

**Q: How did you get in the MRI field? What was your educational background?**

**John Pauly:** My background is in electrical engineering and previous to MR, I'd been working on ultrasound. My advisor, Al Macovski, was just changing from ultrasound to MR when I joined his research group. So I've worked on all sorts of things with them. First, was vessel imaging, and then quite a few things and selective excitation, and some real time imaging, and then a lot of cardiac various different ways, and then compressed sensing and then, after that, more recently image reconstruction with machine learning, those sorts of things.

**Q: Which of your scientific contributions are you best known for?**

**John Pauly:** I think the compressed sensing gets the most citations. That was basically Miki Lustig's work. He was my student at the time. And then selective excitation continues to get cited at a pretty reasonable clip, so I think that probably also has a pretty broad impact.

**Q: Why did you choose MRI research?**

**John Pauly:** Really early on, I had been working at an ultrasound company in Boston, Elscint. It was an Israeli company, and I was applying for graduate school, and I wanted to work on ultrasound tomography, and so I wrote to all the programmes in the US that did that sort of thing and one of them was Al Macovski at Stanford. So I wrote to him and said I was interested, and he said "fine, but I'm getting out of ultrasound and just starting in MR, and so, basically, I started with that as soon as I got out here."

**Q: When was your first SMRM/SMRI/ISMRM Annual Meeting? What is your memory of it?**

**John Pauly:** I used to go to all the ISMRM and also SMRI meetings, and my first SMRM was in Montreal [1986]. They had this "works in progress" deadline, which was later than their normal abstract, and so my first year I submitted one on "velocity imaging with time-varying gradients". So I got an abstract accepted and I went to my first meeting. It was really fun. It was Montreal, so we've been there again since and it's the same conference centre. It was a fun meeting all these people whose papers I'd read. It's actually very intimidating at the beginning. Everyone seemed to have this deep knowledge of mostly NMR and also hardware. People were building their own machines, and coils and stuff, so a lot of impressive people.

**Q: Do you think there's a difference in the types of topics that were prevalent back then versus now?**

**John Pauly:** Absolutely. It used to be that the conference was pretty evenly split between spectroscopy, which a lot of it was – physiology, metabolism, and stuff like that – was about a

third of the conference. And MR was just emerging then. People were showing the kinds of things that it could do, and it was just getting established clinically. And then the other third was technical. People building machines. That was before the gradient recalled echos and the short TRs. Basically everything was spin echo and things like k-space weren't understood at that point. It was really just like lots of interesting things happening, people figuring stuff out, it was a fun time.

**Q: Back then,**

- **were there many trainees (or they were all mostly senior researchers)?**

**John Pauly:** So I always had the impression that the majority of the people at the conference were students or grad students or medical students or residents. And so that was true at the time. With MR being new, there is an awful lot of people just coming into the field to make their careers. Either clinical people, or the engineers and physicists. So there were a lot of new people, it was just really expanding rapidly.

- **what educational programs were available at the time?**

**John Pauly:** What I remember is that the ISMRM was always concerned about making MR accessible to people. They were always very concerned about the educational aspect and bringing people in. The weekend courses went back to my very first meeting, if I remember right. I was looking for the program books to check the schedule but I couldn't find them, but that's something that could be looked up. They always took their educational mission very seriously. I think that that's continued. There's just more formats. There's the weekend and there's the morning courses and then there's the tutorials during the week so it's expanded a lot but the same theme has been there.

**Q: What do you think about the hybrid virtual format of recent years?**

**John Pauly:** One of the advantages is that my students can go to lots of different meetings now, and it removes the financial barrier. And it removes the barrier in the amount of time it takes, and so I think it just opens it up to many more people. And I think that's a really good thing, so I would hope that it's always in a hybrid format from now on. It's been a huge positive from the last couple of years.

**Q: What was the work you presented at the earliest meetings?**

**John Pauly:** My first one was measuring flow with a sinusoidal read-out gradient. Basically, it goes back and forth in spatial frequency, but it also traces out a trajectory in velocity k-space, KV. It was the solution of basically the differential equation of what the spins saw and showed what

the encoding was. It ended up, later, turning into MR Doppler, where you excite a pencil beam and then you read out along the beam direction, and you can resolve both position and velocity. But it took a while - there's probably a decade or two in between that and actually using it for something.

**Q: Do you have any anecdotes from the time when you were at the meeting?**

**John Pauly:** One that I like is, at my first meeting, that I was talking to someone - I don't remember who, but they had worked with AI [Macovski] in CT, I think, and he noticed that AI was getting into MR and he said, "You know, AI's getting into it a bit late. MR is sort-of done." People are always saying that! I don't know how many times people have told me that MR is "over" and it always seems to reinvent itself. Something new comes along.

**Q: What were the challenges 30 years ago VS now that the field evolved?**

**John Pauly:** Just a lot of fundamental things weren't understood. What that meant was that there were a lot of opportunities. There were lots of things to figure out. In the meantime, whole fields of MR have matured and split off and are their own entities. The whole fMRI, things like that, cardiac MR. The interesting thing with MS is, every couple years, something fundamentally different comes along and you get an intense burst of activity. That's what I look for most at the conferences, "what's it this year, what unusual thing has happened?" You look right now, and one of the interesting things is looking at lower field strengths. At my very first conference, there was a company called Instrumentarium from Finland who was making MR scanners for ER rooms throughout Finland, and they were operating at something below a megahertz, and the amazing thing to me is that they actually made real images. I mean, it actually worked. But the field sort of just rushed-by those fields strengths. By the 90s, everything was in the 1.5 Tesla and above, and in the meantime, hardware has gotten tremendously better; the encoding gradients and the fidelity of the RF field. It is possible that looking again at some of the lower field strengths may have something significant. So, definitely, you can make images and the technology is so much better that it'll be interesting to look at those again.

**Q: How has the ISMRM impacted your career?**

**John Pauly:** I talk with a lot of people in other fields related to medical imaging, and the ISMRM, I think, is pretty unique in that it is very conscious about bringing the very broad community together, from basic science people and physics, and biology, all the way through to clinicians. A lot of other fields don't have that. So it is a pretty unique forum, and it really is very helpful, particularly if you're - as we do - getting all of our support from NIH. And you actually need that

entire spectrum in order to be successful in writing fundable grant proposals. You need the entire arc, from something interesting technically all the way through to “how does that affect patient management?” Being able to learn about that entire arc - the whole story - is one of the real strengths of the ISMRM.

Often, when I go to the ISMRM, I don't go to any of the sessions that I already know something about. I go to just random sessions, and try to figure out if there's something that we can do in that space, if there's some interesting problem there, and it's really useful for that.

**Q: Do you have any advice you can give to young MRI researchers on how to make new ground-breaking research?**

**John Pauly:** There are a couple of things. One is that, often, the interesting things happen on the boundaries between disciplines. Often, people will focus on one aspect of a problem but, for example, right now, machine learning is very, very hot but there's a lot of stuff happening in machine learning in other areas, like speech or computer vision, and so translating ideas from one area to another is often a very successful strategy. You could do that with MR and physiology, or MR and physics, or lots of other ways. So that's one - to keep looking beyond your local expertise or your local area.

The other thing that's often useful is, when your experiment doesn't work, ask “why?” Sometimes there's something interesting there, and figuring that out, you can often find some physical effect that you didn't know about, that's exploitable in some way. Try to figure out, once you know what's happening, “Is there something I can do with that?”, and that's been useful for me quite a few times. Some artefact, or something I didn't expect, that turns into being something I could measure, or make an image of.

The other thing is, often people work on making things slightly better, or trying to make something slightly faster, or something like that, but what you really want to look for is crossing some boundary. If you can take a scan that, all of a sudden, it's short enough that you can do it in a breath hold, that makes a huge difference, or you know, or you don't need breath-holding or something that enables fundamental change in the way you do things.