Magnetic Resonance in Medicine

HIGHLIGHTS

There's no place like London:

MRI (r)evolution from the 1980s to the 2020s

Public Engagement:

spreading scientific culture

A tale of two Presidents:

ISMRM's Fernando Calamante & ESMRMB's Eva Scheurer

Highlights' Picks

January 2021 – November 2021

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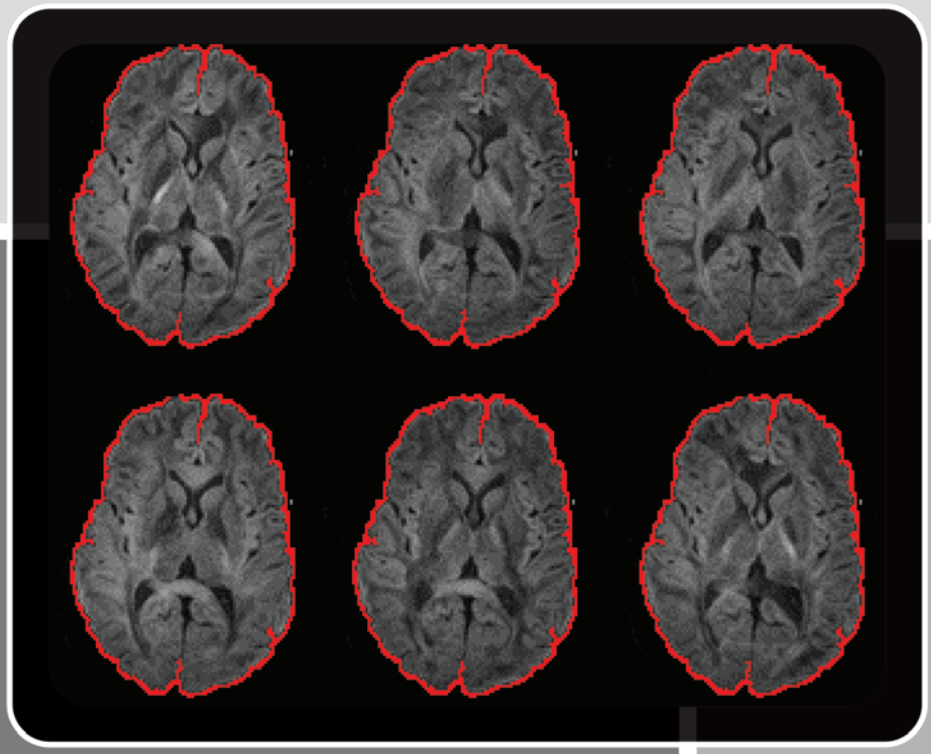

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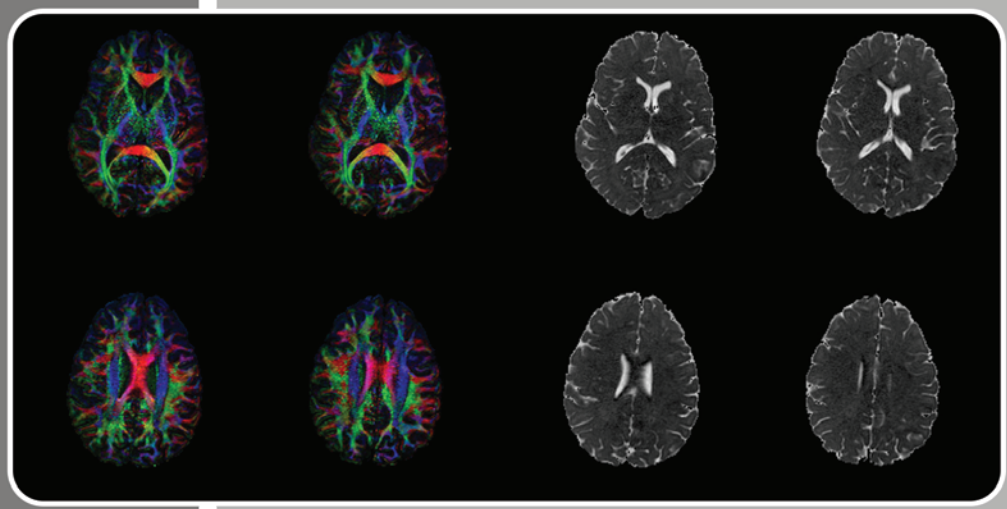

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Welcome (back) to *Magnetic Resonance in Medicine Highlights*

When I started writing this introduction, the first thing I wanted to type was "we're almost there! After two years of virtual meetings, some of us will actually meet in London". But then the uncertainty related to the pandemic has been reinforced by the tragic news regarding the Ukraine-Russian conflict, and I cannot proceed in this foreword without reprising the words of the ISMRM leadership: "To all impacted, please know that the ISMRM community is with you and that you are not alone."

We are grappling with the fact (pun to Hamilton intended) that there is a long road ahead until we fully recover from the impact of these recent events on our lives, but the thought that some of you could read these words on a printed copy of MRM Highlights is somehow reassuring.

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This 7th volume of the magazine is full of inspirational stories. What continues to impress me since I first joined ISMRM is the brilliance of the people in charge within this Society: never trivial, always sharing a noteworthy point of view on life and work in our field. And also, that family feeling that everybody shares when thinking of ISMRM: that is precious and hard to find.

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The issue will take you on a time travel through the history of MR in London, where the (I)SMRM annual meeting last happened back in 1985. Starting from the dawn of the field, at the time of Sir Peter Mansfield, we fast-forwarded to the present day, asking several researchers from Imperial College, KCL, and UCL, what it is like to do MR research in London now. Afterwards, we will overview the past and forthcoming public engagement initiatives within ISMRM, via interviews with the organizing team and profiles of the winner and finalists of the last Magnetic Moments competition. In a world haunted by fake news, we have a responsibility, as scientists, to do our best to spread our scientific knowledge to the general public and fight disinformation. On the occasion of the joint ISMRM-ESMRMB annual meeting, we doubled the traditional presidential interview by talking to ISMRM President Fernando Calamante and ESMRMB President Eva Scheurer. We are also delighted to continue showcasing the amazing early-career talent in our society, starting f rom 25 years ago with Jean Brittain and Yijen Wu, the 1997 winners of the W.S. Moore and I.I. Rabi awards, up to the present with profiles of the 2022 ISMRM Young Investigator Award Finalists. Finally, the magazine will feature the online Q&As, focused on reproducible papers, curated by the Highlights Digital Content team.

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Together with Mathieu Boudreau, Editor of the 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

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London Calling to the MR world

An Informal History of ISMRM in London

INFORMAL HISTORY AND INTERVIEWS BY **MARIA EUGENIA CALIGIURI** AND **LAURA BORTOLOTTI**



Graeme Bydder, Ian Young and Martyn Paley.

The summer of 1985 in London was indeed an unforgettable one. While the echoes of the Live Aid concert at Wembley were still resonating, London welcomed the fourth Annual Meeting of the Society for Magnetic Resonance in Medicine (SMRM), the first held in Europe instead of North America. The local and scientific organizing committees included names of legendary pioneers in our field, such as Dr Ian Young and Professor (later Sir) Peter Mansfield, and the large number of London-based research groups was prophetic regarding the lively and fruitful community that would have characterized the city nowadays (read the following articles to find out more!).

Diving into those great years, when exciting discoveries and huge progress characterized research focused on nuclear magnetic resonance (NMR), we discovered a wonderful resource created by Ian Young himself: an online history of MRI and spectroscopy in the UK (**https://mrishistory.org.uk**). There, we learned more about the names we usually associate with significant MR advances in medicine; here, some of them shared their memories, either by voice or by email, and we cannot thank them enough: Graeme Bydder, David Firmin, Penny Gowland and Martyn Paley.

Ian Young was one of the greats. He helped shape the MR world as we know it. Having graduated from Aberdeen University, Scotland, he worked in both industry (EMI Ltd, GEC plc, Picker International Inc) and academia. In January 1981, Young shifted from EMI to the Hammersmith Hospital, now associated with Imperial College London, providing both knowledge and hardware. Not only did he bring to the Hammersmith the world's first commercial whole-body cryomagnet built by Oxford Instruments, but he also brought his knowledge regarding pulse sequences, as well as a desire to achieve a "decisive clinical advantage" over other medical imaging techniques. In 1984, he was appointed to the role of local organizer of the 4th SMRM Annual Meeting in London, which – according to Young himself – was a quite challenging experience. In addition to providing facilities and support, he ended up

being involved in the organization of the scientific program, including the mechanics of notification of abstract acceptance (imagine the burden, in a pre-email era!) and the creation of the Abstract books. The NMR community response to the news that the meeting would be in London was huge: the conference had far more registrants than expected, which resulted in further struggles to find an appropriate venue that was able to host the seven parallel sessions.

Thus, after the first five years of clinical work in NMR imaging and spectroscopy, ten prolific groups based in the UK were ready to present their pioneering work at the Barbican Centre, the largest European performing arts center, located in the City of London. According to Graeme Bydder, in the online history of MRI and MRS in the UK, the London-based groups were represented by Judith Webb (St. Barts), Ian Mc Donald and George du Boulay (Queen Square), Donald Longmore (The Royal Brompton), and his and Ian Young's group (Hammersmith Hospital). Several new developments were presented, including the application of contrast agents to imaging of brain tumors, novel sequences such as FLAIR, blood flow measurements, and relaxation times measurements. Although all techniques and applications that are well-established now, these were literally being envisaged and validated during that golden decade.

Dr Young also described his favorite highlight of the meeting: the Picker International reception in Queen Square, held outside the National Hospital for Neurology and Neurosurgery. The party had a Victorian theme and was widely attended (and greatly appreciated by all participants, especially overseas visitors).

A glimpse of the 1985 Picker International reception in Queen Square, where attendees had the honor of greeting an impeccable Queen Victoria. (Courtesy of Graeme Bydder and Martyn Paley).

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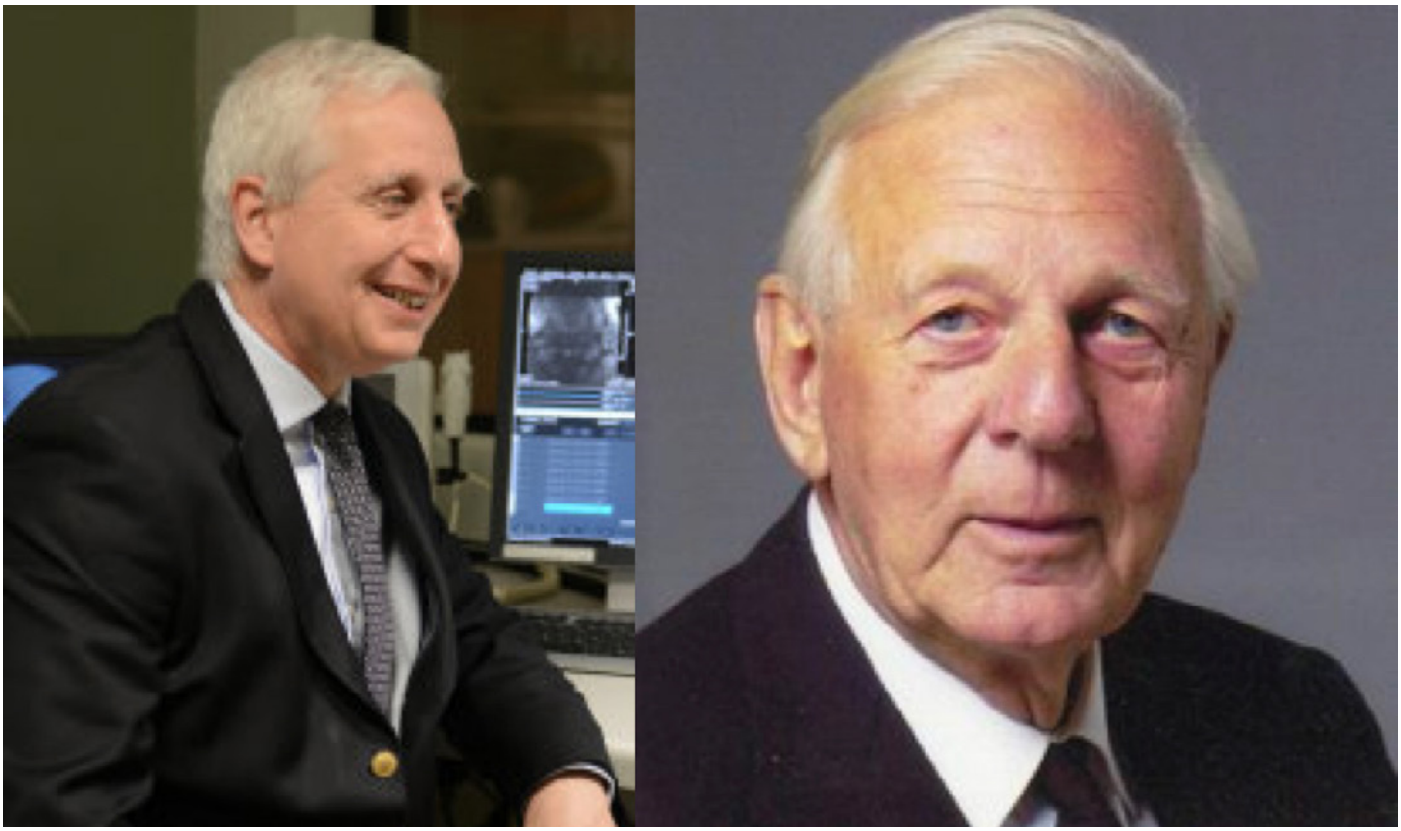
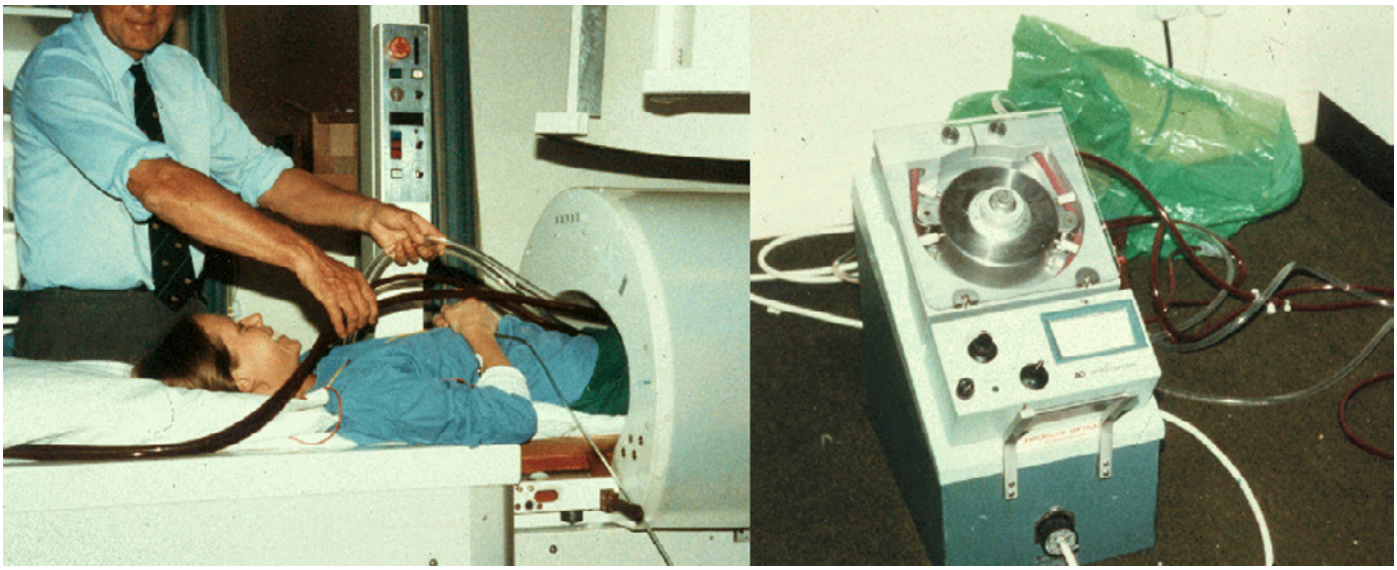


David Firmin and Donald Longmore.

Shortly after Ian Young joined the Hammersmith, a young David Firmin joined the NMR scene. David is now Emeritus Professor of Biomedical Imaging at the National Heart and Lung Institute, Imperial College London and, prior to his retirement in Dec 2020, was the Physics Director of the Royal Brompton Hospitals CMR Unit. He started working at the National Heart Hospital in 1982, under the guidance of Donald Longmore, who was passionate about non-invasively diagnosing and treating heart disease. We asked him to share memories about the early days of MRI in London, as well as of the ISMRM annual meeting in 1985.

MRMH: How did your journey in NMR start?

David: Donald Longmore had seen a lecture by Peter Mansfield and became absolutely



Donald Longmore standing by the 0.15T Hammersmith scanner with a normal volunteer. Tubes for early blood flow experiments are visible. (Courtesy of David Firmin)

certain that nuclear magnetic resonance (NMR) was going to play a crucial role in achieving non-invasive medical imaging of the heart. When I first joined his research group, we were trying to raise funds to buy an MR scanner – we didn't have one! So, we spoked to Ian Young, Graeme Bydder and Professor Robert Steiner (the Director of Diagnostic Radiology at Hammersmith back in those days), and they allowed us to work with them on their scanner, to look at methods for measuring blood flow. That's where we started, working in the evenings and on weekends, when they weren't working on other non-cardiac NMR projects. It was extremely helpful to be able to work with their team: I remember David Bryant in particular, who I worked with in developing methods to measure blood flow.

My first job was building the electronics for gating to the heart and connecting it into the scanner at the Hammersmith, to allow detection of heart waves and triggering. We started doing some blood flow imaging by pumping copper sulphate mixed with out-of-date blood in the tubes, and comparing the signal that we got from flowing blood at different rates. We eventually came out with what is now known as phase-contrast velocity mapping.

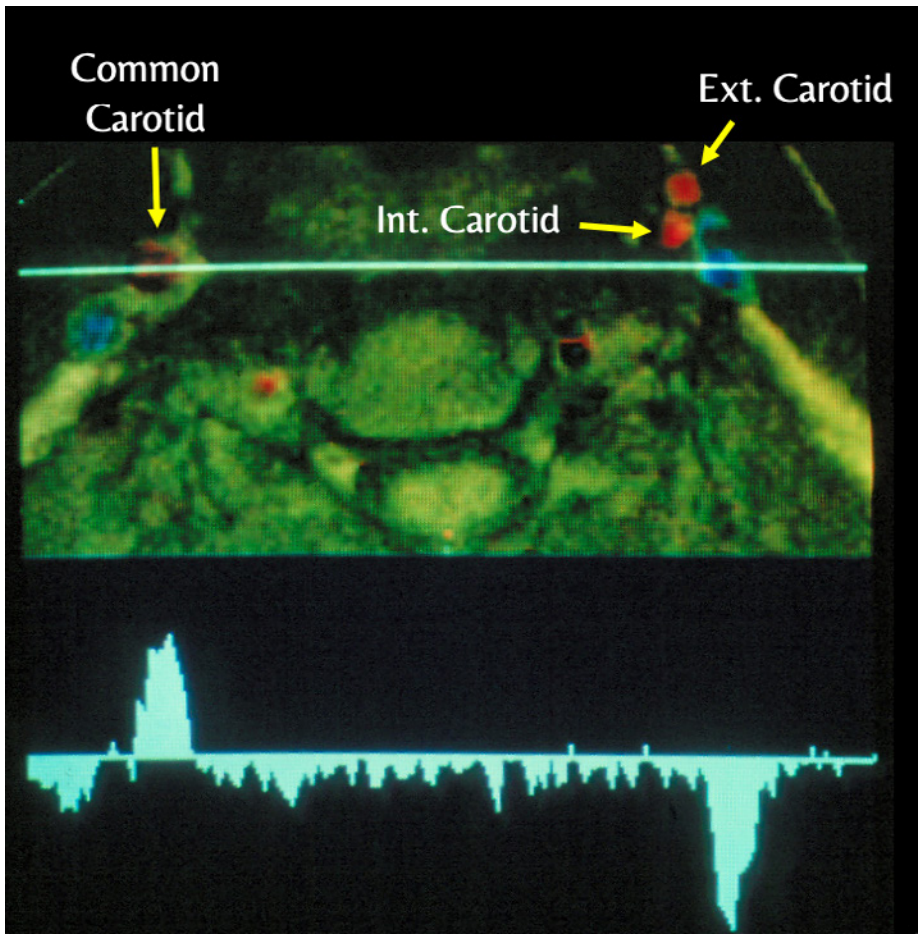
MRMH: So, you made cardiac gating possible for the first time! We can say that those were the days where technologies that we now take for granted were being invented!

David: Yes! The scanner we were using had a very very low field, I can't quite remember its exact strength – probably 0.15 T. You had to be completely enclosed in a small bore, there was a solid door in front of the scanner to ensure RF shielding. For our blood flow studies, I remember being in there for over three hours to acquire a phase contrast image of my neck, probably one of the first we ever acquired, with color-coded flow signal.

MRMH: That must have been uncomfortable!

David: Well, I still found it was more comfortable than some modern scanners! Everything was done at the Hammersmith initially, and then Donald and our group managed to secure funds for a scanner at the Brompton/National Heart Hospital. It was unclear at the beginning where the

David Firmin and Sir Godfrey Hounsfield (Nobel Prize winner for CT) in the Brompton scanner control room in 1984. Sir Godfrey used to work with the Brompton team in the early days of Cardiac MR development. (Courtesy of David Firmin)



Phase contrast image of David Firmin's neck, showing flow in the arteries and veins. (Courtesy of David Firmin)

scanner would have been installed, until a building in the Brompton was chosen in 1984. Luckily, we also continued our collaboration with Ian and Graeme.

MRMH: Do you remember which were the hot topics at ISMRM 1985 in London?

Penny Gowland

David: What I remember best was everything dealing with flow, as that was my interest, but I am sure there was a lot of very exciting stuff going on at that time. I remember talks by David Norris, from the Aberdeen group, as well as by Donald Longmore and other posters from our group. One big question was how much NMR had to offer in cardiac imaging, we were at the very beginning of these lines of research. We really didn't know what to expect from our experiment, every day we learned something new! It was such a nice time to do MR research!

MRMH: What was the meeting like?

David: It was rather small, in comparison to what ISMRM annual meetings are like now. It was held at the Barbican, there were probably a few parallel sessions, and when they finished everybody came out and we could all be together. Something very different from the enormous meetings we have seen in the last few years, before the pandemic!

MRMH: Thank you so much for sharing your memories with us! It was a lovely time travel!

During 1985, another young woman was about to enter the NMR research world, not knowing that she would have contributed to shape and change that field. Penny Gowland is now a researcher at the Sir Peter Mansfield Imaging Centre at the University of Nottingham and Secretary of the ISMRM. She is known world-wide for the development of innovative MRI techniques, and she has shared with us her memories on how her remarkable career started as a student back in the '80s.

MRMH: Would you like to share with us your experience in the London-MRI scene in 1985?

Penny: In 1985 I had just finished my degree in Physics and Astronomy at UCL, and was inter-railing in Eastern Europe (behind the then Iron Curtain) whilst Live Aid and the SMRM happened in London. I had al-

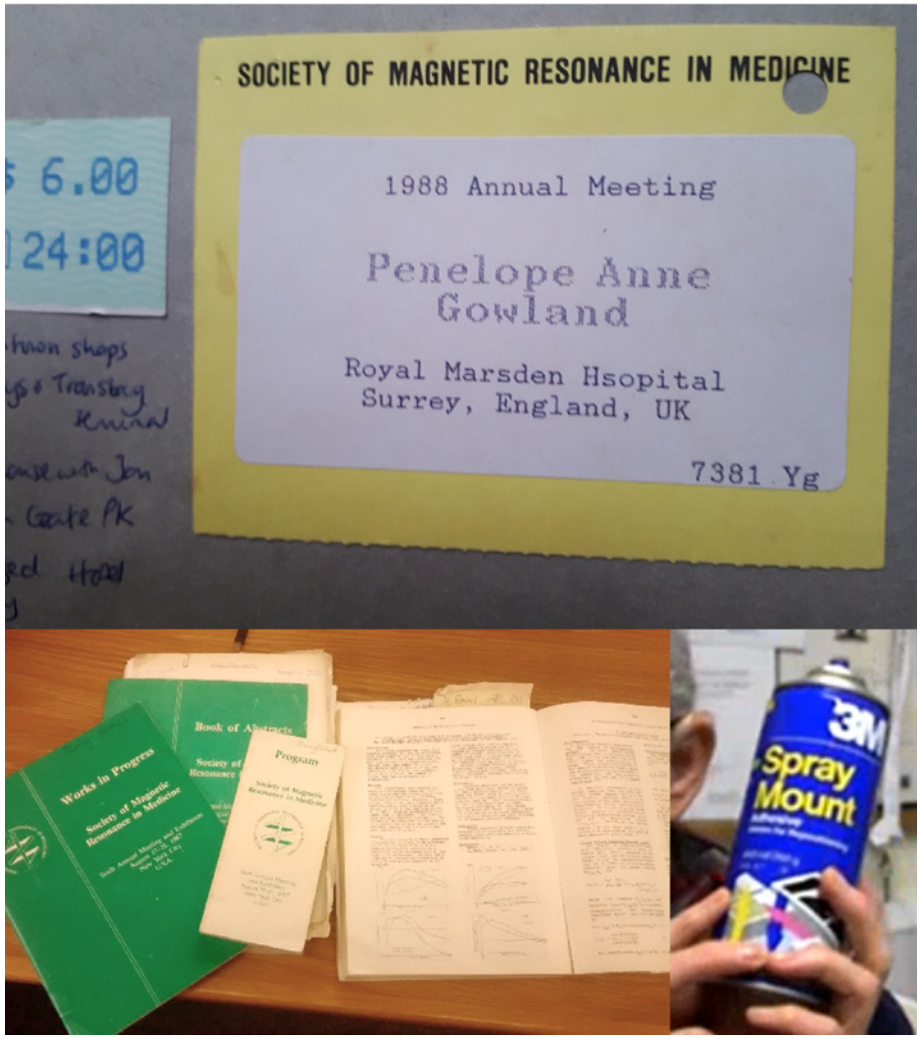
What I remember best was everything dealing with flow, as that was my interest, but I am sure there was a lot of very exciting stuff going on at that time. I remember talks by David Norris, from the Aberdeen group, as well as by Donald Longmore and other posters from our group.

– David Firmin

ready decided that my next step would be Medical Physics, and in 1986 I started at the Middlesex Hospital Medical School in London on an MSc course that was joint with "Barts" (St Bartholomew's Hospital). Barts felt like cloisters buried amongst sky-scrapers: a year or so later my great aunt who sadly had Motor Neurone Disease was given one of the first MRI scans there. The class was diverse and international, with people from Hong Kong, German, Jamaica and Greece, but there was one more person from the UK: Iain Wilkinson, who sadly died last year. There was a new subject to learn about: Nuclear Magnetic Resonance (NMR) Imaging. The combination of long, confusing student discussions about relaxation times, and a mind-blowing sagittal image of a spine made me certain "This is what I want to do!". However, the lecturer told us NMR imaging could never catch on, as it took 30 minutes to acquire this image (EPI had been invented by then so he may have been a bit out of date). Fortunately we also had a few lectures from Paul Tofts, at Queen Square (he is now in Brighton), who gave us more up-to-date teaching, and so the following year I started a PhD with Martin Leach at the Institute of Cancer Research (ICR) in London. Originally I had signed up to do a joint PET/ NMR Imaging project but at the last minute I swapped to NMR Imaging alone. Ironically, the person who did the other project was Simon Cherry (now at UC Davis) who ended up concentrating on PET at the time but now works on combined MRI/PET after all.

The newly installed 1.5 T NMR imaging scanner (the first of that field strength in the UK at the time) was in a clinical unit, so research scanning had to happen late at night. From the outside the scanner didn't look so different to the ones we use now, and at the time I felt that the research field was quite established, with an imaging literature that went back 10 years and an NMR literature that had existed for 40 years. It is scary to realise that 1986 is nearly 40 years ago now! I found my PhD stressful, as I felt I didn't know what I was doing, which seems weird now since, looking back, I certainly did: I was working on Quantitative Imaging, which is still what I still do now!

There used to be an NMR Discussion Group in London. It was the first chance I had to meet people outside my own lab. I clearly remember a talk from Jo Hajnal and Jane Cox from the Hammersmith on susceptibility imaging...a topic that boomeranged back 20 years later of course. I also met Peter Morris (now my colleague at Nottingham) for the first time when he did a talk on RF pulse design.



Memories from Annual Meetings back in the 80s: shipped posters (top), printed abstract books (bottom left) and spray mount to stick the poster pieces together after they arrived via mail (bottom right). (Courtesy of Penny Gowland)

However, the main place I met people was of course the SMRM and now the ISMRM. I have never missed an annual meeting since New York 1988, except for the two years when I had a baby. In those days you had to mail or courier your abstract (or indeed your paper reviews) and we knew which days the mail was flown to the USA to try to get things through on time. Making abstracts and posters involved not only science but also was a craft project in itself, laying out printed text on abstract forms or poster boards and sticking it down with spray mount adhesive that had a smell and stickiness that got everywhere. The conferences were generally held in a Hilton Hotel, with ballrooms for poster sessions and session rooms with windows to the outside world. The first conference centre I went to was Amsterdam (in 1989), which felt like an aircraft hangar.

We have come so far. When I started my PhD I had to explain what "NMR Imaging" was to everyone, but now 'MRI' has entered the general vocabulary. At the end of my PhD I briefly thought 'that's it, what next?'. How wrong I was, MRI keeps spinning new possibilities! ■

MRI in London *now*: Imperial College London

INTERVIEW BY **GASTAO LIMA DA CRUZ**

> *"What's important for me is to find the individual strengths of students and to really support them. Every one of us is different in terms of how we approach research. It's also important to have a goal in mind, and break it down into smaller steps to progress towards the goal."*
>
> – Kerstin Hammernik

Kerstin Hammernik is a research scientist at the Institute of Artificial Intelligence and Informatics in Medicine, Technical University of Munich, Germany and at the Department of Computing, Imperial College London, United Kingdom. **Daniel Rückert** is Alexander von Humboldt Professor for AI in Medicine and Healthcare at the Technical University of Munich where he directs the Institute for AI and Informatics in Medicine. He is also a Professor in the Department of Computing at Imperial College London.

MRMH: To start off: how does the MR community intersect with your research interests?

Kerstin: MR has always been my major research topic since my PhD. Now I'm also expanding a little into different applications, not only MRI reconstruction, but also downstream tasks like image segmentation, classification, image registration, etc.

Daniel: I have been working with medical imaging for a long time. I guess I started out on the image analysis track, developing techniques for dealing with the imaging data after acquisition. Over the last ten years I have shifted much more towards an interest in better understanding how the images are acquired and reconstructed, and realising that there's a lot of potential for machine learning to contribute to these processes. Throughout, I have very much enjoyed being a part of the MR community. There are a lot of people who are interested in physics , which was both very interesting to me and a useful opportunity to get a more holistic view on how you should interpret imaging data.

MRMH: How did you guys end up in London?

Daniel: I did my master's thesis at the Technical University in Berlin in computer science. I decided I would like to go for a year to another country and get some experience and London was always a city that I really liked. So I went and ultimately a year turned into over 25 years. I started with a PhD, and then never really, until recently, sort of thought much about leaving. Even now, that I'm in Munich, I have a lot of connections with London and spend quite a lot of time there. It's a great place not only as a city, but also because it has a number of different big universities and people with different expertise. People always had a very open mindset and everybody was relatively very easy-going about collaborating with whoever is around and had the right expertise. That's something I really enjoyed about London.

Kerstin Hammernik

Kerstin: I did my BSc, MSc and PhD in Graz, Austria, at the Graz University of Technology. I wanted to see the world, but I also wanted to stay in Europe. I find London an exciting place, with many universities and research possibilities. So I was very excited to start a post-doc at Daniel's group in Imperial.

MRMH: What are your current research focuses? How has it progressed through the years?

Kerstin: I studied biomedical engineering with a focus on medical imaging. So during my master's

thesis, I already had the possibility to work together with doctors and to develop practical applications, which was really cool to see. During my PhD, I was in a lab with a strong focus on computer science, computer vision and maths, so it was not always clear how to translate concepts between different research fields. That changed a bit when I trained at Imperial, because there was a very strong focus on medical image computing, and I could see research from a completely different perspective.

Daniel: I think what we have done in the last couple of years, and Kerstin has actually done this sort of thing a lot, is to come up with clever ways of how we can acquire and reconstruct data more efficiently. I still think we have a lot of gaps between the acquisition and the downstream analysis task, where I would like to push more for this integration between

Daniel Rückert

the different stages of the pipeline. However, this is also hard to do because you're then making the imaging sort of task specific. So, in my mind, there'll always be some role for general imaging when we just don't know what we're looking for, but I also think we'd like to be more targeted when we do.

Kerstin: I feel that interdisciplinary work between acquisition, reconstruction and analysis will become even more important in the future, where bridging those gaps will be key.

MRMH: How has research in Imperial changed over the years?

Daniel: Something I've observed is that research has become so interdisciplinary and, overall, I think that's a good thing. There are no longer real boundaries between different departments, because every problem is converging to something where you need mathematics, physics, computer science and mechanical engineering, merged with medicine. Medicine is perhaps still a bit separated, because it's sort of a completely different discipline with a very different history. One of the great things which Imperial has, as a technical university, is a large number of engineering specialists. So when you put all these people together, then I think you have a lot of potential for innovation.

MRMH: We've already touched a little bit on this point, but how do you think the field will evolve over the next 20 years?

Daniel: I guess from my mind, new applications, supported by hardware development in MR, will be of interest. One example is low field MR, which is now becoming much more feasible and, also, perhaps much more affordable. I'm not sure how much you can push this or where the boundary is, but it could be a disruptor that changes how we approach MR. I find it very exciting: a new imaging technology, which is more affordable, or perhaps offers new ways of combining MR with other imaging modalities.

Kerstin: Connecting to what Daniel said, I think that as we get new imaging technologies, what will play an important role in AI deep learning is incorporating the acquisition physics into the reconstruction process and the whole imaging pipeline. We've already seen this in the area of image reconstruction, and I think this will be key in the future too.

MRMH: How do you guys go about choosing a problem to work on?

Daniel: From my point of view, I always like to think of problems where we have some expertise which would complement what other people are doing. What are the problems we can tackle by bringing in perhaps some of our expertise in machine learning, with a good understanding of what the MR and clinical questions are? So I look at this intersection between the MR community, the clinical community and the machine learning/computer science community, because I know we can potentially contribute something to that. The second point is that I also like to do something where potentially you have data which poses unique challenges. Before we did work with cardiac MR, we spent a lot of time with colleagues trying to improve the way we can do, for example, neonatal or foetal imaging. It has unique and interesting challenges which you have to address. The final point is that you also need to have good collaborators who have good knowledge

> *"People always had a very open mindset and everybody was relatively very easy-going about collaborating with whoever was around and had the right expertise. That's something I really enjoy in London."*
>
> – Daniel Rückert

within their own domain, but who can also communicate, because communication is really the key.

Kerstin: So for me, I would say the most important thing is to be excited about a problem and to see that there might be a potential solution to it. Also, to have this big picture in mind. Even if you're working on a niche problem, see how it fits into the big picture and what knowledge is similar/applicable. What knowledge could you use from other domains? How could you involve collaborators, even if they aren't directly related to the topic? Having perspective, I think is key.

MRMH: Picking up on that communication/collaboration point, what is your general approach to managing a group or supervising a PhD student?

Kerstin: I'm pretty new to supervising students. What's important for me is to find the individual strengths and weaknesses of students and to really support them in their strengths. Every one of us is different in terms of how we approach research. It's also important to have a goal in mind, and then break it down into smaller steps that together progress towards the main goal.

Daniel: I think Kerstin made a very important point, which I'd like to reiterate. In my experience, the best way to manage a research team is to find out what are the strengths and interests of each individual member of the team. Your team needs to be quite diverse in the sense that it's great to have a lot of expertise from different disciplines and domains: some people might be focused on the theoretical foundation, some more focused on the applications and others focused on the middle ground. I have also found that this is fortunately relatively easy to do in London. This contact helps you to bring new approaches to problems or new ways of thinking about them, which you probably yourself wouldn't have necessarily thought of. I think that's quite important.

MRMH: What are your hobbies outside of work?

Kerstin: I love to spend a lot of time in the mountains, which was a bit difficult in London, but Scotland is amazing for hiking, and I also love going down to the coast. Otherwise, during my time in London, I really enjoyed cultural events.

Daniel: I can echo that. I also really like the mountains. I really like skiing. In London I have been cycling every day (even though it's not entirely without its hazards). It's a great way of getting around the city. You can cycle in some of the parks like Richmond Park, which even have some hills where you can go up and down.

MRMH: Finally, what is your favourite pub in London? And do you have any recommendations for the people who are attending the 2022 ISMRM?

Daniel: I like the Dean Swift in Shad Thames, close to Tower Bridge. It's a very nice pub.

Kerstin: I really enjoyed being around pubs in Lower Marsh, Lambeth, and Southbank. There are many, many nice areas. I also highly recommend the Vault Festival and Vaulty Towers pub. ■

> *"I feel that interdisciplinary work between acquisition, reconstruction and analysis will become even more important in the future, where bridging those gaps will be key"*
>
> – Kerstin Hammernik

Main entrance of Imperial College.

JOINT ANNUAL MEETING ISMRM-ESMRMB
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07-12 MAY 2022 | LONDON, ENGLAND, UK

Join us for FOOTPRINTS OF THE ISMRM IN THE MR PATH

Session at the Joint Annual Meeting ISMRM-ESMRMB!

WEDNESDAY, 11 MAY 2022 | 09:15-11:15

Throughout the history of MR, many groundbreaking studies have been presented as abstracts at our annual conferences, first at the SMRI and SMRM Annual Meetings, then at the ISMRM Annual Meetings. These influential abstracts presented at the ISMRM have gone on to underlie much of the work we do today.

In a society-wide effort initiated by our president Fernando Calamante, a task force (consisting of 9 ISMRM Junior Fellows) was created to compile a list of some of the most influential 'classic' abstracts that have been transformational in our field. The task force has consulted with our Study Groups, Gold Medalists, Distinguished Service Medalists, past and current Presidents and AMPC chairs, Board of Trustees, ISMRM Historical Archives Committee, and Editors-in-Chief of MRM and JMRI to produce a shortlist of 'classic' abstracts. These abstracts provide examples of the amazing 'footprint' of our historical path and the important role our Annual Meetings have played in being the avenue of choice for presenting new MR methods, tools, and applications that have greatly impacted and transformed how MR is used today.

To celebrate the 40th anniversary of the ISMRM Annual Meetings (including its predecessor SMRI and SMRM Societies), this year's conference will include a dedicated interactive session featuring a distinguished panel to discuss these groundbreaking works, their origins and impact.

We hope to see you at our session in London "Footprints of the ISMRM in the MR path" to witness a moment in ISMRM history and to walk in the footsteps of some of our most classic and influential works!

MRI in London *now*: King's College London – KCL

INTERVIEW BY **LAURA BORTOLOTTI** | TRANSCRIPT BY **NIKOU LOUISE DAMESTANI**

Po-Wah So is Senior Lecturer at the Institute of Psychology, Psychiatry and Neuroscience (IoPPN), King's College London. **Claudia Prieto** is Professor in Medical Imaging, School of Biomedical Engineering & Imaging Sciences, King's College London. **Shaihan Malik** is Reader in Medical Imaging, School of Biomedical Engineering & Imaging Sciences, King's College London.

"What is most exciting for me about doing MR research in London is that there are so many of us in London and it's a great community. I know I can just ring up anybody!"

– Po-Wah So

Po-Wah So

MRMH: Thank you for joining our MRM highlights interview! What was your career trajectory and how did it lead to MRI?

Po-Wah: I started my career in solution state nuclear magnetic resonance spectroscopy (NMR), as I trained as a chemist (believe it or not!). I first used NMR for structural elucidation and then did my PhD on NMR-based metabolomics in liver disease - this was ~10 years before the word 'metabolomics' was first used. We were always talking about using magnetic resonance spectroscopy (MRS) to study metabolism in vivo, but this was in the late 80s/early 90s and MRS was very 'niche' at that time. I stayed in NMR for a while, including working a few years in Pharma. I finally had the opportunity to work with MRS when I moved to Hammersmith Hospital, Imperial College London, in 1998. I worked on a clinical project involving both MRI and MRS to study uterine cervical cancer. But I went back to preclinical research, especially with the founding of the Biological Imaging Center on arrival of new 4.7T and 9.4T preclinical systems. After ~10 years at Imperial, I moved to King's College London in 2008 to initially run the preclinical MRI facility and then became faculty, focusing on the role of iron and inflammation in neurodegenerative disease and also determining the biological substrates that underlie quantitative MRI signals.

Claudia: I studied Electrical Engineering in my home country at the Pontificia Universidad Católica de Chile and did my PhD in the same institution. During my PhD I had the opportunity to do a three-month internship in London at Imperial College with Prof. Jo Hajnal. This was a great opportunity for me, not only in terms of research but also to learn English. Jo had to have a lot of patience with my poor English at that time! I finished my PhD in 2007 and decided to move abroad to do a postdoc. I was lucky enough to receive an offer from Prof. Tobias Schaeffter to work on fast cardiac MRI. This position was a great opportunity for me; it allowed me to learn a lot and gave me access to cutting edge equipment that I couldn't access during my PhD. After my post-doc, a faculty position opened at King's College London and I became a lecturer in 2011 and a Professor of Medical Imaging in 2021. During this time, I have seen the impressive growth of the imaging sciences and biomedical engineering division at KCL and it has allowed me to grow a lot too.

Shaihan: My story interconnects with both Po's and Claudia's! I first came to London for my PhD, after my undergraduate degree in Cambridge (UK) in 2003. As part of the PhD program, one of my rotations involved working on preclinical imaging with Po. I did my PhD in under-sampled image reconstruction with Prof. Jo

Hajnal, which is where I met Claudia. I finished my PhD in 2008 and was planning on leaving, however, they had this very interesting project that involved developing a 3T scanner that had been engineered with a built-in parallel transmit body coil, so I decided to stay but work on something completely different. I was offered a faculty position at King's College London in 2012 and I continued working in parallel transmit MRI. I also got a fellowship to work with the 7T site at UMC Utrecht. We now have a 7T system to do ultra-high resolution imaging and I currently work on the methods needed for developing that system.

MRMH: What is MR research like in London?

Po-Wah: What is most exciting for me about doing MR research in London is that there are so many of us in London and it's a great community. I know I can just

Shaihan Malik

ring up anybody! I often say to people that I will go "across the river" to UCL to connect with colleagues. What's so lovely about doing MRI in London is that we don't necessarily keep to our own universities, it's very broad.

Shaihan: Likewise, it's the variety that you get here in London. Being placed in a diverse clinical environment means that I connect our physics and engineering developments to the real world. It's such a nice place to work as people are working collaboratively at different levels and across the spectrum – from basic research to fully translational clinical work. An example is the 7T system that we have at King's: though a lot of the funding came from King's directly, it also received significant funding from the Wellcome Trust via a collaborative grant with UCL, Imperial and the Institute of Cancer Research. We have set up the management of that facility to promote cross-institutional usage and collaboration on the system. And there are many examples of that kind of work happening. I think we're trying, more than before, to work together.

Claudia: My experience is very much the same. The medical imaging community in general is very large and international in London, and at all levels. Many students are interested in working in our area, for example through the EPSRC Center for Doctoral Training (CDTs) in Smart Medical Imaging at King's College London and Imperial College. These centers foster collaboration, so that students get exposed to supervisors from different institutions as well as the wider MR com-

Claudia Prieto

munity. I also really like that there is a lot of opportunity to work across the pipeline, from MR physics to clinical translation, and there are several opportunities for collaboration. This also helps in terms of grant funding, as we can work on bigger ideas more easily. An example of this is the EPSRC Programme Grant SmartHeart that we hold together with colleagues from Imperial College, Oxford and Queen Mary University.

MRMH: What about access to MR facilities and research opportunities in London?

Po-Wah: The Imperial College Biological Imaging Center that I worked in, many, many years ago, was probably one of the first facilities in the UK that had multiple preclinical non-invasive imaging modalities. This in-

> *"What we have in common is that we all have the intention of moving the field forward and try to collaborate whenever possible."*
>
> – Claudia Prieto

cluded not only MRI, but PET, ultrasound and bioluminescence. The site was quite unique in that it wasn't just for Imperial College users, it was for anybody interested in working on high field MRI. We had many London-based collaborators and a great opportunity to get to know other people with similar interests. Of course, there are now many MR facilities in London, both clinical and preclinical, open to internal and external users, facilitating research opportunities/collaborations.

Claudia: We have fantastic equipment access at King's, from 1.5/3T MRI scanners to hybrid PET-MR. We also now have both a 7T and 0.55T scanner. This provides tons of opportunity, and the environment is very stimulating. I think the reason I have learnt a lot here has been both the great people and the access to cutting edge equipment.

MRMH: You all commented on the benefits of cross-institutional work in London. Do you find that there is any institution-based competition?

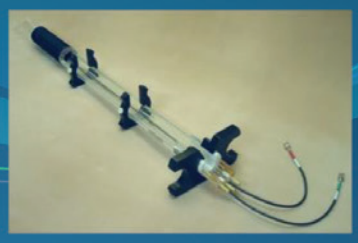
Shaihan: I personally don't feel that it is highly competitive – at least not in a negative sense. Though science is both a competitive and collaborative endeavour, you're never just doing one.

Two of KCL's campuses: Denmark Hill and St. Thomas'.

Claudia: I agree with that. It is not the case that you are racing against each other but there is healthy competition. You might be working on achieving similar goals but following different approaches. What we have in common is that we all have the intention of moving the field forward and try to collaborate whenever possible.

MRMH: Given that London will be in the spotlight for ISMRM this year, what do you think it's going to be like?

Po-Wah: Being the current President-Chair of the British and Irish Chapter of ISMRM, I know the Chapter is very much involved in ISMRM London 2022, and we were invited to be involved by Prof. Steven Sourbron, the AMPC chair. There are a lot of Chapter activities that are happening during London 2022, led by Dr David Carmichael (also at King's). We are also working with the equality, diversity and inclusion (EDI) task force to organize the EDI forum. It's very exciting for us, as an ISMRM chapter, to have the opportunity to be so involved in the organization of the International (London-based) meeting, and we're hoping to bring in much of the community to get involved. For example, there will be volunteer calls to help with tours around London. If the MRM Highlights readers want to hear more about the Chapter and its activities, including at ISMRM London 2022, come and visit our booth in the Exhibition Hall! ■



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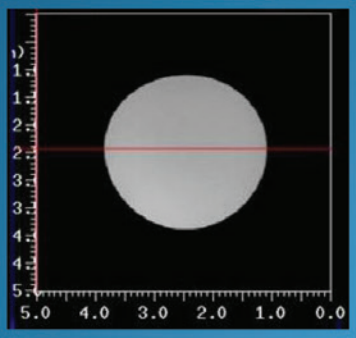

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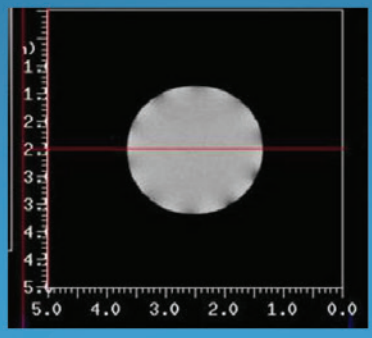

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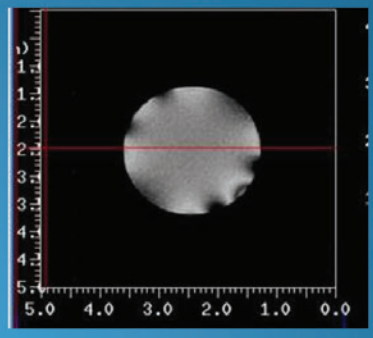

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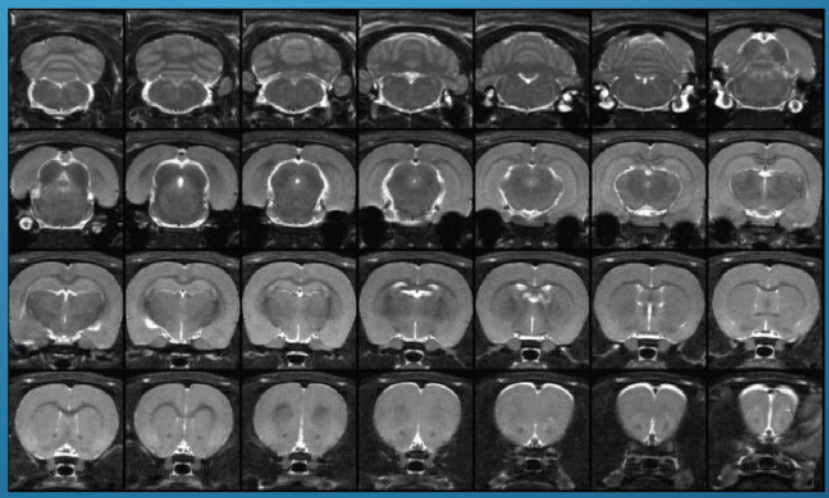

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INTERVIEW BY **EMMA BIONDETTI**

Margaret Hall-Craggs is Professor of Medical Imaging at University College London (UCL) and consultant radiologist at University College London Hospitals (UCLH). **Claudia Gandini Wheeler-Kingshott** is Professor of Magnetic Resonance Physics, UCL Queen Square Institute of Neurology. **Mark Lythgoe** is Professor of Biomedical Imaging, Founder and Director of the Centre for Advanced Biomedical Imaging (CABI) at UCL. **Daniel Alexander** is Professor of Imaging Science, Director of the Centre for Medical Image Computing (CMIC) and deputy head of the Computer Science Department at UCL.

"Being at UCL was crucial because it gave me opportunities to connect with people from inside and outside the clinical field."

– Margaret Hall-Craggs

Margaret Hall-Craggs

MRMH: Thank you for joining our MRM Highlights interview! When did you start working on MR(I)? What attracted you to MR(I) research in the first place?

Margaret: I started in 1988, just after my first child was born, undertaking a doctorate at Great Ormond Street Hospital (GOSH) where one of the first pediatric scanners in the whole world had been installed. I found MRI attractive because it was unexplored territory at that time, and it had so much potential. We would see children with various neurological conditions, and nobody knew what their brains looked like. For us clinicians, having MRI available was like unwrapping a Christmas present.

Claudia: I first thought about MR in 1988-89, when choosing my university degree. My uncle, one of the first Italian neuroradiologists to use MRI, dissuaded me from applying for a medical degree and suggested me to study basic science instead. He believed that basic scientists had a key role in the clinical future of MR. Advised by the then head of the Italian Research Council in Milan (Emilio Olzi) I went on to study solid state physics. My first encounter with medical physics happened in my final year, thanks to my Electronics Professor (Marco Villa), who had started a collaboration with a neurological hospital. Here, I developed a protocol for measuring the brain size, including developing a specific protocol for hippocampal volume, in Alzheimer's disease on a 0.35 T scanner. Interestingly, local clinicians at the time dismissed this protocol as interesting but not clinically practical and useful.

Mark: I started in the early 90s. I was working as a dog trainer in Israel, and I'd heard on the grapevine about a technique called nuclear medicine. When I came back to the UK, I started a PhD investigating hypoxic tracers. However, I was quite frustrated with nuclear medicine: either I had to do autoradiography and slice the brain or use in vivo single-photon emission computed tomography (SPECT), which gave crude images. Around that same time, I started working in David Gadian's lab at GOSH. I compared a new technique called diffusion weighted imaging (DWI) with my hypoxic tracer. We set up a stroke animal model and it worked brilliantly, in part as the area of stroke would light up on DWI. I fell in love with MR, because it gave amazing in vivo pictures compared with nuclear medicine, allowing me to do everything noninvasively.

Daniel: I started in 1998. I had just moved to the US for

a post doc in robotics. However, the head of my lab had just seen an amazing presentation on a new MRI technique, called diffusion tensor imaging (DTI) and told me she wanted me to work on this rather than robotics. I was basically shoved into MRI but spent the next 15 years "obsessing" about DTI. As a computer scientist, I came into an area dominated by physicists and clinicians, thus there were many opportunities to bring new computer science ideas to the table. I found that exciting and that's what kept me there.

MRMH: It sounds like you all had a eureka moment and fell in love with MR. How did you get to start your labs in London at UCL?

Daniel: I had a crisis moment two years later. Because of a tax arrangement for foreign academics in the US, I either had to move to a much higher paid job or leave the country. I found myself having to choose between a job offer in industry, which I didn't really want, and a tentative promise of a tenure track position in the US. At the same time, I got offered a lectureship back at UCL. I accepted and, again, it was really timely because there was such an activity on MRI at UCL and in London in general, and I was the only person in computer science who was working in MRI. This gave me a niche to exploit.

Claudia Gandini Wheeler-Kingshott

Mark: I had been in MR for 10-15 years and was aware that MR couldn't do everything. From my nuclear medicine roots, I knew how good PET and SPECT were for tracer development and molecular imaging, something harder to achieve using MR. Thus, I set up my lab to bring different imaging disciplines together, including MR, CT, PET, SPECT, optical, and ultrasound. I believed that there was a lot more biology, chemistry, and cellular engineering that could cross all these modalities.

Claudia: I came to the UK on a 3-month European grant for newly graduates to work at Surrey Medical Imaging Systems (SMIS). The plan was to learn programming on a console due to be installed on our 0.35 T scanner in Italy. Once in the UK, I was asked to program sequences that I had never seen before, because SMIS were under the impression that I was expert enough, and I didn't dare to say otherwise. So, I just stuck my head in. Then, they offered to pay for my PhD on sequence development at the University of Surrey. However, the SMIS scanner at University of Surrey was replaced after my first year, and I had to find another one running the same console. This is when I contacted Mark at UCL and found myself in London with him and David Thomas using the scanner at the Institute of Child Health, keeping them there until 10-11 pm, all of us doing and finishing our PhDs in similar years. After my PhD, I got a job offer in industry. This would have been the easiest choice. But then I saw an advert to work in the clinical environment at UCL, I applied, and it became obvious to me that that's what I wanted. I moved to UCL in January 1999.

Margaret: I'm a clinician, so I don't have anything as grand as a lab. I just have a large network of collaborators. When I left GOSH, I immediately went into a clinical consultant radiology post working with clinical MRI. I didn't have any research time until 2011, when I was given 8 hours a week for research by the Biomedical Research Centre at UCLH. Between 1991 and 2011, I had to do research in my own time, juggling work and family responsibilities. This meant that research usually happened after 8 pm. I first worked on neurological implications of HIV, then in breast MR. As a radiologist, I would work with clinical academic groups in the hospital who were interested in exploring the use of MRI. Eventually, I worked a lot on musculoskeletal MRI as we had a very big adolescent rheumatology unit. BRC funded research time allowed me the time to apply for grants to support our studies and for PhD students/post-docs. Being at UCL was crucial because it gave me opportunities to connect with people from inside and outside the clinical field. I'm at the opposite end of the spectrum to researchers such as Mark who develop techniques. I try to apply these techniques clinically driven by clear clinical needs.

MRMH: What is your current research about?

Mark: In the last couple of years we've been working on ways to convert an MR system into a therapeutic device. We have developed a minimally invasive ablation therapy that uses an MRI scanner to guide and

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>
> – Claudia Gandini Wheeler-Kingshott

> *"Preclinical imaging is a small slice of UCL. [...] I believe we have only just started to realize the potential of preclinical imaging, and as such, have much room for growth due to the rich environment."*
>
> – Mark Lythgoe

Mark Lythgoe

propel a ferromagnetic thermoseed through tissue to destroy tissue by thermoablation. MR images will help determine the least invasive path, along which the thermoseed will be navigated, and using imaging, the position of the thermoseed can be constantly assessed, giving real-time assurance of the thermoseed's location. Once at the target, an alternating magnetic field (AMF) may be applied, causing the thermoseed to heat and deliver localized cell death. The thermoseed may then be navigated through the target tissue, heating at multiple locations until the whole region has been ablated. Building on this, we have developed a new technique that uses microscopic magnetic particles to remotely activate brain cells, which could lead to a new class of non-invasive therapies for neurological disorders. The pioneering technique called "magnetomechanical stimulation" or MMS, allows touch sensitive astrocyte cells deep inside the brain to be stimulated with a magnetic device outside the body, such as the MRI scanner. Microscopic magnetic particles, or micromagnets, are attached to astrocytes, and used as miniature mechanical switches that can turn "on" the cells when a strong magnet is placed near the head. This makes MMS a promising candidate as an alternative, less invasive therapy compared to the currently used deep brain stimulation techniques that require the insertion of electrodes into the brain. Finally, we're developing non-invasive techniques to image the brain's glymphatic system as well as novel therapeutic cardiovascular biomaterials.

Margaret: We've been running a study in whole body imaging in juvenile idiopathic arthritis and got some stunning results. This has been a real eye opener, because it has enabled us to see how much arthritis people have got and how much treatment they need. For clinical outcome, but also phenotyping purposes, we're interested in the pathophysiological meaning of the MR signal. We're also trying to develop better and quicker sequences, potentially without using contrast agents. Finally, in collaboration with other UCL departments, we're developing artificial intelligence (AI) methods to speed up and improve our diagnostic procedures and our image interpretation.

MRMH: To link with Prof Hall-Craggs' mention to AI, how does it tie with your current research?

Claudia: My focus is multiple sclerosis, but my interests stretch to other diseases and methods development with high translational opportunities, so I approach AI as a user. I have my group at UCL working on developing quantitative imaging from acquisition to analysis methods and a group in Italy working more on the biophysics of signals to investigate neurodegenerative diseases. I believe that AI will change the way we acquire and process MR data, although we'll always need to understand the underlying physics. For example, we've been using AI to calculate fractional anisotropy maps from very fast acquisitions and radiologists now want to use this method in all patients with traumatic brain injury. We've also been using AI for k-space reconstruction, which is challenging. Finally, we're working with Daniel and Microsoft on using AI for sodium imaging quantification.

Daniel: In terms of AI, there's of course a lot of research happening at CMIC. We're both facilitating people in using the latest techniques and developing new algorithms. We're also using AI on low quality images acquired on old MR scanners (for example, in rural areas of developing countries) to estimate what you'd have imaged on the most recent scanners. These algorithms work amazingly well. Furthermore, we're using AI to model disease progression: we're moving away from model-based imaging, where we use computational models to drive imaging techniques, and we're adopting image-based modeling, where we use lots of different imaging modalities and metadata to inform computational models.

MRMH: What are the opportunities and challenges of conducting your research in London today?

Margaret: In general, not just in London, the impact of COVID on research teams cannot be underestimated. A great challenge will be how to reenergize a team. Moreover, because COVID has become a priority, we've really struggled to get any non-COVID ethics approvals. Finally, COVID has prevented charities from raising funds, thus charity-led funding to research is lacking.

Claudia: I agree with everything Margaret said. In general, reengaging with the group has been challenging, but I believe we'll get there. The unique opportunity of UCL is the access to knowledge and facilities, which I hope will enable us to understand the biophysics underpinning pathology. We've got access to several MRI scanners from different manufacturers, including a 7 T installed in Queen Square and another one at KCL St Thomas' Hospital, which UCL participates in. UCL and UCLH are also planning to build a new facility to host six more scanners, one of which could be another 7 T embedded in a clinical environment. In general, the environment and the links between computer science, neurology, and radiology are unique. And, of course, we've got collaborations across the UK, for example with Nottingham and Cardiff Universities.

Mark: I couldn't think of a finer place to work. UCL has got a long history of MR and MRS, so the legacy is outstanding. However, preclinical imaging is a small slice of UCL. We're surrounded by some of the most incredible departments of medicine, cell biology, anatomy, physiology…and this is a curse and a blessing, as at times it is difficult to integrate preclinical imaging across the whole of UCL. I believe we have only just started to realize the potential of preclinical imaging, and as such, have much room for growth due to the rich environment.

Daniel: As everyone said, because of the rich access to imaging and medical data, and the wide communities, there are opportunities all the time. CMIC couldn't exist without this network. We tend to be agnostic to diseases, body areas or even imaging techniques. This enables us to take ideas from a field, for example clinical neuroscience, and transplant them into a different application, for example lung disease or ophthalmology. This is a distinctive characteristic of UCL, because you must have the best of the best of the collaborators in each of those areas for that model to work. This is the big opportunity: being in London and having that huge critical mass of activity happening.

Daniel Alexander

MRMH: Thank you all for your time, it was great speaking with you. ■

UCL main entrance.

> *"Because of the rich access to imaging and medical data, and the wide communities, there are opportunities all the time. CMIC couldn't exist without this network."*
>
> – Daniel Alexander

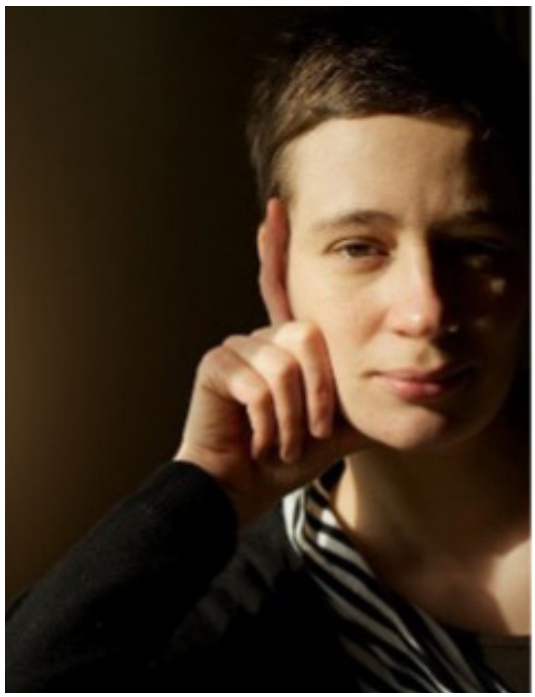
Keep it simple, keep it fun: ISMRM's amazing Public Engagement team

INTERVIEW BY **LAURA BORTOLOTTI**

"Public engagement then becomes not only what you can give to the audience, but also what you can get from them, both parts are involved in a learning experience."

Stuart Clare

Stuart Clare is Associate Professor and Director of Operations at Oxford University's Wellcome Centre for Integrative Neuroimaging. His primary background is in functional MRI, a topic he has had at heart since doing his PhD in Nottingham. Since 1997 he has been conducting his research in Oxford. His first experience with public engagement happened when he had to entertain some colleagues' children: he ended up enjoying it, got addicted and has never stopped communicating science since then!



Carinne Piekema

Carinne Piekema is Public Engagement Manager at the Wellcome Centre for Integrative Neuroimaging. Her primary background is in neuroscience and she obtained her PhD researching short-term memory at the Donders Institute in Nijmegen, the Netherlands. During her post-doc at the University of Oxford, she realised that she did not want to continue work as a researcher, but felt passionate about science and chose to pursue a Masters in Science Media Production at Imperial College London. In this context, she worked at BBC radio before moving to the public engagement role at Oxford University.

This interview and the featured speakers were fun and engaging to deal with! To reflect their teamwork and efforts in developing intriguing Public Engagement initiatives within ISMRM, group answers are provided.

MRMH: Did being involved in public engagement change your mentality about it?

Yes, and that was unexpected. In general, public engagement is seen as an activity where you "give" knowledge to others, and your contribution will help someone in some way. By being involved in those activities, you discover that it is more about being part of a community. You might meet talented people who are into the topic like you, despite not having any scientific background. Public engagement then becomes not only what you can give to them, but also what you can get from them, both parts are involved in a learning experience. By not involving different audiences in research communities, researchers are missing out on interesting points of view.

MRMH: In your opinion, which are the main barriers for scientists willing to dedicate time to public engagement?

Not receiving enough support from the workplace and being stigmatized because of that commitment could represent a big barrier to overcome. Oxford University, for example, set up a dedicated facility to support researchers with engagement, and to take care of any challenges and practical aspects researchers may face setting up and delivering engagement. This allows them to focus on the fun bit of the experience! We hope that many institutions will follow in creating a public-engagement-friendly environment for scientists, providing support, training and funding. It is clear that running these activities is enriching for researchers, as it helps them become better communicators and contextualizes their research in the end-users' world, thanks to external points of view on scientific topics. Feedback from audiences with a lived experience of the diseases we study, for instance, is precious for developing research projects, as ultimately (and hopefully) it is they who will benefit from our scientific results.

MRMH: Which were the main challenges you faced in reconciling your scientific work and public engagement?

The real challenge is trying to fit everything in your weekly schedule, in order to have the right amount of time to dedicate to each task. It is generally true that one "never has enough time", and finding further time and energy is hard. But it is possible, and definitively rewarding across many aspects. It doesn't have to be excessively time-consuming, and connecting with the public improves you as scientist and as a communicator. A further challenge is explaining to researchers who are new to public engagement what is expected of them. The objective is not to be frivolous, which is the common image that some have: connecting with the audience is crucial to effectively communicate your research and most importantly to make people feel comfortable talking about science and sharing their thoughts, experiences and ideas. Also, the nice side effect of doing these activities is to be an inspiration for new generations of researchers because "you can't be what you can't see".

MRMH: Based on your experiences, what is the difficult part of doing public engagement?

One of the biggest challenges is to reach a more diverse audience, by building a trusting relationship with institutions that don't regularly get people coming in to talk about science. For example, it took five years to build up the trust that brought to life the six months' exhibition "Your Amazing Brain" (https://www.banburymuseum.org/events/your-amazing-brain/), scheduled for spring/

David Carmichael

David Carmichael is Reader in MRI at King's College London. He performs research both in imaging physics, multimodal data acquisition and clinical neuroscience. He has experience with public engagement via schools outreach and hosting secondary school students. Being acutely aware of the lack of communication between researchers and the general public at international conferences, he initiated activity by the ISMRM's British and Irish Chapter around the London 2022 meeting so that the two worlds can benefit from each other.

> *"The objective is not to be frivolous [...] but to make people feel comfortable talking about science and sharing their thoughts, experiences and ideas."*

"One of the biggest challenges is to reach a more diverse audience, by building a trusting relationship with institutions that don't regularly get people coming in to talk about science."

summer 2022. Five years of commitments for six months of exhibition sounds like a lot of time for a short event, but the exhibition is now successfully reaching a completely new audience, and through connecting with the museum we are also able to engage with groups who already have a relationship of trust with the museum, thus having an impact on a larger and more diverse audience. To talk to kids is also challenging and may sound scary (we were scared too at first!), but it is actually really good fun, embellished with a sprinkle of chaos that might reinvigorate your research center if they are visiting it. The key is: keep it simple, keep it fun. Many of us can probably relate to being called to your colleagues' kids' school to talk about science. In this case, the trusting relationship that came from the personal connections helped in carrying on the activities in the class in a more relaxing environment. Talking with children about science can be a great experience, they are really inquisitive, and it is an amazing chance to see how enthusiastic they can be about science, to address different levels of interest or specific things they want to know.

It is easy to feel an outcast and unprepared for an event. You may find yourself in an evening event for a museum, the event is not targeted to your area of expertise, and you think that nobody would be interested in coming to your table and talking to you, but they are! And your few brain-imaging pictures that you printed out for the occasion, that maybe have clear artifacts on display, are sufficient to engage a 20-minute-long conversation. The great thing is that conversations settle even if you don't know all the answers to their questions! To experience how interested people are in scientific topics when they have the occasion to feel comfortable to talk about them is always rewarding and never stops surprising us.

MRMH: How has public engagement been handled in ISMRM and what plans are in place for 2022?

It took many years since the first SMRM conference in 1982, but ISMRM is now including more public engagement and is becoming more conscious of its importance and its benefits to the community. However, it is still not yet considered a core role of its main meetings. But it seems that the topic is gaining a good momentum! It all started with "Carinne's corner" at ISMRM2018 in Paris, where researchers had the opportunity of talking to

A shot from the "Your Amazing Brain" exhibition, taking place at the Banbury Museum, Oxfordshire, from February 12th to June 5th 2022.

Carinne about public engagement, and that momentum is growing now, helped edition by edition by the evolution of Magnetic Moments (ISMRM's annual competition inviting scientists to explain their research in the form of short videos).

In 2021, for the first time, we had an educational talk on Public Engagement. This year, for the first hybrid edition of ISMRM, we have great plans. The most exciting one will result in the production of podcasts led and planned by pupils from a state girls' school in East London close to the conference center. The main aim of the podcasts is to give pupils the unique opportunity to touch with their bare hands the MRI world, from the London scene to the international scene. They will have the freedom to choose questions and topics to touch upon. The first podcast will be recorded ahead of ISMRM. Pupils will meet London researchers and probe them with inquisitive questions. The second podcast will be recorded during the ISMRM meeting itself. Pupils will visit the conference center and interview researchers from various parts of the world, who will converge in London for ISMRM. The pupils' diverse background should result in a great variety of interesting questions being asked, allowing us to amplify kids' voices this year. Don't miss out on listening to them!

In addition, a few researchers are going to give a talk and be available to address questions from the adult general public at "Pint of science" nights at local pubs during ISMRM, and the Magnetic Moments 4th edition will be held in person with a panel of judges formed from a mix of kids and people who are experts in running activities in museums.

Finally, a mentorship program is being developed. It aims to target university students from less privileged backgrounds who we know are less likely to apply for a PhD place, even when they are academically excellent. The hope is that it will help them to feel that pursuing an academic career could be an option for them while providing material for PhD interviews. Post-docs, early career lecturers and researchers from the BIC-ISMRM will guide them in discovering what a scientific conference involves, and hopefully show them that we are a community to join where they could feel at home! ■

"This year, for the first hybrid edition of ISMRM, we have great plans. The most exciting one will result in the production of podcasts led and planned by pupils"

2021 Magnetic Moments Winner and Finalists

Magnetic Moments started engaging researchers in 2017 by setting a 3MT-like competition to catch excellent research. Carinne and Stuart created Magnetic Moments as an interesting opportunity to communicate research to peer scientists (and eventually to the general public) in a different way than the classic scientific talks given at conferences. At the time of the first edition in 2018, when the event was held in a Secret Session, there was also time for playing with science in the Resonarium, and to talk directly with Carinne in the "Carinne's corner" secret session. The third edition was delayed to 2021 and it was held on-line. Children were involved in commenting on the videos and sharing their genuine (sometimes almost brutal) opinions on them. We have interviewed the winner and the finalists of 2021 for you!

Sarah Morris – winner.

I did my undergraduate degree at the University of Cambridge and fell in love with the physics of MRI during my MSc there. This led me to a PhD in MRI for neuroimaging applications at University of British Columbia (UBC), where I am now in my final year. My research is focused on developing, validating and applying MRI techniques for quantifying the types of tissue damage which occur after a spinal cord injury.

I was interested in the Magnetic Moments competition in previous years and last year I decided to record a video. The whole process of writing and recording took a couple of days. The biggest challenge was condensing my research into such a short video and cutting out technical jargon which would confuse people. I started by writing the script, trying to build a clear story about why quantitative MRI research is important and how we can do it. Then I realised I wanted some visual aids to hold during the video, so I painted simplified sketches of the spinal cord and a nerve fiber on colored card and printed out MRI and histology images from my research. I decided to record my video sitting under the magnolia tree in my garden. The only downside to this was that I had to delete a few takes when cars drove past, and I had to reduce the loud bird sounds in post processing. I am really pleased with how the video turned out - it has been viewed many times after the conference!

The event at ISMRM 2021 was really fun. I got to meet the other contestants, watch their videos, and talk to Derek Jones who was an excellent host. The judges also had young children watch the videos and give feedback on how understandable the talks were - children are harsh critics!

I think that public engagement is vitally important. Recent world events have shown how dangerous it can be if the public distrusts or misunderstands scientists. There are so many harmful stereotypes about how difficult science is and what a scientist looks like. I'd like to do anything I can to make science less intimidating and more welcoming for everyone. I have been involved with many science communication projects over the years. I volunteered at the Cambridge Science Festival every year and presented at a neuroscience research evening at HR Macmillan Space Center in the planetarium dome. I attended a science writing internship at Wilfred Laurier University to improve my skills and confidence in writing for the public and this year I have been involved in "Ars Scientia", a research cluster at UBC pairing physicists and artists to

explore the overlap and tensions between art and science. My most memorable science communication moment was demonstrating the non-Newtonian properties of a cornstarch slime to children at the Cambridge Science Festival. I could run on top of a tank of it, but when I stood still, I slowly sank in!

Magnetic Moments competition at ISMRM is a great opportunity to have fun with your research. I would highly encourage anyone considering it to just have a go at recording a video. You don't need a lot of fancy technology and your own creativity will probably surprise you! ■

2021 Magnetic Moments Finalists

Anita Karsa

All the brilliant videos showcased at the Magnetic Moments 2021 allowed me to think more about the wide range of tools I could use for public engagement in the future.

Efrat Shimron

I really enjoyed the 2021 Magnetic Moments competition! I had fun preparing the video with my daughter and this event made me develop new strategies to explain my research in simple, friendly ways that would interest a wide audience. I'm looking forward to the next event!

Irene Kuang

I loved participating in the Magnetic Moments Competition because it has challenged me to always keep in mind the big picture societal impact of my research, especially when sharing my work with the toughest of critics--kids!

Laura Bortolotti

Magnetic Moments 2021 was my first time submitting and I am glad to have been selected as a finalist over such a good group of presenters! I had fun finding a way to remotely-engage with the (young) public and to make a presentation that even my granny would have understood.

Noemi Gyori

This was a super fun experience that made me think creatively about my research and how to talk about it to different audiences. Since, I have noticed more when I use too much jargon or lose the interest of other people when I talk to them about my work.

> *The event at ISMRM 2021 was really fun. I got to meet the other contestants, watch their videos, and talk to Derek Jones who was an excellent host. The judges also had young children watch the videos and give feedback on how understandable the talks were - children are harsh critics!*
>
> – Sarah Morris

ISMRM President Fernando Calamante

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

Fernando Calamante is Professor of Biomedical Engineering and Director of Sydney Imaging, the biomedical imaging Core Research Facility at the University of Sydney. His academic journey started in Argentina, where he achieved a BSc degree in Physics, and continued in the UK thanks to a British Council Chevening Scholarship in MRI, which also became the topic of his PhD at University College London (UCL). In 2005, he relocated his academic career to Australia; in 2019 he became ISMRM's Vice President-Elect and in 2021 he became President.

Fernando Calamante

Blast from the past

MRMH: Can you tell us about your experience with (I)SMRM meetings?

Fernando Calamante: For me everything started in 1995 in Nice, France. Since then, I've attended all ISMRM meetings, with the exception of a one-year gap before starting my PhD in London, in David Gadian's Lab. I'm one of those who gets the funny "20+ years" membership ribbon at the meetings! To be honest, it has never bothered me to have the "oldie" ribbon tag at the conference - as I am in good company - but this year, being the President, something caught my eye: the youngest members of the Society were not even born the first year I joined! That proves without doubt that ISMRM has been a lifelong commitment for me. It is mind-blowing, and the family feeling you get by belonging to the ISMRM community helps ease the weight of the years.

MRMH: What were your research interests when you began doing MR research?

Fernando: My first topic of interest was improving the modelling of pulsed Arterial Spin Labelling (ASL). My background in physics provided expertise on theoretical modelling studies, which were for the most part pursued in Argentina in the '90s due to the limited access to laboratory equipment. It was exciting for me, then, to move to a place where there was a broad and established MRI community (and MRI scanners) already in place! Being in London's MRI scene for my PhD was a bit of a shock at the beginning, but it led me to quickly know the British MRI community and feel welcome during the first international conference I attended. From my perspective, 1995 was a great year to jump into ASL, as this research field was still newborn in terms of academic timescale. The ASL field was vibrant, there were a high number of discoveries in a short time. I enjoyed at first the way researchers were creative with ASL sequence names: for example, we had FAIR, then challenged by the FAIRER, the FAIREST, and the UNFAIR variants! Emerging new MRI sequences got and still get funny names!

MRMH: Your first ISMRM abstract: what was it about?

Fernando: My first abstract, accepted for the 1995 Annual Meeting, was focused on getting a better quantification of ASL (entitled "Quantification of perfusion in pulsed labeling techniques", available at https://onlinelibrary.wiley.com/doi/epdf/10.1002/mrmp.22419950206), and I was supervised by Bob Turner. It was a relief to be selected for a Poster presentation, as my English skills were not the best and I was afraid of having to present my work as a talk. My being nervous was well balanced by the non-scientific side of the conference though. It was incredible for me to be in the South of France in August, and to have time to be a tourist in places that were so different from Argentina! The ISMRM society has always cared and done its best in the choice of places where attendees can enjoy the locations in their free time. I would recommend taking advantages of that if you can attend in person, I certainly did in Nice!

Big changes since the nineties: the ISMRM's big-bang

MRMH: You started in the 1990s, when a lot of changes were happening within the ISMRM, right?

Fernando: The birth of the ISMRM society itself was an interesting change. At the very beginning, there were two Societies called the SMRM (Society for Magnetic Resonance in Medicine) and SMRI (Society for Magnetic Resonance Imaging), focused mostly on techniques and medical applications, respectively. They merged to form the Society of Magnetic Resonance in 1994, which was soon after renamed to the acronym we are all familiar with now: ISMRM.

MRMH: The other truly major lifechanging event since the 90s has surely been the CoViD19 pandemic. Can you share your thoughts on this?

Fernando (top right corner, in a black shirt) during his PhD at UCL in the late 90s.

Fernando: The recent pandemic has of course triggered major changes in all of us, both as a community and as individuals. It is interesting to see how everyone has reacted to that, and how we have been inspired to further improve the work of the community. For example, the move from an in-person to a hybrid conferencing format, with more online interactive content, was already being discussed because of the will to increase inclusivity and to reduce our impact on the environment. It was a change that was coming, but the pandemic has forced us to accelerate the transition. I think that the last-minute virtual solution we had in 2020 was largely accepted. The alternative would have been to cancel the meeting, which is something we all wanted to avoid. Improvements in communication technology helped, of course, and this has seen a massive change too! Back in the nineties, it was not that easy to get to know researchers through the internet. Researchers had the unique occasion to associate a face and a voice to the names listed on papers only at conferences. As for now, you get to know them at talks, but also randomly queuing at the café together. Attending conferences was not, and is not, only about getting to hear the talks, but also having the occasion to meet the person hidden behind the researcher's name on the paper, and all those informal interactions.

MRMH: Did you experience a silver lining during these challenging times?

Fernando: Due the inaccessibility of workplaces during the lockdowns, universities and employers now consider flexibility at work as a valid option to cope with life's necessities. This new experience has helped an understanding of the needs of those working with limited equipment, and the community is now learning to use this new awareness to help everyone. Collaborating will keep the momentum going and bring these solutions to the post-pandemic research world. Personally, having two extra hours per day for not having to commute to work daily was fantastic. I spend more time at home with my kids and family now and, at the time we were all forced to stay at home, we had lunch all together and that would have not happened otherwise. We were really lucky!

MRMH: What toll has the pandemic taken on ISMRM?

Fernando: To some extent, CoViD has disadvantaged new members by not letting them get the sense of belonging to a large, friendly community – the 'ISMRM family'. It may also have narrowed their point of view and caused them to miss the broad context that frames MR research. I am glad this year (at least part of) our community will meet in London. I personally really missed the social aspect of the meeting, to talk with new trainees and students, to meet old friends and to have informal chats at the café. "The poster corridor" experience is something that I miss. I miss seeing many people interacting at posters, jumping in and posing or answering questions. We will be keen to put in place networking opportunities for those who cannot be in London in person, and we will encourage them to take advantage of those opportunities. This will be the first hybrid annual ISMRM meeting. It will be a learning exercise for everyone, and the community feedback will help us to improve future meetings, to understand what has worked out well and what hasn't. The aim has always been to bring the conference experience to everyone, to boost their creativity and to inspire them in their research.

Spotlight on the future of the MR world: highly computational work, highly shareable applications, open-science and reproducible research.

MRMH: What is your point of view on the future of MR research?

Fernando: I predict emerging technologies that tackle research using approaches at the two extremes: the ones that require coordination of several groups to get large high-quality data sets, and the ones that are more efficiently applied to routine clinical settings. Each has its own aim, but they affect each other, they are not separate worlds. An example of the first case is the Human Connectome Project. It takes a long time and expensive laboratory set-ups to design and acquire such data, as well as complicated data pre-processing to obtain high quality results that help us to have a better understanding of the specific study scenario. On the other side, an amazing example is represented by improvements that have been made in developing robust low-cost MRI scanners. These exploit smart solutions to address the need of increasing the accessibility of MR to a wider clinical scenario and to world regions that are economically challenged. Massive changes are happening in both fields, and I'm sure we'll witness very interesting progress at this year's meeting.

MRMH: In your opinion, is it worth investing in reproducible research practices?

> *"ISMRM has been a lifelong commitment for me. It is mind-blowing, and the family feeling you get by belonging to the ISMRM community helps ease the weight of the years."*

Fernando skiing with "ISMRM-friends" after the 2000 Annual Meeting in Denver. From left to right: Vicky Holloway, Quyen Nguyen, Fernando and Dave Thomas.

"Being part of the community means being part of a living organism that gives and receives, to stay alive and function. I always suggest getting involved in the ISMRM community. [...] Volunteering leads you to have great experiences."

Fernando: Yes, absolutely. Reproducibility fosters translation of research results to clinical practice. If a result is exceptional, it gets easily published, but if it is not also reproducible it won't have the outstanding impact that is strongly required in medicine. Papers that prove the reproducibility of a method hardly get published, because sometimes journals privilege novelty of the findings over confirmatory ones. Likewise, to get negative results published is almost impossible, whereas it would be worth knowing beforehand when meaningful research paths that look sensible actually lead you nowhere, and how. The search of novelty at all costs by journals can lead to a very biased view of the field. There is a new balance between novelty and reproducibility that needs to be found, and some small changes are starting to take place.

MRMH: What about Open Science?

Fernando: Open Science is something that I am really passionate about, as collaboration is the key to speeding up results and improving research. I was part of the Perfusion Study Group committee that promoted this practice in the first place. We had a section dedicated to creating contacts between developers and users of open-source software, in a way that both sides could benefit from each other's ideas. For example, while I was doing my PhD, I found it nonsense that the same algorithm was being implemented over different research centers. The implementation would have been better handled with an open-source approach where everyone could ameliorate the previous solution. "There is no point in reinventing the wheel", let's collaborate to make the wheel more efficient!

EDI & ISMRM: Together, Everyone Achieves More.

MRMH: ISMRM has an incredible task force to ensure Equity, Diversity and Inclusivity (EDI). What has been your experience working with them as President?

Fernando: I was recently amazed by how much the membership is willing to be involved in EDI. It all started last year, when we noticed that, due to a technical error, the EDI was not among the choices of the call for committee volunteering. It was added immediately after the error was noticed, with a new call but with a very short deadline. The short time notice was not a drawback, we had 70 people willing to volunteer: the positive response was overwhelming!

I must thank Liz Morris, Chair of the EDI Committee at ISMRM, for the work she and the committee have done in the past few years. "Everything is perfect with our EDI, and nothing needs to be improved" is not true! Things can always be improved! The EDI group is so energetic and always comes up with great new ideas. The general response from ISMRM members has been really positive. The rate of attendance at the EDI forum is growing and the Q&A session is fantastic, even if it is not always possible to tackle every single aspect. Looking at the geographic distribution of the members, we are a really diverse community, and, from a personal point of view, I am proud to be the first president coming from one of the underrepresented areas (South America), which does not reach a critical mass in terms of number of members. I have the occasion to plant the seed of change in this role and I feel like I set things in motion for future generations.

MRMH: After the emergence of further barriers due to the pandemic, what are the next steps that ISMRM is taking towards increasing inclusivity?

Fernando: One of the most discussed aspects these days is the hybrid meeting format, of course. The numbers you can possibly get in virtual/hybrid meetings are huge because these meetings overcome many issues that prevent members from traveling or exposing themselves to the pandemic, but a good internet connection is of

course needed. We need to learn where the potential and the dangers of hybrid meetings are. An example of the potential of hybrid meetings could be to break language barriers. For example, if I think about my younger self as a non-native English speaker jumping into an English-based meeting, I would have felt more relaxed in typing my question in a chat rather than speaking into a microphone, and I would have taken advantage of reading live transcripts and live translations when available. There is a huge proportion of ISMRM members who might find themselves in the same position now. However, the flip side of hybrid meetings with a large number of attendees might be the fragmentation of the community into those who would reach the venue in person and those who wouldn't over the years. So, in trying to reduce one type of bias, a new one could be created. We are all learning how to deal with hybrid meeting formats, and we are all shaping this new dimension of research by attending them and giving proactive feedback to the community.

Suggestions for (young) members of ISMRM: "be a driver, not a passenger".

MRMH: What advice do you have for younger researchers?

Fernando: I would suggest being a (pro)active member of the community, not an observer. There are plenty of ways in which you can do that, and not all of them require you already having had a long-term commitment. You don't have to wait to be nominated to do something in the Society anymore, you can propose yourself! For example, getting involved in Q&A sessions might sound scary, but it is easier than you think, and it is something that you can learn. When I was at an early stage in my career, I found asking questions difficult at first because of a lack of confidence due to the language barrier. By observing other researchers at the Q&A sessions, I learned how to come up with questions and how to formulate questions in a constructive way. Questions from the audience should aim at promoting and stimulating discussions (not at preventing them) and it is important that the speaker feels comfortable in replying. As a speaker, the art of framing the answer is important too, and it is not necessarily related to the understanding of the topic. To deliver a brilliant talk and to be able to address questions are different abilities to develop. I learned a lot just by paying attention to these dynamics. I challenged myself in asking one question at each session I was attending. I forced myself to sit as close as possible to the microphone, not in the dark far from it. This gave me no excuse for reaching it late: you had to act quickly before someone else got to the microphone if you'd liked to ask a question! In a few years' time, I became an active participant! You are going to get much more from the experience if you get involved in the Q&A session. For those attending the hybrid meeting online, being active by posting questions in the chat, and going to the virtual poster sessions is the way to accomplish this.

Being part of the community means being part of a living organism that gives and receives, to stay alive and function. I always suggest getting involved in the community. The path that led me to become this year's president is paved with all the times I did not miss an opportunity to contribute to the community. Volunteering helps networking, it helps you in knowing people and in being known, and that's what creates connections between researchers. Volunteering leads you to have great experiences. There is a lot to learn from these experiences as they challenge your collaborative, organizational, creative and leadership skills. Committing to be a volunteer for ISMRM's activities or the activities of its chapters would help your growth as well as the Society's: it is a win-win experience. However, I would recommend doing it if you have enough time and energy to dedicate to it, and to do it properly.

In volunteering, I was not driven by personal ambitions; I was willing to be an active member of the Society, not a passenger but a driver, to be able to make a difference. I first became involved with ISMRM activities as a volunteer, starting with the British and Irish Chapter (BIC-ISMRM) and the former "Diffusion & Perfusion" Study Group, where in 2002 I was elected as Program Director (the role in the study group designed for early career researchers at the time). I got involved in many different committees, sometimes invited to join. I ran for the Board of Trustees for the first time in 2005, When I was not elected and that was ok, it did not put me off! I took another chance in 2012 and I was elected. In 2019 I was elected Vice President, and 2021-2022 has been my Presidential year – if you ask my 5-year-old child, he thought I was the President of the World. That's a rewarding outcome! ■

Fernando (center) visiting Niagara Falls after ISMRM 2003 in Toronto, with Karin Shmueli, J-Donald Tournier and Laura Parkes.

ESMRMB President Eva Scheurer

INTERVIEW BY **FRANCESCO SANTINI**

Eva Scheurer is Professor of Forensic Medicine at the Department Biomedical Engineering, University of Basel, and Director of the Institute of Forensic Medicine at the HealthDepartment Basel-Stadt. Her current research interests include post-mortem validation of neuro-MRI findings, the investigation of skeletal MRI regarding fractures in children, and the application of in vivo MRI of the neck for evaluating strangulation victims. She is currently President of ESMRMB.

Eva Scheurer

MRMH: Thank you, again, for agreeing to this interview. I would like to start with the classic question that has characterized the Presidential interviews so far. Which one was your first meeting? And how many have you attended since?

Eva Scheurer: Actually, my first meeting was an ISMRM meeting. It was 2002 in Honolulu, Hawaii. This was a great start. In the same year, I also went to the ESMRMB meeting in Cannes. Since then, I have attended almost all meetings, ISMRM, as well as ESMRMB.

MRMH: You're both a physicist and a medical doctor. First of all, congratulations for that. Do you have any tales that you would like to share about the first step in MRI research? Did you start from the clinical side or from the methodological/physics side?

Eva: I actually started from the clinical side. I was a forensic medical doctor in my first year in Bern. The director of the Institute asked me if I was interested in research. I said: "of course", but I had no idea of what this meant. The next day, he came to my desk, and gave me a huge tower of papers. It was terrible. I could hardly understand anything, because it was all physics with terribly many formulas. But in the end, I had the idea to measure some metabolites in the brain that increase with time post-mortem in order to calculate when the person died. We approached the group of Chris Boesch. In the first meeting, my boss explained his vision and I – as a complete newcomer to the field – explained my idea and showed him some papers. This was the start of my first research project and how I came into the MR world. I found it so interesting to work with the physicist's group, and the annual scientific meetings were like a whole new world to me. This was why I decided to study physics. After that, I went to Graz also to work on methodological questions, not only to implement MRI in forensic research questions, but also to use the possibilities we have in forensic medicine to validate findings for clinical medicine. This is really important, because it's not that easy to validate findings in clinical MRI.

MRMH: What about the society? You are now president of the ESMRMB, how did you get involved with it, both as a member and as a more active participant? How did it work out?

Eva: I always went to the meetings, and at the beginning, I didn't know many people. I just knew Chris Boesch and the members of his research group, so I was hanging out with them a lot. Chris Boesch was the president of the ISMRM in 2002, so he knew literally everybody, and people came and talked to him. At a later time, at the ISMRM 2013 in Salt Lake City, I got to talk with Oliver Speck from the ESMRMB board and he asked me if I would be interested in joining the ESMRMB Executive Board. I was interested in getting to know how the society works. I was elected and joined the board in October 2013.

MRMH: So would you say that approaching people and trying to get mostly direct and personal contact is the most important advice for someone who wants to be involved?

Eva: Yes, I think it's very important to build your professional network. If you are interested in becoming more active in the society, you can also contact the board members, why not? Apart from being a board member, you can also participate in educational activities or in the early career researchers committee where you could just start in getting involved. You get to know people and people get to know you.

MRMH: Now that you've reached the presidency stage of the ESMRMB, do you think that it is worth it? Would you recommend to other people to work towards this goal?

Eva: Yes, absolutely. I met so many people, and I am looking forward to meeting them in person very soon.

Eva at the 7th Research Day of the Department of Biomedical Engineering, University of Basel, 2021. (Photo by Reinhard Wendler)

I would have never met many of them if I hadn't been involved in the society. It is particularly important for young researchers to get involved and to implement their ideas. I know how it is when you're young and you think all the "old ones" know how it works and you think you don't know anything. But actually, it's the young people who should shape the society. It's not so complicated, just do it.

MRMH: Did ESMRMB change over the last few years?

Eva: Yes, it changed, and the direction is quite clear. ESMRMB is not a little sister of ISMRM. I think some people initially thought so, even if not explicitly said. But in the last 10 years we realized that this is not the aim. It's nice to be small, it has advantages, and – of course – also disadvantages. ESMRMB focuses on diversity, more active integration of younger people, students, early career researchers, and the inclusion of different aspects of MR such as applications in biology. Of course, due to its much smaller size, ESMRMB is more familial, which is an advantage. It's easier to get in touch, build networks and to get to know people when you're in a more regional context. On the other hand, we are not able to cover every topic as in depth as the ISMRM can. When you go to the ISMRM meeting you have 6 days, 10 hours a day, when you can follow just your own topic, if you want to. At an ESMRMB meeting not all topics can be covered in depth. That's why we set a focus on certain topics, and can help people to integrate with each other.

MRMH: Has this focus on certain aspects been integrated into the ESMRMB annual meetings or will it be integrated in the future?

Eva: The annual meetings have already become smaller, not particularly for topical reasons, but for financial reasons. A drastic change for ESMRMB was that the sponsoring we got 15 years ago from the big firms has almost disappeared. We still get certain amounts for specific things, and we are very grateful for that. But it has drastically dropped. We needed to readapt the organization, and it also made us think about what we really want. We realized that we need to build on our strengths, which are networking, getting in contact, offering activities without the need for long flights. The COVID pandemic additionally forced us in the same direction, as it wasn't possible to fly to the US.

MRMH: It's now become easier to have a virtual meeting that is attended by people everywhere. Does it still make sense to call yourself a European society? Is this geographical identity still meaningful?

Eva: Yes, I think so. My heart is – and has always been – in both societies [ISMRM and ESMRMB]. But I really think a European society is needed. In-person meetings and hands-on workshops are easier, as there is no need for long flights. Apart from training networks and work groups, ESMRMB established a strong relationship with other European societies, which is something that works really well and I think that this is also the kind of interdisciplinarity we need for good collaborations in research and in practice. ESMRMB has, for instance, well-established relationships with the European Federation of Radiographers Societies, the European Institute for Biomedical Imaging Research, the European Society of Radiology, and the European Federation of Organizations for Medical Physics, with collective educational activities and workshops.

MRMH: At the same time, you also have important outreach projects, and this is in line with what you mentioned before about building an inclusive society. For example, you have CAMERA [Committee for Advancement of MRI Education and Research in Af-

> *"We will get to the point where we need to think: should we develop more mobility in our systems? Should we have a closer look at effectiveness? What is really the aim of that? I know it's cool, but is it really useful? Does it have an effect? Does it have a benefit for anyone? Or is it just nice to do?"*

Eva pictured at the Institute of Forensic Medicine in Basel, which she leads.

> *"The Society is there for the members, not vice versa."*

rica]. Would you like to tell us a little bit about these outreach and inclusivity projects?

Eva: As I've already mentioned, it's really important that the members of the scientific world connect with each other. This inclusion is important for all sides, on one hand to support each other, on the other hand to get important input, e.g. in which direction techniques should be developed. About 12% of ESMRMB members are from non-European countries, most of them not from North America, but from many different countries all over the world. I think this is a very good starting point. We need to connect with them, should include them and be a scientific and familiar home for them.

MRMH: Can you tell us something about the current ESMRMB demographics? What kind of members do you mostly have?

Eva: In December ESMRMB had about 700 members and about 1/3 are junior members. They are a really important part of our membership. About 10% of our members are radiographers. We would like to push this number up through our relationship with the European Federation of Radiographers Societies. I think their input is important for developers and for researchers. Finally, about 50% are regular members, many of them being very loyal and long-standing members.

MRMH: Do you have other occasions to facilitate building networks apart from the annual meeting? Do you also have other events where people meet each other?

Eva: A few years ago, we established a preclinical day, just immediately prior to the scientific annual meeting. Additionally, there is the GREC [Gadolinium Research & Education Committee] network, where researchers discuss the application of gadolinium contrast agents, and the CAMERA network, both with activities in addition to the annual meeting. The scientific annual meeting is just a central meeting point for everybody and for all networks. Additional initiatives are always very welcome, the ESMRMB is happy to support good ideas. An excellent example is the MRI Together workshop, which you personally know very well. Congratulations again, by the way, for this amazing and really successful initiative. I would also like to mention the ESMRMB educational program with activities and workshops for all members, which is also open to non-members of course. These are all opportunities to get actively involved and to get to know people in MR.

MRMH: In practice, if I want to know more about CAMERA or about GREC, what should I do?

Eva: The easiest thing is to go to the ESMRMB website and to look for the working groups where the responsible people of contact are mentioned, or to write to the office you're interested in and you will get redirected to the right person.

MRMH: We talked a bit about the society. Let's talk about MRI itself. Which technologies have been, in your opinion, most transformative in the whole history of MRI? What were the big game-changing ideas that shaped our field?

Eva: I think the most dominant and most important development was getting into higher fields, because this allowed many other methodologies to come up and give a more detailed and helpful output, such as spectroscopy, which profited a lot from higher fields, but also quantitative MRI. Fingerprinting is also a methodology that has not reached its full potential yet, I think it could still advance, because sometimes some time is needed to get used to an idea which we never had or could never work with. Hardware changed a lot as well, in the last 10-20 years.

MRMH: Sorry to interrupt but when you say higher fields, what field strengths are you talking about? 7+ Tesla or the clinical 1.5/3T fields?

Eva: I started with 1.5 Tesla. This was the maximum, and we felt it was already very good. Then it advanced to 3T and further, which opened a lot of doors. This progression allowed more than we could even think of. Now we are already talking of more than 7T. I think we're at the point where we have to think carefully if we really need a higher field for a certain application or if we can I do it equally well at a lower field.

MRMH: For the future, what do you think the important research fields will be?

Eva: Of course, the development in higher fields will go on, but will just cover a very small range of applications as it will not be available to most people, and it's also less applicable at the actual time. Very important topics will be, I think, reproducibility and validation. Additionally, machine learning and AI will change a lot in how we analyze data, how we interpret findings, and how we reconstruct our images. There will also be more thoughts about sustainability. I don't think that it will hamper de-

velopment, because people are always feeling like "Oh, I can do this! Well, this is great! Let's do it!", but we will get to the point where we need to think: "Should we develop more mobility in our systems? Should we have a closer look at effectiveness? What is really the aim of that? I know it's cool, but is it really useful? Does it have an effect? Does it have a benefit for anyone? Or is it just nice to do?"

MRMH: And on the other hand, which obstacles do you see for MRI?

Eva: I wouldn't say obstacles. But the challenges we have to meet in the future will be that we will really need to work more together interdisciplinarily. I think collaborations between physicists / engineers and clinicians / radiologists already at a very early stage of an idea would be very important. I know that it's very difficult. I know the clinicians, I know the physicists, they live in two separate worlds. But if the interaction works well, it is extremely useful. I think that it's really important to promote interdisciplinary work groups and collaborations, and also, to show the benefit of what we do. I don't know if this is the case everywhere, but at least here in Switzerland, discussions about costs and benefit come up increasingly. There will be even more systems in the future because, of course, any patient would want to have an MRI if they would know that this makes their diagnosis easier, earlier, better. And I completely agree. But we need to differentiate what examinations and what applications are really beneficial, and what applications are in a scientific and research state.

MRMH: You are also describing a more rigorous way of doing research and this is also something that is very important to me, and to the readership of MRM highlights. I'm talking about reproducible research practices. What does or what can ESMRMB do with regards to reproducible practices, for example, standardization of acquisition, data sharing, method sharing...?

Eva: We are supporting and promoting initiatives to improve these interactions. And, of course, we will promote the second edition of MRI Together. Contacts in the EU (e.g. EIBIR) will be used to facilitate common and shared repositories. At the European level, authorities are more and more aware that we need to interact, and we need to share data. We actually just had this discussion this week on a regional basis with different hospitals and the university regarding how we could facilitate data sharing and IT services. Additionally, a discussion on the ethical aspects will be important.

MRMH: I think we're almost at the end but I have I have a couple of more questions for you. First question, is the joint annual meeting in London really happening? I almost can't believe it myself!

Eva: Yes, it is happening! I will go to London! I really think it will be possible and I am looking forward to meeting all the people I haven't met for years now. I'm optimistic and I think the time has come. We should go on. [laughs]

MRMH: The last question is somewhat personal because the next meeting will also be in a way a little bit sad for you. You are one of the "unlucky" ESMRMB presidents, whose mandate only lasts from the ESMRMB meeting of the previous year to next year's ISMRM meeting which is in spring instead of autumn. If you had more time, what would you wish to implement in ESMRMB and what would you wish for ESMRMB for the future?

Eva: We should advance into the activities where our strengths lie: in the familial setting, in networking, in interdisciplinary collaborations. For that, we need to advance towards a less formalized society. This should allow for more inclusion of membership, so that more members could participate actively. The society is there for the members, not vice versa. We already started revising our statutes accordingly. We need to think about our aims, and how to achieve them, and this also applies to the next ESMRMB annual meeting, which will be in autumn 2023.

MRMH: I'm really looking forward to seeing the evolution of the society. I'm happy to be a part of it. With this, I would really like to thank you for this time that you granted us. I really feel honored that I could interview you and I'm sure that our readership will appreciate this interview as well.

Eva: Thank you very much. It was an interesting talk for me. I am grateful that I had the opportunity to express my ideas and thoughts and I hope that this will be of interest to the readers. ■

"ESMRMB focuses on diversity, more active integration of younger people, students, early career researchers, and the inclusion of different aspects."

Eva during an interview in 2018.

Looking Back: ISMRM's Young Investigator Award Winners

INTERVIEW BY **KATHERINE BLANTER**

Jean Brittain won the 1997 W.S. Moore Young Investigator Award for her paper entitled "Three-Dimensional Flow-Independent Peripheral Angiography". After completing her PhD and post-doc in Electrical Engineering at Stanford University, she worked for GE Healthcare and then the University of Wisconsin. She is now CEO and Co-Founder of Calimetrix, an MRI phantom development company. **Yijen Wu** won the 1997 I.I. Rabi Young Investigator Award for her paper entitled "Manganese ion enhances T1-weighted MRI during brain activation: An approach to direct imaging of brain function" After receiving her PhD from Carnegie Mellon University, she took some time out to be with her family. She is now an Assistant Professor and Director of the Rangos Research Center Animal Imaging Core at the University of Pittsburgh.

Jean Brittain; Jean Brittain and Dwight Nishimura.

Jean Brittain

MRMH: How did you get into MRI and Angiography?

Jean Brittain: In 1988, when I was an undergraduate at Iowa State University, I had an on-site interview with General Electric (GE) in Waukesha, Wisconsin at what was then called GE Medical Systems. I had never heard of MRI before that interview. I had always known that I wanted to do something that was medically related and that helped patients, but I didn't want to be a doctor. During my interview at GE, I was given a big-picture explanation of how MRI works, and I realized that MRI physics combined my favorite parts of electrical engineering ("signals and systems"), with a fascinating medical application. I accepted a position with GE as part of a 2-year training program that allowed me to change jobs every 6 months. I was fortunate that my second job rotation was in GE's MRI business, so I was able to learn more about the MRI system and its applications. That experience solidified my desire to work in MRI. However, I soon realized that I wanted to understand MRI physics at a much deeper level. I asked members of GE's Applied Science Lab and other GE leaders what MRI-focused graduate programs I should consider, and I applied to a variety of schools. I was fortunate to be accepted by several schools, and I visited several strong programs. Honestly, I think I could have been happy in any of them, but when I visited the Magnetic Resonance Systems Research Lab (MRSRL) in Stanford's Electrical Engineering Department, I felt particularly at home. Also, one

of my standard questions when talking to graduate students in the different groups when their advisors weren't around was to ask what they didn't like about the group/program/school. I was amazed that none of the students in MRSRL could come up with a single thing that they didn't like. I was sold! I was then very fortunate to be offered an NSF fellowship, which made it possible for me to attend Stanford. Finally, I will forever be grateful to Drs Dwight Nishimura and Al Macovski for accepting me into their group. Drs Graham Wright, Bob Hu, John Pauly, Steve Conolly, and Craig Meyer were also amazing mentors and helped me a great deal. Graham Wright was moving from Stanford to the University of Toronto around the time that I joined MRSRL, and I took over a project on non-contrast-enhanced angiography that he had recently started. That is how I ended up working on MR angiography. I feel very lucky that I discovered MRI when I did and that I was able to join such a strong and supportive research group.

MRMH: Were you sure you could succeed when starting the project?

Jean: No, I was not at all sure it would work. I first presented a technical talk on our 3D flow independent angiography (FIA) work at the 1995 ISMRM Meeting in Nice, France. At that point, we had gotten the 3D FIA technique to work well in healthy volunteers, which was relatively straightforward. However, after the Nice meeting we tried the method in patients, and the results were inconsistent. My advisors were planning to submit a grant focused on peripheral angiography, and we needed promising patient results for the preliminary data for the grant. As the student working on the most relevant project, I really wanted to get good results to support the group's grant application. At that time, the MR method that was most often used for peripheral angiography was 2D time-of-flight (a non-contrast-enhanced method that relied on the in-flow of fresh spins for contrast), and X-ray angiography was considered the gold-standard imaging approach. Contrast-enhanced MRI was being developed at the same time, but it was still limited in the spatial resolution it could achieve during the first pass of contrast agent, because methods like TRICKS were just being developed. The flow-independent method that we were working on used differences in T1, T2, and chemical shift to separate arterial blood from other tissues including muscle, fat, and venous blood. In normal volunteers, moderate T2 weighting was sufficient to separate arterial blood from venous blood and muscle, and we could use chemical shift to eliminate signal from fat. However, when we started scanning patients there were a lot of differences. In patients, the venous oxygen saturation in deep veins was a lot higher than in normal volunteers, resulting in less of a T2 difference between arterial and venous blood. So, the moderate T2 weighting that worked in normal volunteers didn't suppress deep veins in patients. In arteries below the knee, each artery is paired with two veins that are on either side of the artery, so if the venous signal wasn't suppressed, we couldn't see the artery well in the maximum intensity projections (MIPs) that we used to view the data. Also, many patients had soft tissue edema, and that was a whole new issue. My co-authors, Drs Eric Olcott, Garry Gold, Andrzej Szuba, Graham Wright, Pablo Irarrazaval, and Dwight Nishimura all helped a great deal as we worked as a team to develop approaches to address these new challenges in time for the grant submission. Those months prior to the grant submission deadline were the time of my life when I worked the most intensely for a sustained period of time. I wanted to get strong results to pay back all of the amazing things that my advisors and the MRSRL group had done for me. Over those months, we were able to optimize the different parameters impacting contrast (e.g., TE, TI, TR) and enhance the technique to address the challenges in patients. It truly was a team effort with my advisor, co-authors, mentors, and fellow graduate students all helping when needed. It was a huge relief when all of the intense work paid off with good results. We also got the grant! My advisor, Dwight Nishimura, suggested that I should apply for the Young Investigator Award as well. Bottom line, I was not at all sure the method would work in patients, but with a lot of intense team effort, we got it to work!

MRMH: What was it like to win the YIA in 1997?

Jean: It was surreal! I really did not expect to win…I was very surprised. When they called my name, I felt like I floated up to the front of the room, shook hands, and floated back. It was extra special because Dwight Nishimura, my primary PhD advisor, was moderating the plenary that followed the awards ceremony, so he was on the dais near the podium when I got the award. I was very glad he was there because he had helped so much with the project.

MRMH: Did winning the Moore award influence your career?

Jean: It definitely gave me a confidence boost, and it gave my work visibility, so in that way it definitely did. To be honest, it's still something I'm proud of today.

MRMH: Do you have any advice for early career researchers who are today where you were in 1997?

Jean: I think it is sometimes tempting to get something to work in normal volunteers, to write the paper, and then to move on. However, getting the method to work in patients is often much harder than just demonstrating the technique in healthy volunteers. My advice would be to not shy away from translating new methods into clinical use if you have the opportunity. The challenges that you encounter in patients will inspire real innovation, and it's very rewarding. For example, in the project that my YIA paper described, there was

> *"And I still love MRI. It's so elegant. The fact that you can model the physics with math, do the experiment, get your data, and it matches the theory… it still amazes me."*
>
> – Jean Brittain

Yijen Wu

a patient whose vessels were not detectable with either 2D TOF or X-ray angiography, but they were visible with our flow-independent approach. I don't know if the clinical team used our results in surgical planning or not, but our images could have made a difference. My second piece of advice is that, as you progress in your career, you often have a choice in collaborators. Choosing people that you like to work with can make work much more fun and rewarding. Also, don't hesitate to collaborate outside your group. Over the years I have realized that the more you expand your connections, the bigger your world becomes and the more you can accomplish. I feel very lucky to have had the experiences that I have had, and I still love MRI. It's so elegant. The fact that you can model the physics with math, do the experiment, get your data, and it matches the theory… it still amazes me.

Yijen Wu

MRMH: How did you get into fMRI and alternative endogenous contrast agents?

Yijen Wu: My journey into fMRI was not a direct path. My original thesis project in Dr Alan Koretsky's lab – to develop an MRI-trackable reporter gene using a transferrin receptor construct – did not turn out as we hoped for. Meanwhile, as a new graduate student, I had to learn how to operate the MRI scanner. To make learning more fun, Alan told me to use manganese (Mn) to change brain contrast. At that time, BOLD and ASL were hot topics in the MR field for detecting brain activation. BOLD and ASL fMRI measure neurovascular coupling, but don't directly look at neuronal activation. I was thinking whether there's a way to directly look at neuronal activation with MRI. I remembered from my earlier days of doing fluorescent calcium measurements that we used Mn2+ to quench fluorescence for intracellular Ca2+ quantification, because Mn2+ is a biological Ca2+ analog that can enter cells via L-type voltage-gated calcium channels. I'd seen Mn2+ "in action" with fluorescence experiments before. So, I was wondering, since Mn2+ is a Ca2+ analog and is also a T1 contrast agent, could I leverage its dual properties to see Ca2+ influx upon neuronal activation with MRI? So I tried it, and the rest is history.

MRMH: Were you sure you could succeed when starting the project?

Yijen: Not at all! My main thesis project did not work. Mn2+ was just a fun side thing for me to learn how to use MRI. This "plan B" turned out to be my main thesis.

MRMH: What was it like to win the YIA in 1997?

Yijen: Coming to the 1997 ISMRM conference in Vancouver was a wonderful experience for me. The atmosphere in ISMRM has always been very encouraging, inclusive, supportive, and family-like, especially for women and minorities. I felt that this is my village that I can belong in. Racial and gender inequalities have always been important concerns in American society. Coming from the USA, it was quite different from what I normally felt.

MRMH: Did winning the I.I. Rabi YIA award influence your career?

Yijen: Yes. However, it's not so much "winning" per se. It's more of the whole experience. The 1997 YIA experience taught me that ISMRM is really encouraging of innovative approaches and supporting new and creative ideas, even though it might seem very different or wild at the time. This set up the mentality or paradigm of my whole life, both in doing MRI research and also in my personal life, to be bold to pursue a unique pathway. I was very fortunate to work under two ISMRM Gold Medal winners: Dr Alan Koretsky for my PhD thesis work and Dr Chien Ho for my post-doctoral work. Both Alan and Chien lived out the ISMRM spirit very well. They are very encouraging of new, creative, and wild ideas; they gave me the freedom to explore and try new things in the lab. During my post-doc years, I tried *in situ* labeling of macrophages with very large micron-size iron oxide particles to detect cellular infiltration foci in allograft rejection after heart and lung transplantation. Chien was very encouraging and supportive for me to try it even though others in the lab said that the micron-size particles would harm the animals. That work ended up being published in PNAS and won the Best Basic Science award in the Society of Cardiovascular Magnetic Resonance (SCMR) meeting in 2005. In my post-doctoral years, medical and family needs made it necessary for me to work part-time to take care of high-risk infants with many health issues. The YIA spirit helped me to carve out a unique path. Back then, there were not many female scientist role models to see. People often pressured me: "Did you get a PhD to change diapers?"; "You cannot let children and family get in the way of your career"; "Many people work more than full-time in academia yet still cannot make it"; "There's no way that you can make it by working part-time". Once again, the YIA spirit of encouraging innovative new approaches encouraged me to create a new and different path that

no one in our center had done before. My postdoctoral mentor Chien and his wife Nancy were very supportive of me and my family. Chien allowed me to work part-time to run animal MRI experiments on the weekends when my husband could be home with the babies, and to work from home for data processing. Our children never went to daycare. I established a habit of starting to work at 3 AM until my kids woke up. Although difficult, doing MR research was fun for me, albeit at a much slower pace. Working part-time was a hobby for me during those years, to keep me sane and keep my brain working when I did not have any grown-ups to talk to during the day. I fully enjoyed every bit of it!

MRMH: Do you have any advice for ECRs and students who are today where you were in 1997?

Yijen: I would say, "Be true to who you are and your values": never try to fit the mold of the world by bending you, your loved ones, or your values, because it is never worth it. (Inspired by Romans 12:1-2). Also, "Everything has a season": you may be able to have it all, but just not all at the same time. (Inspired by Ecclesiastes 3:1-8). Third, "Be generous: your father has more cookies." And finally, "Be open minded, do not only focus on your own little field. Look outside". I read in a book, "For the world, you are just one; but for the one, you are the world". For the MR world, I'm just one; but for my husband and my baby, I am their world. My husband has only one wife and my children only have one mother. No one else can replace me as their wife and mother. So, I decided to give up my academic career to stay home and work part-time to take care of my children. Both of my children were high-risk infants with multiple health issues. Aside from being there for many ER trips and hospital stays, I was there when my children took their first steps, spoke their first word, and prayed for the first time. I was there when my elder son asked about death. I would not trade these experiences for anything else in the world! There is a season for everything. After the slow and winding road through the seasons of raising children, I am back to the season of full-time academic career. We are very blessed with a wonderful marriage and family. Although my classmates are now full professors with successful careers, and I am still a junior faculty, looking back I would not have exchanged the rocky and slow years of working part-time for a more successful career. On generosity: My husband was teaching my young son to share when he was maybe 2 years old. My husband asked him to share his cookie with him. My young son was massively struggling, and finally broke a tiny piece to share with my husband. Then my husband showed him, he actually had a lot more cookies! Whatever my son shared with him, his father can give it all back and much, much more!! This is one thing I wish I had known when I was younger. Over the years, I've seen people struggling because someone took someone else's ideas. Now I learned "Be generous! There are always more." Be generous. Don't be afraid to give out your ideas. You will always have more ideas. Now I have many more ideas than all the hands can do in my lab! Now that I'm older, I finally recognize that every encounter with people is an opportunity to bless them. As the Director of the Imaging Core, I can bless others, to contribute to their research by bridging the gap to help with MR imaging components. This brings me so much satisfaction and joy at my job day after day! The YIA project came about by bringing my experience using Mn2+ in cellular Ca2+ fluorescence imaging and my Mn contrast agent experience together. Learning how to balance family, work, and volunteer service at church and school taught me the valuable management and administrative skills that come in handy now for managing the core facility and many different types of project. I would encourage people to widen their life experiences and look at other fields when coming to ISMRM. There's a big world out there! ■

Yijen during graduate school, holding a chimeric transgenic mouse (coat colors white and agouti), sitting in front of the MRI console.

Yijen and her family.

> *"Be generous. Don't be afraid to give your ideas. You will always have more ideas. Now I have many more ideas than all the hands can do in my lab!"*
>
> – Yijen Wu

2022 ISMRM Young Investigator Award Finalists

EDITED BY **MARIA EUGENIA CALIGIURI**

Every year the Society nominates three finalists for each of two Young Investigator Awards (YIA), and the winners are announced at the Annual Meeting. The W.S. Moore Award, is given for original clinical research to authors of papers published in JMRI, whereas the I.I. Rabi Award, is given for original basic science research to authors of papers published in MRM. As usual, we have an outstanding group of finalists, and we have the pleasure of showcasing them here, in the Highlights magazine.

Nan Meng

W. S. Moore YIA Finalist

Nan Meng

I grew up in a beautiful city called Zhumadian in Henan Province, China, which is famous for its post stations in ancient China. Having witnessed the misfortune of many relatives and friends suffering from diseases, I applied as a major in medicine for the college entrance examination. My interest in MRI began as part of my clinical radiologist experience and postgraduate education in the First Affiliated Hospital of Xinxiang Medical University. Currently, I am a Ph.D. candidate in Imaging Medicine and Nuclear Medicine at Zhengzhou University People's Hospital under the supervision of Prof. Meiyun Wang.

My current main research direction is the clinical application of multi-parameter MRI in oncological diseases, in which amide proton transfer-weighted (APTWI) and diffusion-weighted imaging (DWI) occupy my main energy. In my early work, I applied APTWI, intravoxel incoherent motion (IVIM), and diffusion kurtosis imaging (DKI) techniques to the evaluation of cervical cancer patients, and the results showed that the related parameters could be used as potential imaging markers to noninvasively evaluate tumor tissue subtypes, grades, and Ki-67 expression levels. Subsequently, my collaborators and I gradually applied these techniques to the evaluation of patients with breast cancer, liver cancer, and endometrial cancer. APTWI has been called the affordable version of molecular imaging, so if it can be captured and validated against positron emission tomography (PET), a true molecular imaging technology, it could bring greater benefits to patients. Curious about this question, and under the guidance of Prof. Meiyun Wang, my collaborators and I are currently conducting in-depth research on this issue using PET/MRI.

It is a great honor to be selected as a finalist for the Young Investigator Award and I would like to thank the ISMRM committee for this opportunity. Those who are shameless are fearless, and those who are fearless are invincible, which is my favorite phrase. In the future, I will continue to maintain a kind of fearless attitude and contribute to the development of MRI career.

NOMINATED PAPER:

"Amide proton transfer-weighted imaging and multiple models diffusion-weighted imaging facilitates preoperative risk stratification of early-stage endometrial carcinoma"

The risk stratification system based on histological subtype, grade, and the international federation of gynecology and obstetrics (FIGO) stage is an essential reference for the selection of surgery methods in early-stage (stage I) endometrial carcinoma (EC). Amide proton transfer-weighted imaging, intravoxel incoherent motion (IVIM), and diffusion kurtosis imaging (DKI) can reflect a variety of microscopic information such as mobile proteins and polypeptides content, tissue structural

compactness and heterogeneity, and microcirculatory perfusion within biological tissues, so we speculate that these techniques may be useful in the preoperative risk stratification assessment of early-stage EC.

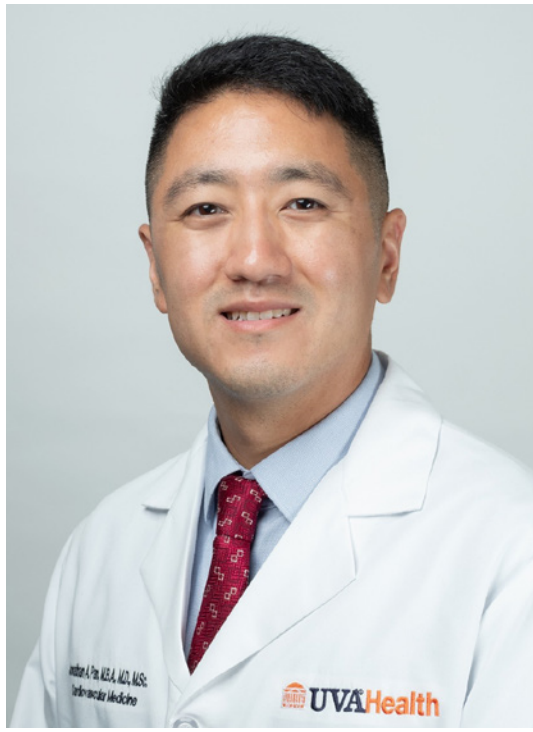
In this work, we included 80 patients with early-stage EC. MRI was performed with a whole-body 3.0-T MRI system equipped with a 16-channel phased-array body coil. The magnetization transfer ratio asymmetry (MTRasym (3.5 ppm)), apparent diffusion coefficient (ADC), diffusion coefficient (D), pseudo diffusion coefficient (D*), perfusion fraction (f), distributed diffusion coefficient (DDC), water molecular diffusion heterogeneity index (α), mean kurtosis (MK), and mean diffusivity (MD) were calculated and compared. Independent predictors were determined by regression analyses. Correlation coefficients were calculated between each parameter and risk classification. The results were as follows: 1. The α, ADC, D, DDC, and MD were higher and the f, MK, and MTRasym (3.5 ppm) were lower in the low-risk group than in the non-low-risk group. 2. MTRasym (3.5 ppm), D, and MK were independent predictors of risk stratification, and their combination was better able to identify low- and non-low-risk groups than each individual parameter. 3. MK and D were positively and negatively correlated, respectively, with risk; ADC, DDC, MD, and α all showed moderate negative correlations with risk; MTRasym (3.5 ppm) and f were moderately positively correlated with risk. Based on these results, we suggest that the DWI, IVIM, DKI, and APTWI parameters have potential as imaging markers for risk stratification in early-stage EC, which may have positive significance for EC patients.

Jonathan Pan

W. S. Moore YIA Finalist

Growing up in Virginia, I had always dreamed of becoming an engineer. I spent much of my childhood fixing household appliances and taking apart junk that we no longer needed. I went to college at the University of Virginia (UVA) and studied biomedical engineering. I joined Dr Michael Salerno's group in 2010 as an undergraduate researcher and worked on multiparametric MRI of myocardial ischemia-reperfusion injury in large animal models. In 2013, I enrolled in medical school at UVA to train as a physician but also continued to work as an engineer and researcher in the Salerno Lab. Over the next 8 years, I graduated from a combined MD/MBA program, obtained a Master's of Science in Clinical Research (MS-CR), and finished my residency in Internal Medicine. Presently, I am a cardiology fellow at UVA and will complete a NIH T32 funded training program in Advanced Cardiovascular Imaging.

My research interests include validating novel quantitative cardiac stress prefusion MRI techniques to identify and risk stratify patients with cardiovascular disease. In our lab, I evaluated the clinical application of a non-Cartesian technique known as variable-density spiral (VDS) trajectories to reduce imaging artifacts, improve spatial resolution, and shorten readout durations. We were able to quantify myocardial perfusion reserve and blood flow in 3 short-axis slices using a saturation recovery accelerated VDS pulse sequence. This technique has demonstrated excellent results when used to identify patients with obstructive coronary artery disease (CAD) as well as microvascular disease. I have also used quantitative perfusion imaging to show microvascular dysfunction in patients with heart failure with preserved ejection fraction and its correlation with diffuse fibrosis based on extracellular volume (ECV) on MRI and cardiometabolic serum biomarkers. In many respects, cardiac MRI with stress perfusion is an ideal modality that provides a comprehensive evaluation for newly diagnosed cardiomyopathy. After my fellowship, I hope to build a career dedicated to advancing cardiac MRI and its integration into everyday patient care.



Jonathan Pan

NOMINATED PAPER:

"Diagnostic Accuracy of Spiral Whole-Heart Quantitative Adenosine Stress Cardiovascular Magnetic Resonance with Motion Compensated L1-SPIRIT"

Cardiovascular disease continues to be the leading cause of death in the US, with over half of the cases resulting from myocardial infarction. Non-invasive imaging modalities are used to detect myocardial ischemia and play an important role in determining the need for invasive coronary angiography. However, only about 40% of these positive cases have obstructive CAD on subsequent coronary angiography. Cardiac perfusion MRI, however, has high diagnostic accuracy when compared with coronary angiography with fractional flow reserve and can dramatically change medical management. Cardiac MRI can also quantify myocardial blood flow, which is helpful in multivessel disease and microvascular dysfunction.

In the clinical setting, cardiac perfusion MRI protocols do not include whole-heart coverage due to limited tempo-

ral and spatial resolution. In our prior work, we achieved whole-heart coverage by combining parallel imaging, rigid-motion compensated compressed sensing, and accelerated VDS trajectories. We were able to image eight short-axis slice locations per R-R interval over 60 heart beats at rates up to 125 bpm by acquiring three interleaves per slice and two interleaved slices per saturation recovery. In our study, we validated this whole-heart quantitative perfusion imaging sequence by identifying obstructive disease in 25 patients with chest pain and known or suspected CAD. Whole-heart coverage should be the clinical standard in cardiac MRI perfusion imaging. It would provide simultaneous detection of flow-limiting CAD and estimation of prognostically significant ischemic burden. Whole-heart coverage could enable cardiologists to identify small areas of ischemia that are contributing to severe symptoms that would otherwise be missed with standard three-slice models. In addition, a rapid multislice approach is convenient for the operator because it eliminates the planning needed for slice selection and is less susceptible to cardiac motion-induced artifacts. Whole-heart coverage would enable MRI to serve as a high spatial resolution alternative to other functional imaging modalities, which often require harmful radiation and expensive radiotracers.

Mariya Pravdivtseva

W. S. Moore YIA Finalist

Mariya Pravdivtseva

When I was a child, I was impressed by surgeons and firefighters, actively saving someone's life. I wanted to be like them, I wanted to contribute to people's well-being. However, my doubtful mindset was vitally opposed to professions where you have to act here and now. What if my little hesitations were to have unspeakable consequences?

Then I realized that all great results are a product of teamwork. Medical operations are not a one-person job. We all benefit greatly from the creative activities of scientists all over the world. Therefore, I decided that I wanted to be a scientist in the front line in the life-saving business. Towards this goal, I studied biochemical physics at Novosibirsk State University in the middle of Siberia.

As an undergraduate student, I was a lab assistant at the International Tomography Center. My research focus was on NMR-based metabolomics of laboratory animals. Here, I realized that I wanted to be closer to people's immediate needs. Thus, I joined the Department of Radiology and Neuroradiology at the University Hospital Kiel as a Ph.D. student.

Currently, I am focused on improving the diagnosis and treatment of intracranial aneurysms (IA). An aneurysm is a pathological enlargement of the vessel wall, which might rupture and cause life-threatening bleedings. In particular, I'm working on the accurate identification of those IAs that are prone to rupture and their personalized treatment.

During my Ph.D., I developed a protocol to produce patient-specific aneurysm models and optimized novel MRI methods for patients with aneurysms. I analyzed the effects of aneurysm treatment on intraaneurysmal flow to guide the development of new treatment concepts. In December 2021, I defended my Ph.D. thesis and continue to work on aneurysm challenges now.

I am extremely happy to work in a hospital. I am in constant contact with medical doctors and see patients waiting for treatment. I know that the knowledge I gain from my research contributes ultimately to people's well-being, even though I am neither a surgeon nor a firefighter.I am a scientist.

NOMINATED PAPER:

"Pseudo-Enhancement in Intracranial Aneurysms on Black-Blood MRI: Effects of Flow Rate, Spatial Resolution, and Additional Flow Suppression"

An intracranial aneurysm is a common vascular pathology. Most aneurysms never rupture, but if one does, it often has fatal consequences for the patient. A reliable assessment of aneurysm rupture risk remains a clinical challenge. Vessel wall enhancement on black-blood MRI (BB MRI) has been associated with vascular wall inflammation and has been proposed as a marker of increased rupture risk. The cause of BB enhancement is still unknown; hypotheses include accumulation of contrast agents in the aneurysm wall and slow flow. Flow-related enhancement leads to false-positive conclusions. Two sources of BB enhancement can be separated using in vitro settings.

Therefore, in this study, we aimed to evaluate the contribution of slow flow to the BB signal using 3D-printed patient-specific aneurysm models. We investigated the effect of spatial resolution and motion-sensitized driven equilibrium (MSDE) preparation on flow-related enhancement.

To this end, we constructed three patient-specific aneurysm models and studied the effect of various parameters (voxel size, MSDE, velocity) on BB MRI.

In addition, the BB signal in the aneurysm lumen was compared to the velocity values acquired with 4D flow MRI and computed with flow simulations. We observed a hyperintense BB signal in the aneurysm lumen, which matched areas with a slow flow velocity. MSDE and higher flow rates reduced the BB signal, but changing the spatial resolution did not produce a clear result. For some combinations of velocity and aneurysm geometry reducing voxel size led to the decreasing BB signal, while for others it was the opposite.

In conclusion, slow-flow phenomena contributed substantially to aneurysm BB enhancement. This should be considered in the clinical setting when assessing wall enhancement in patients with unruptured aneurysms. Not all apparent BB enhanced signal is an indication of inflammation. To reduce slow-related BB signals additional flow suppression methods can be applied. In addition, we have shown that BB signal varied depending on MRI parameters (voxel size, MSDE), thus a standardized MRI protocol for rupture risk assessment is needed to avoid the difference in signal interpretation within various healthcare institutions.

Ahsan Javed

I. I. Rabi YIA Finalist

I am a post-doctoral fellow in the Laboratory of Imaging Technology of the National Heart Lung and Blood institute in Bethesda, Maryland. I am interested in developing and sharing new imaging technologies that can improve human health. My research is focused on cardio-pulmonary imaging with the goal of developing new acquisition, reconstruction, and post-processing methods to improve diagnosis and monitoring of disease.

I was introduced to Magnetic Resonance Imaging at Brigham Young University by Dr Neal Bangerter. Working in his laboratory convinced me to pursue a doctorate in electrical engineering with a focus on MRI. My interest in cardiac imaging led me to join Dr Krishna Nayak's lab at the University of Southern California. During my doctoral studies, I developed novel non-contrast myocardial perfusion imaging methods for diagnosis and monitoring of ischemic heart disease. In prior studies, non-contrast myocardial perfusion imaging was limited due to low-sensitivity and limited spatial coverage. I developed methods to solve these challenges by developing new labeling schemes to improve sensitivity, and by implementing an echo planar based imaging sequence to improve spatial coverage of non-contrast myocardial perfusion imaging. After graduation, I joined Dr Adrienne Campbell-Washburn's lab to develop cardio-pulmonary imaging methods for both structural and functional imaging on a novel high-performance low-field MRI system. I am excited about low-field MRI because of its potential to improve diagnosis of cardio-pulmonary disease and to increase accessibility of MRI technology with significantly reduced purchasing and siting costs. My recent work has focused on using efficient non-Cartesian imaging to enable robust pulmonary imaging on our low-field system. I am also developing fast GPU-based reconstruction methods to enable seamless clinical translation of our techniques. Finally, I am passionate about reproducible research and improving accessibility of advanced MRI methods. To this end, I believe developing cloud-based technologies paired with open-source frameworks such as Gadgetron can allow faster dissemination of computationally intensive advanced MRI methods.

Ahsan Javed

NOMINATED PAPER:

"Self-gated 3D Stack-of-Spirals Ultra-Short Echo-Time Pulmonary imaging at 0.55T"

High performance low-field MRI systems can potentially improve the accessibility of pulmonary MRI and may enable comprehensive assessment of lung disease. These systems may allow us to image the lung more easily due to the reduced susceptibility gradients and prolonged T2* times. However, dedicated optimization of acquisitions and reconstruction methods is needed to enable robust imaging on these systems. We developed a novel image acquisition and reconstruction method to generate high-resolution images of lung structure using low field MRI.

In our work, we developed a free-breathing 3D spiral acquisition for isotropic high-resolution pulmonary imaging. In addition, we developed a fast GPU-based reconstruction pipeline with corrections for trajectory errors, concomitant fields, and fluctuations in the navigator signal. This pipeline is available open source. The reconstruction was deployed in-line on the MRI scanner for robust pulmonary imaging, which was applied to patients with lung nodules, and COVID-19 infection.

We made several technological developments to enable high-resolution lung imaging using low-field MRI. SNR is reduced at lower fields because MRI sig-

nal is directly proportional to field strength. We mitigated SNR loss by leveraging the increased T2* times to use longer readouts with efficient spiral k-space trajectories. Spiral readouts are feasible for lung imaging at lower fields due to the reduced susceptibility which makes them less sensitive to off-resonance blurring. However, spiral readouts are more susceptible to blurring due to concomitant fields at lower fields. Concomitant fields are nuisance fields, generated whenever a gradient is switched on and are inversely proportional to field strength. We incorporated rapid concomitant field corrections in our reconstruction and demonstrated a significant improvement in image quality. Finally, adoption of MR pulmonary imaging in the clinic is hindered by slow, offline image reconstructions, which we resolved with our rapid inline implementation.

We show excellent image quality using our methods in healthy volunteers and patients. The technology presented in this work can be expanded for functional pulmonary imaging applications in addition to structural imaging. This technology can also be used to improve pulmonary imaging at both higher and lower fields than 0.55T. We hope that our technique will make pulmonary MRI more robust and accessible for routine clinical assessments.

Emil Ljungberg

I. I. Rabi YIA Finalist

Emil Ljungberg

My journey into the world of MRI began with my graduate studies at the University of British Columbia, Vancouver, Canada. I was very fortunate to end up in the lab led by Prof. Alex Mackay and Dr Shannon Kolind, who have been inspiring mentors to me from day one. My research during the time in Vancouver focused on myelin water imaging, a quantitative method for measuring myelin content in the brain, pioneered by Alex Mackay two decades earlier. During this time, I attended my first ISMRM annual meeting and was amazed not only by the incredible scope of MR research, but the openness of the MRI research community.

During my PhD studies at King's College London working with Prof. Gareth Barker, I transitioned from image post-processing to image acquisition. My PhD project came to focus largely on pulse sequence programming and image reconstruction. In collaboration with GE Healthcare, I worked on a Zero Echo Time (ZTE) imaging sequence which can operate near silently. Together with my supervisors and colleagues, we explored methods for producing various image contrasts and optimizing reconstruction methods for 3D non-Cartesian data.

My YIA finalist paper was the culmination of years of groundwork on ZTE development where I got to see the whole development process from sequence design, to image reconstruction and post-processing. All these pieces came together by thorough teamwork from our lab and collaborators at GE Healthcare.

In August 2021 my academic journey came full circle when I started a postdoctoral position at Lund University, Sweden, where I completed my undergraduate degree. I continue to work on silent MRI with ZTE while building up a new research program focused on accessible low-field MRI.

NOMINATED PAPER:

"Motion Corrected Silent Neuroimaging with MERLIN"

This work addresses two critical issues in MRI relevant for both clinical and research practice: acoustic noise, and motion artifacts. We wanted to resolve these two issues together by incorporating motion correction through self-navigation into a silent ZTE sequence, resulting in a framework we call MERLIN (Motion Elimination & Retrospective correction Leveraging Interleaved Navigators). Here, we demonstrate MERLIN for T1-weighted neuroimaging.

The idea behind MERLIN is simple. Patient motion is resolved by separating the data acquisition into multiple k-space spirals which can be reconstructed into navigator images, i.e., self-navigation. The individual navigator images are then co-registered and rigid body motion correction is applied to the raw data. Translations are equivalent to a linear phase ramp in k-space, and centered image rotations are equal to the same rotation in k-space.

In practice though, implementation proved more difficult. To maintain silent acquisition with rapid self-navigation the k-space trajectory must be designed to ensure minimal gradient switching. For this we used a 3D spiral phyllotaxis trajectory. Another feature of ZTE sequences, besides silent acquisition, is high sensitivity to materials with short T2, such as the head coil and padding. We therefore had to use automated head masking to exclude these features from the images, as they remain static when the subject moves.

We demonstrated the utility of MERLIN in a group of healthy volunteers who were instructed to move their head according to a visual paradigm. MERLIN was able to correct for head motion in all cases, demonstrating greatly improved image quality, even for rotations up to 20 degrees.

We hope that MERLIN can increase the value of MRI by enabling access to all patient groups, and deliver improved image quality for more accurate diagnosis, even in the presence of motion. This would reduce costs to hospitals and researchers and improve the experience for patients undergoing an MRI exam.

Sai Abitha Srinivas

I. I. Rabi YIA Finalist

My fascination with MRI began during my undergraduate studies for a senior design project where a team of us made a gradient system pipeline for a very low field MRI system at VTU, Bangalore. With a severe lack of clinical MRIs in my home country, I was motivated to begin learning about MRI physics and building things from scratch. During my master's at University of Michigan under the guidance of Dr Luis Hernandez Garcia I got my hands on a 7T pre-clinical scanner and implemented velocity selective ASL as part of my thesis. Although I enjoyed my experience at high field, I wanted to go the low-field route given the potentially immense impact of such a system on the developing world. Fortunately, after completing my Master's degree I was given an opportunity to work at the A.A. Martinos center under Drs Clarissa Cooley and Lawrence Wald. There, I worked on building optimized RF coils for the portable Halbach magnet. Although this MRI system worked well in a shielded room, the last piece of the puzzle to make it truly portable was to come up with an electromagnetic interference (EMI) mitigation technique to eliminate the need for a copper shielded room. This became my project in the lab and my YIA project. During the project I got true hands-on experience with RF hardware design, sequence programming and meticulous testing on the scanner. This knowledge was invaluable and helped guide me to pursue my PhD at Vanderbilt University under the supervision of Dr William Grissom. At Vanderbilt we have a 47.5 mT scanner which was fully functional except for the fact that there was no shielding in the room. I was able to implement EDITER on this scanner as well which fundamentally enabled in-vivo imaging on this scanner. My current research aims to develop Bloch-Siegert based RF encoding for low field MRI for gradient-free MRI. In addition to hardware design and construction and sequence programming, I have really enjoyed RF pulse optimization, simulations, and image processing and reconstruction involved with this project. My overall career goal is to make accessible, low-field MRI more clinically viable.

NOMINATED PAPER:

"External Dynamic InTerference Estimation and Removal (EDITER) for low field MRI"

Sai Abitha Srinivas

External Dynamic InTerference Estimation and Removal (EDITER) is a self-calibrated EMI mitigation method that enables MR imaging outside of shielded rooms, which is a central requirement to make portable, point-of-care low-field MRI feasible. The method is based on recording electromagnetic interference (EMI) signals simultaneously during imaging using external tuned RF coils and/or ECG electrodes attached to the body. The main innovation of the technique is that it does not require separate calibration data acquired prior to scanning, but instead fits the EMI detector signals directly to the proton coil signals before subtracting the EMI, in a manner similar to GRAPPA. This approach is based on the assumption that there is low correlation between the EMI and proton signals, but this is generally true and obviating separate calibration data collection ensures that the kernels relating the sensor data to the proton coil data are correct, even if the EMI changes dynamically during a scan. The kernels can be fit line-by-line during a scan, or across limited temporal windows. Importantly, EDITER can be applied to any scan without modification and makes no assumptions about the pulse sequence structure or k-space trajectory. To demonstrate this method, we used controlled EMI sources including narrow band, broadband and mixed sources in a shielded room on the 80mT Halbach Magnet. This was then rigorously tested on the 47.5mT magnet for uncontrolled EMI sources outside a shielded room. In my view, EDITER's robustness to time-varying EMI is its most important feature because in real-world scenarios where portable MRIs need to be in Emergency rooms or ICUs, equipment in the room switches on and off constantly and the EMI it produces can vary over the duration of the scan. Overall, the dynamic nature of this method and the ease of its implementation make clinical translation feasible. ■

Adaptive baseline fitting for 1H MR spectroscopy analysis

INTERVIEW BY **AGAH KARAKUZU**

HIGHLIGHTS' PICK FOR JANUARY

This MRM Highlights Pick interview is with **Martin Wilson,** a researcher at the Centre for Human Brain Health and School of Psychology at the University of Birmingham, UK. His paper is entitled "Adaptive baseline fitting for 1H MR spectroscopy analysis". It describes an adaptive baseline fitting algorithm (ABfit) for performing baseline estimations in automated analyses of routine MR spectroscopy (MRS) measurements. This paper was chosen as this month's Reproducible Research pick because Martin shared R code making it possible to fully reproduce all the results reported in his paper.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM.

"I can say, as a reviewer, is that I am always much happier to see poor code than no code at all"

– Martin Wilson

Martin Wilson

MRMH: Tell us about your background and how your research interest shifted towards MRI and spectroscopy?

Martin: My undergraduate degree was in physics, and I was mostly interested in the theoretical side because that seemed to be what I was better at. Afterwards, though, I was craving to do something more applied, and something that would be immediately beneficial to people's lives. So medical physics seemed like something worth exploring in order to satisfy those desires. At the time, there was an opportunity to do a PhD with a clinician, an oncologist named Andrew Pete who researches childhood brain tumors. The project I worked on involved studying tumor tissues and cancer cell lines at high field using high-resolution magic angle spinning, and that is how I got my introduction to MRS. At that time, there was another PhD student called Greg Reynolds, and together we realized we wanted to automate the analysis of these high-resolution spectra, as they were still done manually at the time. We started work on a software project called TARQUIN; the aim of the software was to fit the data with minimal user interaction. I stayed with the same group to do a postdoc, and that's when I got more involved with in vivo spectroscopy. That was quite good fun as well, because we were based more in a hospital environment, working with clinicians and discovering some of the barriers that prevent spectroscopy from being used clinically. I think it's really this combination of fundamental physics, signal processing, software development, and clinical applications that has kept me interested in spectroscopy for the last 15 years.

MRMH: I actually took an MRS class during my masters and thought the method was amazing because you can quantify so many metabolites across voxels. But then I asked my professor how often people use it in clinics, and she said almost never. So, why isn't everyone using MRS in clinics?

Martin: Have you ever heard the expression death by 1000 paper cuts? In other words, the reason lies in lots and lots of little things, and a few big things as well. In my view, though, the main issue is reliability. It seems there's a lot more that can go wrong with clinical MRS compared to other imaging techniques. We need to have really high static field homogeneity ; we need to be careful about distortions from scalp lipids also water artifacts and unsuppressed water signals. We have to deal with chemical shift displacement, too, which is a sequence-related artifact. All that on top of standard MRI problems, like claustrophobia, subject movement, etc. Right now, I would say that you really need local expertise in order to get useful MRS data and accurate analyses.

MRMH: Can you explain the importance of baseline modeling for short echo time MRS?

Wilson, M. Adaptive baseline fitting for 1H MR spectroscopy analysis. *Magn Reson Med.* 2020; 85: 13– 29.

https://doi.org/10.1002/mrm.28385

https://blog.ismrm.org/2021/01/22/qa-with-martin-wilson/

https://blog.ismrm.org/2021/01/29/reproducible-research-insights-with-martin-wilson/

Martin out on the trail.

Martin: So, for MRS we like to have as short an echo time as possible, because it lets us see more metabolites. But the downside of that is increased sensitivity to artifacts. Signals from lipids and residual water, which are very broad in nature, are more pronounced at short echo times and thus make the metabolites harder to measure. These signals are called baseline because they have a much smoother appearance compared to the metabolite peaks. And if you don't correctly account for this baseline signal, or these artifacts, then you can bias your metabolite estimates, so that what you're really looking at is the baseline interference rather than the true underlying metabolite levels.

MRMH: What was the motivation for your adaptive baseline fitting (ABfit) work?

Martin: Most MRS analysis methods do have a way to deal with baselines. Typically, there's a parameter that you can adjust that will set how smooth or how rigid you want the baseline to be. But it's very much a Goldilocks kind of problem: if your baseline is too smooth, you're biasing metabolite levels, and if it's not smooth enough and too wiggly, the baseline can become quite unstable. Basically, you want to get the sweet spot between the two. Although this can be done manually for single voxel spectroscopy, with spectroscopic imaging you can't be going through hundreds of voxels and manually adjusting the baseline parameters. So, the idea with ABfit was to automate that process. And the way it does that is through a series of rough analyses at different levels of baseline smoothness, after which it just picks the best one based on a statistical metric.

MRMH: You've been an open science proponent for a long time now, and for this paper in particular you share all the code necessary to reproduce your entire paper. What advice would you give to people just starting to dip their toes into open science and other reproducible research practices?

Martin: I guess to start off with, I'd recommend you just try and use open source tools whenever possible. When you find bugs, by all means get in touch with the authors and report them, and try and work together to solve any problems. And, of course, it's always good to share your own analysis code. I acknowledge that for a younger researcher, that's probably quite a scary thing to do because when you're just starting out you might feel that your code is not good enough quality, or has bugs. But what I can say, as a reviewer, is that I am always much happier to see poor code than no code at all. And we're researchers ourselves, of course, so we understand that not everyone has time to be a perfect programmer and write perfect code. But seeing code really gives us a sense of confidence. Even if not everything is well documented, or there happens to be a bug, if we can see the steps in your code, there's

Martin and daughter.

value in that. It's like when you were at school and you were asked to solve math problems: even if you got the end result wrong, you could still get credit for showing your reasoning. I think we should approach code-sharing in the research world in a similar way. And then, finally, I'd encourage people to share their data whenever possible.

MRMH: To finish off I usually like to ask authors about what they like to do when they're not doing research, however during this video call I noticed you have a guitar in the background. Is that what you enjoy doing?

Martin: [chuckles] Yeah, this is my Fender Telecaster. I've been playing guitar for years. I started off acoustic but then went electric a few years ago. There's something quite nice about making a loud noise.

MRMH: What do you enjoy playing?

Martin: I play blues mainly, but more recently I've been trying to learn a bit of Black Sabbath, comes from being in Birmingham I think! I'm well out of practice though. Before the pandemic lockdown I also used to do indoor bouldering climbing, but now it's quite difficult to do that because a lot of places have had to shut down. Hopefully this year I'll be able to pick that up again. ■

> *"It's like when you were at school and you were asked to solve math problems: even if you got the end result wrong, you could still get credit for showing your reasoning. I think we should approach code-sharing in the research world in a similar way."*
>
> – Martin Wilson

Comparison of single breath hyperpolarized 129Xe MRI with dynamic 19F MRI in cystic fibrosis lung disease

INTERVIEW BY **MATHIEU BOUDREAU**

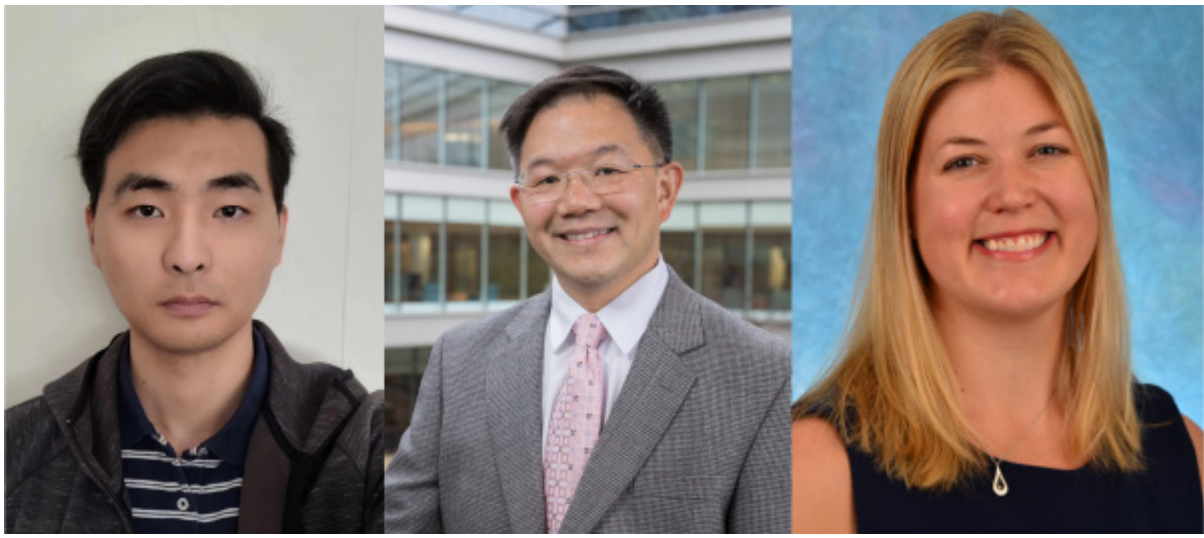
HIGHLIGHTS' PICK FOR FEBRUARY

This MRM Highlights Pick interview is with **Sang Hun Chung, Yueh Lee,** and **Jennifer Goralski,** researchers at the University of North Carolina in Chapel Hill, North Carolina. Their paper is entitled "Comparison of single breath hyperpolarized 129Xe MRI with dynamic 19F MRI in cystic fibrosis lung disease" and it was chosen as this month's Reproducible Research pick because they shared code and data that reproduce several of their figures.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM.

"When you're in these smaller research fields, having other people look at your data and process it in different ways to explore new opportunities is always exciting."

– Yueh Lee



Sang Hun Chung, Yueh Lee, and Jennifer Goralski.

MRMH: Could you please tell us a little about yourselves and how you came to be involved in this project?

Sang: I am a graduate student doing a PhD in biomedical engineering, and Dr Lee is my advisor. When I first entered the field of MRI, I was working only on fluorine, but I then progressed to doing some wash-in and wash-out analysis with xenon. For this paper, my main responsibility was the data processing.

Jennifer: I am a physician-scientist — an MD trained in pulmonary/critical care and pediatric pulmonology. My clinical area of interest is cystic fibrosis. Yueh and I started a research collaboration in 2014 to pursue a shared interest in exploring outcome measures that could be used, in particular, to image ventilation. With the help of our colleague, Dr Cecil Charles at Duke, I have therefore developed a special interest in working with perfluorinated gas MRI.

Yueh: I'm a neuroradiologist, but my PhD field was MR physics. I have therefore always had more of a translational approach to medical imaging in general. I've been

McCallister, A, Chung, SH, Antonacci, M, et al. Comparison of single breath hyperpolarized 129Xe MRI with dynamic 19F MRI in cystic fibrosis lung disease. *Magn Reson Med.* 2020; 85: 1028– 1038.

https://doi.org/10.1002/mrm.28457

https://blog.ismrm.org/2021/04/09/qa-with-sang-hun-chung-yueh-lee-and-jennifer-goralski/

https://blog.ismrm.org/2021/04/16/reproducible-research-insights-with-sang-chung-yueh-lee-and-jennifer-goralski/

responsible for the technical component in getting the fluorine-19 work started up here at UNC, while Jen's really been the clinical component of this collaboration. Sang, our PhD student, has performed the heavy lifting in keeping the system running, and has led in the data analysis. We're very excited to be able to take this work straight into humans and really help move CF research simultaneously.

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

Sang: In this study we compared fluorine MRI (where we scan multiple breaths of perfluorinated gas to image dynamic ventilation) with hyperpolarized xenon imaging in a set of ten patients with mild cystic fibrosis. Regarding the fluorine data we acquired, we analyzed early breath data (first breath) separately from the maximum ventilation data (last breath), whereas for the hyperpolarized xenon imaging we compared low-resolution scans and high-resolution scans. We compared the VDP (ventilation defect percentage) values measured in each condition and also compared the correlations between each pair of datasets.

Jennifer: We knew it was going to be an uphill battle when we first decided to study perfluorinated gas rather than hyperpolarized gas, which (in the cystic fibrosis world, at least) is becoming more mainstream. We really wanted to try to perform as direct a comparison as possible between these two modalities. I was a little bit surprised at some of the ventilation defect mismatches we observed (these occur when the two gases fail to detect the same VDPs). In my view, the occurrence of these mismatches really does highlight what we gain from getting a dynamic image using multiple breaths of perfluorinated gas as opposed to a single breath, and it also shows that these imaging modalities could complement each other well. Also, there has recently been a major transformational shift in the care of cystic fibrosis patients, thanks to the availability of CFTR modulators, which are drugs that target the genetic defect underlying the disease. The traditional outcome measures that we depend on for tracking the disease clinically are not going to be relevant much longer. And so, having another, potentially more sensitive, tool that can allow us to detect changes in the disease state is really important to the cystic fibrosis community right now.

Yueh: The xenon imaging world is very well established and has multiple groups who are very experienced. We were fortunate to have Dr Rosa Tamara Branca here on our campus as a resource to collaborate with us on that side of this work. It was great to be able to work with her and develop this protocol, focusing very much on making that direct comparison with fluorine. As mentioned, we stumbled on these very interesting mismatches, and trying to work through those was a little worrisome at first. Thankfully, we had a broad group of collaborators and concluded that something real was driving the signal in the mismatched areas.

MRMH: What are your main takeaways from this study?

Sang: What we observed was that the VDP calculation seems to be dependent on a lot of things, such as the different imaging resolutions for xenon. So that is something to bear in mind. And with fluorine, the slow filling of the air spaces may lead to a mismatch between single versus repeated breaths of gas, which in turn may result in some areas being miscategorized as ventilation defects, whereas in fact they may just be slow-filling areas.

Yueh: I think the mismatch is the critical area, where obviously there's something going on with the xenon signal that is unusual and different compared with fluorine. And so, I think there's a lot of interesting physiology that, ironically, can be derived from the xenon side of things, but that fluorine can't get at in the same way.

Jennifer: The real challenge we faced with the data analysis and interpretation was related to the difference in lung inflation: in other words, the fact that the gas the subjects breathed was a fixed volume in our xenon inhalation scans, as opposed to tidal breathing and then breathing to inspiratory capacity on our 19F scans.

MRMH: You shared coding data with your paper – is this something you normally do for all your papers?

Yueh: This is the first time that we have shared code and data to this extent. When you're in these smaller research fields, having other people look at your data and process it in different ways to explore new opportunities is always exciting.

Jennifer: The scientific community as a whole has benefited from more open sharing of science, as evidenced by the Covid vaccination projects. I've had a lot of patients ask, how is it possible that these vaccines got approved so fast? And when you really delve into it, you find that it is largely because people were open about sharing their science, which allowed scientific progress to be made more rapidly. So, I think that this is the direction science should be moving in.

MRMH: You are all lung imaging researchers – I imagine the past year hasn't been easy for you, because of the pandemic. How have you adapted?

Jennifer: Yes, it's been a challenge for sure. We essentially lost three months where no one was even allowed in the lab or the imaging center until we got better access to Covid testing and PPE. When we reopened in June, there were a lot of rules needing to be respected, such as wearing PPE, screening patients for symptoms, and doing Covid testing prior to certain procedures such as spirometry.

Yueh: It was also challenging because Jen, as a clinician, also works in the ICU, so she's actually caring for these Covid patients. So, on top of everything else, and trying to keep her research going, she was on the frontline in this pandemic. I had no concerns in maintaining our protocols to keep both our team and our subjects safe, since she's used to taking care of some of the sickest patients we have in the hospital. ■

"I've had a lot of patients ask, how is it possible that these [Covid] vaccines got approved so fast? And when you really delve into it, you find that it is largely because people were open about sharing their science, which allowed scientific progress to be made more rapidly."

– Jennifer Goralski

Phase Unwrapping with a Rapid Opensource Minimum Spanning TreE AlgOrithm (ROMEO)"

INTERVIEW BY **EVA ALONSO-ORTIZ**

HIGHLIGHTS' PICK FOR MARCH

This MRM Highlights Pick interview is with **Simon Daniel Robinson** and **Korbinian Eckstein** (Medical University of Vienna) and **Barbara Dymerska** (University College London). Their paper, entitled Phase Unwrapping with a Rapid Opensource Minimum Spanning TreE AlgOrithm (ROMEO), introduces a new approach to phase unwrapping. It was chosen as this month's Reproducible Research pick because they made the code for ROMEO open source and provided the community with executables for Windows, Linux and macOS.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM.

"the experience made me realize that it's really important to let the coauthors or colleagues review the code you want to publish as part of the manuscript."

– Barbara Dymerska

MRMH: To start off, could you tell me a little bit about yourselves and how you all came together to work on this paper?

Barbara: I did my PhD with Simon, on improving the reliability of functional MRI at high field strength using phase information. After that, I joined Dr Karin Shmueli's group at University College London as a Marie Skłodowska-Curie Fellow to work on Quantitative Susceptibility Mapping (QSM) of microbubbles.

Korbinian: After doing my bachelor's in Munich, I moved to Vienna for my master's. While there, I did a project in Simon's group and immediately felt at home. So, I finished my master's there and afterwards Simon convinced me to stay on for a PhD. My main project was working with phase images (in the context of Susceptibility Weighted Imaging (SWI)).

Simon: My background is in physics. I did a PhD in nuclear physics at Manchester University, then a master's in medical physics, as part of the training to be a clinical medical physicist. That also involved a placement in MRI, in which I worked on phase-contrast angiography, my first taste of phase! Actually, I'd been skirting around MRI; a lot of medical physicists at that time were getting into MRI because it was considered the most interesting and most diverse medical imaging modality. I swam against the tide for a while and did a PET project for my masters instead. In the end, though, I realised that

Barbara Dymerska and Korbinian Eckstein.

MRI was the way to go, and moved to Vienna to start working with Ewald Moser at the Medical University of Vienna. After postdocs in Vienna and at The University of Trento, Italy, I got a position with Siegfried Trattnig in Vienna and set up a small group. I'm now working on fMRI-QSM at the University of Queensland for the first two years of a three-year sabbatical, with the final year at the Medical University of Graz (which is all also a Marie Skłodowska-Curie project).

With regard to ROMEO, Korbinian and I had been reviewing a paper that somebody had submitted together with a Jupyter notebook. I had more or less finished the review, but I couldn't get the notebook to work. So,

Dymerska, B, Eckstein, K, Bachrata, B, et al. Phase unwrapping with a rapid opensource minimum spanning tree algorithm. *Magn Reson Med.* 2021; 85: 2294– 2308.

https://doi.org/10.1002/mrm.28563

https://blog.ismrm.org/2021/03/26/reproducible-research-insights-with-barbara-dymerska-korbinian-eckstein-and-simon-robinson/

https://blog.ismrm.org/2021/03/19/qa-with-barbara-dymerska-korbinian-eckstein-and-simon-daniel-robinson/

From left to right: David Bancelin (post-doc in Simon's group working on the correction of physiological noise using fMRI phase), Simon Robinson, Beata Bachrata (a PhD student Simon's group: a co-author on ROMEO and ISMRM YIA finalist in the 2021 competition for the I.I. Rabi Award), Korbinian Eckstein, and Pedro Cardoso (post-doc working with Prof. Siegfried Trattnig on fingerprinting in clinical populations; formerly working in Simon's on exploratory fMRI analysis).

I said "Korbinian, you might be interested in this". He came back the very next day enthusiastic about Jupyter. That was the first you'd heard of the Julia programming language, wasn't it?

Korbinian: Yes, that's right. And I immediately realized it was a cool new language!

Simon: Knowing that Korbinian desperately wanted to move on from MATLAB, which had been our 'group language', I agreed to let him go off and experiment with Julia. At that point, I'd had an idea for a phase unwrapping method based on unwrapping in 1D. I told Korbinian about it, and he said he'd also been working on an unwrapping method, in Julia. It was more or less an early form of ROMEO.

MRMH: Let's take a step back for those who haven't read the paper. Simon, could you very briefly describe what the paper is about?

Simon: Phase can encode a lot of interesting information; from flow velocity in angiography to temperature and, probably most importantly, magnetic field strength. An immediate problem in using phase is that it is mapped into a range of 2π radians. Outside of that, it's wrapped. We use the term "wraps" because a relatively smooth underlying phase leads to distinct boundaries between regions in which the phase is correct and regions that need multiples of 2π to be added to them in order to reveal the underlying true phase; that is the process of unwrapping. Phase unwrapping algorithms fall into different categories; temporal and spatial, with the spatial category including Laplacian-based methods, region-growing methods and path-following methods. ROMEO is in the path-following category, where you are trying to identify a reliable seed voxel and then follow a path through the image that only goes through other reliable voxels, or actually connections between voxels. Korbinian was interested in reading up on and implementing his idea for a phase unwrapping method, but less keen to write about it. That's why we got Barbara involved; she's incredibly efficient at analysis and putting a paper together. As well as being fast and accurate, ROMEO is also open source. That allows users to modify the weights which determine the path taken through the object, or other aspects of the algorithm, for their own use case.

Korbinian: Once we had decided to collaborate with Barbara, the first step was to make the code more approachable and share it with her so that she could run the analysis. At first it didn't work because her environment was different. So, I looked into how to make it portable, in Julia, which proved quite easy to do. The Julia code is now available as a package on GitHub but we also provide compiled command line versions for all three major operating systems, so it is very straightforward to set up. I must add that ROMEO started out as a 3D unwrapping algorithm and with the feedback and involvement of Barbara, we turned it into a hybrid method which uses temporal information as well. We also added new features like unwrapping multiple separated regions, performing a weighted combination of unwrapped phase images and removing phase offsets in multi-echo data.

Barbara: When I first saw Korbinian's code, the Julia programming language was new to me, but Korbinian made it easy to review because he writes elegant code. This experience made me realize how important it is to have one or two other people look through code thoroughly, really trying to understand it line by line, as you would with a manuscript. When somebody sends you a manuscript, you normally tend to look at the figures, the final results, the text and maybe derive the equations yourself, while the code is not examined. And yet, quite often it can contain a mistake, subtle, but very substantial. And you will never trace it if you look only at the final results. I just want to point out that, in Korbinian's case, there were no such mistakes. But the experience made me realize that it's really important to let the coauthors or colleagues review the code you want to publish as part of the manuscript. ROMEO wasn't my idea and I had to understand how it works from the code and select appropriate data for testing it. I hope that made me write about ROMEO in a way that is approachable and interesting. ■

Barbara Dymerska, Beata Bachrata, and Simon Robinson discussing ROMEO in Montreal at the 2019 ISMRM.

Additional text and figures can be found online.

Improving FLAIR SAR efficiency at 7T by adaptive tailoring of adiabatic pulse power through deep learning B1+ estimation

INTERVIEW BY **PINAR S. ÖZBAY**

HIGHLIGHTS' PICK FOR APRIL

This MRM Highlights Pick interview is with **Shahrokh Abbasi-Rad, Markus Barth** and **Steffen Bollmann,** researchers at The University of Queensland, Brisbane, Australia. Their paper is entitled "Improving FLAIR SAR efficiency at 7T by adaptive tailoring of adiabatic pulse power through deep learning B1+ estimation". Their method uses information from B1+ localizer scans and estimates B1 field bias for slice-wise correction using a convolutional neural network. They also made their training dataset and code available on GitHub for the benefit of the MR community.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM.

Shah on his frequent therapeutic visit to Lone pine koala sanctuary, learning from red kangaroos how to meditate and chill out; Markus teaching his son how to surf – being a beginner himself – on one of Queensland's fantastic beaches; Steffen climbing Cascading Crystal Kaleidoscope (CCK) in the Gunks during our 1 year research exchange at the MGH Martinos Center.

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

Shahrokh: During my bachelor's studies, I took an elective course on MRI. This course left me with a lot of questions, as I was a newbie to the field, and I grew increasingly enthusiastic about it. I decided to continue in the field of MRI for my master's degree, which I did at Tehran University of Medical Sciences (TUMS). There I worked on cortical bone water quantification. I was keen to gain further experience with both MRI and pulse sequences, and so I sent an email to Markus. Luckily, he was pleased to help. Later I moved to Australia and joined his lab for my PhD studies.

Steffen: I studied Biomedical Engineering in Ilmenau, Germany, where I worked on EEG/MEG source localization. For the latter, we were using forward models and extracting this information from MR data, and it was this work that sparked my interest in MRI. I was given the

Abbasi-Rad, S, O'Brien, K, Kelly, S, et al. Improving FLAIR SAR efficiency at 7T by adaptive tailoring of adiabatic pulse power through deep learning estimation. *Magn Reson Med.* 85; 2462-2476.

https://doi.org/10.1002/mrm.28590

https://blog.ismrm.org/2021/04/23/qa-with-shahrokh-abbasi%e2%80%90rad-markus-barth-and-steffen-bollman/

https://blog.ismrm.org/2021/04/30/reproducible-research-insights-with-shahrokh-abbasi%e2%80%90rad-markus-barth-and-steffen-bollmann/

Research group photo.

chance to do an internship in Jena with Prof. Reichenbach's group. After that, I continued down the same path and moved to Zurich. I did my PhD in EEG/fMRI and GABA spectroscopy with Ruth O'Gorman and Klaas Pruessmann. Following my PhD, I started looking for a country with a little bit more sunshine and better weather for rock climbing and outdoor pursuits, and that is how I came to Brisbane working with Markus.

Markus: During my master's studies, a professor from the Nuclear Physics Department taught us a little bit about NMR. I became very interested and he suggested I join an MR lab at the University of Vienna. There I had a chance to work on blood oxygenation and fMRI, which had just been invented around that time. It went on to be the main part of my PhD work. Following my PhD, I joined Prof. Norris's group in Nijmegen, where I had the opportunity to gain experience with a 7 Tesla system. I worked on projects related to laminar fMRI and sequence development for many years, and eventually I decided to build up my own group. And that's the story of how I ended up in sunny Brisbane.

MRMH: Tell us about your paper and how the work came about.

Shahrokh: We wanted to use a FLAIR sequence at 7 T for brain imaging. 7 Tesla offers a high signal-to-noise ratio (SNR) and allows you to visualize subtle anatomical features of the brain. But the specific absorption rate (SAR) presents a problem; if you want full coverage, the scanner requires you to reduce the number of slices or increase the repetition time (TR) time. However, we didn't want to reduce our field of view or increase the scan time. So, we decided to try reducing the SAR of the FLAIR pulse sequence.

Steffen: I think the idea actually originated during a couple of coffee meetings with other scientists in the center. Basically, we were aware that the FLAIR sequence wasn't working well at 7 T. And then they (our Siemens engineers) said, well that's obvious because there are adiabatic pulses in the sequence, which consume a lot of SAR because they are overdriven to ensure full inversion everywhere in the brain. We initially thought about acquiring a B1 map and measuring what we needed, and then just scaling the pulse down. So, that's pretty much how it started, as a summer project in 2016. In the meantime, I started working on deep learning projects and later we came up with the main idea for the paper.

Markus: We wanted to make the method robust and useful over a large population. But we also knew that B1 map acquisition takes a long time. Then, it suddenly came to us: all we need to know is the B1 bias field, which we can predict from the localizers that only takes 20 seconds to be acquired (and needs to be acquired anyways)! And we decided to leverage deep learning to do so. But, in any case, we would not have come up with this idea without our coffee meetings!

MRMH: Could you also briefly describe the deep learning model and outcome?

Steffen: We acquired localizer scans and B1 maps in 28 volunteers and also made them publicly available. We trained a convolutional neural network to estimate the B1+ profile from the localizers and calculated slice-specific scale factors. We assessed the predicted B1+ profiles and the effect of scaled pulse amplitudes on the FLAIR inversion efficiency in oblique transverse, sagittal and coronal orientations.

Shahrokh: I think, the main achievement of our work is the use of a FLAIR sequence with whole brain coverage at 7 Tesla, with less SAR, and without the need of dielectric pads or a pTx system, while getting the most out of a single-channel coil. Also, the method is not limited to FLAIR, so any 2D pulse sequence that uses adiabatic pulse can benefit from it.

MRMH: What was the biggest challenge in the implementation?

Markus: We wanted to find an automatic solution for lowering SAR for FLAIR at 7 Tesla. And the challenge was really to put all the different pieces together.

Shahrokh: This project had various aspects: sequence programming, deep learning, RF pulse design, and image processing. Also, although the scale factor calculation initially seemed very straightforward — we all thought, it's just a curve, and we simply need to reduce the scales as we move up in the brain — making it robust actually turned out to be a lot more difficult. In fact, I also had to perform simulations based on Bloch equations, to look carefully into the B1 maps.

MRMH: What is your take-home message for MRM Highlights readers?

Markus: Ideas are great. But I also find it very important to assemble all the other necessary ingredients to turn your ideas into something useful — so other people are able to use it for their ideas, projects and applications.

Steffen: Definitely. It took just two days for us to advance from that coffee meeting to the first prototype. But then, implementing the method in the scanner in a robust way and publishing the work took years. We should also appreciate the work done by the company and vendor engineers. As researchers, we are breaking their systems on purpose!

MRMH: I couldn't agree more! Again, congrats on your nice work. I hope to see you virtually during the upcoming ISMRM conference! ■

> *"Ideas are great. But I also find it very important to assemble all the other necessary ingredients to turn your ideas into something useful — so other people are able to use it for their ideas, projects and applications."*
>
> – Markus Barth

Additional text and figures can be found online.

FSL-MRS: An end-to-end spectroscopy analysis package

INTERVIEW BY **AGAH KARAKUZU**

HIGHLIGHTS' PICK FOR MAY

The MRM Highlights Pick interview this month is with **William T. Clarke** and **Saad Jbabdi,** researchers at Oxford University. Their paper is entitled "FSL-MRS: An end-to-end spectroscopy analysis package". It was chosen because their software and algorithms were shared open-source, and integrated as a package for the FSL software.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM.

"I think if you give people a good interface to explore the results, it can minimize the post-processing effort needed"

– William T. Clarke

Will taking a break in Utrecht in 2019.

Saad showing extreme brand loyalty at a Christmas dinner at Papenburg, Germany.

MRMH: How did you get involved in MRI research?

William: I first got involved in MRI while doing a chemistry degree here at Oxford, specifically when working with Chris Rodgers on a 9-month project dealing with phosphorus cardiac spectroscopy. Afterwards, I ended up doing a doctorate in the same field, and then moved on to brain imaging for my post-doc, which also focused on spectroscopy.

Saad: I started off my career by doing a degree in applied maths in France, which was when I first heard about signal processing. I found this topic very interesting, and so I followed that path for a while. Then, later on, I heard someone from GE give a talk about imaging the body, which I found such an interesting application of mathematics. That prompted me to join GE for a little bit doing X-ray tomography. After working with them for half a year, my supervisor mentioned a lab that does brain imaging that I might be interested in, and so I pursued an opportunity to do a PhD with them. I was really fascinated by the fact that they studied the brain and needed a lot of maths in order to do so, specifically in diffusion MRI applications. Later on, I joined Oxford — where I still am — because the lab here was one of the leading groups working on diffusion MRI.

MRMH: What convinced you to spend time developing this FSL-MRS tool? What gap does it fill in the current landscape of open-source MRS tools?

William: Our center has about 16 ongoing studies that use MRS. All these projects involve people who are mostly non-expert spectroscopy users. Running the imaging sessions is fairly straightforward, whereas MRS data analysis can be a really tricky point for them. Basically, the existing pipelines weren't very user friendly for non-experts. So, in the context of this paper/software, there was certainly that element — the desire to produce something that did everything our local users needed. And we hoped that it would go on to be a useful tool for other researchers around the world, too.

Clarke, WT, Stagg, CJ, Jbabdi, S. FSL-MRS: An end-to-end spectroscopy analysis package. *Magn Reson Med.* 2021; 85: 2950– 2964.

https://doi.org/10.1002/mrm.28630

https://blog.ismrm.org/2021/05/28/qa-with-william-t-clarke-and-saad-jbabdi/

https://blog.ismrm.org/2021/06/04/reproducible-research-insights-with-william-t-clarke-and-saad-jbabdi/

Will (second from right) racing for the first time in two years in early May.

And the second reason, which is really what first got me and Saad working together, was the need to analyze dynamic spectroscopy data, which we also deal with in this software.

Saad: I was one of the contributors to FSL, and I was always frustrated by the fact that there weren't any MRS tools for it, even though MRS was taking off in the imaging community. I even did an internal poll once to see what people would like to see next in FSL, and MRS was up there at the top of the list. So, one day, I just decided to find a way to make this happen. There was this new guy, Will, and he seemed really smart, so I just asked him to teach me about MRS, and in exchange I tried to draw him into this project of creating a tool for MRS. I would say dynamic MRS fitting is one of the major needs that is filled by this software compared with other currently available tools. With dynamic MRS, people are acquiring multiple spectra, and crucially, there are biophysical models linking across the spectra. For example, in diffusion MRS, you can have models of say non-Gaussian diffusion linking across spectra. Everyone out there just fits the spectra independently and then post-hoc fits the diffusion model. We thought we should create a framework that allows you to inform your MRS fitting with these models, so as to fit everything at once. Linking across modalities in this way can also help to boost the SNR of acquisitions with potentially low SNR. There isn't really another tool that can do that.

MRMH: So, with this software, the idea is to provide a kind of turnkey platform, which guides people through the full MRS analysis, right? In other words, it's end-to-end, starting with a data conversion step. You convert your raw data using a conversion module: spec2nii. Could you tell us something about MRS-NIfTI, and what users need in order to convert their raw data to this format?

William: It can be endlessly frustrating trying to get your MRS or MRSI data and all the results displayed alongside structural images. For brains it's a bit easier, but for cases like oblique cardiac data it can get quite mind bending. But still, one of the aims is to get to the point where people can do MRS easily. That's really the vision behind moving MRS data into an NIfTI format. The NIfTI format means that you can exploit many of the great tools that are already out there. As for what people need in order to use the converter (spec2nii), I hope very little. Which, as you can probably guess from its name, is completely inspired by Chris Rorden's DCM2NII. There are obviously cases which are still very, very hard to handle, such as when you need to know the trajectory of a non-cartesian sequence. But yeah, for a lot of standard sequences, I think the user will have to provide very little additional information in order to use the converter.

MRMH: I really enjoyed the interactive HTML outputs. Why was it a priority for you to include this feature?

William: We included it because I think if you give people a good interface to explore the results, it can minimize the post-processing effort needed, and this makes using FSL-MRS a more pleasant experience overall. What we are now doing is looking at presenting all the relevant data in FSLeyes as a standardized interface. In the long run we hope that might ease the communication of results. In FSLeyes, the ability to zoom around in your data and look at the whole thing or a specific part is a great feature, particularly for MRSI, where you can have thousands of individual spectra in your data.

Saad: I completely agree with Will. The HTML reports are a great first pass when exploring your data. The limit to them, however, is that the user can only see what we decided they should see. Even though the HTML report is interactive, it's still kind of far from the data. FSLeyes can offer the opportunity to dig deeper into the data, and Will is developing a plugin for FSLeyes to do just this. Paul McCarthy, the main developer of FSLeyes, has made this work much easier than it used to be in the past.

MRMH: To end off, what do you enjoy doing outside working hours?

William: During off-hours, I actually row quite a lot for the local city club. During the lockdown, I also picked up gardening.

Saad: I enjoy cooking a lot, and watching my son develop into a person.

William: You didn't want to mention your amazing dancing skills?

Saad: I was asked about my current pastimes; dancing is behind me I'm afraid [chuckles]. ■

> *"the existing pipelines weren't very user friendly for non-experts. So, in the context of this paper/ software, there was certainly that element — the desire to produce something that did everything our local users needed. And we hoped that it would go on to be a useful tool for other researchers around the world, too."*
>
> – William T. Clarke

Improved 3D real-time MRI of speech production

INTERVIEW BY **MATHIEU BOUDREAU**

HIGHLIGHTS' PICK FOR JUNE

This MRM Highlights Pick interview is with **Ziwei Zhao** and **Yongwan Lim** (co-first authors) and Krishna S. Nayak, researchers at the University of Southern California in Los Angeles, California. Their paper is entitled "Improved 3D real-time MRI of speech production". It was chosen not only because the authors share code and data with their paper, but also because their code repository is well documented and they used the BART Toolbox in their implementations.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM.

"In my personal experience, when I was first learning about image reconstruction, I explored any published code that I could find at the time. And I found it extremely helpful."

– Ziwei Zhao

The authors of the paper selected as this month's MRM Highlights pick. From left to right: Dani Byrd, Krishna S. Nayak, Yongwan Lim, Ziwei Zhao, and Shrikanth Narayanan.

MRMH: Could you tell me a little bit about yourselves and your background?

Ziwei: I got my bachelor's degree in biomedical engineering from China. My experience with MRI began at the time when I was an undergraduate. By that time I did an internship with an MRI company, and fell in love with MRI. Afterwards, I came to the US and got my master's degree in electrical engineering. I had a chance to pursue my interests during my masters and got more experience on MRI reconstruction. I am also excited about MR physics and decided to continue exploring. Currently, I'm a second year PhD student at USC. I am eager to develop MR imaging techniques and to see it meet other researchers and radiologists' needs, and speech is one of the applications that I am focusing on.

Yongwan: I'm currently a research scientist at the Dynamic Imaging Science Center at USC, where I work on some really exciting dynamic MRI applications at 0.55T. I got my masters from KAIST in South Korea, which was when I first got into the field of MRI. When I first learned about MRI, I was amazed by how the signal processing theory can be applied to such a wide variety of medical imaging applications. After that, I joined

Zhao, Z, Lim, Y, Byrd, D, Narayanan, S, Nayak, KS. Improved 3D real-time MRI of speech production. *Magn Reson Med.* 2021; 85: 3182– 3195.

https://doi.org/10.1002/mrm.28651

https://blog.ismrm.org/2021/07/01/qa-with-ziwei-zhao-yongwan-lim-and-krishna-s-nayak/

https://blog.ismrm.org/2021/07/16/reproducible-research-insights-with-ziwei-zhao-yongwan-lim-and-krishna-s-nayak/

Krishna's group at USC for my PhD studies, and to continue working in MRI.

Krishna: I am a professor of Electrical and Computer Engineering at USC, and have courtesy appointments in BME and Radiology. My path started with a BS in electrical engineering, computer science and applied math at Florida State University, followed by MS and PhD degrees in electrical engineering at Stanford. I first fell in love with MRI after taking Dwight Nishimura's graduate class on MRI physics, and I joined his lab shortly afterwards. There are so many things about MRI that attracted me: the elegant math, the practical applications, the joy of working with images, potential to impact healthcare, and the fact that you can engage almost anyone with this topic. I've always focused somewhat on fast imaging and dynamic imaging, including the project that you have selected for this feature.

MRMH: Could give me a brief overview of your paper?

Yongwan: So, in this paper, we present a 3D real-time imaging technique for analysis of human speech production. This work is an extension of previous work we published, and in it we evaluate several innovative k-t sampling patterns by using 3D constraint image reconstruction. We show that by using an optimal sampling pattern, we can dramatically improve spatial and temporal resolution for 3D imaging applied to speech. We also demonstrated that some interesting phenomena relating to speech production can be captured using our optimized technique.

Ziwei: Yes, we demonstrated that our optimized 3D k-t sampling strategy is able to acquire with improved spatial and temporal sharpness, making it possible to capture the clear articulator boundaries even in the fast speech rate. We also demonstrated that it allows us to visualize the complex tongue shapes during alveolar consonant segments, which can be very subtle and difficult to image with other currently available techniques.

Krishna: To some extent, speech imaging is still uncharted territory; human speech is not easily repeatable, and lacks a convenient reference method. Gated approaches fail, because the vocal tract dynamics are not precisely repeatable, even in trained vocalists. The really exciting thing about this work is that our linguist co-authors saw, in these results, several unique dynamic 3D patterns in articulator shaping that they were expecting based on airflow mechanisms, and that was a very satisfying outcome.

MRMH: How would you say this work fits in with your broader research goals?

Yongwan: My personal research goal has always been to improve fundamental imaging trade-offs, especially for dynamic imaging. We have been working closely with linguists in our interdisciplinary research team, and we always seek insights from them in order to be able to tackle their unmet needs.

Ziwei: Beyond speech applications, I think the work we do can be useful for a variety of 3D applications, such as real-time wrist imaging and fetal imaging. I am happy to see this technique actually can have a broader impact on other applications.

Krishna: I agree with everything Yongwan and Ziwei have said. As a technology development group, we are driven to pursue diverse applications. Speech imaging is a great launchpad – many applications of real-time imaging have dynamic boundaries, and so what we learn from the speech application informs many others.

MRMH: What was the main motivation behind your decision to share code with your paper?

Yongwan: I think it's natural to want to share code and data. I mean, why not? We have been collecting data at the hospital for many years, and processing data every week, so it is clear that we needed to write the code in such a way that people can use it in a scalable and repeatable way.

Ziwei: In my personal experience, when I was first learning about image reconstruction, I explored any published code that I could find at the time. And I found it extremely helpful. I therefore think it would be beneficial for a lot of trainees to have open-source code available to them. When I was preparing this GitHub repository, Krishna also suggested that we find some people who are not familiar with our code and get their feedback.

Krishna: I'm happy that this has become the new culture in our ISMRM community. Whenever possible, sharing code and sample data is the right thing to do, and helps move our field forward.

MRMH: How has this pandemic and/or lockdown impacted your research?

Yongwan: The pandemic was tough for everyone. As far as our research activities are concerned, we were not able to access the scanner at the hospital during most of the pandemic, meaning that we were not able to get new data. But because we had been collecting data for five years, I was able to work on processing the data that we already had, leading to a public dataset paper.

Krishna: It was very tough. For many people, just being isolated was very difficult. We suspended data-collection activities in March of 2020, and only resumed human data collection a couple of weeks ago. It was a long break, but one silver lining is that we had time and opportunity to curate datasets. Our speech team was already on the ball with regard to code and data sharing, but some of the other project teams in our lab used the time to clean up their software implementations so that they are ready to be shared when the time comes.

MRMH: Last thing, what do you enjoy doing when you're not working?

Krishna: I have young kids, and they love hiking – California has beautiful outdoor spaces. We spent last weekend in Yosemite National Park. So that's been our favorite activity, even during the pandemic, spending time outdoors. ■

"I'm happy that this has become the new culture in our ISMRM community. Whenever possible, sharing code and sample data is the right thing to do, and helps move our field forward."

– Krishna S. Nayak

Additional text and figures can be found online.

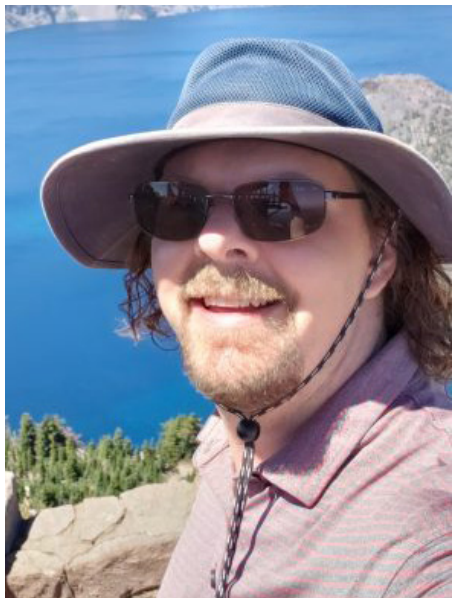
PreQual: An automated pipeline for integrated preprocessing and quality assurance of diffusion weighted MRI images

INTERVIEW BY **SIDDHARTHA DHIMAN** AND **EMILIE MCKINNON**

HIGHLIGHTS' PICK FOR JULY

This MRM Highlights Pick interview is with **Leon Y. Cai, Kurt G. Schilling,** and **Bennett A. Landman,** researchers at Vanderbilt University in Nashville. Their paper is entitled "PreQual: An automated pipeline for integrated preprocessing and quality assurance of diffusion weighted MRI images". It was chosen not only because the authors share their pipeline code with their paper, but also because they integrated emerging tools in their project that may be of interest to the MRM community, such as Singularity and BIDS.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM.



Leon Y. Cai; Kurt G. Schilling; Bennett A. Landman.

MRMH: Could you tell us about yourselves and how you got involved in this project?

Leon: I am an MD-PhD student here at Vanderbilt, currently in the fifth year of the program. My focus is to look at multiscale structural aspects of neuroimaging and see how we can derive some meaning and learn about different disease states from those images. PreQual evolved as a project in the course of this activity.

Kurt: I'm a research assistant professor at Vanderbilt Medical Center. I got my PhD at Vanderbilt and did my postdoc at Vanderbilt Med Center in Dr Landman's MASI (Medical-image Analysis and Statistical Interpretation) lab. My research has focused on the microstructure and connectivity of the central nervous system, that is, the brain and spinal cord. My high-level research goals are to better image microstructure and connectivity. To do that, we need to make good images, and that, in turn, can be achieved by improving

Cai, LY, Yang, Q, Hansen, CB, et al. PreQual: An automated pipeline for integrated preprocessing and quality assurance of diffusion weighted MRI images. *Magn Reson Med.* 2021; 86: 456– 470.

https://doi.org/10.1002/mrm.28678

https://blog.ismrm.org/2021/07/29/qa-with-leon-y-cai-kurt-g-schilling-and-bennett-a-landman/

https://blog.ismrm.org/2021/08/20/reproducible-research-insights-with-leon-y-cai-kurt-g-schilling-and-bennett-a-landman/

either the hardware and acquisition, or the image processing. This project focuses on improving the latter.

Bennett: I did my PhD in neuroimaging and diffusion tensor imaging (DTI), and for the last decade I have been leading a lab down here, looking at quantitative image processing largely in neuro; we do a lot of quantitative harmonization and modeling of diffusion. We love to develop and encourage technologies that allow integration of quantitative diffusion imaging across sites and protocols, so we can really drill into the biology. We are working on many AI-driven, biophysics and data synthesis techniques that will hopefully allow us to realize this harmonized quantitative diffusion process. We're excited that PreQual is a solid next step in that evolution and a conversation piece that we can then build off of.

MRMH: Could you give us a brief overview of what your paper and PreQual are all about?

Leon: Essentially, the paper is an overview of a pipeline we built. We found that, for our purposes, there was a gap in the available toolboxes. There are many different ways you can preprocess diffusion imaging, and we wanted one that would set you up well for any type of analysis and quality assurance (QA) performed to ensure preprocessing is working sensibly. The paper details how we chose different toolboxes and packages that we were already familiar with, and put them together.

Bennett: Human time is expensive and valuable, while machine time is cheap. We were looking to develop a reproducible way of optimizing machine time and better exploiting more valuable human time. This was the aim that kickstarted the development of a set of analyses that the programs run on all the data that are acquired, even before anyone checks to see whether all the gradient directions were even sampled. Back in the day this took 30 hours of processing. But computers have gotten faster, and we've gotten cleverer, so now it takes less time. This paper takes that kernel of an idea and then really extends it with long-term reproducibility and stability through containerized processing, and then makes all that accessible in a command line interface that can keep going year after year.

Kurt: I think the biggest benefit of PreQual is the PDF file it outputs. It's a beautiful way to check through hundreds of datasets in just minutes. Simply looking at it, I can quickly see whether outlier distortion correction worked, what the fractional anisotropy (FA) map looks like, and whether I get a big U-shape in the middle of the corpus callosum. It's an awesome way to go through big datasets well, while at the same time having the assurance that a state-of-the art pipeline has been run on your data.

MRMH: Where does PreQual fit into the wide variety of DWI processing tools available?

Leon: We have all these awesome packages available that each do their thing really well. Our intention wasn't to reinvent the wheel, but rather to exploit the advantages that these different tools afford — for example, we took advantage of the power offered by MRtrix and FSL. In this way, instead of all these different tools, we could just provide one that you run with simple commands, and it funnels all of the best things that we think are out there, saving users the need to learn about this fragmented space.

Kurt: The ISMRM Diffusion MR Study Group is involved in one of the consensus efforts on preprocessing. This is an area where we need to understand the contribution of different potential steps, different potential packages, and the different potential decisions that we make. I think there's a lot to learn here. I'm excited to see where that effort will lead and also how PreQual evolves over time.

Bennett: I'd like to underline that the fragmentation of the field is actually a product of our success. In the last five or six years, there's been a huge amount of creativity largely driven by the Human Connectome Project (HCP) project, new scanners, new acquisitions, and the willingness to use computation to fix imaging artifacts. These ideas have created a lot of different baselines and perspectives that aren't really targeting all possible situations. With these consensus efforts and consensus pipelines, we're able to reach a common baseline which we can then build off of. This allows us to target innovation and target improvements, so that we know where the field needs to go and where the next steps happen to be.

MRMH: How does PreQual integrate into your workflow?

Leon: There are two ways we use it on our side. One is where we manually run it in the command line, with default options. We do exactly what Kurt said, we look through the PDFs and make sure that our data look reasonable before we do any secondary modeling like tractography. The other is to integrate it with the infrastructure Bennett has built at Vanderbilt that automates clinical research on the imaging side.

Bennett: The Vanderbilt University Institute for Imaging Science (VUIIS) runs the extensible neuroimaging archiving toolkit (XNAT) server. With our code, called the Distributed Automation toolkit for XNAT (DAX), XNAT can communicate with our High-Performance Computing (HPC) Center. This allows us to run Docker or Singularity containers that implement protocols like PreQual and automate that processing. DAX will stage and process the data, so that we can add value to the imaging sequences. When you come back in to check whether it worked, you're not scrolling through multivolume images trying to look for artifacts, you see these nice PDFs. And that explains the inspiration for PreQual. ■

> *"We love to develop and encourage technologies that allow integration of quantitative diffusion imaging across sites and protocols, so we can really drill into the biology."*
>
> – Bennett A. Landman

Additional text and figures can be found online.

Analysis of deep complex-valued convolutional neural networks for MRI reconstruction and phase-focused applications

INTERVIEW BY **JESSICA MCKAY-NAULT**

HIGHLIGHTS' PICK FOR AUGUST

If you don't work in the machine learning space, you might be surprised to discover that most convolutional neural networks (CNNs) split data into real and imaginary channels, ignoring the underlying structure of complex-valued data altogether. Recently, researchers, including **Elizabeth Cole** and **Shreyas Vasanawala** et al. at Stanford University, have started asking whether complex-valued CNNs would perform better. In their paper "Analysis of deep complex-valued convolutional neural networks for MRI reconstruction and phase-focused applications", which is this month's Highlights pick, they go a step further, seeking to evaluate the effect of complex-valued CNNs on some clinical MRI applications that rely heavily on phase. They were surprised to find that using a complex-valued CNN made a big difference in the measurement of peak velocity of blood flow in the heart. Their paper was chosen as this month's pick because of their exemplary reproducible research practices; for example, they shared their code on GitHub, included a requirements file of their dependencies, and provided details on how to train/test their deep learning models.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM.

Elizabeth Cole; Shreyas Vasanawala.

Cole, E, Cheng, J, Pauly, J, Vasanawala, S. Analysis of deep complex-valued convolutional neural networks for MRI reconstruction and phase-focused applications. *Magn Reson Med*. 2021; 86: 1093– 1109.

https://doi.org/10.1002/mrm.28733

https://blog.ismrm.org/2021/09/10/qa-with-elizabeth-cole-and-shreyas-vasanawala/

https://blog.ismrm.org/2021/09/17/reproducible-research-insights-with-elizabeth-cole/

MRMH: First, why don't you tell me a little bit about your background and how you ended up in MRI research?

Elizabeth: Sure! My background is in electrical engineering and signal processing. I joined the lab not knowing anything at all about MRI – so that was quite a learning curve! I got into MRI both because my background was in signal processing, and because I wanted to go into machine learning. So, it was kind of the perfect combination. Currently, I am going into the fifth

year of my PhD, and I've been working a lot on machine learning, primarily in reconstruction.

Shreyas: I studied mathematics as an undergrad and then pursued an MD/PhD at Stanford. I had the good fortune of taking a class from Dwight Nishimura on MRI, and wound up joining his group. While training in radiology and then specializing in pediatric radiology, I kept up with some MRI research. Since 2007, I've been practicing pediatric radiology and working on developing new approaches to pediatric MRI.

MRMH: Before we get into the details, how would you describe a convolutional neural network (CNN) to the average person? Or to a scientist who isn't familiar with deep learning?

Elizabeth: I would say that a CNN is an algorithm that can take a data set, typically images, and assign importance to certain aspects of it, and also differentiate one image from another. To a scientist, I would say that CNNs are a way to model complex mappings and functions for a given task without having to explicitly define those complex functions yourself. And by complex, I mean complicated, not complex valued; we should probably differentiate!

MRMH: Why do most deep learning applications and MRI only consider the real values?

Elizabeth: I also wondered this at the start of the project. And the answer is actually simple: it is because deep learning platforms only provide real-valued capability in the most common building blocks of CNNs. If you try to run complex-valued data through a typical CNN in something like TensorFlow, you're going to get an error because it hasn't been built into those platforms. I think that's a big obstacle for people wanting to use complex-valued networks.

MRMH: How could we solve that problem as a research community?

Elizabeth: One avenue would be where my work came in; indeed, the code repository I published was not just for reproducibility purposes, but also to surmount this issue. If you're a scientist who has some complex-valued data, you'll find that, unfortunately, TensorFlow and pytorch don't support your data. So, you can use my function!

In terms of getting TensorFlow or pytorch to implement complex-valued CNN building blocks, I think you would need to have enough people coming forward, and enough papers showing them that "Hey, this is needed!" To give an explanation as to why this hasn't been provided already, I would say that the deep learning community was based on typical RGB images, like photographs of people or landscapes, that are not complex valued. Using complex-valued medical images is a cultural shift and an application shift that will simply need to happen.

MRMH: You know, it's funny, but even though I'm acutely aware that MRI uses complex-valued data, it hadn't occurred to me that deep learning in MRI is done on real-valued data. I was so surprised on reading your paper; I had never even thought about it.

Elizabeth: I think I was the opposite. Coming into the PhD I didn't know anything about medical imaging, so I thought "Wait, this is complex valued!?" It really depends on which side you're coming from.

MRMH: [Laughs] You look at your MRI data and say, "What do I do with these i's?!"

Are there any other challenges in using complex values?

Elizabeth: No, I wouldn't say so. It's mostly just a practical problem that the platform simply doesn't support.

MRMH: In research, there are so many practical obstacles that you have to overcome that aren't scientifically interesting, or even aspects you would write about in a grant application, and yet you still have to get over those hurdles.

Elizabeth: Exactly. I've learned that that's pretty much what research is — trial and error of the silliest things that can make or break a project. You have to persevere, though. Especially, DICOMs… don't even get me started on writing DICOMS! I'm at the point that if Shreyas mentions DICOMs around me, I'm just gonna leave! [laughs]

Shreyas: We certainly don't want that!

MRMH: [laughs] Yes, I feel your pain!

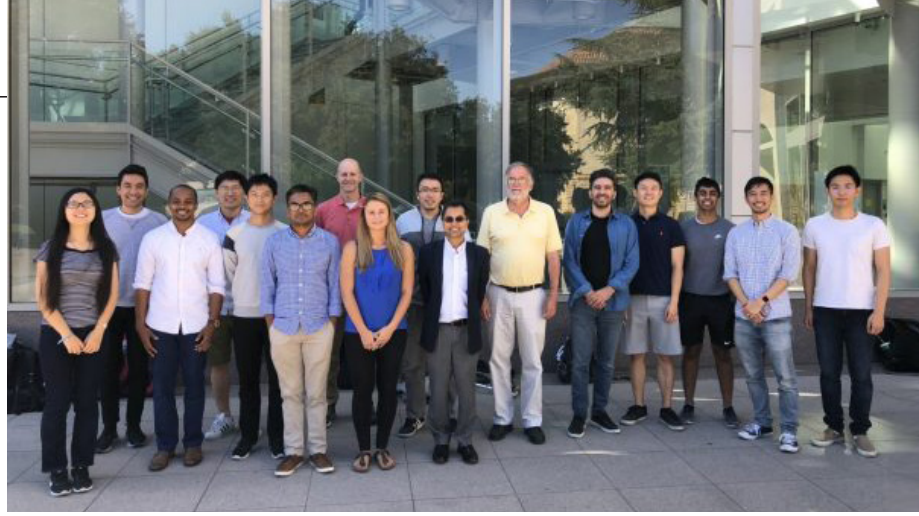
Elizabeth: Another practical question is whether you have access to the complex-valued data. It can be hard for some researchers to find MRI datasets, or often they only have magnitude image data sets where you don't have k-space or the complex-valued data. In that case, you have to use a real-valued network.

MRMH: It sounds like we may need to rethink data sharing and put more effort into saving and sharing the complex-valued data.

Elizabeth: It would be ideal to have easy access to the raw k-space data; you would then be able to do so much more with that data. We actually have a site from our lab called MRIdata.org, where we upload different raw k-space data sets to try to make them more public and accessible to people whose universities aren't linked with a hospital.

Shreyas: It has helped other researchers across the world who don't have access to clinical patients or even scanners.

MRMH: I've learned a lot here today! Well, it was great to get to chat with you. And I guess I will be seeing around Stanford! ■



Group photo at Stanford.

> *"I've learned that that's pretty much what research is — trial and error of the silliest things that can make or break a project. You have to persevere, though."*
>
> – Elizabeth Cole

Additional text and figures can be found online.

A model-based framework for correcting B1 inhomogeneity effects in magnetization transfer saturation and inhomogeneous magnetization transfer saturation maps

INTERVIEW BY **NIKOLA STIKOV**

HIGHLIGHTS' PICK FOR SEPTEMBER

This MRM Highlights Pick interview is with **Christopher Rowley** and **Christine Tardif,** researchers at the McConnell Brain Imaging Centre of the Montreal Neurological Institute in Montreal, Canada. Their paper is entitled: "A model-based framework for correcting B1 inhomogeneity effects in magnetization transfer saturation and inhomogeneous magnetization transfer saturation maps". Their paper was chosen this month because the authors shared their code with their paper and also provided very detailed documentation inside and outside their code.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM.

Christopher Rowley; Christine Tardif.

Rowley, CD, Campbell, JSW, Wu, Z, et al. A model-based framework for correcting B1+ inhomogeneity effects in magnetization transfer saturation and inhomogeneous magnetization transfer saturation maps. *Magn Reson Med.* 86; 2192-2207.

https://doi.org/10.1002/mrm.28831

https://blog.ismrm.org/2021/10/28/qa-with-christopher-rowley-and-christine-tardif/

https://blog.ismrm.org/2021/11/12/reproducible-research-insights-with-christopher-rowley-and-christine-tardif/

MRMH: Chris, to start with, we'd love to know how you got into MRI and ended up working with Christine.

Chris: I started my undergrad studies doing a general life sciences degree at McMaster University, in Hamilton, Ontario. There was an option to take an elective class in medical physics that included a brief introduction to MRI and I got really excited about the whole topic. So, I ended up doing a major in medical physics, picking up any of the MRI classes that were offered along the way. I then worked for a few summers with Dr Nicholas Bock at McMaster University, on intracortical myelin processing techniques. I chose to do my PhD with him, where I undertook a project studying cortical changes in bipolar disorder using T1-weighted imaging. My PhD experience was heavy on the processing side, but I also wanted to learn more about the physics of MRI. So that's why I joined Christine's lab.

MRMH: And you Christine?

Christine: I did my undergrad at McGill in computer engineering, specializing in signal processing. After I graduated, I wasn't ready to move on to a job in industry. It was during a study abroad program in Glasgow that, while having a beer with colleagues in a pub actually, I first learned about MRI. It seemed like a natural progression to move from 1D signal processing to 2D and 3D image processing. So, I went to Imperial College London to do a one-year masters program, followed by a PhD at McGill and a post-doc in Germany. Although I still do some image analysis, I really enjoy working on the data acquisition part of MRI, so that's what I focus on more now, here at The Neuro.

MRMH: Could you introduce the concepts of MTR (magnetization transfer ratio) and MTsat, and explain why MT techniques are good for quantifying brain microstructure and myelination?

Chris: Sure. In MTR you acquire two images, one with and one without an MT-weighted preparation pulse. Generally this is an RF pulse that is applied off-resonance, on the order of 1-10 kHz. The energy from that RF pulse saturates the longitudinal magnetization of the bound pool protons, and then, through stochastic processes, transfers some energy to the water pool where it is observed in the form of decreased longitudinal magnetization. This leads to a water signal decrease that will be proportional to the quantity of bound protons in that voxel, providing us a measure of the macromolecular content. The MTsat technique is an extension of this technique that uses signal modeling to account for the T1 of the voxel that counteracts the MT contrast, which effectively reduces contrast between white and grey matter in the image. But in order to use MTsat, you need to know the T1 as well, so you have to acquire a third image that is T1-weighted. These three images can then be used to calculate the approximate percent signal drop achieved through application of your saturation pulse, and that's what we call MTsat.

MRMH: And so how does B1 come into the story?

Chris: So, this brings us back to the saturation pulse, which is modulated by the B1 profile that your subject experiences in the scanner. We can liken this to what you experience when you place food in the microwave, where the center of your meal will be colder and the edges will be warmer. In MRI, it's the inverse; the energy your B1 deposits (proportional to the B1 map) will generally be higher in the middle and lower towards the outside. If you don't correct for that, you'll have more magnetization transfer in the center of the brain. Therefore, in order to measure something that's reflective of pure anatomy, you need to correct for B1 in MT techniques.

Christine: B1 inhomogeneities have been haunting the quantitative MRI field for a long time. For me, this has been an issue from the beginning of my career in MRI research since B1 field variations are quite significant in the cortex. For MTsat, Gunther Helms did address B1 nonuniformity in his original paper. He showed that MTsat is relatively robust to small variations in B1. At 3T, a B1 map can be used to further improve MTsat using an empirical correction factor, as seen in work by Nikolaus Weiskopf. What I really like about the B1 correction that Chris has developed here is that it can be applied not only to widely used MTsat protocols, but also to broader applications such as ihMT.

MRMH: So, to summarize, previous approaches involving application of B1 correction to MTsat used empirical factors, whereas here you are properly modeling it so that it can be applied to different pulse sequences. What do you think is the major contribution of this concrete work to the field?

Chris: I think the major contribution is just the flexibility of the method. It was developed with ihMT in mind as, to date, I've seen very few papers that have used the same saturation or readout, which doesn't lend well to using a standard empirical correction factor.

MRMH: Can you tell us about the modeling aspect of the study?

Chris: Yeah, so the idea behind the whole approach was that we can use modeling to account for the difference in MT caused by the differences in B1 values. To make it flexible for use in both MTsat and ihMT, we needed to model three pools: a water pool, a bound pool, and a dipolar pool. We then ran simulations through the differential equations to model the steady state signal changes for a range of different B1 values and tissue parameters. We found that there are two variables that seem to have a high impact on the MTsat value that you would get, namely the longitudinal relaxation rate R1 (1/T1) and the bound pool fraction.

MRMH: And all of this is done for 3T, right? How challenging would it be to apply this to higher field strengths, like 7T?

Christine: That's our next challenge. Chris' B1 correction method should work at 7T as well, despite the larger range of B1 variation. Obviously at 7T, SAR is a huge issue as well, so I think part of the challenge will be to optimize the acquisition parameters of the MT sequence to achieve the best MTsat efficiency.

Chris: Also, for the simulations, we need to know the tissue parameters such as the T1 and T2 for each the water and bound pools, magnetization exchange rate and relaxation time of the dipolar order. Because quantitative imaging has been around for so long at 3T, even though there's still a lot of variability in the literature with regard to what those values are, you nevertheless have a good idea of the range and can simulate for that range. But the literature is not as well established for 7T, and so you'd have to run more simulations for a wider range of potential values. Because the B1 range is also a lot broader at 7T than at 3T, you'd have a much larger range of those values to simulate for, too.

MRMH: Lastly, what do you enjoy doing outside of work?

Chris: When I'm not in the lab, I'm generally on my bike riding around town and also racing, which has got me in trouble on occasions, landing me in hospital, but I've been lucky so far in Montreal. My PhD supervisor wanted me to stop. He saw me have a couple bad accidents, so it was a reasonable request! [laughs].

Christine: Outside of academia, I'd say in this phase in my life, it's mainly about spending a lot of time with my family. My girls are 8 and 10 years old now and super active. So we spend our time playing sports, tennis, skiing, hiking, etc. And travelling… I am really looking forward to travelling again! ■

> *"It seemed like a natural progression to move from 1D signal processing to 2D and 3D image processing."*
>
> – Christine Tardif

Accelerated calibrationless parallel transmit mapping using joint transmit and receive low-rank tensor completion

INTERVIEW BY **MATHIEU BOUDREAU**

HIGHLIGHTS' PICK FOR OCTOBER

This MRM Highlights Pick interview is with **Aaron T. Hess** and **Mark Chiew,** researchers at the University of Oxford in the United Kingdom. Their paper is entitled "Accelerated calibrationless parallel transmit mapping using joint transmit and receive low-rank tensor completion". Their paper was chosen because, in it, the authors demonstrated exemplary reproducible research practices; in particular, they shared all the scripts and data required to reproduce every figure published in the paper.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM.

Aaron and his son outside the Radcliffe Camera; Mark Chiew's research group. From left to right: Charlie Millard, Xi Chen, Mark Chiew and Mo Shahdloo.

MRMH: Could you each tell us a bit about yourself?

Aaron: I grew up in Zimbabwe. I've always enjoyed making and building things and seeing how things work, and so, at the University of Cape Town, I chose to do electrical engineering. That's where I was introduced to MRI as a field of interest, and I went on to do a master's degree and PhD in MRI and MRS. I've always been really fascinated by motion in the MRI scanner, like what you see when something moves in the heart or the brain. So, in the last 10 years, I've been doing 7T MRI in the heart, which has been fabulously intriguing. And I've recently shifted roles from doing research to being a support physicist.

Mark: I did my undergrad at the University of British Columbia, in engineering physics. I was first exposed to MRI through a summer co-op term where I worked for a pediatric research lab that used fMRI. At that point, I had no real involvement in imaging, I was basically just doing grunt work for the lab. But it gave me that first exposure needed to trigger my interest in MRI. So, I went and did a PhD in medical biophysics at the University of Toronto, working on methods for real-time fMRI. And then, in 2012, I moved to Oxford to work on low-rank

Hess, AT, Dragonu, I, Chiew, M. Accelerated calibrationless parallel transmit mapping using joint transmit and receive low-rank tensor completion. *Magn Reson Med.* 2021; 86: 2454– 2467.

https://doi.org/10.1002/mrm.28880

https://blog.ismrm.org/2021/12/10/qa-with-aaron-t-hess-and-mark-chiew/

https://blog.ismrm.org/2022/01/14/reproducible-research-insights-with-aaron-t-hess-and-mark-chiew/

methods for fMRI. In the last few years, I've shifted emphasis towards more fundamental image reconstruction problems using low-rank methods and exploring the space of image acquisition and reconstruction.

MRMH: Could you unpack the term "low-rank tensor completion" used in your title?

Mark: Sure – the easiest way to think about tensors is to think of them as multi-dimensional arrays. For example, matrices can be viewed as two-dimensional arrays with rows and columns, and tensors are just a multi-dimensional generalization of that concept. A tensor is essentially a mathematical construct that we use to organize or structure data. It is quite convenient, because we can use it to exploit redundancy in the dataset across all of these dimensions, and that is where the low-rank concept comes into play. So, whether it's a tensor with dimensions of space and time, or coils and echoes, or contrasts and TEs, or any combination of these different dimensions, we can take this tensor and exploit redundancies or correlations in the data that we've rearranged into what's called a block-Hankel matrix. These structured matrices are just a particular way of reorganizing the k-space data within the tensor to more easily exploit linear interdependencies.

MRMH: I also just wanted to thank you for your attention to detail when creating Figure 1 in your paper, as the visual support it provided helped me to understand better how you constructed the block-Hankel matrix.

Mark: Thanks for noticing that! It was very important to me that the figure be a true representation of what was actually happening, because I too have been in the situation of trying to understand a paper and struggling to understand the math, and if the illustration accompanying the text doesn't exactly follow the description, it's very frustrating.

MRMH: Could give us a brief overview of the paper?

Aaron: So, the problem I was interested in when starting to work on this paper was how to measure transmit field maps in the heart for parallel transmit applications. Parallel transmit is quite slow to map because you've got to map each channel by itself, and that means you can't typically do it in a breath hold, which is a requirement for cardiac imaging. And we also have to be able to do parallel imaging on it, which means that you also need to measure receive sensitivities. We decided to investigate calibrationless methods, and it dawned on us that there must be extra redundancy in the data that could lead to accelerated acquisitions, because we were making multiple measurements across different transmitters. It wasn't clear to us at first which matrix completion method was the appropriate one to use for this application, so we formulated our question differently, asking ourselves which, of three different methods, would be the right way. Should we consider it a purely parallel imaging problem, a purely parallel transmit problem, or a joint problem. Intuitively, we thought that approaching it as a joint problem would give us the best results, and indeed that's what we found when we used Mark's implementation of a joint transmit and receive low-rank tensor completion solution. Our results show that you can rapidly map your transmit array using the acceleration factors enabled with the joint approach, and this makes for much easier cardiac imaging.

Mark: One of the ways in which I like to think about where this data redundancy comes from is based on the fact that, for example in a parallel transmit system, we might have say eight transmit channels. And just for the sake of easy math, let's say we're working on an MRI system that has eight receive channels. If we're going to acquire a set of images to map every transmit channel, we end up with 64 images, i.e., eight receive images for every transmit channel. But, if we think of how many independent degrees of freedom we have in that problem, it's actually just 16 (8 receive channels plus 8 transmit channels). So clearly, there's some redundancy there to be exploited, and that's what we tried to do with our approach here.

MRMH: Why did you choose to share all the code and data needed to reproduce your figures?

Mark: I think, in general, it's part of a broader push within our community. It's important for reproducibility concerns, but also very valuable for didactic reasons. If you're just learning about these methods and these techniques for the first time, having the code there and readily available is hugely beneficial in my view, as it reduces the barrier to entry for newcomers in our field. I believe we'll all benefit from this movement, as it creates this effect of a rising tide that lifts all boats. It's also just good practice for us, because developing these scripts with a view to sharing was an incentive to document the code well, which you often don't do when you know no one else will see it. Having scripts that reproduce all our work and our figures makes our research more self-contained and reproducible, and it's very packageable. It's basically everything you would want yourself when archiving work done in your own lab.

Aaron: I think for me, it's the transparency aspect. I also think making research more transparent gives a lot more strength to your results.

MRMH: What do you enjoy doing when you're not in the lab or doing research?

Aaron: I spend a lot of time with my young family. There's a lot of countryside around Oxford with farms, parks, and zoos. So, there are plenty of fun things to do with children here.

Mark: I spend a lot of my free time with my family as well. I have two young kids and it's just amazing to sort of watch them grow and play with them. When my kids are asleep, I like to play chess online and crossword puzzles, exciting things like that [laughs]! ■

> *"For me, the interesting thing here was essentially coming across an opportunity to explore new formulations for image reconstruction to explore how much value you can extract from as little data as possible."*
>
> – Mark Chiew

Additional text and figures can be found online.

Image- versus histogram-based considerations in semantic segmentation of pulmonary hyperpolarized gas images

INTERVIEW BY **MARIA EUGENIA CALIGIURI**

HIGHLIGHTS' PICK FOR NOVEMBER

Jaime Mata and **Nick Tustison** met 22 years ago, working side by side as master's degree students, and they have been very good friends ever since. After taking different career paths for a few years, they were reunited as associate professors of radiology and medical imaging at the University of Virginia. In case you are wondering, yes, their research work is as inspiring as their lifelong friendship!

Here, we discuss their work entitled "Image- versus histogram-based considerations in semantic segmentation of pulmonary hyperpolarized gas images", in which they demonstrated how deep learning outperformed traditional approaches to quantification strategies in lung imaging. We also talk about how they made the entire processing and evaluation framework available open source.

> TO DISCUSS THIS Q&A, PLEASE VISIT OUR DISCOURSE FORUM.

Nick Tustison and Jaime Mata at the awards ceremony of the 2020 Zion Half-marathon, where Nick finished in first place and Jaime finished second in the overall Masters category.

McCallister, A, Chung, SH, Antonacci, M, et al. Comparison of single breath hyperpolarized 129Xe MRI with dynamic 19F MRI in cystic fibrosis lung disease. *Magn Reson Med.* 2020; 85: 1028– 1038.

https://doi.org/10.1002/mrm.28457

https://blog.ismrm.org/2022/02/11/qa-with-jaime-mata-and-nick-tustison/

[Missing link to Reproducible Research Insights]

MRMH: Could you each tell us a little about yourself and your background?

Jaime: I grew up in Portugal, where I graduated in applied physics at the University of Lisbon. After that, I continued my master's degree and PhD studies at the University of Virginia, where from the outset I was involved with MRI, developing pulse sequences in the university's pioneering program on polarized gas MRI. Currently, I am principal investigator in many clinical trials, including working towards obtaining FDA approval for these techniques, so that physicians will be able to prescribe MRI of the lungs.

Nick: Like Jaime, I have an undergrad background in applied physics but with a computer science emphasis. While he focuses on the acquisition side, my area is post-processing and image analysis. After my master's degree, I went to Washington University in St. Louis, where I worked on applications of cardiac MRI. After that I did a post-doc with James Gee at the University of Pennsylvania, where I met my good friend and colleague Brian Avants, with whom I co-founded the Advanced Normalization Tools (ANTs) software. The algorithm proposed in this paper, El Bicho ("The Bug"), is now part of the ANTs deep learning library, called ANTsXNet.

MRMH: Can you explain the potentialities of hyperpolarized gas imaging of the lungs?

Jaime: With hyperpolarized imaging, we can overcome traditional lung imaging limitations and develop multiple applications, depending on the pulse sequences and the gases used. Twenty years ago, we started with Helium-3, but now we are using hyperpolarized Xenon-129,

which dissolves into lung tissue and is then carried away attached to the red-blood-cells, so we can get MR images and other regional detailed information from multiple lung compartments.

MRMH: How does it work?

Jaime: First, there's no radiation involved. The imaged subject inhales a gas that we polarize by changing the nuclear spin of the atom to the ½ state. In this way, the MR scanner can detect the signal, using appropriate coils tuned to the specific frequency of the gas. Depending on the pulse sequence, we can then acquire ventilation images and see if the airways are blocked or narrowed by mucus or inflamation, stopping the gas from getting through. Since we can get multiple slice images with high resolution in a single short breath-hold of less than 10 seconds, we can clearly see which areas of the lung are working well or show some deficiency. Another application very popular in this field is achieved through dissolved-phase imaging, which allows us to measure how much Xenon-129 is dissolved into the tissue, how much is binded to the red-blood-cells, as well as the T2* of the gas in those compartments and the respective chemical shifts, among other physiological parameters. All these parameters help us in diagnosing, characterizing and evaluating different pulmonary diseases.

MRMH: That's really impressive! How do you think all this might be translated into clinical practice?

Jaime: As researchers, we must remember that the goal of using new techniques in clinical research is really to help patients further down the line, in other words, to achieve earlier and better diagnoses, and therefore to improve their clinical outcomes. We are currently doing multiple longitudinal clinical trials, in which the baseline MRI can be followed by treatment every two or three weeks for some time. In this way, it is possible to see, within a relatively small timeframe, whether patients are responding to the treatment or not. In cases where it is not working, we can early on switch to a different treatment. I believe diagnostic tools like these will expand in a future with more and more individualized medicine available. There is a research community of about 30 centers worldwide now developing hyperpolarized MRI techniques, and once these are approved by the FDA for clinical use — hopefully in the next four-five months — I think the entire field will explode! This is one more reason why we developed this algorithm which is capable of processing and analyzing large amounts of lung ventilation MR images in an advanced, more precise, reproducible and autonomous way.

MRMH: Can you tell us a bit more about your decision to make El Bicho open source?

Nick: When Brian and I started working on ANTs, we felt the need to facilitate its use for other researchers. At first, given the popularity of open-source toolkits such as R and Python, we developed two interfaces, ANTsR and ANTsPy respectively. Then, after the deep learning phenomenon hit, we started working on add-on packages called ANTsPyNet and ANTsRNet. In this setting, it was straightforward to continue following the open-source philosophy with El Bicho, too.

MRMH: How did you address training and validation in El Bicho?

Nick: We have been working on deep learning applications for quite some time now, and as part of the development process we gained considerable experience with all the training and validation aspects. Last year, we demonstrated how our well-known cortical thickness pipeline works really well when adapted to a deep learning/convolutional neural network context. Thus, when El Bicho came along, we already had a pretty good understanding not only of the base network and the add-ons that we wanted to use, but also of how to get the most out of limited training data.

MRMH: How could you possibly expand your training data?

Nick: Obviously, we'd like to have more training data from other sites, but the main message of our paper is "Hey, even though everyone has been using histogram-based algorithms for a long time, it's really worth exploring the possibilities of deep learning." We don't want people to use our algorithm necessarily, but to look at deep learning as a developmental platform for pushing this field forward.

Jaime: The kind of analysis that El Bicho does on ventilation imaging and segmentation has been a focus of study in our field for quite a while, like 15 years or so. Most research groups are very fond of histogram-based image segmentation, even though it's manually oriented and time consuming. Thus, each group ends up with a very small number of normal subjects that conforms with the binomial distribution, but in the end does not really represent real-world data. Using deep learning might help to move away from that manual input, so that each group can grow their own normative dataset. It's time to move away from those old algorithms and try something new, something reproducible.

MRMH: What are your next steps to promote this change?

Jaime: We have a consortium that acts as a forum for meetings and discussions with other investigators in our field, and also allows us to define standard protocols for image acquisition. Our goal is to get data from different institutions, acquired using different scanners and imaged from patients with different diseases, identify sources of variation, and train our algorithm to model them. And of course, at the same time, we also would like other groups to use deep learning algorithms at their own sites, doesn't really matter if those algorithms were based on our or a completely different software. Because the only way to really progress in a field is to leave your comfort zone, innovate create and move forward! ■

"As researchers, we must remember that the goal of using new techniques in clinical research is really to help patients further down the line, in other words, to achieve earlier and better diagnoses, and therefore to improve their clinical outcomes."

– Jaime Mata

Additional text and figures can be found online.

CONTRIBUTORS

Maria Eugenia Caligiuri

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

Magnetic Resonance in Medicine Deputy Editor for Science Outreach & Highlights Online Editor

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 grad students feel anxious about not having a proper backup of their computers.

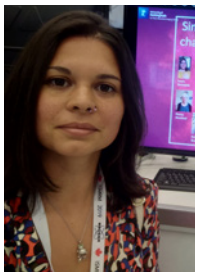
Emma Biondetti

Emma is a postdoc at University of Chieti-Pescara, Italy, which she joined after getting her PhD from University College London (UK) and after a two-year postdoc at the Paris Brain Institute (France). Her research focuses on developing quantitative methods for studying brain oxygen consumption and tissue magnetic properties with applications to neurodegeneration and neuroinflammation. She is passionate about impactful research that improves patient outcomes. Within the ISMRM, she has served as the Trainee Representative for the Electro-Magnetic Tissue Property and Quantitative MR Study Groups, and she now serves in the committee of the Italian Chapter. In her spare time, she enjoys reading, music (including playing the drums), and travelling/exploring.

Katherine Blanter

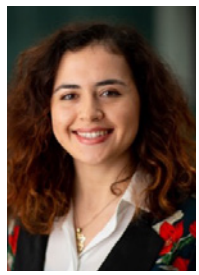
Katya is a first year PhD student at the Cardiff University Brain Research Imaging Center. She is currently working as part of a multi-disciplinary team to improve the unsafe tissue heating and worsened image quality caused by involuntary participant motion at 7T MRI. Besides that, she likes cats and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

Laura Bortolotti



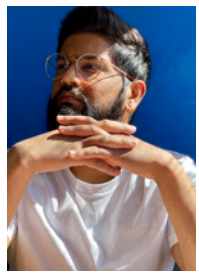
Laura (she/her) is a Post-doc at the Sir Peter Mansfield Imaging Centre (SPMIC) at University of Nottingham, England. Her works focused on developing Motion Correction (MoCo) techniques for MRI. She developed a contact-less head motion tracking at 7 T using NMR field probes during her PhD and now she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

Nikou Louise Damestani



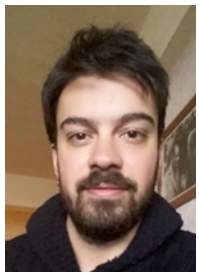
Nikou is a Research Fellow at Athinoula A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital. She is a member of the Cerebrovascular Aging and Spin Labelling (CASL) group, specializing in developing novel physiological MRI acquisition techniques. She obtained her PhD in Neuroimaging Physics at King's College London. She is an advocate for accessibility and inclusion initiatives, and in her free time she enjoys kickboxing and watching superhero movies.

Siddhartha Dhiman



Siddhartha Dhiman joined Brain Imaging Diffusion Group (BRIDGE) at Medical University of South Carolina in 2018, after getting his Master's in Biomedical Engineering from the State University of New York at Buffalo. His focus is on developing hands-off dMRI processing pipelines, with PyDesigner being his most notable work, and researching digital biomarkers in Alzheimer's. Outside of work, he enjoys gaming, cooking cuisines from all over the world, playing his electric guitars, and exploring local music scenes.

Agâh Karakuzu



Agâh is a PhD student in Biomedical Engineering with NeuroPoly Lab at Polytechnique Montréal. His research is centered on developing a reproducible quantitative MRI platform, with a particular focus on neurocardiology. He is an open science enthusiast and plays an active role as a science communication contributor for several platforms including MR Pulse and OHBM blog. He enjoys graphic designing, skiing and exploring specialty coffee.

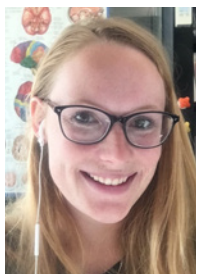
Gastao Lima da Cruz

Gastao did his PhD at King's College London, where he remained as a research associate. His research focuses on quantitative MR, motion correction and accelerated methods for cardiac and abdominal imaging. When not debugging MR artefacts, he enjoys drinking coffee, cooking, playing boardgames, watching movies, listen to Pixies and drinking more coffee.

Jessica McKay

After getting a Ph.D. from the University of Minnesota, Jessica joined the Body MRI Research Group at Stanford University as a postdoctoral fellow. Her research focuses on improved detection and characterization of breast cancer, including the development of high quality and resolution breast diffusion weighted imaging (DWI). Jessica loves contributing to the MRM highlights initiative to broaden science communication and collaboration. She also enjoys all types of skiing: cross-country in flat MN, water skiing on the lake, and downhill in the CO Mountains.

Emilie McKinnon



Emilie is an MD-PhD Candidate at the Medical University of South Carolina. She is currently finishing her PhD which focused on the application and development of diffusion MRI techniques at high b-values. In her free time, Emilie plays competitive roller derby for the Lowcountry Highrollers and for the South Carolina state team. In these circles she is better known as Waffle, named after the delicious treat from her home country Belgium.

Eva Alonso Ortiz

Eva is an Assistant Professor at Polytechnique Montréal. Her research revolves around MRI, and ranges from magnetic field mapping to biophysical modeling. As the outgoing OHBM Open-Science Room co-organizer she is a strong believer in the value of open-science and hopes to see a significant change in the research and dissemination culture of our time. Outside of work, she loves to play tennis and enjoy a good microbrew.

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 novel contrast mechanisms for brain imaging, particularly quantitative susceptibility mapping at high field MR systems. At the NIH, she has been widening her interests towards fMRI, i.e. investigating fMRI signal characteristics during wake and sleep, together with physiological and EEG signals. She enjoys painting, stone carving and pilates, and is still discovering new coffee spots in DC.

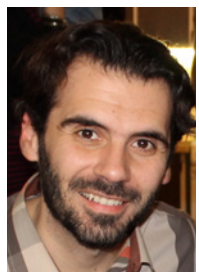
Alix Plumley

Alix is a 4th year PhD student at Cardiff University Brain Research Imaging Centre. She works as part of a multi-disciplinary team to develop prospective motion correction techniques for use with parallel-transmit hardware at 7T. Outside of work, Alix loves music, board games, and being outdoors… whether she's in the sun, sea, or snowboarding in the mountains - she's happy!

Francesco Santini

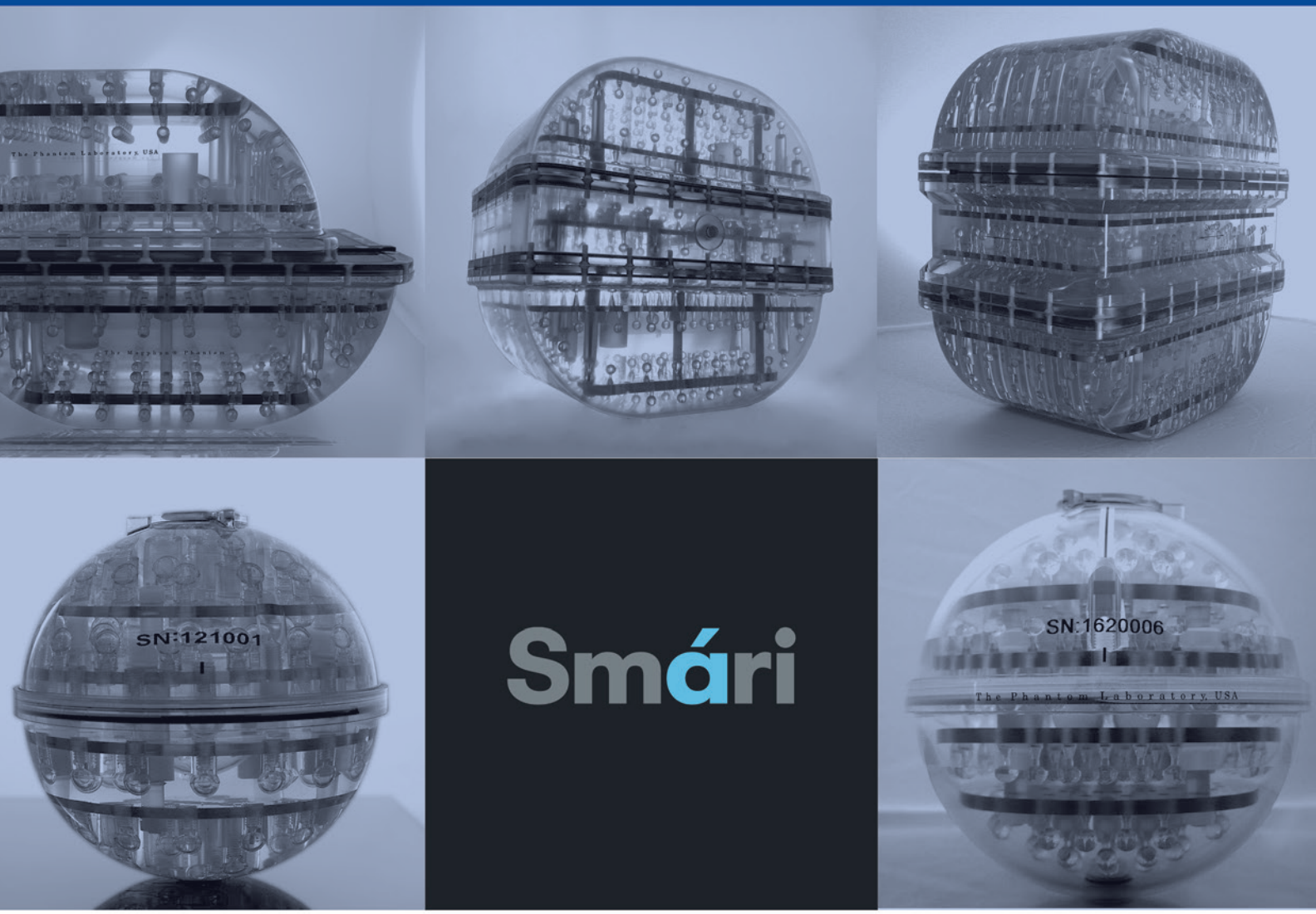
After growing up and studying Electrical Engineering in Florence, Italy, Francesco moved to Switzerland in 2005 for his PhD, where he still is a Research Group Leader on Muscle MR Imaging at the University of Basel. His work focuses on method development for MRI, from data acquisition to image postprocessing, with a particular interest in dynamic imaging of the heart and muscles. He describes himself as a geek and a maker, who loves bringing his hobbies of programming, soldering, and hitting stuff with a hammer until it fits into his professional career too.

Nikola Stikov



Prior to joining the faculty of École Polytechnique (University of Montréal), Nikola completed his post-doctoral training at the Montréal Neurological Institute, and his BS, MS, and PhD degrees at Stanford University. A son of a sports journalist, Nikola has made journalism his hobby by periodically contributing pieces on science and film to newspapers and blogs in his home country, Macedonia. His career and his hobby are finally united in Magnetic Resonance in Medicine Highlights.

Meet the Magphan family, and say hello to Smári.



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