Performance Indicators- 3.0 T Biospec Bruker MRI

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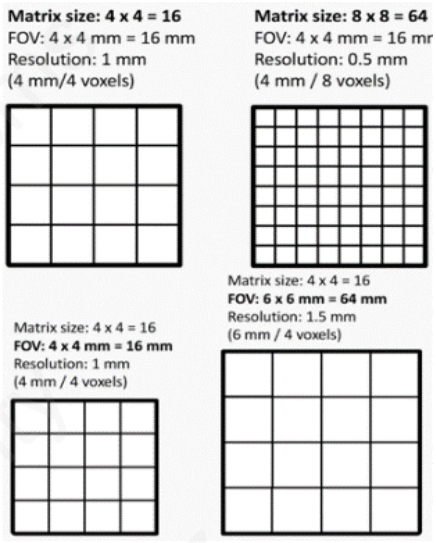

MRI quality relies on a combination/balance of…

- **Spatial Resolution (SR)**
  - Ability to distinguish distinct structures from each other, defined by **3D voxel volume = ST*(FOV/MS)**, can be non-isotropic 1, 2
  - **In-plane resolution** = voxel size within 1 slice (i.e., in 2D) = FOV/MS
  - ↑SR ↓voxel volume (=↑detail), ↑NSA (=↑scan time)
  - **Resolution limit** (↑RL=↓SR)**:** lower bound for accurate diameter estimation. Challenged by: partial volume effects, field inhomogeneities, off-resonance, cardio/respiratory motion, intravoxel dephasing (minimized by small isotropic voxels), diffusion & T2* effects 3, 4, 5
- **Temporal resolution (scan time)** 6
- **Signal per voxel (= number of protons per voxel = proton density "PD")**
  - Larger voxels receive more MRI signal than smaller voxels
  - **Signal to Noise ratio (SNR)** = $\boldsymbol{VV} * \sqrt{\frac{\boldsymbol{NSA} * \boldsymbol{N_x} * \boldsymbol{N_y}}{\boldsymbol{BW_{read}}}}$
    - Where $\mathrm{VV} = \text{voxel volume} = \triangle x * \triangle y * ST$ (source CAF, "SNR 2D")
  - **Noise** = constant baseline, influenced by subject intrinsic noise (>>system) 7
    - ~ B_0^2 * body geometry & conductance * coil's sensitivity pattern 8
  - **Signal** = acquisition-dependent, SNR modulation relies on change in signal ONLY via spatial resolution (max PD is fixed/limited!!)

General considerations to ↑SNR

- ↑voxel volume via ↑ST & ↑FOV (= ↑SR)
  - Although ↑ST = ↑partial volume effects (undesired)
  - **FOV**: large (whole signal can sampled in PE direction) vs small (aliasing from signal outside ROI?)
  - ↑slice gap = ↓crosstalk of signal saturation
- ↑NSA, because SNR ∝ sqrt(NSA), although ↑scan time (2^{NSA}) and doesn't increase SR
  - Common saying "fast advanced techniques = SNR starved" 9
- ↑#phase or frequency encoding steps (Nx, Ny)
- ↓BW (=narrower =↓noise, but readout G must increase to keep FOV → ↑TEmin & chemical shift)
- Avoid partial FT (pFT = ↑noise, although no effects in SR)
- TI & FA effects not straightforward
- ↑TR (= ↑Mz can recover between excitations), ↓TE (= ↓Mxy decay between excitation and sampling)

General information

- Magnet field BioSpec 30/18… 128 MHz, Magnet Bore 17 cm
- Homogeneity (50 mm DSV) = 0.3 ppm peak-peak; Stray field (center to 0.5 mT) = 0.53/0.94 (radial/axial)
- Gradient: 105 inner diameter, **450 mT/m strength** (can be upgraded to 900?), 4200 T/m/s slew rate
- Mouse body coil: 40 mm inner diameter (ID), 1H transmit and receive (TR) capabilities, circularly polarized
- Rat body coil: 82 mm ID, 1H transmit and receive (TR) capabilities, circularly polarized, active detuning

ABBREVIATIONS

BWread = readout bandwidth
FOV = field of view
MS = matrix size
Mxy = transverse magnetization
Mz = longitudinal magnetization
NSA = number of signal averages
Nx = points in the readout direction
Ny = points in phase-encoding direction
PD = proton density
pFT = partial Fourier transform
SNR = signal-to-noise ratio
SR = spatial resolution
ST = slice thickness
TE = echo time
TR = repetition time

References

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