

Magnetic Resonance Imaging

Week 5; Lecture 11; Section 1: Spin-echo sequence for proton-density weighted image

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Section 1

Spin-echo sequence for proton-density weighted image

Generation of an MRI image

Tissue specificity in MRI is generated principally by three physical quantities:

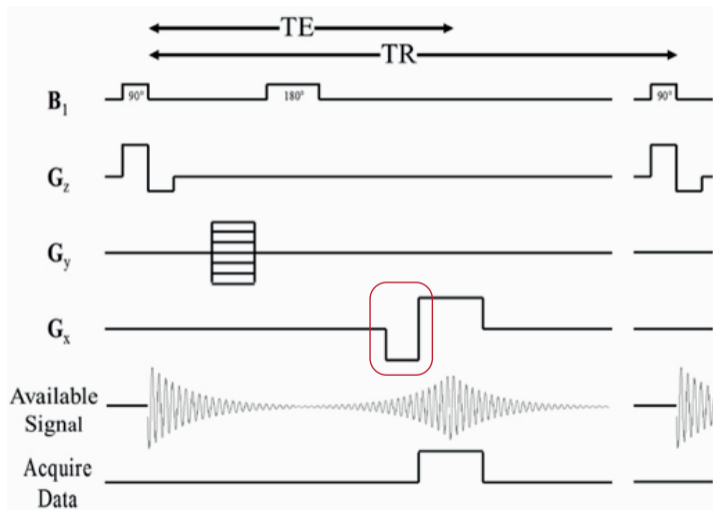
- The net magnetisation at equilibrium, M_{eqm} :
 - This is a measure of “proton density”;
 - Often referred to as proton density and M_{eqm} expressed as the fraction its value for water
- T_1 : the spin-lattice relaxation time constant; and
- T_2 : the spin-spin relaxation time constant

In a spin-echo sequence the time to repetition, TR, and the time to echo, TE, are adjusted to enhance the sensitivity of the signal amplitude to these three basic characteristics

The instantaneous signal intensity is proportional to the instantaneous magnitude of the magnetisation transverse to \mathbf{B}_0

This statement is **important** to get to grips with the generation of contrast in MRI

Pulse sequence; reminder



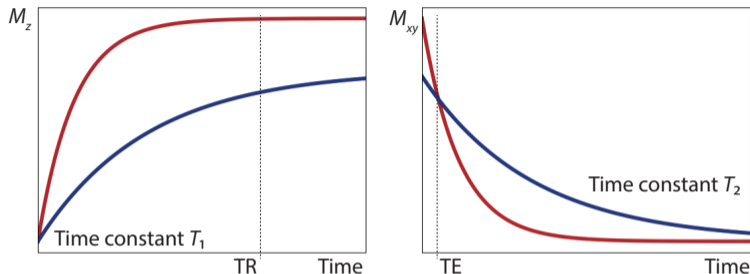
Note presence of “pre-winding pulse” circled in red

- Phase-encoding pulse causes phase to be position dependent
- Incoherence induces causes a loss of signal, so
- “Negative” gradient pulse applied in frequency encoding direction to “pre-wind” spins and cause an echo re-enforcing the signal at readout

Values of the basic parameters for a variety of tissues

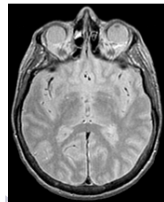
Tissue	Proton density	1.5 T		3 T	
		T_1 ms	T_2 ms	T_1 ms	T_2 ms
Cartilage	0.94	1024	42	1168	37
Skeletal muscle	0.95	1084	37	1416	41
Blood	0.97	1441	308	1932	275
Fat	0.94	343	160	380	130
CSF	1.00	4550	60	4550	30
Brain matter (white)	0.99	688	81	833	68
Brain matter (grey)	1.00	1195	97	1436	93

Proton-density weighted image



$B_0 = 3 \text{ T}$; set $TR = 2500 \text{ ms}$ and $TE = 10 \text{ ms}$

	T_1 (ms)	$\frac{TR}{T_1}$	T_2 (ms)	$\frac{TE}{T_2}$	Relative brightness
Blood	1932	1.29	275	0.04	Medium
CSF	4550	0.55	30	0.33	Low
White matter	833	3.00	68	0.15	High
Grey matter	1436	1.74	83	0.12	Medium



Proton-density weighted image

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Proton-density weighted image:

- TR long: long enough that M_{eqm} is restored between repetitions
- TE short: such that effects of different T_2 are not allowed to evolve

Such images have strong signal from all tissues, but relatively low contrast between them

Summary of section 1

Proton-density weighted image:

- TR long
- TE short

Strong signal from all tissues, relatively low contrast compared to other sequences