

T1 Relaxation Times

Typical in-vivo T1 values at 3T (healthy adults, $\approx 37^\circ\text{C}$):

Tissue	T1 at 3T (ms)	Example reported values
White matter (WM)	900–1100	$\sim 940 \pm 65$ (Rooney 2007); ~ 860 – 980 (Deoni 2005)
Gray matter (GM)	1300–1500	$\sim 1330 \pm 80$ (Rooney 2007); ~ 1370 – 1450 (Deoni 2005)
Cerebrospinal fluid (CSF)	4000–5200	$\sim 4300 \pm 300$ (Rooney 2007); ~ 4200 – 5000 (various)

Notes:

- Values vary with sequence, fitting method, age, and temperature.
- CSF shows wide variability due to flow and partial-volume effects.

T1 values of water with and without Salt (NaCl) at 3T (≈ 22 – 25°C)

Percentage of NaCl	T1 at 3T (ms)
$\ll 0.9\%$	3000–3300
0.9 % (physiological saline)	2800 – 3100
10 %	1200 – 1700
20 %	700 – 1200

Rule of thumb: each 0.1 M NaCl reduces T1 by about 5–10% at 3T.

Ernst Angle

- In a FLASH MR sequence, the Ernst angle is the flip angle that gives the largest steady-state signal for a given TR and T1.
- Intuition: Think of a cup that refills with water (magnetization) between sips. T1 = how fast it refills; TR = how long you wait between the sips; flip angle = how big a sip you take. Too big a sip drains the cup; too small wastes potential. The Ernst angle is the sip size that maximizes what you drink each time you repeat.

Key formula

- $\alpha_E = \arccos(e^{-TR/T1})$
- Shorter T1 or longer TR $\rightarrow$ larger α_E . If TR $\ll$ T1, α_E is small.

Quick examples (approximate)

TR (ms)	T1 (ms)	Ernst angle
10	1000	$\sim 8^\circ$
20	1000	$\sim 11^\circ$
15	500	$\sim 17^\circ$

Why it matters

- Using $\alpha \approx \alpha_E$ maximizes signal (SNR per unit time) for that tissue.
- For contrast: choosing α near the Ernst angle of a short-T1 tissue boosts it relative to long-T1 tissue (T1-weighting). Different tissues have different α_E .

Classroom Demo (optionally)

- Ask pupils to “refill and pour” with a water cup:
 1. Refill time = TR; refill rate = T1.
 2. Try small, medium, large “sips” (flip angles) every TR.
 3. Observe which sip size yields the most water per cycle - this corresponds to the Ernst angle.