Journal of Magnetic Resonance 213 (2011) 532

Contents lists available at SciVerse ScienceDirect

Journal of Magnetic Resonance

journal homepage: www.elsevier.com/locate/jmr

Historical Perspective

EPI – In the beginning

Sir Peter Mansfield, FRS

Schools of Physics and Astronomy, The University of Nottingham, University Park, Nottingham NG7 2RD, United Kingdom

ARTICLE INFO

Article history:
Available online 7 September 2011

Keywords:
EPI
Ultra-fast imaging
MRI

ABSTRACT

The ideas and thoughts that resulted in the creation of EPI are recalled.

Interview with the author(s).

A video interview with the author(s) associated with this Historical Perspective and the original article can be found in the online version, at doi:10.1016/j.jmr.2011.08.017.

This short note has resulted from a relook at my original paper in **J Phys C 10, L55 (1977)**, which was followed by a Journal of Magnetic Resonance publication **J Magn Reson 29, 355 (1978)**. It is hoped that the reader will enjoy learning more about how I reached the conclusions described in the paper.

In 1976 following the introduction of point scanning by Hinshaw and line scanning by me I was trying to devise a way of gathering imaging data from a plane of material in a single shot.

I remember struggling day and night, wondering how one could encode a complete two dimensional plane of data.

I knew from my background in NMR about spin echoes and how a free induction decay signal could in certain circumstances be slowed down in its decay to zero by the application of a train of 180° RF pulses. If this procedure were carried out while the spin system was subjected to a small gradient it seemed that this could be viewed as a one dimensional encoding of an image. The question that I wrestled with for many days was how this process could be generalized to produce a two dimensional image.

There was a problem with 180° RF pulses, namely, imaging of biological systems posed a significant risk due to RF power deposition in the subject. However I knew from spin dynamics that RF pulses could be replaced in principle by gradient reversals. However, regular gradient reversal meant that the spins of the subject being imaged were periodically subjected to, in effect, a positive and negative gradient. For a perfectly spherical object or a cylindrical object reversal of the imaging gradient made no difference but with an asymmetric object periodic reversal effectively inverted the image projection. But the real question in the back of my mind was what would happen to these image projections if a second gradient was applied.

I knew that the second gradient had to be directed along an axis orthogonal to the first axis. If it were not so it would simply add to or subtract from the first axis thereby making no difference to the image projection. On the other hand if the second gradient were orthogonal to the first gradient the two gradients could be added to produce a single gradient pointing along an intermediate axis, so again it was not obvious that such an approach would lead to the desired result.

My breakthrough came when I realized that the second gradient strength had to be much less than the first gradient. This process I called 'nesting'. By this I meant that the second gradient, called the broadening gradient, had to be quite small. The reason for this was simply that in Fourier transform the first gradient produced a discrete set of delta functions with a spacing that was controlled by the switching of the gradient. This is the so called stick spectrum. The overall profile of the delta function set was simply the discrete projection of the object in the first gradient. The gaps in the discrete spectrum were where the discrete spectrum could be expanded by the broadening gradient. That imposed a limit on the strength of the broadening gradient and meant that it could not exceed the level where the broadened stick spectra began to overlap. If the broadened stick spectra did overlap it resulted in image wraparound. These ideas and the corresponding mathematical analysis are contained in the above mentioned publications.

The first experimental results were obtained a year or so later. In 1976 the very first meeting on NMR Imaging was convened by Professors Raymond Andrew in Nottingham. There were about two dozen attendees at this meeting mostly from Britain but also one or two people from Holland and elsewhere. Professor Richard Ernst and Paul Lauterbur were also in the audience. I was invited to give a short talk and I chose to speak about my latest ideas on imaging including EPI. The talk took about 20 min and I invited questions but there was a deadly silence in the audience. Not one question was asked. Whether this response was due to sheer disbelief or incomprehension remains a mystery to me to this day.

E-mail address: Pamela.Davies@nottingham.ac.uk

1090-7807/$ - see front matter © 2011 Elsevier Inc. All rights reserved.
doi:10.1016/j.jmr.2011.08.017