Parameters which can be “optimized”

•Functional Contrast	•3/1 to 5/1
•Image signal to noise	•100/ to 500/1
•Hemodynamic Specificity	
•Image quality (warping, dropout)	
•Speed	
•Resolution	•1mm to 5 mm
•Functional image quality (minimally sensitive to motion, etc..)	
•Brain coverage	•15 to 30 slices depending on orientatioin

Parameters that can be varied

- Bo
- RF coils
- Gradient strength and slew rate
- Pulse sequence (GE, SE, IR/ASL…)
- TR (0.5 to 5 sec)
- TE (20 to 60 ms)
- TI (for ASL techniques: 900 to 1400 ms)
- Flip angle (90 if TR -> 2 sec, otherwise less)
- Voxel volume (3 x 3 x 5 mm)
- Receiver bandwidth (64 MHz to 500 MHz)
- Diffusion weighting (b = 50 to 200)
- Multi-shot imaging (1 to 10 shots)
- Spiral
- EPI
- Outer volume saturation
- Shimming techniques (linear to higher order) and (manual and auto - localized and whole brain)

Hardware

Pulse sequence parameters

Image readout strategy

Pre-sequence preparation

Functional Contrast to Noise

- Gradient-echo, TE ≈ T2*
- Averaging ≈ Sqrt(n)
  - (at least 200 images)
- Local rf coils
- Higher Bo
- Voxel size ≈ functional unit size
  - (1.5 mm to 4 mm)

Image signal to noise

- Averaging ≈ Sqrt(n)
- Local rf coils
- Higher Bo
- Larger voxels

Hemodynamic Specificity

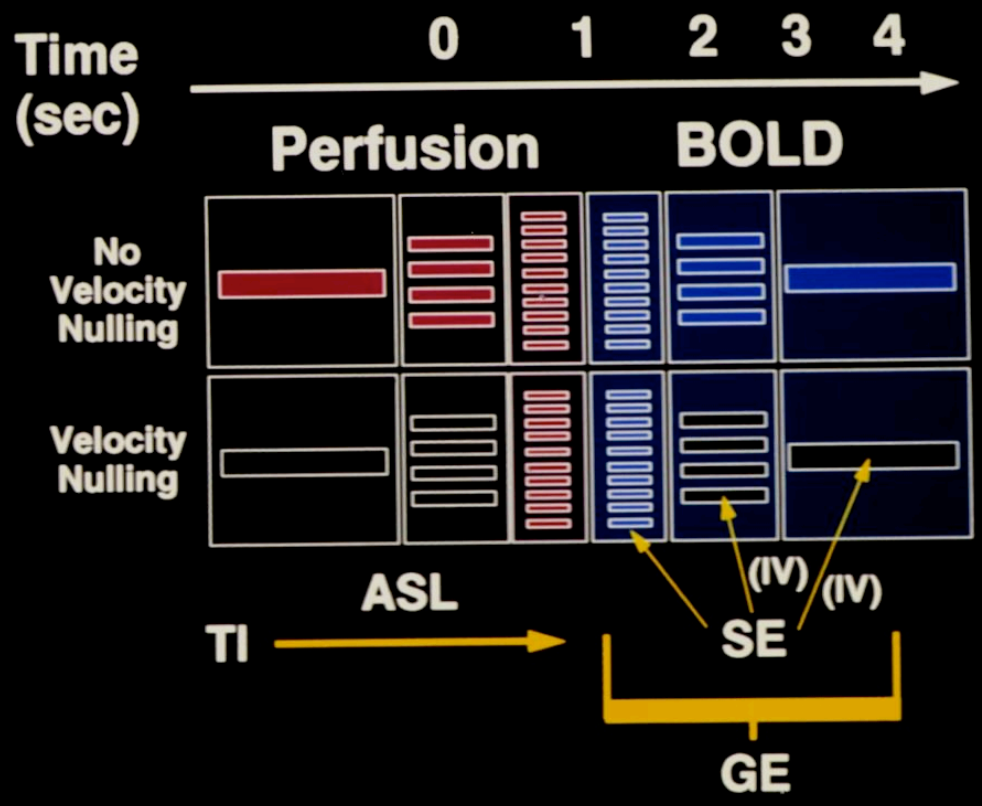
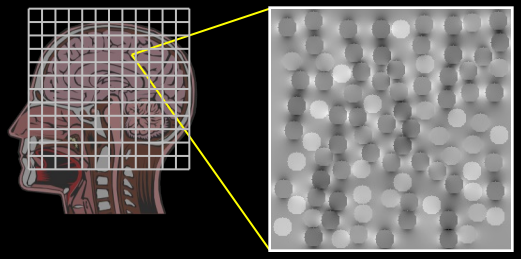
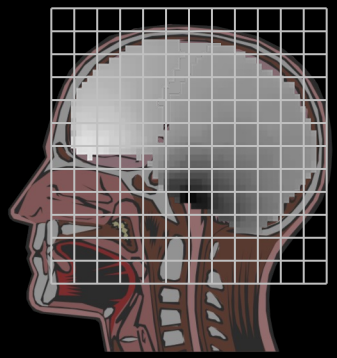


Image quality (warping, dropout)



Microscopic:

T1, T2, T2* BOLD



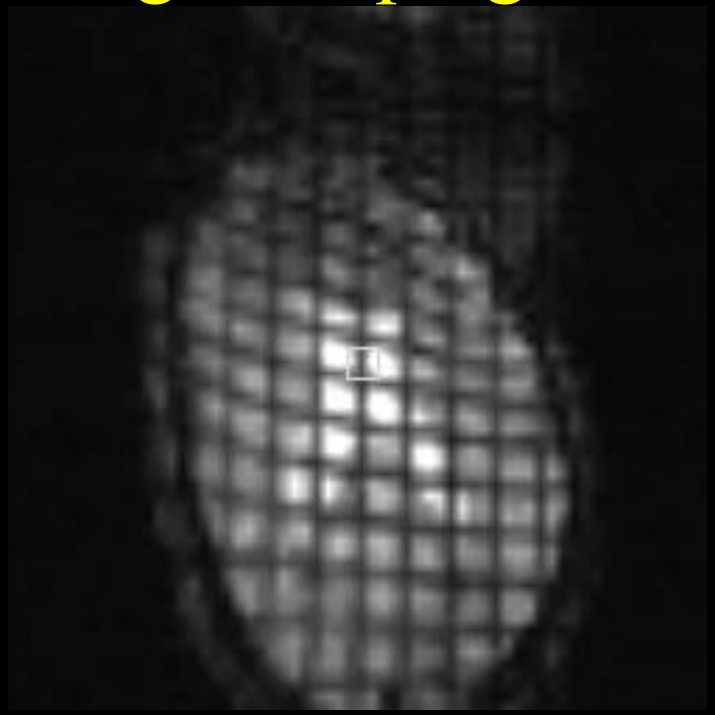
Macroscopic:

Image warping
Image blurring

Image quality

Effect of ΔB on EPI images

- Image Warping



phase

Long readout time

↓

More time for phase errors to accumulate

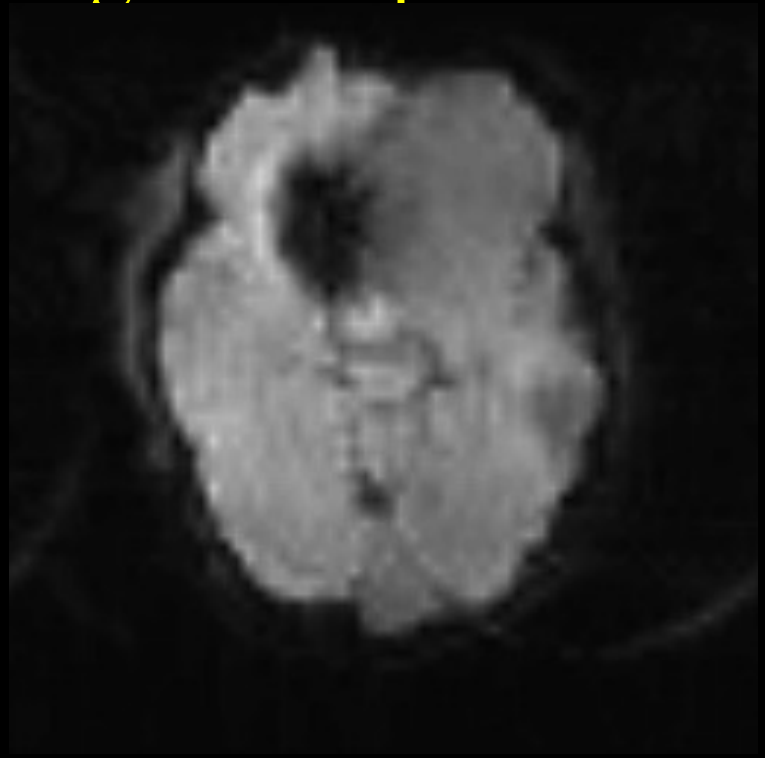
ϕ (k) ~ shift (x)

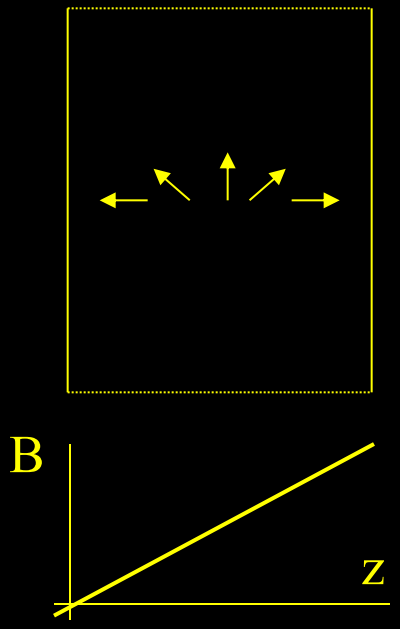
Typical EPI:

22 Hz → 1 pixel shift

Effect of ΔB on EPI images

- Signal Dropout





Typical EPI:

210 Hz through slice → Complete signal loss

Image quality

Warping:

- Shorter readout window
  (bandwidth, gradients,multi-shot)
- Spiral scan
- Shimming
- Bo correction

Dropout:

- Small voxels
  (bandwidth, gradients, multi-shot)
- Short TE (spiral)
- Spin-echo
- Slice orientation
- Shimming
- Lower Bo

Speed

- Single-shot
- Gradient-echo
- Decreased brain coverage
- …gained by increase contrast to noise..

Resolution

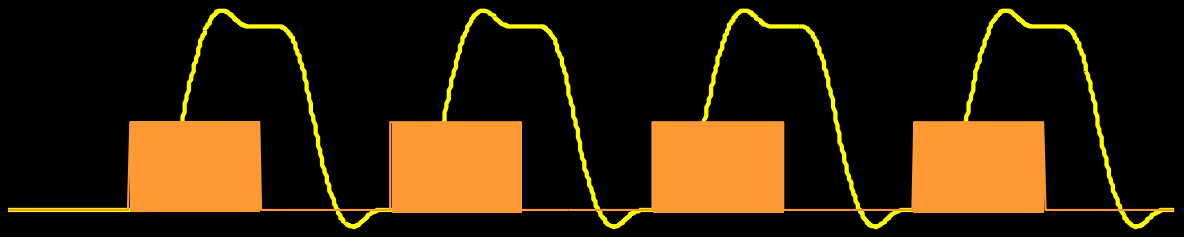
- Higher Signal/Noise and Contrast/Noise
  - Averaging ≈ Sqrt(n)
  - Local rf coils
  - Higher Bo

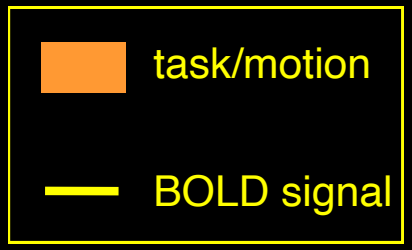
- Multi-shot imaging
- Longer readout window..(to a point)

Functional image quality
(minimally sensitive to motion, etc..)

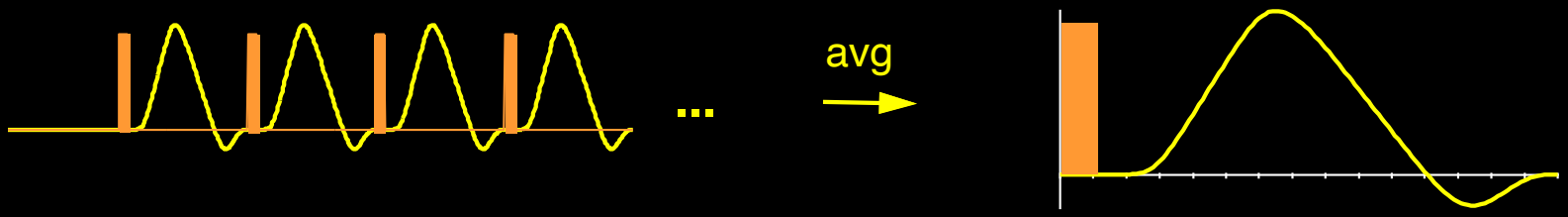
- With multi-shot..
  - Navigator echo
  - Spiral
- Bo mapping (unwarping)
- Flat image contrast
- Paradigm timing
  (multiple on/off cycles, event-related)

Block-trial

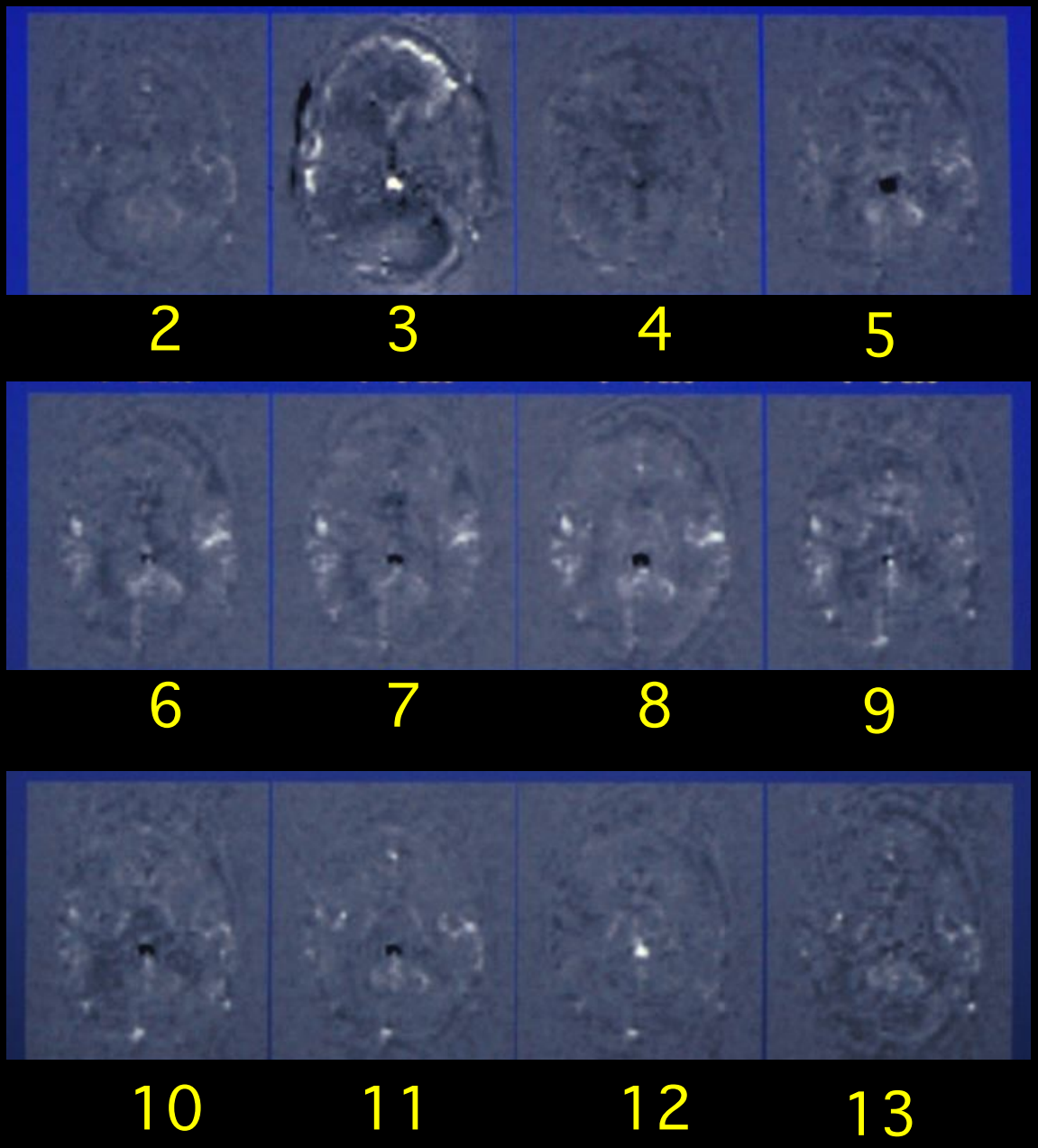




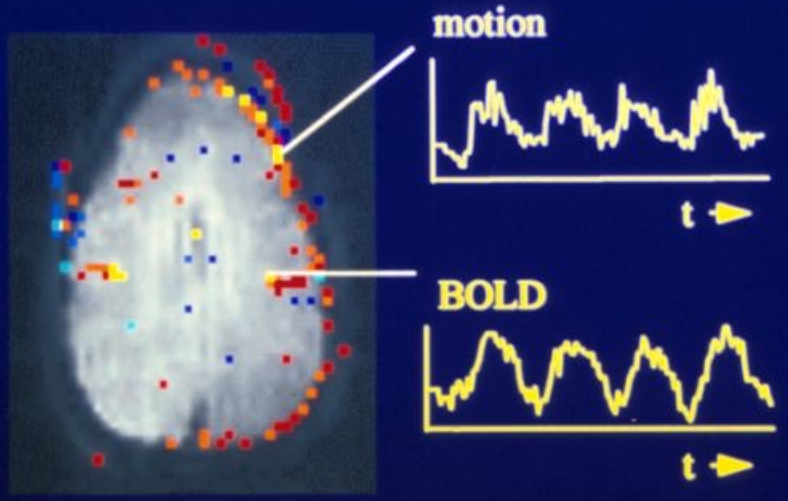
Single-trial (brief stimulus)

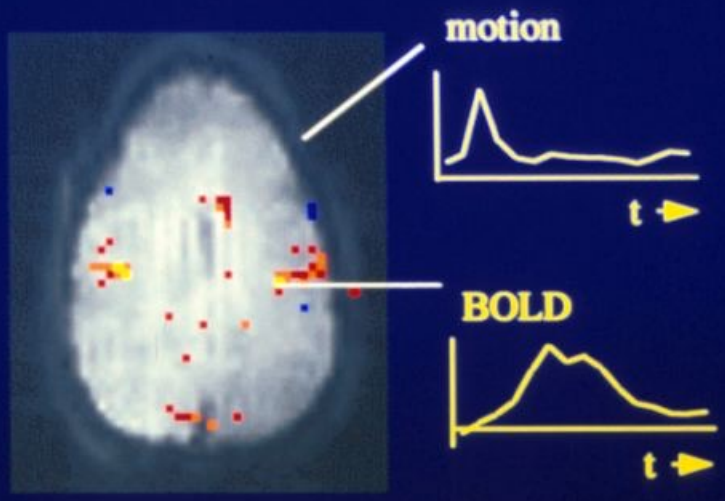


Overt Word Production



Motion-Decoupled fMRI:
Functional MRI during of overt word production





"block-trial" paradigm

Motion induced signal changes resemble functional (BOLD) signal changes

"single-trial" paradigm

Motion induced and BOLD signal changes are separated in time

R.M. Birn, et al.

Brain coverage

- BOLD contrast
- Single shot
- Whole brain rf coil
- Minimal dropout at base of brain
  - Small voxels
    (bandwidth, gradients, multi-shot)
  - Short TE (spiral)
  - Spin-echo
  - Slice orientation
  - Shimming
  - Lower Bo

example 1

Whole Brain Imaging

≈16 images/sec
≈20 slices per volume
≈200 images per time course
≈8 time courses

example 2

Imaging Orbital Frontal Activation

Smallest voxel dimension in S/I direction
saggital or coronal slices

example 3

Ocular Dominance Column Mapping

Multishot imaging
Needs one or more:
    spiral sequence
    navigator pulses
Imaging time per slice increased x #interleaves
    usually translates into less slices
        (ie focus is on one area)

example 4

Event - related fMRI

Need to have enough points to sample hemodynamic response function:
TR at most should be 2 sec.

If TR <= 2 sec. Is not possible (I.e. whole brain coverage or multishot), then need to make stimulus timing different Multiple of TR. I.e TR = 4 sec, ISI = 16.2 sec. This way, the "effective TR" is 0.2 sec. If ISI = 17 sec, effective TR = 1 sec. When doing this, the overall time course duration needs to be increased.