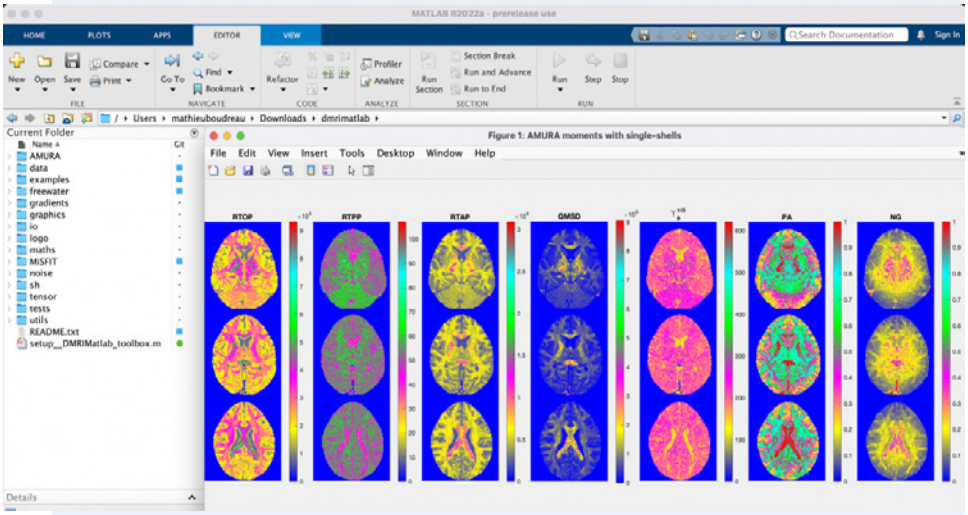
4. How do you think we might encourage researchers in the MRI community to contribute more open-source code along with their research papers?

We think this is really a question for academic institutions. In our country, being a regular contributor to or maintainer of a given software, even if it is used by hundreds of researchers worldwide, has very little added value for your CV, which is evaluated mostly in terms of your number of publications in JCR journals or citations received. Coding (and, above all, maintaining) software is really time consuming, and it is not properly recognized. Consequently, researchers are not motivated to invest time in this very important activity.

continued



Logo for the software tool dMRI-Lab developed and maintained by Antonio and Santiago.



Screenshot of one of the demos provided with dMRI-Lab.

Questions about the specific reproducible research habit

1. How does dMRI-Lab fit into the larger landscape of diffusion MRI software tools?

We do not claim that it can substitute or compete with any other software solution. Our aim, with the methods we have developed, is to complement these other tools, so that interested researchers can try and test different processing pipelines and choose the most appropriate one for their needs, without being conditioned by software availability.

2. What questions did you ask yourselves while you were developing the code that would eventually be shared?

The most recurrent question was whether we should develop an easy-to-use code aimed at end users, fixing most of the design degrees of freedom and algorithm parameters to default values, or instead keep the code as flexible as possible, so that other researchers working on image processing might further develop and improve on our methods. In other words, the aspect we wondered about most was the target users of our software.

3. What advice do you have for people that want to develop and maintain a long-term software project like dMRI-Lab?

Document the code and take the time to write detailed help on your functions/modules/ methods/commands. Do not simply direct the user to your paper in order to find out how to use the software.

4. Are there any other reproducible research habits that you didn't use for this paper but might be interested in trying in the future?

Yes, sharing scripts that can exactly reproduce the results included in the paper; however, this is not always possible due to the use of data that cannot be shared. ■

MRMH: You have shared the code you developed for this work in the context of a larger software project that's on dMRI-Lab. Do you want to say a little bit about that project?

Antonio: Basically, it's been our way of packaging all the work we've been doing over the last 10 years or so. Having said that, we only decided to package and upload it to a public repository about three years ago. We also uploaded some individual pieces on the MATLAB file exchange, such as those related to denoising and noise estimation.

MRMH: How has the COVID pandemic impacted your research?

Santiago: Well, the week before the first lockdown (Winter 2020), we started a very ambitious longitudinal clinical study. But after scanning only two patients, we had to stop, and it is only now (Winter 2022) that we are picking that up again. Because we were mainly working from home, we have done a lot of theoretical work over these past two years.

MRMH: What do you enjoy doing when you're not working on your research? And can you tell us a little bit about your city?

Santiago: Valladolid and the surrounding area is very nice, there is a lot of history here and the food and wine is amazing. We are thinking of organizing a workshop here in the near future, because I'd love it for the people in the ISMRM community to discover our part of Spain. As for free time, I have two kids, so I have very little of it [chuckles].

MRMH: Is that a collection of graphic novels I see behind you, too?

Santiago: Oh, yeah (laughs). I used to read more than I do now, but the lockdown was a good opportunity to get back into them. Some of these are my brother's; he is actually an artist for Marvel, he did a well-known run of the Hawkeye comics

MRMH: Oh cool! And how about you, Antonio?

Antonio: I'm quite into fitness and sports, either outdoors or at the gym. And my interest in signal processing branches out into my hobbies as well, as I'm enthusiastic of photography and digital editing of pictures. ■

Deep neural network based CEST and AREX processing: Application in imaging a model of Alzheimer's disease at 3 T

INTERVIEW BY **MATHIEU BOUDREAU**

MRM HIGHLIGHTS' PICK

This MRM Highlights Pick interview is with **Jianpan Huang** and **Kannie Chan**, researchers at the City University of Hong Kong. Their paper is entitled "Deep neural network based CEST and AREX processing: application in imaging a model of Alzheimer's disease at 3 T". We chose to highlight this paper because the authors demonstrated exemplary reproducible research practices; in particular, they shared code and sample data, in addition to a demo and scripts that reproduce some of their figures.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM AT MRM.ISMRM.ORG

MRMH: Tell us about yourselves and your background.

Jianpan: I received my bachelor's and master's degrees from Xiamen University, which is where I started getting involved with MRI. I then did my PhD degree in biomedical engineering at the City University of Hong Kong, where I'm currently working as a postdoc. My research focus is CEST MRI and deep learning, and their applications in detecting neurological disease.

Kannie: Actually, I'm a chemist by training, but I've always been fascinated by imaging molecules in the body. I went to Johns Hopkins Medicine for my postdoctoral training, which is where I first started working in MRI applications, and then became an assistant professor there. In 2016, I joined the City University of Hong Kong, where I'm now an associate professor. My research focuses on the development of CEST-detectable biomaterial and imaging neuropathology using CEST MRI, mainly for applications in brain cancer and neurodegenerative disease, such as Alzheimer's disease.

MRMH: Before we dive into the paper, could you briefly explain what CEST and AREX are, for those not familiar with the terms?

Jianpan: So, CEST stands for chemical exchange saturation transfer, and CEST MRI is a technique that probes molecules with exchangeable protons, such as proteins, glucose, and glutamate. AREX is short for apparent exchange-dependent relaxation, which is a relaxation-compensated CEST contrast. It is calculated based on the inverse metric of steady-state Z-spectra and T1 metric, thus correcting the effects

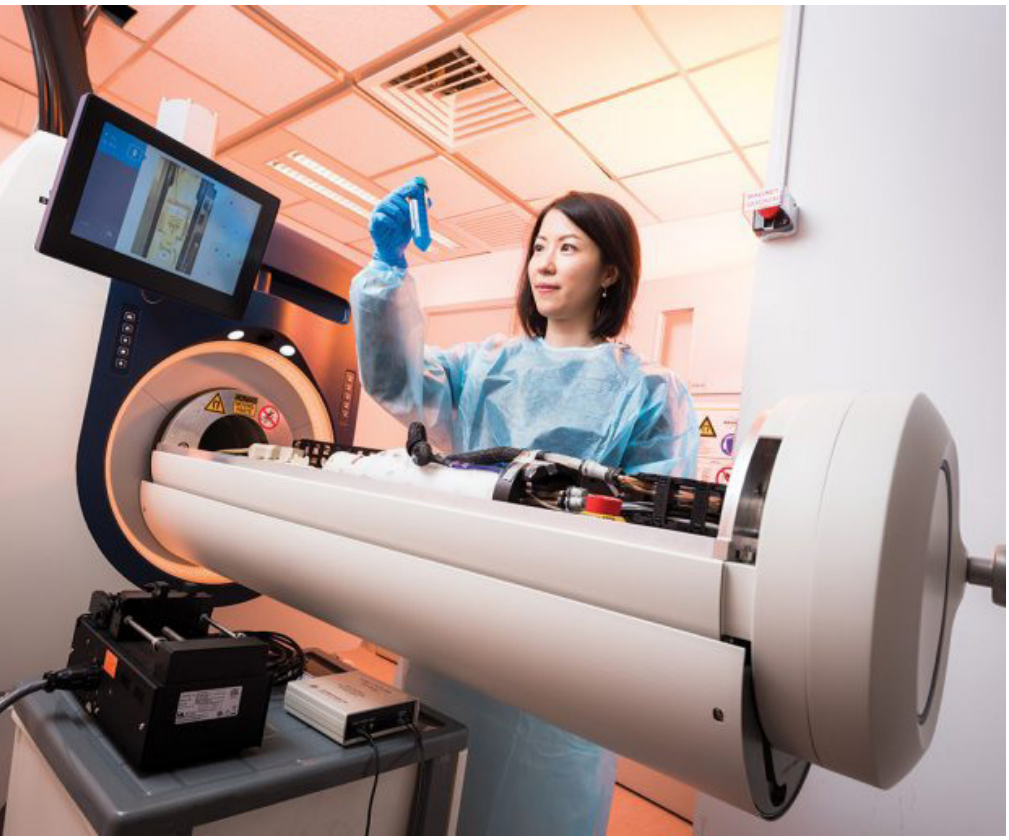
Kannie WY Chan and Jianpan Huang discussing MRI results.

Huang, J, Lai, JHC, Tse, K-H, et al. Deep neural network based CEST and AREX processing: Application in imaging a model of Alzheimer's disease at 3 T. *Magn Reson Med.* 2022; 87: 1529–1545. doi:10.1002/mrm.29044

https://blog.ismrm.org/2022/05/20/qa-with-jianpan-huang-and-kannie-wy-chan/

https://blog.ismrm.org/2022/05/27/reproducible-research-insights-with-jianpan-huang-and-kannie-wy-chan/

Jianpan Huang setting up an MRI experiment.



Kannie WY Chan examinning an MRI phantom.

of spillover dilution and T1 scaling.

MRMH: Could you give us a brief overview of your paper?

Jianpan: It's well known that CEST MRI is a promising molecular imaging approach that is sensitive in detecting low-concentration molecules with exchangeable protons, however postprocessing CEST data is not trivial in practice and requires expert knowledge to do. It is also quite time intensive. In this study, we used deep learning to process CEST imaging data (deepCEST), an approach that would simplify and accelerate the data processing for users, and applied the technique in a mouse model of Alzheimer's disease (AD). Moreover, we proposed extension of this deep learning model to predict the AREX contrast (deepAREX). Our results showed that both deepCEST and deepAREX could rapidly generate accurate results at 3T in the mouse model, at higher processing speeds compared with the conventional fitting methods, and the network generalization was validated on unseen data. Interestingly, the deep learning based methods could detect the CEST signal changes in AD mouse brain.

Kannie: By using deep learning, we hope to be able to facilitate the postprocessing, so that it can be shared with others, and that, in turn, will hopefully facilitate clinical translation.

MRMH: Were you surprised with the results?

Jianpan: Yes. The results were quite surprising. A previous study showed that deepCEST could be used to generate CEST contrast, and here we found that deepAREX could also produce high-accuracy AREX contrast that requires additional processing procedures (B0 correction, inverse Z-spectrum analysis, and T1 compensation). Moreover, we were also surprised that the molecular change of AD mouse brain could be detected by CEST MRI (both deepCEST and deepAREX) at a clinical field strength of 3T. This indicates this approach has potential for clinical application.

MRMH: How does this work fit into your broader research goals?

Kannie: We aim to facilitate the clinical

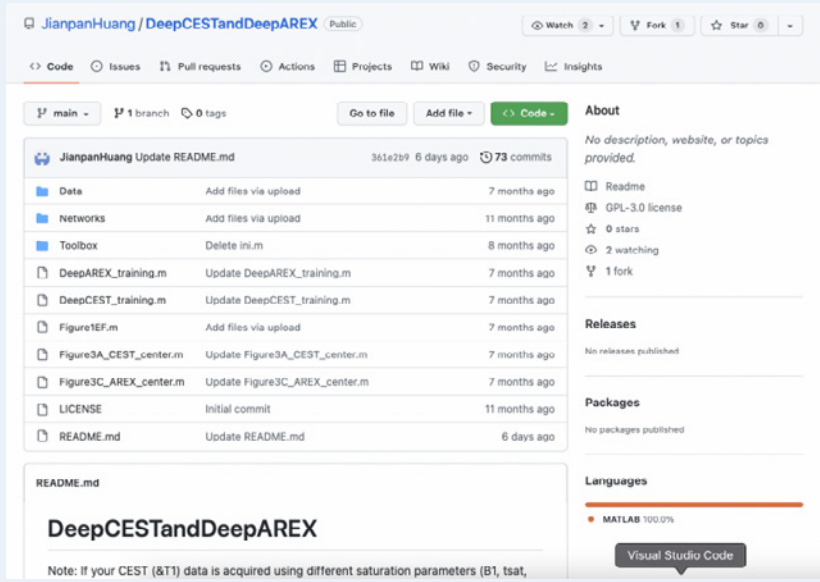
translation of CEST using deep learning, as we believe it could be applied in assessing neuropathology – to identify subtle molecular alterations in the brain, for example. We work a lot with animal models because we can perform molecular confirmation or validation to demonstrate the sensitivity to certain neuropathologies of the techniques we develop. In another study, we demonstrated that CEST can sensitively detect glucose alteration in AD. We really want to make CEST a robust approach that can probe molecular changes in the brain, especially in the earlier stages of the disease.

Jianpan: In this work, we only demonstrated the ability of deep learning to accelerate the postprocessing of CEST MRI data. I'm also interested in applying deep learning to accelerate the acquisition of CEST MRI data. For example, we know that deep learning can be used to reconstruct high-resolution images from low-resolution images, so applying this to CEST MRI could accelerate the data acquisition by just acquiring low-resolution images. Also, there is data redundancy in CEST datasets (in CEST, multiple images from the same location are acquired using different saturation frequency offsets), and deep learning may make it possible to leverage this, through undersampling of the k-space within each CEST image.

MRMH: Since this is a preclinical study, how do you envision the clinical translation of this work?

Jianpan: Reducing the scan time is the first challenge that will need to be overcome, as we just discussed. Lowering the number of saturation offsets is also an option, but at the risk of losing some molecular information. The second challenge is the SAR (specific absorption rate) issues. The approach we used for our animal study was continuous-wave saturation based CEST; however, this is not viable for human studies as it creates high SARs, so a pulsed CEST approach will be used instead. As for the deepCEST and deepAREX, they can be easily translated to clinical usage.

Kannie: Yes, I definitely agree. The fact that the mouse brain is so different from the



Screenshot of the GitHub repository where the code for this paper was shared, and is available here.

Reproducible Research Insights with Jianpan Huang and Kannie WY Chan

General questions

1. Why did you choose to share your code/data?

There are two main reasons. First of all, we chose to do it for reproducibility purposes. CEST analysis using deep learning is an emerging CEST postprocessing method that is not yet widely used in this setting. Our hope, in sharing our code/data, is that researchers who are working in the CEST field and/or are interested in deep learning-based CEST analysis might be able to use our code directly for processing their own CEST data. The networks in this study were trained on CEST data acquired from mice. Although the trained networks cannot be used directly to perform prediction tasks in other CEST studies, the shared code could easily be applied for training different CEST datasets, such as human CEST data or CEST data acquired using other CEST parameters. This could make it possible to generate the specific networks for prediction. The second reason is to promote the deep learning based CEST/AREX postprocessing method. We believe that this method would have more impact if it were easier for researchers to use the shared code and apply it to their studies. This could provide an avenue for researchers to share their ideas and thus help to improve this approach.

2. What is your lab or institutional policy on code/data sharing?

Currently, our lab does not have a formal policy on code sharing. We encourage members to share code that has been developed in our lab, especially when the related work has reached the publication stage. This is good practice for making code open and transparent, thereby allowing internal or even external researchers to validate the findings and use the methods. With regard to data sharing, we share the preclinical animal data among our members for research purposes. Decisions on whether data can be shared to external researchers/repositories are guided by our institutional data policy.

continued

3. At what stage did you decide to share your code/data? Is there anything you wish you had known or done sooner?
We made this decision at the time of submitting the revised manuscript, which is the appropriate stage at which to decide on code/data sharing. With hindsight, it would have been useful to consider the possible issues with code sharing while actually developing the code, so as to reduce the time spent checking and revising it before uploading.

4. How do you think we might encourage researchers in the MRI community to contribute more open-source code along with their research papers?
The MRM Highlights initiative is one way of encouraging this. In addition, I think the journal could perhaps consider flagging published papers that provide 'open-source code', also by way of an acknowledgement. Also, if 'open-source code' were among the filters that readers can apply when using the Search function, it might be easier to find studies offering this.

Questions about the specific reproducible research habit

1. What advice do you have for people who would like to share their deep learning code/data along with their paper?
It is helpful to share the code used for generating the main figures in the paper, so that readers can easily follow the paper and get started with the code. Furthermore, since it is practically impossible to train two identical networks, even if the training dataset and hyperparameters are the same, it is always advisable to save the networks, especially those used to generate the results presented in papers. When sharing deep learning code/data, it is also useful to add descriptions about how to implement the code (prerequisites and procedures) and, for the benefit of users, to suggest possible errors/bugs.

2. What questions did you ask yourselves while you were developing the code that would eventually be shared?
One aspect considered was how to make the code easy to use, which meant asking ourselves a series of questions. What kind of data format is more convenient if readers want to try this method with their own dataset? What errors/bugs could appear if the code were run in other devices/systems? What changes should be made to the code if it is run on a device with/without a GPU? How could the code be made more readable and easier to use for people who are interested in this paper? The latter, for example, could be achieved by naming variables appropriately and adding comments where necessary.

3. How do you recommend that people use the project repository you shared? Can they use the trained model you shared as is, or should they generate their own training datasets?
I would highly recommend this project repository to people interested in CEST analysis using deep learning. Although they cannot use the trained model directly if their experimental setup is different (in terms of CEST parameters, B0, subject type, etc.), the shared code is applicable to different CEST studies and can easily be implemented for training their own CEST data. People only need to prepare their input data in an appropriate format and feed them into the shared code. Once the network is trained, it can be used to quickly process CEST data in their project.

4. Are there any other reproducible research habits that you didn't use for this paper but might be interested in trying in the future?
As regards data sharing, I recently noticed that Zenodo is another general-purpose open repository that allows researchers to deposit research papers, datasets, software, reports, and any other research-related digital artifacts. Moreover, a persistent DOI is assigned to each submission, which makes the stored items easy to cite. I am interested in trying this open repository in the future. ■

human brain means that clinical translation has its challenges, as Jianpan mentioned. Another hurdle is the resolution, because we need to be able to identify very small lesions with our quantitative techniques. We believe emerging deep learning approaches could facilitate clinical translation.

MRMH: Is there anything else that you'd like to mention?
Kannie: Yes, in addition to what we've discussed, I'd like to highlight that the pulse sequence design is also very important for CEST. For clinical applications, alternative sequence designs such as radial readout could also help if applied to CEST MRI.

MRMH: Finally, what do you enjoy doing when you're not in the lab?
Kannie: I like running outside when I can! Currently we're under some restrictions again, unfortunately, so I've also been enjoying practicing yoga, playing the piano and painting at home.
Jianpan: I enjoy playing basketball quite a lot. Hong Kong is also such a beautiful place, and I like to go hiking or biking if the weather is nice. ■

Generalized Bloch model: A theory for pulsed magnetization transfer

INTERVIEW BY **PINAR S OZBAY**

MRM HIGHLIGHTS' PICK

This MRM Highlights Pick interview is with **Jakob Assländer** and **Daniel Sodickson**, researchers at NYU Langone Health. Their paper is entitled "Generalized Bloch model: A theory for pulsed magnetization transfer". They propose a new quantitative magnetization transfer (qMT) theory that unifies the original Bloch model, Henkelman's steady-state theory for magnetization transfer, and the commonly assumed rotation induced by hard pulses (i.e., strong and infinitesimally short applications of RF fields). Their model describes the data of an inversion recovery-magnetization transfer experiment with varying durations of the inversion pulse substantially better than established models can. This allows the use of pulse durations smaller than 300 µs. We chose to highlight this paper because the authors demonstrated exemplary reproducible research practices; in particular, they shared all the code, data, and scripts needed to reproduce their figures, and also created a beautiful tutorial with interactive figures and MyBinder links to run the code from any browser.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM AT MRM.ISMRM.ORG

MRMH: Could you briefly tell us about your backgrounds and how you got into the field of MRI?

Dan: This work took me back to my roots in MR, which were not actually in imaging. I did graduate work in solid-state NMR, and worked on classical and quantum models of spin diffusion. It was a couple of years later that I took an accidental turn and got into the imaging side.

Jakob: I was pursuing my MSc degree in physics in Würzburg, Germany, and I was looking for a job on the side to earn some money. There happened to be a job opening with the local MRI group and so I started my MRI journey. I later moved to Freiburg to do my PhD with Jürgen Hennig.

Jakob Assländer

JOHN MADERE/NYU LANGONE HEALTH

Daniel Sodickson at the NYU Langone RF lab

Assländer, J, Gultekin, C, Flassbeck, S, Glaser, SJ, Sodickson, DK. Generalized Bloch model: A theory for pulsed magnetization transfer. *Magn Reson Med.* 2022; 87: 2003– 2017. doi:10.1002/mrm.29071

https://blog.ismrm.org/2022/06/24/qa-with-jakob-asslander-and-daniel-sodickson/
https://blog.ismrm.org/2022/06/29/reproducible-research-insights-with-jakob-asslander/

MRMH: Could you share the story behind this work and tell us how the idea evolved?

Jakob: I was working on relaxometry methods, similar to MR fingerprinting. It turned out that magnetization transfer was a big confounding factor. My

Reproducible Research Insights with Jakob Assländer

General questions

1. Why did you choose to share your code/data?

Being funded with public money, I feel it is my job to facilitate scientific progress. In my humble opinion, sharing publishing code and data is an important part of working together as a scientific community. But I think there are also benefits to be had for authors too, as open-source code can help to promote the publications that relate to it.

2. What is your lab or institutional policy on code/data sharing?

Our department is putting a lot of effort into curating and sharing code, data, and even hardware. Our shared resources, available through the Center for Advanced Imaging Innovation and Research, include over 50 software packages that have been downloaded over 15,000 times. The fastMRI dataset contains the raw data of over 8000 scans and the download traffic of this dataset is about 1000 TB/year. Furthermore, we are shipping, free of charge, a pilot tone transmitter to interested academic sites. Long story short, I could not wish for an environment that places greater emphasis on sharing code and data.

3. At what stage did you decide to share your code/data? Is there anything you wish you had known or done sooner?

To me, deciding to write a paper about a topic and choosing to publish any useful code associated with it are one and the same thing. To answer the second question, with every software project, I feel that I start cleaning up the code and writing tests too late. Both really can make programming much more efficient, and so these steps should be taken early on.

4. How do you think we might encourage researchers in the MRI community to contribute more open-source code along with their research papers?

Documentation website for the MRIgeneralizedBloch.jl package, which includes interactive figures, code, and MyBinder links.

original intention was not necessarily to use the specificity that MT offers, even though that has become a big focus of my work right now. Originally, I just wanted to get rid of the confounding factor. I was looking into the literature on MT modeling and was trying to recreate the existing models for magnetization transfer during RF pulses. I just couldn't get it to work for me mathematically; I couldn't connect these models to the Bloch equation. Maybe somebody will see this interview now and will show me how it's done. But while I was struggling with that, essentially jotting down equations, I came up with the formulation that we now call the generalized Bloch model. AIt turned out that it covers all the extreme cases, and allows for the incorporation of arbitrary line shapes or FID functions. Mathematically, it all worked out very nicely, and so we tried a small NMR experiment and found that the generalized Bloch model describes the experimental data well.

MRMH: Can you explain briefly how your model differs from other existing models?

Dan: The paper sets out a number of cases, but one of them is that of a very short pulse, where you can, in principle, invert the macromolecular pool, which is something the steady-state picture doesn't allow. So, that's one way in which our model overcomes a clear limitation of previous models.

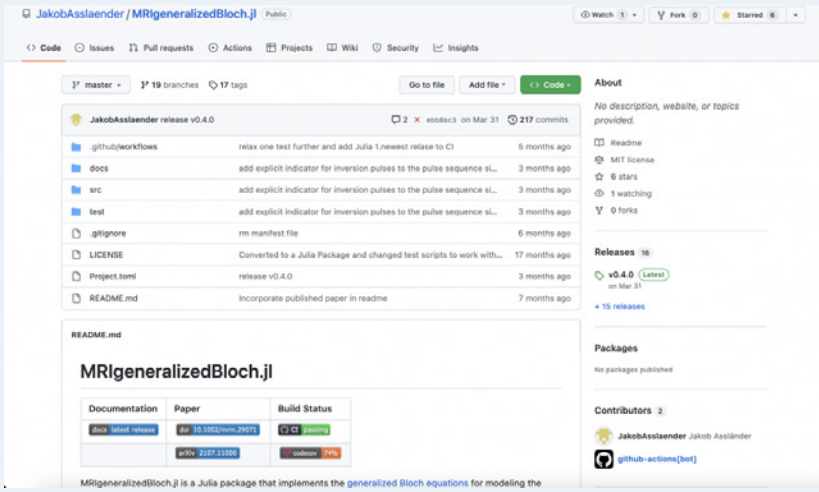
Jakob: And it's not just the steady state; all the MT models that I'm aware of essentially say that if your RF pulse gets shorter and shorter, your semi-solid pool will be saturated to zero, whereas it has actually been shown that if your RF pulse gets short enough you can invert the semi-solid pool. That is, indeed, something covered by our model.

Dan: But, on the other hand, you may not want to go towards short pulses. If you want to determine the incidental MT effect in a standard experiment, it is very nice that you can accurately describe the signal for any pulse length you happen to be using.

MRMH: Would you say there is room for further improvement of the model?
Jakob: I'm sure that other people will see limitations and possible improvements that I haven't seen. I also have a few things in mind. For example, I would be curious to examine in more depth the connection between this classical model and a quantum mechanical description. The main sources of relaxation are intra-molecular dipole-dipole interactions, which are fundamentally quantum mechanical effects. In large molecules that have, say, hundreds or thousands of protons interacting with each other according to different geometrical relations that we don't really know, quantum mechanical simulations become rather difficult. Even worse, biological tissue contains many different large molecules. In the paper, we state that one of our assumptions is that these dipole-dipole interactions are dissipative, i.e,. we assume only relaxation and neglect unitary evolutions that can lead to solid-state spin echoes and similar phenomena. We have to make this assumption to make this classical model work, and when averaging over all dipole-dipole interactions in many different large molecules, these effects likely cancel each other out, so we don't actually see them in clinical imaging. Therefore, this assumption is probably fine, but, again, I'm a curious person, and I would like to understand this a little better.

MRMH: Any limitations?
Jakob: I think the biggest limitation is experimental access to these effects. Even with zero-TE imaging, it is hard to get effective echo times that are short enough to directly observe the magnetization of the semi-solid spin pool. Therefore, we are limited to observing the semi-solid pool via exchange (or magnetization transfer) with the liquid pool. Exchange models entail many processes that happen at similar time scales. To disentangle these processes requires high SNR and low artifact levels.

MRMH: Is there anything you would like to add?
Dan: I would just say watch out for magnetization transfer. Working with Jakob has taught me that MT plays a larger role in everyday contrast than most people realize. So don't ignore it. ■



Screenshot of the GitHub repository where the code for this paper was shared, and is available here.

My experience has always been that publishing code helped me more than it hurt me. Hopefully, this blog, filled with many success stories, will help!

Questions about the specific reproducible research habit

1. Why did you choose to do your work with the Julia programming language?
That is a great question and I am very opinionated about this: I think Julia is the future of scientific computing and that we should all switch to it! It allows you to jot down an idea with the same ease as MATLAB and Python, and combines this with C-like speed, all in the same language! In addition, the ecosystem, the package manager, and available IDEs are all state-of-the-art and very thought through, making it easy to use them, easy to share code, and easy to reproduce the same environment.

2. As a way of showcasing the research from your article, you've created a beautiful website that incorporates code, interactive figures, and text. What motivated you to put in the extra effort in making it, and do you have any tips on using the tools you needed to create it?
I must say that the Julia packages Documenter.jl and Literate.jl made this a lot easier. But still, I can't deny that it takes some work to set things up and create the content. I think I was just hoping that people would find it useful, and maybe it will inspire others to replicate this approach. From a technological point of view, it is very easy to replicate: everything is open-source and published in my GitHub repository, so it is just a matter of cloning the repository and replacing the content.

3. Are there any other reproducible research habits that you didn't use for this paper but might be interested in trying in the future?
In this project I only used a very small NMR dataset, which I simply published in a GitHub repository. One day, I will have to learn how best to publish larger MRI datasets and how to deal with facial recognition from high-resolution 3D datasets. ■

Integration of an RF coil and commercial field camera for ultrahigh-field MRI

INTERVIEW BY **MATHIEU BOUDREAU**

MRM HIGHLIGHTS' PICK

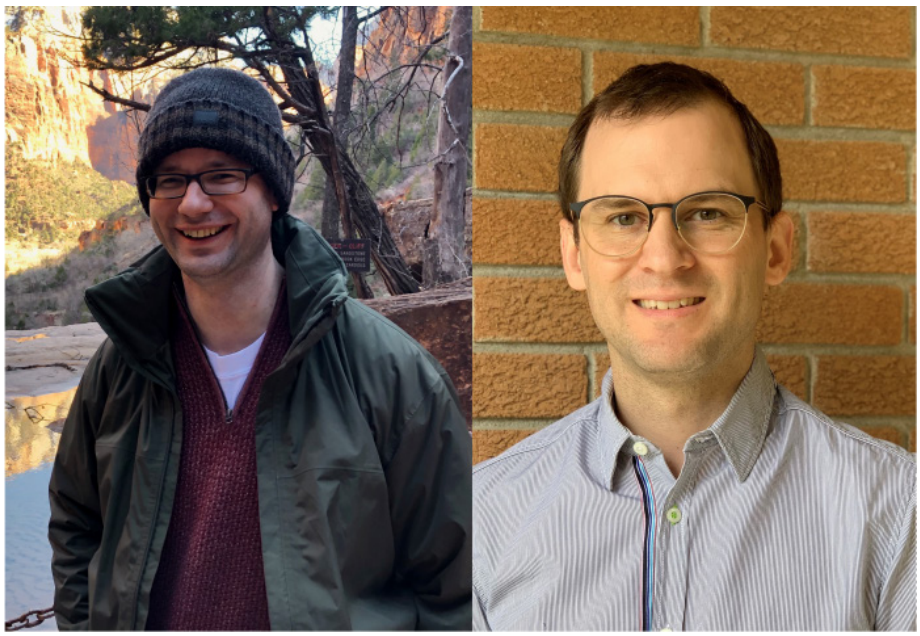
This MRM Highlights Pick interview is with **Kyle Gilbert** and **Corey Baron**, researchers at the Centre for Functional and Metabolic Mapping (CFMM) at Western University in London, Ontario. Their paper is entitled "Integration of an RF coil and commercial field camera for ultrahigh-field MRI". It was chosen because of the exemplary reproducible research practices implemented by the authors, who shared their coil design CAD file, performance files and their image reconstruction code.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM AT MRM.ISMRM.ORG

MRMH: Tell us about yourselves and how you first became interested in MR?

Kyle: I grew up in Vancouver and attended my undergrad at UBC in the Department of Physics. I came to Western in 2003 to attend graduate school and did my PhD in physics in Blaine Chronik's lab, working on MR hardware. Afterwards, I stayed in London and joined the Centre for Functional and Metabolic Mapping (CFMM) where I did a postdoc and became a research scientist, which is my current position.

Corey: I'm somewhat of a farm kid – I grew up on a farm in northern Alberta. I went to the University of Alberta (U of A) for my undergraduate degree in engineering physics. I went on to receive an MSc in Electrical Engineering where I did research involving laser physics, which was interesting. After thatI wanted to do something I felt would have more of an impact on people. So, I joined Christian Beaulieu's lab at the U of A to do a PhD working in MRI. I then did my postdoc at Stanford in Dwight Nishimura's lab. I'm now an assistant professor at Western University here in London.



Kyle Gilbert (left) and Corey Baron

MRMH: Before we jump into your paper, could you explain what a field camera is in this context and how it works?

Corey: Basically, when we do MRI scanning, there are many unwanted magnetic fields present. When you want to use more sophisticated k-space trajectories during your acquisitions, like the single-shot spiral diffusion sequence used in our paper, it's really important to know how all these extra fields are behaving due to things like eddy currents, breathing motions, etc. The purpose of the field probe system is to directly measure, in real time, all these extra fields that are normally ignored. This information is then used in the image reconstruction process to remove artifacts from these fields. As for the way this field camera works, it's composed of a series of probes connected to a dedicated spectrometer. Each probe consists of a small solenoid with a sample of fluorine inside. When a pulse sequence trigger is sent, typically just prior to the k-space readout, a simple hard pulse is applied to the fluorine samples and the free-induction decay (FID) signal from the probes is acquired. The phase of the FIDs measured by the field probes can then be used to determine field changes during the k-space readout. This process is repeated for every k-space readout in the scan, which results in characterization of field changes for the entire scan.

Gilbert, KM, Dubovan, PI, Gati, JS, Menon, RS, Baron, CA. Integration of an RF coil and commercial field camera for ultrahigh-field MRI. *Magn Reson Med*. 2022; 87: 2551– 2565. doi:10.1002/mrm.29130

https://blog.ismrm.org/2022/07/22/qa-with-kyle-gilbert-and-corey-baron/

https://blog.ismrm.org/2022/07/29/reproducible-research-insights-with-kyle-gilbert-and-corey-baron/

MRMH: Thanks! Could you give us an overview of the paper?

Kyle: Although field cameras are not very widely used right now, they are becoming increasingly popular and so there are commercial systems available. We purchased our field cameras from a company called Skope, which offers several solutions for 3T and 7T. For 7T, they offer what are called clip-on cameras, where the probes can be affixed on top of your coil. But here at Western, our 7T magnet is actually a head-only magnet, one of the few of this kind in the world. Thus we also have a head-only gradient in the bore. Because of this, we have to build all our own RF coils for our 7T system, and therefore the clip-on cameras don't fit on top of our current coils. This paper presents our solution for getting around this problem, which was to design an RF coil, integrating these field probes inside of it right from the design stage. This gave us a lot of freedom to optimize the whole system. Another main goal of this project was to improve workflow, which hopefully will encourage more users to use the system. We looked at the performance of the coil with and without the integrated field probes, and found there was very little difference overall on both sides (coil and field camera). In particular, the transmit coil performance wasn't affected much, which is really important from the perspective of Specific Absorption Rate and safety concerns at high field using parallel transmit systems. The FIDs of the field probes did have slightly shorter lifetimes because some of them are positioned in the nonlinear region of the gradients, but Corey and his graduate student Paul Dubovan have been working diligently on some correction algorithms, which have substantially improved the image quality.

MRMH: Did you expect your coil-camera setup to perform as well as it did?

Kyle: Were we surprised? I would say yes. I was surprised that we could add 16 different field probes with 16 cables in such a tight space, and that with proper positioning it would end up having very little effect on the RF transmitter and receiver – I was a little shocked by that. I was pleasantly surprised at how little it actually affected the field probes. I think at the beginning, I was more worried about the impact on the RF coils. I honestly thought the transmit field was going to be a disaster,

Reproducible Research Insights with Kyle Gilbert and Corey Baron

General questions

1. Why did you choose to share your code/data?

Over the last handful of years, we have been putting nearly all our published coil designs, code, and manuscript data online. We feel that this accelerates scientific development, and we have benefitted from public data/code posted by others and would like to give back to the MRI community. We also believe sharing our code/data is important for accountability when using public funds for research.

2. What is your lab or institutional policy on sharing research code and data?

While we have no set policy, we try to make as much of the pertinent data/code publicly available as is feasible. We typically place code in publicly shared git repositories and data in public repositories such as OSF (that can be referenced with a DOI). We have also started to post most articles as preprints to allow others to read about our research sooner and ensure it is not behind a paywall. All of the CFMM's open-source hardware and software projects are listed on the CFMM website: https://cfmm.uwo.ca/resources/open_source_projects/index.html. Our in-house software for expanded encoding model iterative reconstructions is located at https://zenodo.org/record/4495477#.YsRy2OzMLDI and https://gitlab.com/cfmm/matlab/matmri.

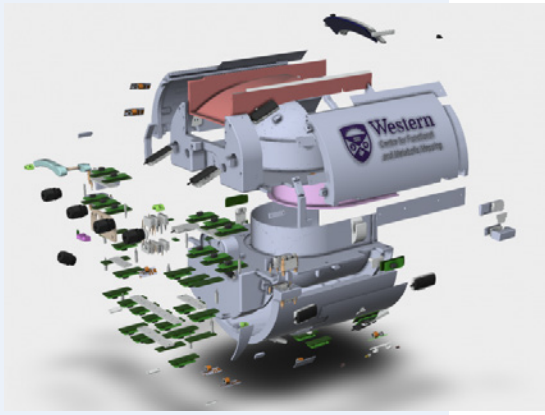
3. At what stage did you decide to share your files/data? Is there anything you wish you had known or done sooner, prior to submitting your manuscript to the journal?

We begin projects under the assumption that all data (CAD drawings, imaging data, software pipelines) will be made publicly available. Knowing from the beginning that there will be public accountability helps to motivate good practices in organizing/commenting data and code.

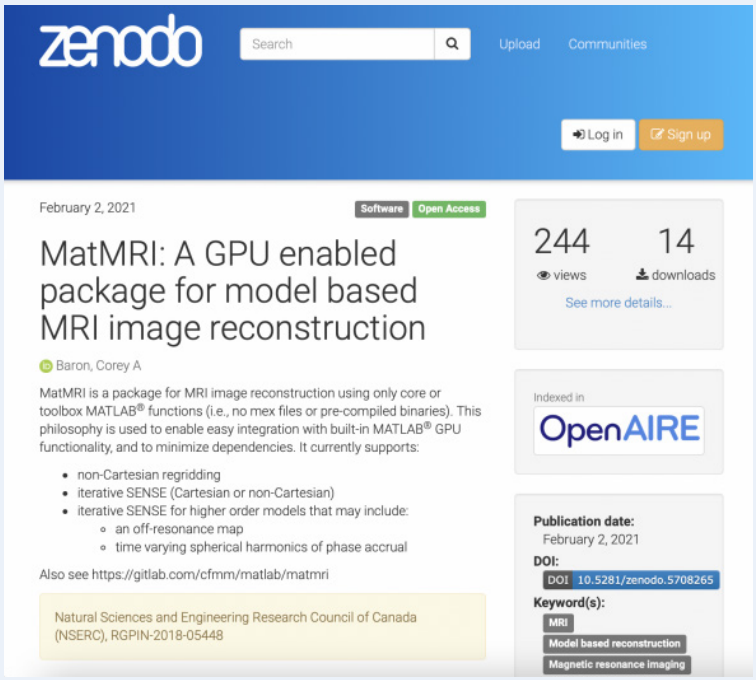
4. How do you think we might encourage researchers in the MRI community to contribute more open-source content along with their research papers?

We believe the expectation should come from funding sources, which is what we are already beginning to see with open access publishing. Also, journals could more strongly mandate the inclusion of data and code with publications, as opposed to just encouraging it. We also need to see a bit of a culture shift — a movement away from competitive mindsets and the focus on glamorous journals, to greater focus on collaboration and making science accessible both between researchers and to the public. While shifting the culture is not an easy task, improving awareness through focused sessions at conferences, workshops, and publications like MRM Highlights can help to convince the next generations of scientists of the benefits of open science.

continued



A view of the CAD file of the coil setup shared with this article. It is downloadable here along with the performance files.



Screenshot of the Zenodo repository for the reconstruction code shared with this article, available here.

Questions about the specific reproducible research habit

1. What are CAD files, and why was it a priority for you to share the CAD file of your coil setup along with your paper?

CAD files are computer-aided design files, which are 3D drawings (renderings). In our case, they are the 3D drawings of the coil housing and most of the constituent components. With 3D printing becoming commonplace, CAD drawings can now be used to easily reproduce parts. Even if other coil designers do not use them directly, hopefully our CAD drawings might give them ideas to develop that improve upon our work, for the benefit of the entire MRI community.

2. What advice do you have for people who would like to share sufficient details and open-source content about their MR hardware to make them replicable?

I would suggest sharing as much detail as you possibly can, including CAD files, EM simulation files, circuit schematics, bill of materials with product numbers, and tips and tricks that may not have made it into a manuscript, and to make them all easily found. Software analysis tools and pipelines are also key. While the raw data is helpful, oftentimes the post-processing tools are also needed in order to fully reproduce research.

3. Are you aware of any community resources or websites focused on open-source MRI hardware tools and content?

A great resource that encourages submissions of open-source hardware is https://www.opensourceimaging.org/. ■

that we would have a very difficult time trying to get a uniform transmit field after integrating so many peripheral devices inside the transmit coil. Luckily, I was wrong on that, and the setup performed beyond my expectations.

Corey: I was also pleasantly surprised, but not for the same reasons as Kyle. Because the linear region of the gradients is only a 20-centimeter diameter region around the isocenter, some of the field probes had to be placed outside that region; some of them were up to 12 centimeters away from the isocenter – right on the edge of where the linear region transitions to non-linear. But when you perform the fits for the field changes that we've now developed, even though the probes are in fact in that nonlinear region, you can still reconstruct the k-space trajectory and eddy current dynamics accurately.

MRMH: You shared some code, coil performance files, and a CAD file for your hardware design with your paper. What were your intentions in sharing these with the MRI community?

Corey: Overall, whenever possible we tried to put our material online for others to use. The software that Paul and I developed that performs custom image reconstructions using the field probe data is publically available, for example.

Kyle: For a few years now, I would say, we have been making a concerted effort to make our work publicly available, as much as we possibly can. I think that encourages reproducibility. And also, because we're publicly funded, we feel we should give back as much as we can. As for the CAD file, I know that readers are not going to take a CAD design and just replicate the RF coil directly – and I wouldn't expect them to do that. After all, as engineers, we're all curious and typically want to do better than previous work that's available. So, I expect RF engineers will want to look at my CAD file and say, "Okay, these are the things that I'm going to use, and these are the things that I'm going to change". I'm hoping that it will give other people ideas and help them move forward with their own designs.

MRMH: Have you yourself ever used somebody else's CAD design for a coil in this way?

Kyle: Absolutely. I love looking at other designs and reading papers by other coil designers, to see what their designs are like, and when it comes to designing coils, my ideas are often a conglomeration of ideas from other people. There's no need to be doing everything from scratch. There are a lot of brilliant people out there, so you might as well tap into their ideas. ■

VESPA ASL: VElocity and SPAtially Selective Arterial Spin Labeling

BY **MATHIEU BOUDREAU**

MRM HIGHLIGHTS' PICK

This MRM Highlights Pick interview is with **Joseph Woods** and **Divya Bolar**, researchers at the University of California San Diego (UCSD). Their paper is entitled "VESPA ASL: VElocity and SPAtially Selective Arterial Spin Labeling". It was chosen because of the exemplary reproducible research practices implemented by the authors, who shared their data, simulation code, and analysis code on Zenodo.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM AT MRM.ISMRM.ORG

MRMH: To start off, please tell us a bit about yourselves and your backgrounds.

Joseph: I did my undergraduate degree at Southampton University in the UK, where I studied maths and physics. I got into MR research almost accidentally – after my undergrad, I was looking at different potential research paths like photonics, microscopy, and MRI. I came across a DPhil (PhD) course at Oxford that was still open. I submitted an application and they very kindly took a chance on me, given that I had no biomedical imaging experience of any sort. After my DPhil at Oxford, I went to work with Div and Eric Wong at UCSD. And now I'm back at Oxford.

Divya: I was a biomedical and electrical engineering undergrad at Johns Hopkins, and in my last year I took a class called Magnetic Resonance in Medicine taught by Elliot McVeigh, an MRI guru and pioneer of cardiac imaging. I was blown away by the course. The physics behind MRI fascinated me – how spinning protons could create an image of the human body – and I was immediately hooked. I graduated soon after and knew two things for sure: one, that I wanted to study MRI, and, two, that I wanted to move to California. I searched up and down the California coast and ended up working with Professor Paul Friedman at UCSD on cardiopulmonary MRI. Serendipitously, I shared lab space with Eric Wong, Rick Buxton, and Tom Liu, who were always talking about this arterial spin labeling technique – little did I know that they were world experts in the field! I knew almost nothing about ASL, but remember saying to Dr. Friedman, "Hey, there are these researchers using ASL to image perfusion in the brain, maybe we could use it in the lung?" So, pulmonary ASL became my main project and the rest, so to speak, is history.

Joseph (left) gardening and Divya (right) with his two boys.

MRMH: Before we dive into your paper, could you give us a brief overview on the difference between spatially selective and velocity-selective ASL?

Joseph: Sure – they are two main categories of ASL. Spatially selective ASL typically labels blood outside of the brain, in the neck, using a spatially selective inversion pulse. The blood then flows into the brain and we acquire an image after a specific time delay. Widely-used spatially selective ASL techniques include pulsed ASL and pseudo-continuous ASL (PCASL). In contrast, velocity-selective ASL labels blood everywhere in the brain based on a pre-specified velocity profile, so that things that are moving very

Woods, JG, Wong, EC, Boyd, EC, Bolar, DS. VESPA ASL: VElocity and SPAtially Selective Arterial Spin Labeling. *Magn Reson Med.* 2022; 87: 2667– 2684. doi:10.1002/mrm.29159

https://blog.ismrm.org/2022/09/02/qa-with-joseph-woods-and-divya-bolar/

https://blog.ismrm.org/2022/09/09/reproducible-research-insights-with-joseph-woods-and-divya-bolar/

Reproducible Research Insights with Joseph Woods and Divya Bolar

General questions

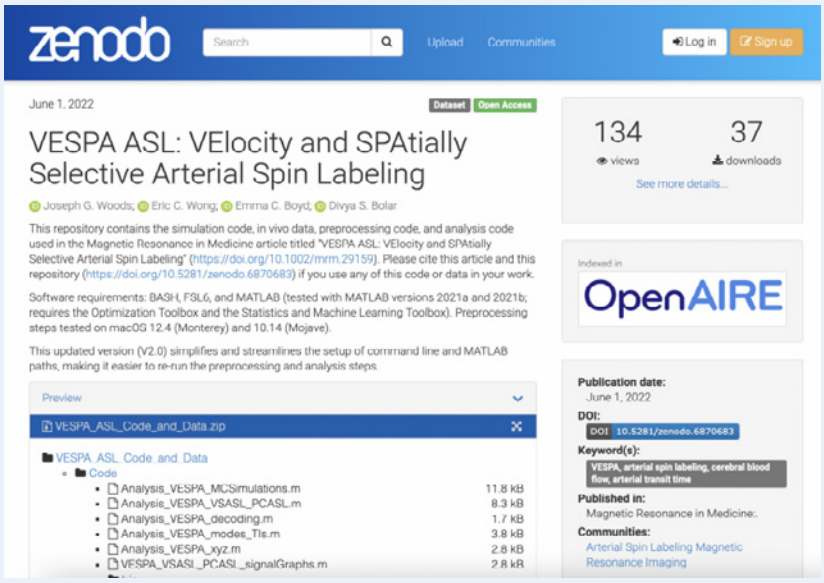
1. Why did you choose to share your code/data?

JGW: I chose to share our code and data for three reasons. One was to allow readers of our paper to check the validity of the results we present, should they wish to do so. This transparency can only improve the trust people have in our results and it is sometimes an option I wish I had with other papers I read. The second reason is so that readers can run further analyses on the data. There may be a question someone has that we didn't answer, or they may want to explore a novel question unrelated to the main aims of our paper. Freely sharing the data enables them to do this and could potentially lead to novel ideas which benefit us all. The third reason for sharing was in case anyone might find the code I wrote for the project useful. This thought is partly inspired by researchers like Brian Hargreaves who has made lots of useful code available from various projects, from which I have learnt a lot. There are very few reasons I can think of not to share code, whereas sharing data can be trickier, because of privacy concerns.

DSB: I concur with all Joe's points – Dr. Hargreaves' code in particular (both his Bloch simulator and his spiral code) has been so useful for my own work in the past. I would also emphasize the importance of sharing MR pulse sequences themselves; if the ultimate goal is to translate innovative MR technology to the clinic, it first needs to be rigorously vetted by a broad user base beyond just a few institutions.

2. What is your lab or institutional policy on sharing research code and data?

JGW: As far as I'm aware, the University of California San Diego encourages the sharing of code and data but doesn't require it. We didn't have any funder requirements for this work.



The Zenodo repository where the authors shared their VESPA ASL code and data. The DOI for this supplementary material is doi:10.5281/zenodo.5817354.

Joseph and his partner.

slowly don't get labeled, whereas things that are moving above some threshold (like blood) do. The labeled blood then flows into the tissue and we acquire an image.

MRMH: Thanks! Can you give us an overview of your paper?

Joseph: The aim of this paper was to combine these two categories of ASL into a single technique so that we can leverage the benefits of both. In other research published a few years ago, Div found that acquiring both velocity-selective and spatially selective ASL images is useful, because while the velocity-selective images would give you a measurement of tissue perfusion that is not sensitive to transit time, spatially selective ASL is able to provide information about the transit time, which can be long in cardiovascular diseases. So, we worked towards combining the two into a single scan using an efficient technique called Hadamard encoding, that doesn't require extra scan time, and we called this technique VESPA. We can use the images to get a quantitative estimate of the true tissue perfusion, and also a quan-

titative measure of the transit time.

Divya: I'd just add that back when we were doing ASL in subjects with moyamoya disease at Boston Children's Hospital, we found that PCASL and pulsed ASL approaches failed to provide accurate perfusion since these patients have pathologically narrowed arteries that result in long transit times. The CBF images would look totally wonky even in asymptomatic patients; there would be huge perfusion deficits, yet we knew that the brain was getting adequately perfused based on conventional angiography findings and lack of acute neurologic symptoms. We decided to use the VSASL technique to circumvent the transit delay – it worked like a charm and gave us accurate perfusion. But looking back at the pulsed ASL data, we were like, "Wow, there's a lot of useful information here!" We could visualize the volume of at-risk tissue and the collateral pathways maintaining flow to this tissue. Acquiring images with both techniques provided complementary information and gave us a more complete picture of these patients' cerebral circulation. The idea for combining PCASL and VSASL came to mind soon after, though actually taking VESPA from concept to reality is really a testament to Joe's creativity, tenacity, and hard work – he hit it out of the park!

Joseph: It was very much a team effort with lots of exchanges. I'm really grateful for Eric and Emma's contributions, and for the conversations with Div.

MRMH: Is VESPA ASL aimed only at certain applications, or should everyone that does either spatial or velocity-based ASL be using it moving forward?

Joseph: Div can speak about the clinical uses much better than me, but I would say that there are some caveats to consider when deciding if you should be using VESPA. In the current implementation, when transit times are in a normal range, you take a little bit of a hit in terms of SNR compared with something like multi-delay PCASL, but there are some things we're developing to address that SNR loss.

Divya: I'll take a bolder stance than Joe and say, yes, this is what everybody should be using, and let me tell you why! Joe does

3. At what stage did you decide to share your code/data? Is there anything you wish you had known or done sooner?

JGW: From my perspective, I have always intended to share as much as possible, while respecting volunteer privacy and institutional policies. When I published my first paper four years ago, I shared the data and code to generate the figures in the paper and I've tried to share more each time, as well as improving the setup, quality and documentation of the code. It's a continual learning curve to improve your own process, but taking the time to comment your code while you're writing it definitely reduces the workload later! I think that starting off with the intention of releasing your code provides a very good incentive to do things carefully and reproducibly.

DSB: One thing I have learned is the importance of verifying that shared software runs as expected on as many different platforms as possible. Our goal is that code should run on a variety of different systems without modification. If the user has to modify scripts, MATLAB .m files, etc. they may be less enthusiastic to use the software. We have now successfully tested the code on several systems to ensure compatibility.

4. How do you think we might encourage researchers in the MRI community to contribute more open-source content along with their research papers?

JGW: Initiatives like MRM Highlights, which showcases people's efforts to share content, will hopefully encourage others to do the same! Funder and journal requirements are helping, but it will probably need to become clearly beneficial or essential for researchers' careers to convince many people to put in the effort.

DSB: Practical workshops at ISMRM and other meetings also provide incentive for content sharing; at a Member Initiated Training (MIT) session at this past ISMRM, Joe walked a room of a hundred people through code to generate velocity-selective ASL pulses (he really is a champion of open source!); not only did this benefit the participants, it also provided Joe with well-deserved exposure as an expert in the field.

Questions about the specific reproducible research habit

1. Why did you choose Zenodo to host your article's code and data?

JGW: It was a case of habit more than anything. Zenodo is a prominent and easy to use repository that I came across four years ago when submitting my first paper and I've now uploaded four datasets to it. A DOI is provided for every submission on the website, making it easy for others to cite the repository if they use the code or data (I'm still waiting for my first citation from that though!). I was also reassured that it was linked to CERN and so would likely be around for a long time.

2. What considerations went into ensuring that the code and data you shared can be used, maintained and/or improved in the long term (on the user or the developer side)?

JGW: In terms of writing code, I generally try to comment it well and make it easy to understand. How successful I am at this is for others to judge! In terms of ensuring that it could be used by others, we did various tests to check that the analysis code could be successfully rerun on other computers with minimal setup efforts beyond installing the required external software. The main obstacle to using our code is that it uses MATLAB, which not everyone has access to.

3. What practical advice do you have for people who would like to write code that creates reproducible figures to be shared along with their paper?

continued

JGW: Make the code as easy to understand as possible and get other people to test it (and follow good programming practices)!

4. Are there any other reproducible research habits that you didn't use for this paper but might be interested in trying in the future?

JGW: I have definitely started to think about how I can make my code more widely accessible in the future and this might include switching to an alternative programming language like Python and using a platform like Docker to streamline the setup process. It would be terrific if, in the future, we could open any paper online and simply click a link to take us to the data and analysis/simulation code which could be easily rerun or reused. ■

Divya with his family.

make a good point, namely that because velocity-selective ASL uses saturation rather than inversion, there is an inherent SNR penalty. However, a lot of the newer approaches actually implement a velocity-selective inversion to get some of that signal back. Furthermore, if you're just doing PCASL, you're missing out on potential signal from blood immediately delivered to the microvasculature. By adding the velocity-selective labeling scheme, you get immediate delivery of the VSASL label, plus the delayed, high-signal PCASL label that follows. In a sense, you're getting the best of both worlds. From a clinical standpoint, I would argue, because there are so many diseases in which there are changes or delays in arterial transit, such as stroke, carotid stenosis, and moyamoya disease, etc., having VESPA provide both accurate CBF and transit time information is invaluable. Even in patients without known steno-occlusive disease, there can be considerable arterial transit heterogeneity and delay, particularly as patients age. VESPA has the potential to provide more accurate CBF in these cases as well – and then of course, you get the cherry on the top, which is the arterial transit time map.

MRMH: To finish off, what do you enjoy doing when you're not in the lab?

Divya: I've got two small boys, a three year old and a one year old, so even though it sounds cliché, I do spend most of my time chasing them around! Before having children, I would say my main hobby was music: playing the guitar and going to live concerts. I've been to hundreds of live shows, and I hope to do a little bit more of that as COVID subsides.

MRMH: Is there any one show that stands out in your mind from all the ones you've seen?

Divya: I'm a big Phish fan, so maybe one of their New Year's shows would figure among my all-time great experiences.

MRMH: What about you, Joe?

Joseph: My partner and I got an allotment this year. We rent a bit of land and grow vegetables on it, so I've been spending a lot of time doing that. I also enjoy running and cycling, and hiking/backpacking. ■

Correcting inter-scan motion artifacts in quantitative R1 mapping at 7T

INTERVIEW BY **MATHIEU BOUDREAU** AND **NADIA BLOSTEIN**

MRM HIGHLIGHTS' PICK

This MRM Highlights Pick interview is with **Yaël Balbastre** and **Martina F. Callaghan**, researchers at the Wellcome Centre for Human Neuroimaging at UCL in London. Their paper is entitled "Correcting inter-scan motion artifacts in quantitative R1 mapping at 7T". Their article was chosen as this month's Highlights pick because it demonstrated exemplary reproducible research practices; in particular, they shared their code and integrated it into an open-source toolbox (hMRI), as well as shared scripts that reproduces all their simulation figures.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM AT MRM.ISMRM.ORG

MRMH: Could you tell us about yourselves and how you got into MR?

Yaël: I'm not an MR physicist by training, I studied computer science in France. While I was doing my PhD there, I worked on MR image segmentation in a preclinical imaging context; after that, I moved to London for a postdoc where I worked with John Ashburner and Martina. Martina was the one who somewhat dragged me into the MR physics side [chuckles], and I found it really cool to see how everything works in the image acquisition process. Now I'm currently in Boston working at the Martinos Center.

Martina: As for me, I first became aware of MRI as a technique when I was studying physics in Ireland, and thought it was just super cool. I knew I wanted to study it for my PhD, and that took me to London where I worked in Jo Hanjal's lab in Hammersmith Hospital at Imperial College. After my postdoc there I left MRI for a while, but came back into it about 10 years ago, when I joined the Department of Imaging Neuroscience that hosts the Wellcome Center for Human Neuroimaging. I really enjoy the work environment here, as I get to meet people coming from different backgrounds in computer science and cognitive and computational neuroscience; it's very diverse.

Yaël Balbastre and Martina F. Callaghan

MRMH: Before jumping into the paper, could you give us a brief explanation of the receive B1 field (B1-) and the transmit B1 field (B1+)?

Yaël: Sure, so the receive field is non-uniform because the sensitivity of the coil elements, used to measure the MR signal, changes according to how far away the source tissue is; the farther you are from the coil elements, the lower the signal will be. When the image is reconstructed, this will show up as darker areas and brighter areas, which represent purely multiplicative signal changes. It is actually the transmit field that rotates the bulk magnetization out of alignment with the main magnetic field, which will then precess and generate a signal in our receiver coils. The longer the transmit field is turned on, the larger the flip will be, and this will, typically, result in a larger signal. But this transmit field is also going to vary proportionally to the distance from the tissue, so you will get different flip angles in different locations in the volume. However, the transmit field has a multiplicative effect on the flip angle, and this will change the signal differently depending on the pulse sequences.

Martina: I'd just like to add that a fundamental assumption in many quantitative MRI techniques is that the receive field variations just cancel each other out. But a few years

Balbastre, Y, Aghaeifar, A, Corbin, N, Brudfors, M, Ashburner, J, Callaghan, MF. Correcting inter-scan motion artifacts in quantitative R1 mapping at 7T. Magn Reson Med. 2022; 88: 280- 291. doi:10.1002/mrm.29216

https://blog.ismrm.org/2022/12/02/qa-with-yael-balbastre-and-martina-f-callaghan/

https://blog.ismrm.org/2022/12/13/reproducible-research-insights-with-yael-balbastre-and-martina-f-callaghan/

Reproducible Research Insights with Yaël Balbastre and Martina F. Callaghan

General questions

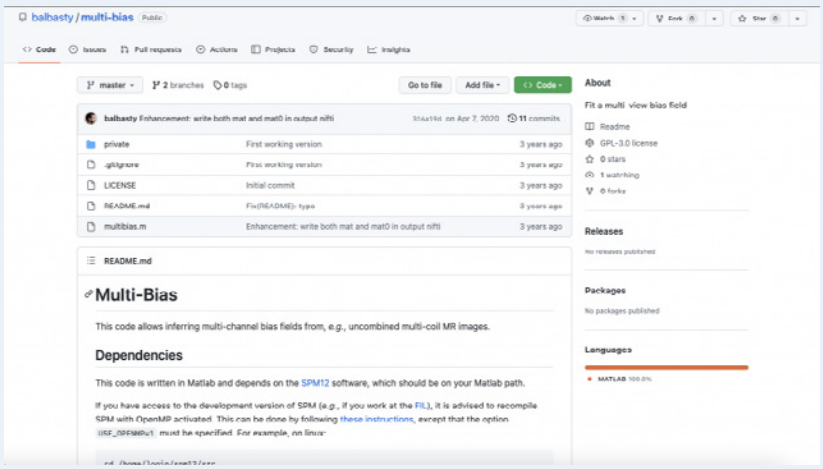
1. Why did you choose to share your code/data?
To help others to use the methods we were reporting and to recreate our results as simply as possible.

2. What is your lab or institutional policy on sharing research code and data?
We are hugely committed to open science. The Statistical Parametric Mapping (SPM) neuroimaging analysis package created and developed in our department (UCL's Imaging Neuroscience Department / The FIL / The Wellcome Centre for Human Neuroimaging) has been available to the community as open source with a GNU General Public License since the nineties. Following in this tradition, we always seek to make other code we create as open and accessible as possible, and that includes the hMRI toolbox, which is a plugin for SPM.

While we do also share data, this can be trickier because of the need to respect anonymity/data protection regulations (mostly structural images), and/or because of the complexity of paradigms (functional images).

3. At what stage did you decide to share your code/data? Is there anything you wish you had known or done sooner?
The code for the main methodology was developed on GitHub in a public repository. Actually, this repository was public before the paper was even written. The sharing of the simulation code was motivated by the valuable revision process at MRM, and this code was made available on a separate GitHub repository that we use for isolated code snippets/simulations associated with our papers.

4. How do you think we might encourage researchers in the MRI community to contribute more open-source content along with their research papers? Initiatives like this, highlighting the practice, will hopefully make people think more about sharing, as might explicitly requesting sharing as part of the submission process.



The GitHub repository where the authors shared their multi-channel bias reconstruction code.

ago, we realised that this assumption is violated if the patient moves between measurements; this type of motion resulted in low reproducibility in our R1 maps.

MRMH: Could you expand on that? In quantitative MRI, even if the patient moves between measurements, why doesn't image registration result in the receive fields "cancelling each other out" in any case?
Martina: I think the fundamental point is that, although the person has moved, the coils themselves are static. In other words, since the tissues are at different distances from the coils in the two positions, the receive field will be modulated differently, and image registration can't correct this difference in the images.

MRMH: Could give us a brief overview of the paper?
Yaël: The paper is concerned with inter-scan motion in quantitative MRI, where you have to acquire multiple scans with different parameters. For the R1 mapping technique we were interested in, just two acquisitions are needed. As Martina said, this type of motion will lead to different receive field modulations between the two positions. In a previous paper, Martina suggested how these modulations might be corrected at 3T by using the body coil, but at 7T this isn't possible because there is no body coil, so our aim with this application was to build on her previous work. We figured out that if the relative field between the two positions is known, you don't need to actually measure both receiver fields to correct for them sufficiently for qMRI. So, the main point of the paper is that you can correct for these modulation changes in qMRI by acquiring rapid images before your main scans only from the array coil, in order to estimate the relative sensitivity between two positions. We also found that while the transmit field is "flat" enough to do this simple relative receive field estimation at 3T, at 7T this is not true, so we improved on our understanding of the correction for this case.
Martina: Yes, the transmit field changes at ultra-high fields impact the calibration data themselves, which then become transmit field sensitive. And that was the part that we explored with our simulations.

Although our correction works well, we still have more to do in order to address this transmit field issue.

MRMH: What prompted your decision to share code and data with your paper?
Yaël: We always try to share code when we can, and since the hMRI toolbox we used for R1 processing is open-source, it made sense to share it there too. As for the simulations, that was all Martina's doing.
Martina: It's also important to note that the institute where I am working, and where Yaël was at the time of the study, is the home of SPM. And so, we've been surrounded by the whole open-source ethos that was adopted here since the 90s, that is, since before open science was really a thing. With the hMRI toolbox, too, the idea was to make it all available. More recently, we've tried to do the same for simulations used in our papers and make them available as well. It's beneficial because if somebody wants to really learn how you did something, this really makes it easier for them to understand your work. From my perspective, I started doing research when none of these tools like GitHub existed, so I've really benefited from the trainees joining the lab, and those that are part of the hMRI development consortium, showing us what's new and can potentially boost the impact and reproducibility of our research.

MRMH: To finish off, what do you enjoy doing when you're not in the lab?
Martina: Well, I loved it when Yaël was here, because Yaël, Nadège (she's also a co-author on the paper) and I would play board games and card games a lot. Those two were really into puzzles, and it was just lovely to see how they would never be put off trying to figure out whatever the problem was, and I could then see them applying that same approach to their work. I also really love going to gigs as well; the last one I went to was Metronomy, who were playing in London during ISMRM.
Yaël: At the moment, I'm just trying to make the most of being in the US. So, I've been visiting a lot of parks and such. Last weekend I went for a two-hour drive to go leaf peeping, because the Fall is beautiful here; everything is red, yellow, or orange. ■

It may be that the more people benefit from open-source content, the more they will consider sharing. Ensuring that code is recognized as an important scientific output also from the perspective of career advancement is also very important, and might help us to move away from the publication-driven mentality.

Questions about promoting reproducible research habits

hMRI group logo. Their GitHub organization can be found here: https://github.com/hMRI-group

1. What advice do you have for people who would like to contribute to established software projects like the hMRI toolbox?
We would be very happy for people to contribute. We are a small team but have regular monthly meetings where we try to make the toolbox more modular and, by incorporating unit tests and also providing templates for new users to use, easier to contribute to. A publicly available data set also allows people to test that they don't break functionality and allows us to perform integration testing. We review pull requests at our monthly meetings, so you may sometimes have to wait a little bit for a response — please be patient with us!

However, thanks to funding from the Max Planck Society, we are now recruiting someone to work specifically on the toolbox, which will help to accelerate our efforts considerably. If you are an experienced MATLAB software developer and would be interested in joining us, please see our advert here.

2. What considerations went into ensuring that the code and data you shared can be used, maintained and/or improved in the long term (on the user and/or the developer side)?
For the hMRI toolbox, we have a mailing list to provide support to users. Developers can contribute via GitHub. Anyone is welcome to raise issues — letting us know about problems they encounter or enhancements they would like to see implemented.

3. What practical advice do you have for people who would like to write code that creates reproducible figures to be shared along with their paper (as you did with your simulations)?
Make sure that someone else tests them so you know they can work on different systems. This will also tell if you have inadvertently included any hard links/local dependencies/confusing documentation.

4. Are there any other reproducible research habits that you didn't use for this paper but might be interested in trying in the future?
In my team, we are not formally trained in software engineering, and so effectively we are "learning on the job". We benefit greatly from being part of the hMRI toolbox development consortium and from large scale open-source initiatives like Gadgetron. We learn a lot by collaborating with people who really do know about software development, and we try to adopt good habits all the time — unit testing, code repositories, Docker containers, etc. We will try to keep on learning and improving our practices! ■

Vendor-neutral sequences and fully transparent workflows improve inter-vendor reproducibility of quantitative MRI

MRM HIGHLIGHTS' PICK

This MRM Highlights Pick interview is with **Agah Karakuzu** and **Nikola Stikov**, researchers at the NeuroPoly lab at Polytechnique Montreal. Their paper is entitled "Vendor-neutral sequences and fully transparent workflows improve inter-vendor reproducibility of quantitative MRI". Their article was chosen as this month's Highlights pick because it demonstrated exemplary reproducible research practices; specifically, they shared open-source pulse sequences, a Docker image, BIDS-compliant data, and a beautiful interactive Jupyter Book.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM AT MRM.ISMRM.ORG

Nikola (left) and Agah (right) recreating "The Creation" at an evening event in Glasgow.

MRMH: Could you briefly tell us about your backgrounds and how you got into the field of MRI?

Agah: I studied biomedical engineering for my undergraduate degree in Turkey, and at that time it was really difficult to get my hands on any kind of MR images online. I had to jump through a lot of hoops to find some, but when I did, I managed to write MATLAB code to segment MS lesions on FLAIR images for my undergraduate dissertation. I presented that work at the Turkish Society of Magnetic Resonance conference in Ankara in 2012. I followed that up with an MSc at Bogazici University where I developed a multimodal MRI method for in vivo musculoskeletal mechanics. This led to another poster presentation, this time at the 2014 MR Balkan conference, which was organized by Nikola. Little did I know that that poster would be my ticket to Canada, where I did my PhD with Nikola and with whom I am currently doing a post-doc as well. My focus and passion since arriving in Montreal has been tackling the problem of reproducibility in qMRI research, from scanner to publication. The work presented in this article reflects this passion.

Nikola: I've also been in the field of MRI for quite a while. I started with my undergraduate at Stanford, and stayed there for a master's. During that time, I got to meet John Pauly, who became my PhD supervisor. It was towards the end of my PhD that I decided to organize a conference for MRI researchers in the Balkans. We organized the first two meetings in Macedonia (2008 and 2011), and then the third one was in Turkey in 2014, which is where I met Agah. Two years later he joined my lab, and since then we have been working together. And as Al Macovski (the PhD advisor of my PhD advisor) once said, you just need to find good students and then get out of their way. When you get out of Agah's way he accomplishes a lot, so I'm very happy that he's still with me getting things done in the lab.

MRMH: Could you share the story behind this paper, and tell us how the idea evolved?

Agah: The story begins with qMRLab, which is an open-source toolbox for quantitative MRI analysis and simulation. During my second year of involvement with qMRLab, we brought it into the cloud so that it could be integrated into any data processing

Karakuzu, A, Biswas, L, Cohen-Adad, J, Stikov, N. Vendor-neutral sequences and fully transparent workflows improve inter-vendor reproducibility of quantitative MRI. *Magn Reson Med.* 2022; 88(3): 1212- 1228. doi:10.1002/mrm.29292

https://blog.ismrm.org/2023/03/10/qa-with-agah-karakuzu-and-nikola-stikov/
https://blog.ismrm.org/2023/03/17/reproducible-research-insights-with-agah-karakuzu/

workflow. This development got me excited about the idea of trying various projects at hackathons in Canada and Europe, such as the Brainhack in Montreal, and OpenMRI in the Benelux countries.

It was during these hackathons that I realized that there is no common data standard that would make it possible to perform comparative quantitative MRI studies. So, I started working on qMRI BIDS (BEP001), a BIDS (brain imaging data structure) extension proposal. It took many years to get a consensus for it, but now it is in active use and facilitates the sharing of quantitative MRI data, and it also enables multiple software packages, developed in different languages, to use the same input-output conventions for easier data workflow development.

Later, I wanted to find more ways to make publications reproducible, but one problem we encountered was that we didn't know where to publish these reproducible research objects. This led to the creation of another project that I became an active developer on. It is called NeuroLibre, and it is an initiative of the Canadian Open Neuroscience Platform (CONP). My idea was to create a scanner to publication platform, but in this case, the missing component was the acquisition step, so for that we turned to the RTHawk real-time imaging system. My hypothesis was that if we could standardize the pulse sequences across vendors before the measurement stage, we could get rid of the variability sources that are not easy to identify. On this basis, I developed a vendor-neutral 3D SPGR sequence and magnetization transfer preparation block to acquire T1, MTR, and MTsat maps. And then I connected these ad hoc applications with qMRLab and other software packages using qMRI-BIDS. And that's how the VENUS workflows came to existence.

Nikola: I think this article touches on a central theme of the work that we do in the lab, which stems from our recognition that there are problems with quantitative MRI, and MRI in general. The solutions we've focused on developing are related to standards, workflows, sharing code, and making it easier for people to reuse openly available tools. What the VENUS project does is bring quantitative MRI under one umbrella. That is, it makes it possible to open up the scanner, deploy an open-source sequence on that

Reproducible Research Insights with Agah Karakuzu

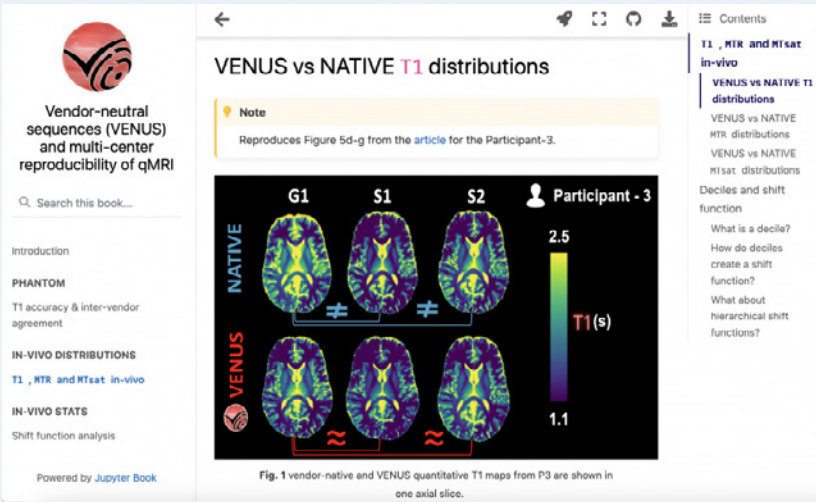
General questions

1. Why did you choose to share your code/data?
While standardizing acquisitions using vendor-neutral pulse sequences is an important step towards addressing the multi-center reproducibility problem, it only tackles a portion of the issue. To achieve comprehensive reproducibility, it is also necessary to establish a unified downstream processing pipeline. This is why, in our article, we emphasized the importance of sharing both the code and the data alongside our findings.

2. What is your lab or institutional policy on sharing research code and data?
At NeuroPoly, open-source is an important priority, and we strive to extend this beyond just developing software packages. As long as we have permission from the IRB, we make it our standard practice to share both code and data alongside our articles.

3. At what stage did you decide to share your code/data? Is there anything you wish you had known or done sooner?
This study is rooted in our commitment to sharing code and data from scanner to publication. This decision was made before we even began our work, and we have upheld this principle throughout the study. As we versioned these materials in their respective repositories, I believe there is nothing I wish we had done earlier in this context.

4. How do you think we might encourage researchers in the MRI community to contribute more open-source content along with their research papers?
An effective strategy could be to offer incentives to encourage researchers to contribute their work to MR-Pub. For example, they could be offered a discount on conference registration fees, free access to specific events or resources, or any other rewards designed to recognise the extra effort required to share their work. Over time, this could become a fundamental aspect of the publishing process, rather than an additional effort, and garner wider recognition as such.



The Jupyter Book for the project that also showcases reproducible and interactive figures.

continued

Questions about the specific reproducible research habit

1. What advice do you have for people who would like to develop and share open-source pulse sequences?

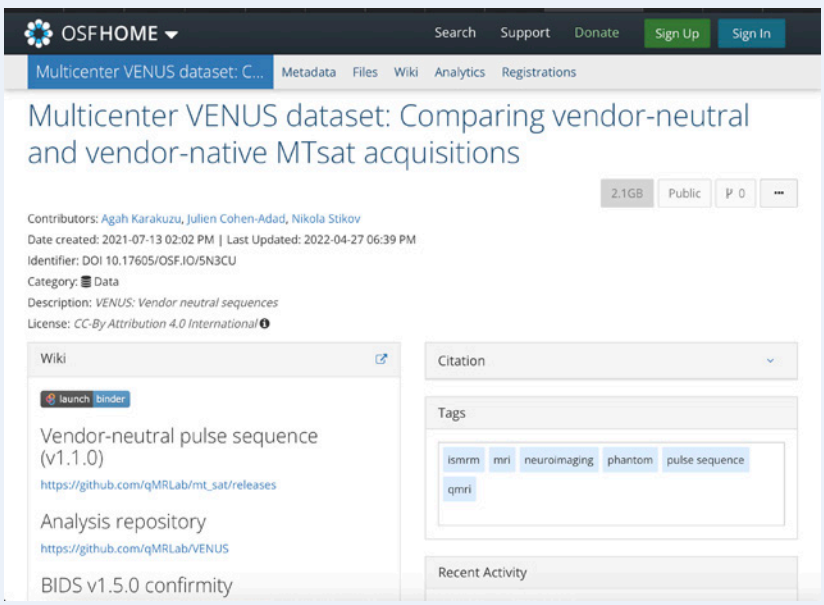
I strongly recommend prioritizing the creation of comprehensive documentation for the development process. The final version of a project may not reflect the challenges and issues that arose during its creation. While many of the solutions to such problems may not be relevant to an article's content, documenting them can help other developers understand why certain implementation and setting choices were made. This can ultimately benefit the development community and promote more efficient and effective problem-solving in future projects.

Caption ...

2. Can you share some resources to help others get started using VENUS and RTHawk?

A good starting point would be https://qmrlab.org/VENUS, where users can find the necessary resources to test and simulate gradient/RF waveforms using SpinBench. However, for those interested in developing an RTHawk application, it is important to note that the software development kit is part of a proprietary product. Thus, guidelines for starting such development are only accessible to license owners.

3. In addition to sharing your code and data, you created a website that contains interactive versions of your paper figures. Why did you put in the extra



The Jupyter Book for the project that also showcases reproducible and interactive figures.

system, and do all of the processing using an open-source tool. And it's also important to note that if you read the description of the Siemens scanner, for example, you'll actually find it says "this scanner is not a measurement device". So, what we are trying to do is bring measurements back into MRI by standardizing measurement techniques and their quantities.

MRMH: What was the biggest challenge in the implementation, both sequence-wise and vendor-wise?

Agah: I guess the biggest challenge was that we were trying to run an experiment on three different scanners in two different cities, Montreal and Toronto, in the middle of a pandemic. But my main problem, in general, when I'm developing any kind of software is the lack of documentation, or a good application programming interface design of the programming environment. But that wasn't the case this time for the pulse sequence development; actually, it went quite smoothly thanks to Spin Bench and RTHawk. Another challenge was making sure that the quantitative MRI protocols can be properly executed on different vendors' systems that come with different interfaces and result in different data outputs. Actually experiencing these problems was crucial in helping us to address them through this project. As a result, now, with VENUS, for example, we can export data in the standardized qMRI-BIDS format, and it has a unified user interface.

Nikola: I would like to address the whole administrative/regulatory side of things, because here we are, you know, trying to open up a system that is inherently closed and driven by IP. And I'm very grateful that both GE and Siemens understand what we're trying to accomplish. Because it's not always easy to use open-source MRI with a closed-source black box system.

MRMH: Could you briefly discuss the outcome?

Agah: We made it so that the outcome of this work will be the most visited section of the article, and the outcome is summed up in its title: Vendor-neutral sequences and fully transparent workflows improve inter-vendor reproducibility of quantitative MRI. What we are saying is we cannot rely on black

box implementations to achieve precise measurements across different centers. And we showed significant reduction in non-biological variants with this approach, and this brings us closer to capturing true biological variability in quantitative MRI applications. Another important outcome is that everything from pulse sequences to statistical analyses is on GitHub at qMRLab.org/VENUS.

Nikola: Just to put it in context, variability in quantitative MRI is very big. If you think about T1 at 3 Tesla in white matter, it should be a very, very sharp peak. When you implement different protocols, you get variability in T1 that goes from 700 to 1100 ms. We ran a T1 mapping challenge to show that even when you follow the same protocol, the values will change between sites. We observed this kind of variability (even though it was the same subject), between three scanners from different vendors, and with VENUS, we saw that variability dramatically decreased. And I think with our paper, we managed to kind of hint at what is causing this.

MRMH: Do you have any ideas on how to improve the current workflow?

Agah: We achieved vendor neutrality, but we should also aim to achieve scanner upgrade immunity. Because, most longitudinal data collections that run over years are affected by at least one scanner upgrade. And in the context of clinical trials, this is a big cost in terms of developing quantitative biomarkers. The idea is usually to use a single scanner so that the biomarkers better capture the effect size, but then the scanner gets upgraded, and the measurements can change by a considerable amount. And lastly, the benefits of vendor neutrality are not limited to quantitative applications; we are also working on an integration of the Spinal Cord Toolbox (SCT), which is another open-source software, developed by our lab and led by Julien Cohen-Adad, and together with a new member of our lab, Nadia Blostein, we are trying to perform robust spinal cord cross sectional area (CSA) measurements with VENUS.

Nikola: In our lab, we spend a lot of time on outreach, as we think this is the only way to make sure that the work is properly vetted, and can also then be reused. And I think that we could be doing a better job of convincing people to work collaboratively rather than in silos. Because while all of us are good engineers, good physicists, who can do very important work, improving our own workflows, it's much more challenging to get everybody to work collaboratively on a project, and make sure that the same project is installed at several sites. And yet, for clinical trials, this is a big money saver, while for research, it is a big timesaver.

Agah with his parents and sister enjoying traditional Turkish tea.

MRMH: Anything to add?

Nikola: I have to say it feels good to be on the other side of the Highlights interview. It's really nice that this initiative has continued for 7 years since Erika Raven and I first started it. ■

effort to do this, and are there resources available to help other researchers create similar content?

My primary goal is to move from papers that only include code to papers that are compiled from that code. While well-organized code and data are critical, runtime dependencies can pose significant issues that hinder reproducibility. To overcome this obstacle, I decided to develop a Jupyter Book. The interactive figures on this website enable readers to access the most condensed version of the data, directly from the figures. This feature not only allows readers to explore data from various perspectives, but also facilitates future meta-analyses by enabling easy importing (and possibly modification) of relevant information.

4. Are there any other reproducible research habits that you didn't use for this paper but might be interested in trying in the future?

While interactive figures provide a window into a specific aspect of the data, they offer only a snapshot. Developing a dashboard, on the other hand, allows a more panoramic view of the published research and can help to answer questions that the article may not have explicitly addressed. Moreover, each user interaction on a dashboard interface re-executes the functions that generate the output, enabling users to reproduce the analysis at each click. Additionally, dashboards can be made available with zero downtime. For an example of this, please see https://rrsg2020.dashboards.neurolibre.org. ■

Fourier-based decomposition for simultaneous 2-voxel MRS acquisition with 2SPECIAL

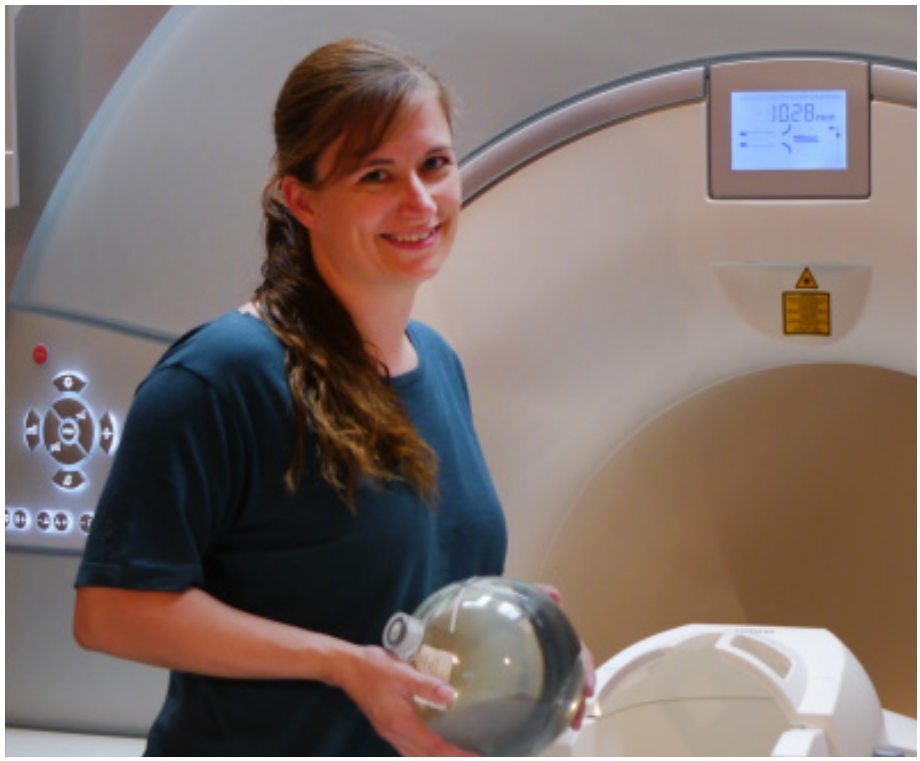
INTERVIEW BY **MATHIEU BOUDREAU AND NADIA BLOSTEIN**

MRM HIGHLIGHTS' PICK

This MRM Highlights Pick interview is with **Layla Tabea Riemann** and **Ariane Fillmer**, researchers at Physikalisch-Technische Bundesanstalt (PTB) in Berlin. Their paper is entitled "Fourier-based decomposition for simultaneous 2-voxel MRS acquisition with 2SPECIAL". Their article was chosen as this month's Highlights pick because it demonstrated exemplary reproducible research practices; specifically, they shared example data, their vGRAPPA algorithm code, and a demo script, all packaged in a nice Gitlab code repository.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM AT MRM.ISMRM.ORG

Layla Tabea Riemann



Ariane Fillmer

MRMH: Tell us about yourselves and your background.

Layla: I have a master's degree in medical physics, and I did my PhD at Physikalisch-Technische Bundesanstalt (PTB), which is the German metrology institute in Berlin. This paper was part of my PhD, which I'm defending in a few weeks. I first met Ariane during an internship I did at PTB between my bachelor's and master's degrees; we worked together and she lit the spark that made me want to do a PhD in spectroscopy. I have just moved to Hamburg and started work as a group leader in the university hospital's Department of Applied Medical Informatics.

Ariane: I first studied physics in Dortmund, and when I started my diploma thesis I reached a crossroads, where I was considering just applying for 9-5 jobs. But then I discovered that research is really fun. So, I started applying for PhD positions instead, and got one at ETH in Zurich. That's when I started doing MR, focusing on MR spectroscopy under Anke Henning's supervision. After that, I got a position here in Berlin where I could continue doing MR spectroscopy research, and then I got

Riemann, LT, Aigner, CS, Mekle, R, et al. Fourier-based decomposition for simultaneous 2-voxel MRS acquisition with 2SPECIAL. *Magn Reson Med.* 2022; 88: 1978- 1993. doi:10.1002/mrm.29369

https://blog.ismrm.org/2023/03/30/qa-with-layla-tabea-riemann-and-ariane-fillmer/

promoted, becoming head of the research group, so I was able to start supervising students. Layla is my first graduating PhD student. Unfortunately, my time in active research is coming to an end, as there are no viable long term options in MRS research in Berlin for me. I will instead switch to project management in research funding.

MRMH: Before getting into the specifics of your paper, could you briefly explain to us the acronym in your title, "2SPECIAL"?
Layla: So, SPECIAL (spin-echo, full-intensity acquired localized) is a very established MRS sequence. Its appeal is that you can attain very short echo times without sacrificing signal intensity. The "2" refers to an addition to SPECIAL that we've introduced in this work, namely, we took the adiabatic pulse and multi-banded it to acquire two voxels simultaneously.

Ariane diving

MRMH: Thanks! Could you give us an overview of your paper?
Layla: As I just mentioned, our idea revolved around acquiring MRS spectra in two voxels simultaneously, and we developed 2SPECIAL for this purpose. First, we looked at implementing multivoxel SPECIAL using a multi-banded hyperbolic secant adiabatic pulse for signal inversion, as the hyperbolic secant pulse was the adiabatic pulse implemented in the original SPECIAL implementation, but this pulse has some disadvantages due to its high peak voltage, which translates into a high peak SAR. So, in this work, we instead used a multi-band WURST (wideband, uniform rate, smooth truncation) pulse, which, in addition to having a lower SAR, overall gave us more parameters to vary. I did Bloch simulations for the multi-band adiabatic pulses, and we were surprised to see in the B1+ that there was an unintended partial inversion outside the voxel region in some cases, particularly when the voxels came closer together. After doing some literature research, I found a paper, published 30 years ago (!), that accurately describes this exact phenomenon. But few people seem to be aware of it. To decompose the signal, we also developed a voxel-GRAPPA (vGRAPPA) algorithm, and compared it with a SENSE-based approach. We validated our work in phantoms and in vivo in symmetrical anatomical regions.

Layla after having defended her PhD, wearing an awesome hat made by her awesome colleagues.

MRMH: How does this work fit into your broader research goals?
Layla: This was actually only the second part of my PhD thesis. My first paper investigated the repeatability and reproducibility of the quantified metabolite concentrations and the

Layla while on vacation in Algave.

impact of different inversion pulses – as one example of a parameter – on the reproducibility and repeatability.

Ariane: PTB is a somewhat unique environment given the metrological background. I started here at the time the NeuroMET project began, and the follow-up project, NeuroMET, was also partly used to finance this work. One of the main aims of NeuroMET (which focuses on Alzheimer's disease) is to improve and investigate the predictive values of non-invasive or minimally invasive biomarkers to diagnose the disease and improve cohort stratification. MRI and MRS are certainly more feasible as a stratification tool than alternative, more invasive, imaging methods, especially from an ethical point of view. There is specifically a lot of potential in MRS, as the structural changes have to be triggered by some more subtle chemical changes, before atrophy is exhibited. But you need to do it right, in order to exploit this potential, and so far, we are not doing this. One of the big challenges in order to use spectroscopy as a diagnostic tool is distinguishing between what are real changes and what are only statistical fluctuations. And that aspect led me — and Layla — to explore the measurement uncertainties of the quantified metabolite concentrations, and how to properly determine them. Another big challenge is certainly the amount of measurement time required to achieve a high spectral quality (and a low measurement uncertainty). And this is why we looked into how doing spectroscopy in two voxels simultaneously might be used for accelerating MRS and what the limitations of that would be in terms of a target spectral quality.

MRMH: Do you think there might be ways to extend this technique further, i.e., to more than two voxels?

Ariane: Yes, you could multi-band the adiabatic pulse to three, four, or even five bands if you're interested in doing that. However, you'd need to make the voxels very small, or else have a really large brain in order to fit all the bands in. And as we showed in this paper, the closer together your voxels are, the more MRS signal leakage problems you are going to get between them. Other multivoxel MRS techniques exist, such as MRSI (MRS imaging), however with those you get a broad point spread function, which essentially blurs the signal and makes it tricky to say with certainty that the signal is really coming only from a given voxel.

Layla: There's definitely a trade-off. If you want the best spectral quality, then measuring a single voxel may be the way to go. If you're interested in multivoxel applications, then it's important to consider the constraints that your multivoxel MRS technique has, and we explore a few in this work.

MRMH: To end off, what do you enjoy doing when you're not in the lab? And is there anything you'd like to share about your city?

Layla: I'm a fairly active person. I do karate and running — we had a running group at PTB. I do a lot of sports. I also play the alto saxophone, and am quite fond of the opera. As for Berlin, I definitely recommend visiting. It's a really beautiful city. I'm from the eastern part and I really like how you can still see that it was separated. It's such recent history, and something I haven't seen in other cities. Just going between two different metro stations can feel like switching between different worlds.

Ariane: I'm a big DIY person. We've just bought a house, and I've been doing all the renovations with my partner. There's still a lot to do though. I also like sewing, crafting, and knitting. Furthermore, I love to be outside, hiking and scuba diving! Also, I just had a baby, which means the majority of my time is now occupied – in the best way possible. ■

Ariane working on some home renovations

CONTRIBUTORS

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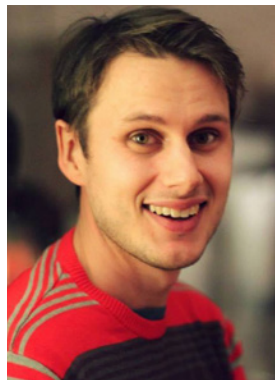
Magnetic Resonance in Medicine Highlights Magazine Editor

Maria Eugenia is an Assistant Professor in Applied Physics at the Magna Graecia University in Catanzaro, Italy. She completed her PhD and part of her post-doctoral experience working at the Institute of Molecular Bioimaging and Physiology of the National Research Council. Her work focuses on advanced methods for multimodal MRI fusion and on their application in the field of neurological disorders and healthy brain aging. Maria Eugenia is the proud mom of Federico and Michelangelo (tiny humans) and Pulce (a not-so-tiny cat), and in her free time enjoys listening to music, binge-watching TV series with her husband, and being a crazy-cat-lady.

Mathieu Boudreau



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Mathieu is a research fellow at the Montreal Heart Institute, after completing his PhD at McGill University. His current research interests are in developing open-source software for quantitative MRI techniques and other related image processing tools. In his free time, Mathieu enjoys cooking, hiking, and making graduate students feel anxious about not having a proper backup of their computers.

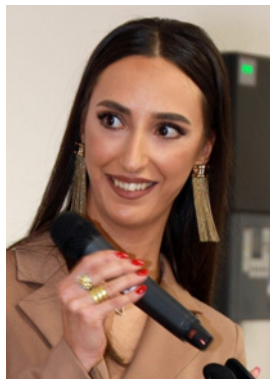
Katherine Blanter

Katya is a first year PhD student at the Cardiff University Brain Research Imaging Center. She is currently working as part of a multi-disciplinary team to improve the unsafe tissue heating and worsened image quality caused by involuntary participant motion at 7T MRI. Besides that, she likes cats and brownies.

Nadia Blostein

Nadia Blostein obtained a Master's degree in Neuroscience from McGill University, where she gained neuroimaging data processing and analysis skills under the supervision of Dr. Mallar Chakravarty. She is currently working at Polytechnique Montreal under the co-supervision of Dr. Julien Cohen-Adad and Dr. Nikola Stikov. Her projects range from planning parties in Masonic Temples to contributing to the development of vendor-neutral ways to image the spinal cord. In her free time, she enjoys cross-country skiing, experimenting with coffee and curating Spotify playlists.

Maria Celeste Bonacci



Maria Celeste Bonacci is a PhD student in biomarkers of chronic and complex diseases at the Magna Grecia University of Catanzaro. Her research is focused on the discovery of new biomarkers in neurological diseases, with particular attention to epileptic syndromes, through the analysis of multimodal MRI images and electrophysiological data (EEG and qEEG). In her spare time, she likes sports, watching TV series and loves to travel and have new experiences.

Laura Bortolotti

Laura (she/her) is a Post-doc at the Sir Peter Mansfield Imaging Centre (SPMIC) at the University of Nottingham, England. Her works focuses on developing Motion Correction (MoCo) techniques for MRI. She developed a contact-less head motion tracking at 7T using NMR field probes during her PhD . Now she has transitioned to implementing MoCo on a 0.5T

upright scanner. Laura loves being involved in public engagement, and she finds difficulties on balancing enthusiasm for volunteering opportunities and working hours. She is an advocate for improving Equality Diversity Inclusivity (EDI) and sustainability in the workplace.

Maria Guidi

Maria is a PostDoc at MARBILab, Enrico Fermi Research Center in Rome, Italy. She obtained her PhD at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, Germany. Her research focuses on high-resolution fMRI for the study of brain physiology in healthy aging and in disease. She also worked as an editor and writer of physics textbooks. Maria likes a good sense of humor, dogs, cats, certain humans and spaghetti with mantis shrimps.

Kerstin Hammernik

Kerstin Hammernik is a Post-Doc at the Technical University of Munich, Germany and Imperial College London, United Kingdom. She received a PhD in Computer Science from Graz University of Technology, Austria, with her PhD thesis on "Variational Networks for Medical Image Reconstruction". Kerstin is passionate about bridging the gap between machine learning and inverse problems in medical imaging, focusing on static and dynamic MRI reconstruction. In her free time, Kerstin regularly escapes from the city to the mountains, enjoying nature through backcountry skiing, rock climbing, hiking, or mountain biking.

Pinar Özbay

Pinar joined the Advanced MRI group at the National Institutes of Health in 2017, right after obtaining her PhD at ETH Zurich. During her PhD, she worked on developing novel contrast mechanisms for brain imaging, particularly quantitative susceptibility mapping at high field MR systems. At the NIH, she widened her interests towards EEG/fMRI, i.e., investigating brain signal characteristics during wake and sleep, together with physiological and EEG signals. In 2022, she returned to her homeland, Turkey. She joined the Institute of Biomedical Engineering at Boğaziçi University as a junior faculty member and established her research group, the Multimodal Imaging and Physiology Lab. While trying to get used to Turkish coffee (again), she is open to fruitful collaborations and is always looking for bright students to join her team.

Sophie Schauman

Sophie is a postdoc at Stanford University. The focus of Sophie's research is novel acquisition and reconstruction methods, in particular methods focusing on rapid multi-contrast brain scans. In addition to her research, Sophie is involved in multiple reproducible research and open science initiatives both at Stanford and at the ISMRM.

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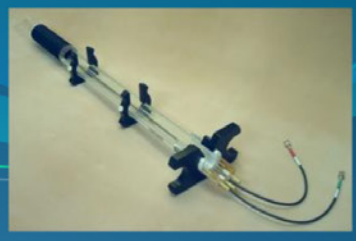

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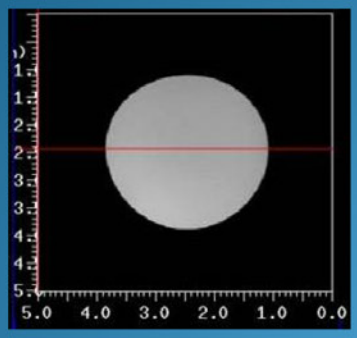

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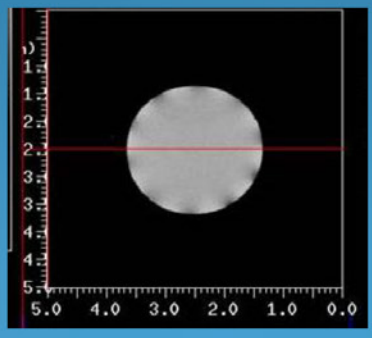

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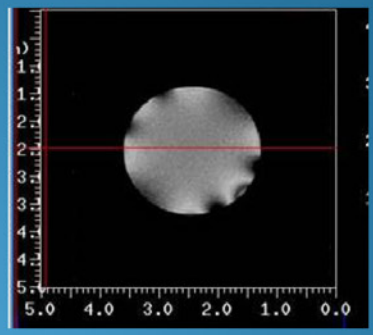

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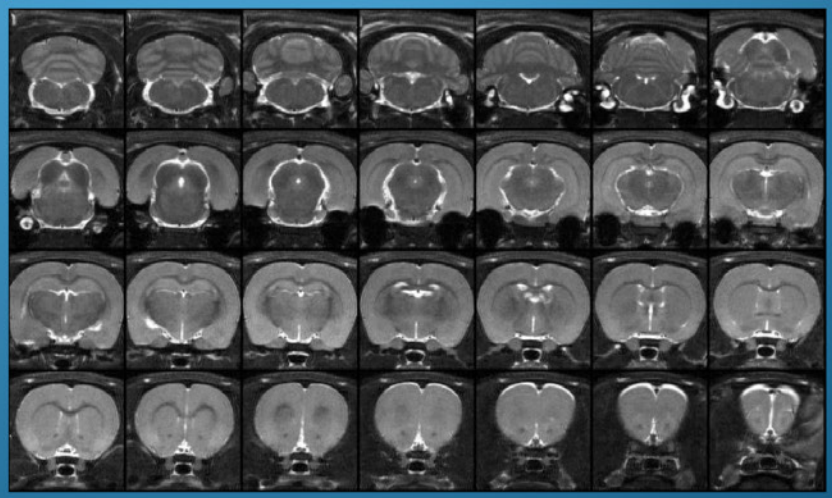

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