Magnetic Resonance Imaging (MRI)
Invented in 1977

Functional MRI (fMRI)
Invented in 1990

MRI

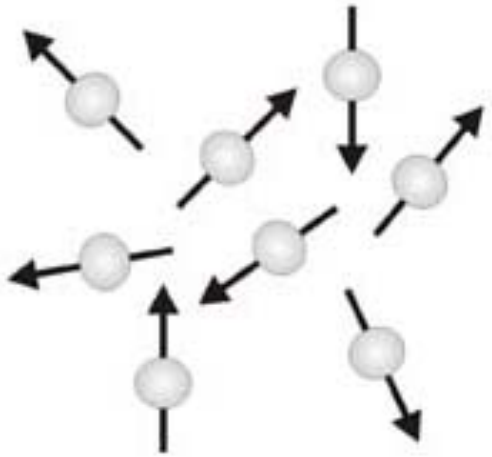
by the NIH:
https://www.youtube.com/watch?v=1CGzk-nV06g

Basics of MRI

Our bodies are mostly water and have a high concentration of hydrogen nuclei.

1. The nuclei of hydrogen atoms (called protons) normally point randomly in different directions.

1.



Basics of MRI

Our bodies are mostly water and have a high concentration of hydrogen nuclei.

2. However, when exposed to a strong static magnetic field, the nuclei line up in parallel formation, like rows of tiny magnets. In an MRI set-up, a strong external static magnetic field is applied across the brain in order to line up the hydrogen nuclei. (This field can be up to 80 000 times stronger than the earth's magnetic field.)

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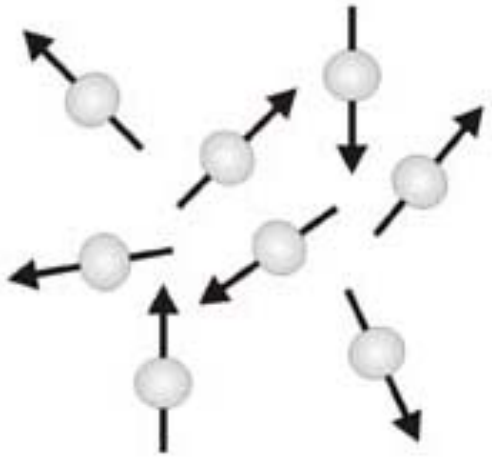

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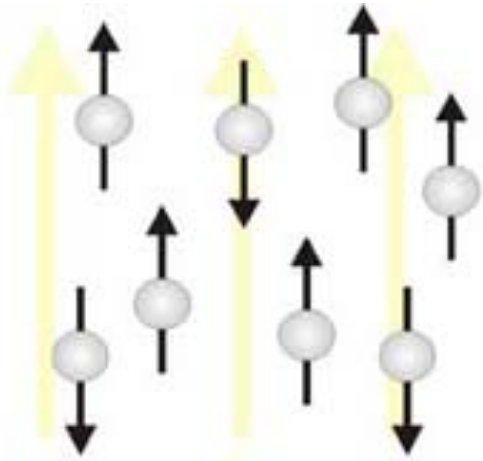

Basics of MRI

Our bodies are mostly water and have a high concentration of hydrogen nuclei.

3. Then this parallel formation, called *equilibrium*, is disturbed by sending out radio waves from the MRI machine

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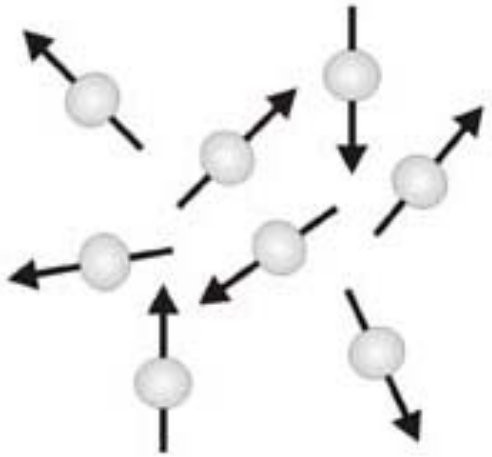

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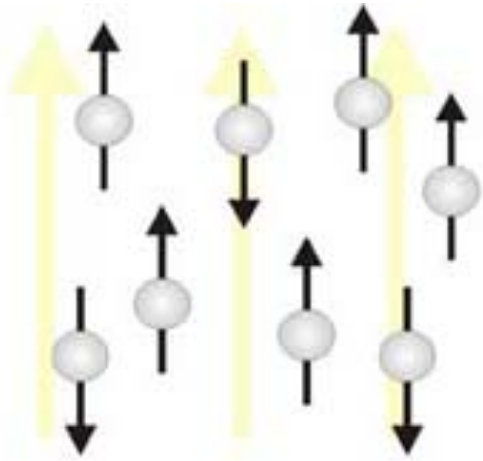

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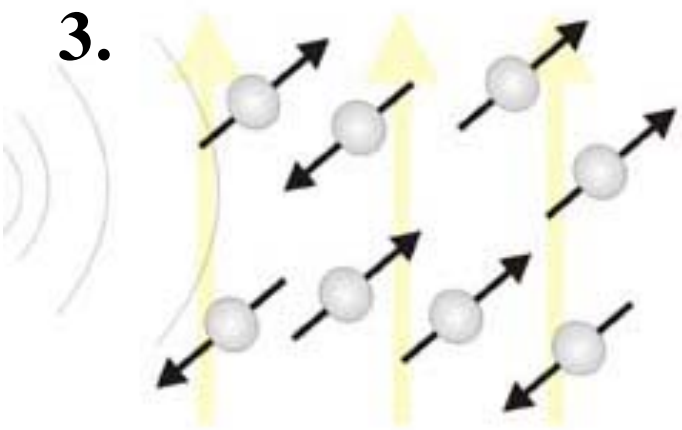
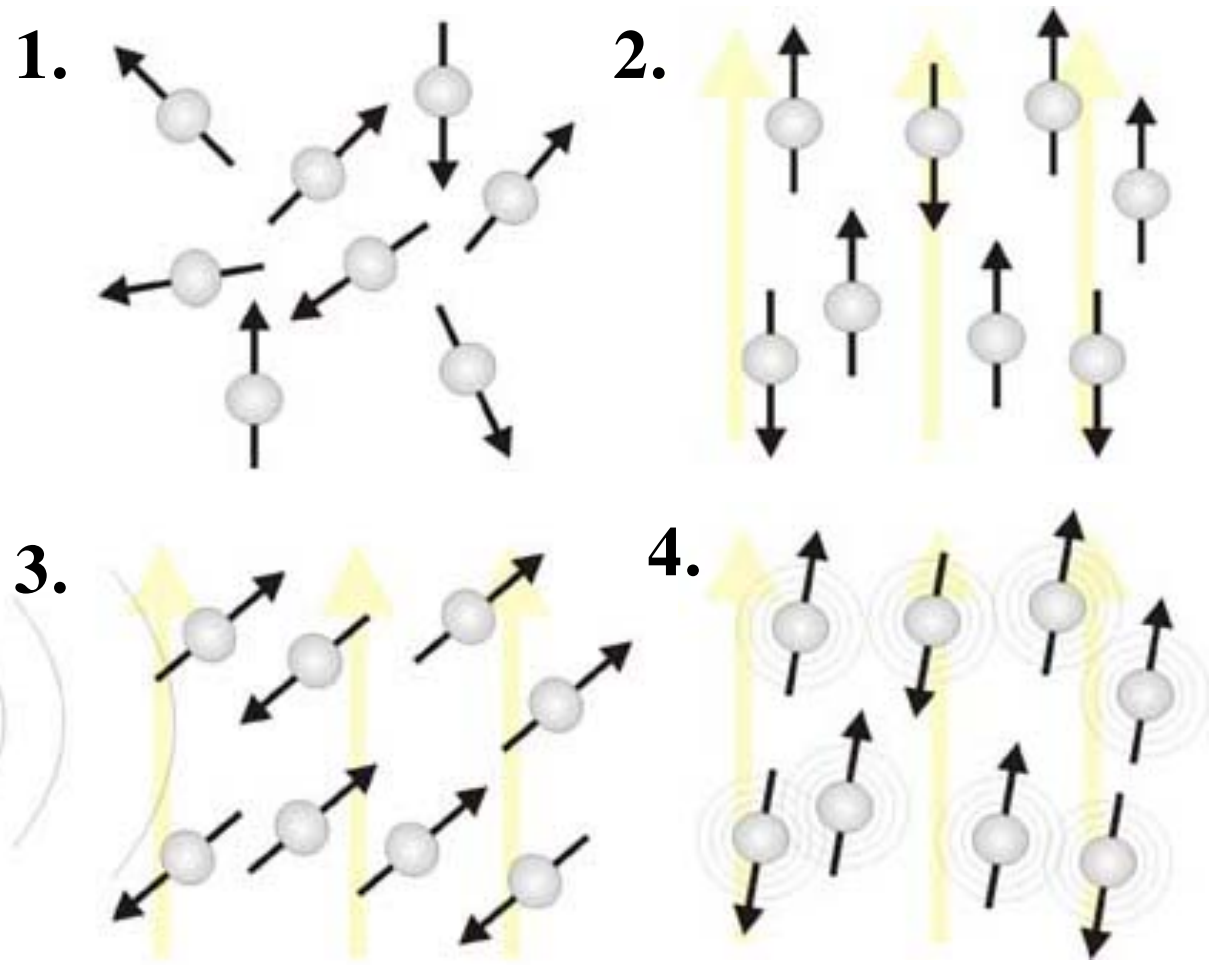


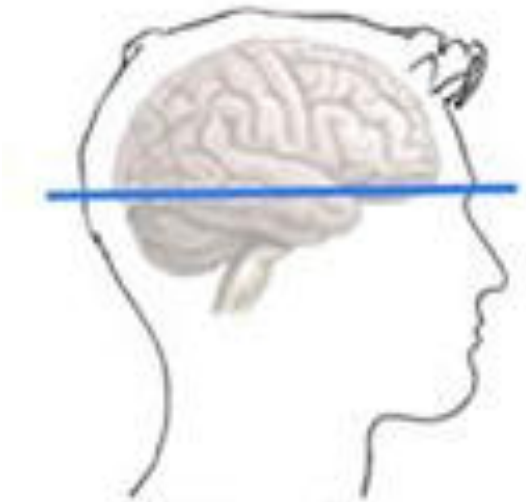
Basics of MRI

Our bodies are mostly water and have a high concentration of hydrogen nuclei.

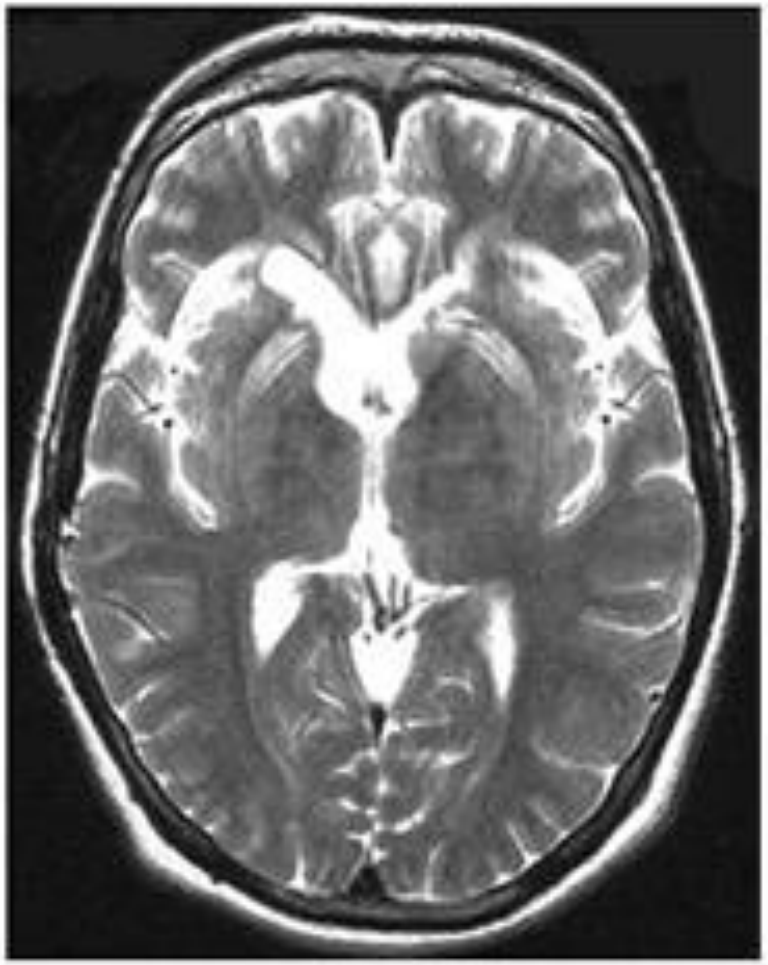
4. As the hydrogen nuclei fall back into alignment, they produce a detectable radio signal. MRI signal decay rates are different for different biological tissues. For example, tissues that contain little or no hydrogen (such as bone) appear black. Those that contain large amounts of hydrogen (such as the brain) produce a bright image.



Basics of MRI



Level
of section



MRI of brain

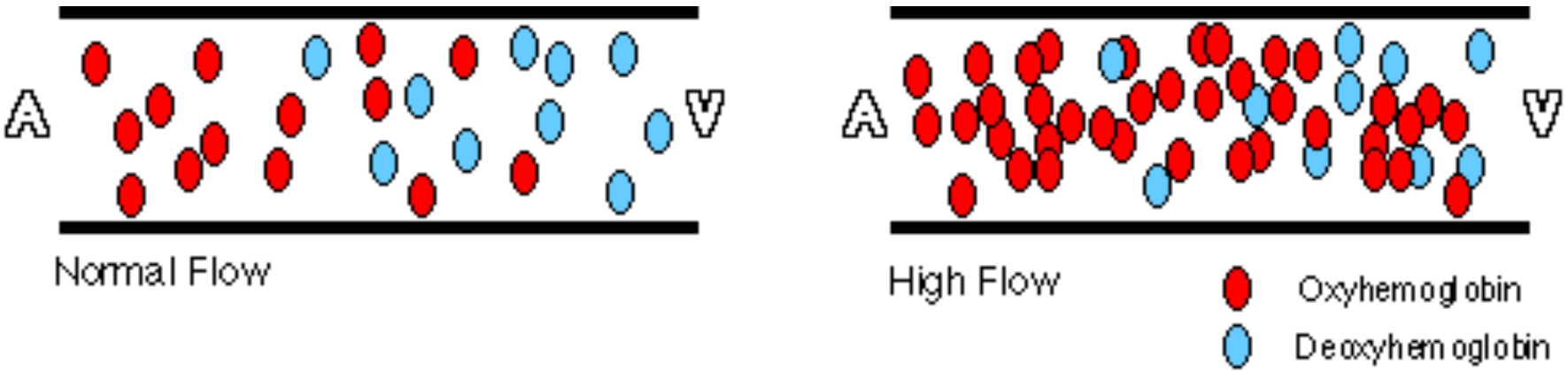
fMRI

https://www.youtube.com/watch?v=uVht8AMknfc

Functional MRI (fMRI)

- Blood Oxygenation Level Dependent (BOLD) signal
  - **Blood is more oxygenated in an activated region of the brain than in a nonactivated region.**
  - **Oxyhemoglobin and deoxyhemoglobin differ in their magnetic susceptibility: Deoxy Hb has a higher magnetization decay rate than does oxy Hb.**
  - **On YouTube:**

    https://www.youtube.com/watch?v=Rb_mdzgw-Jc



The subtraction method

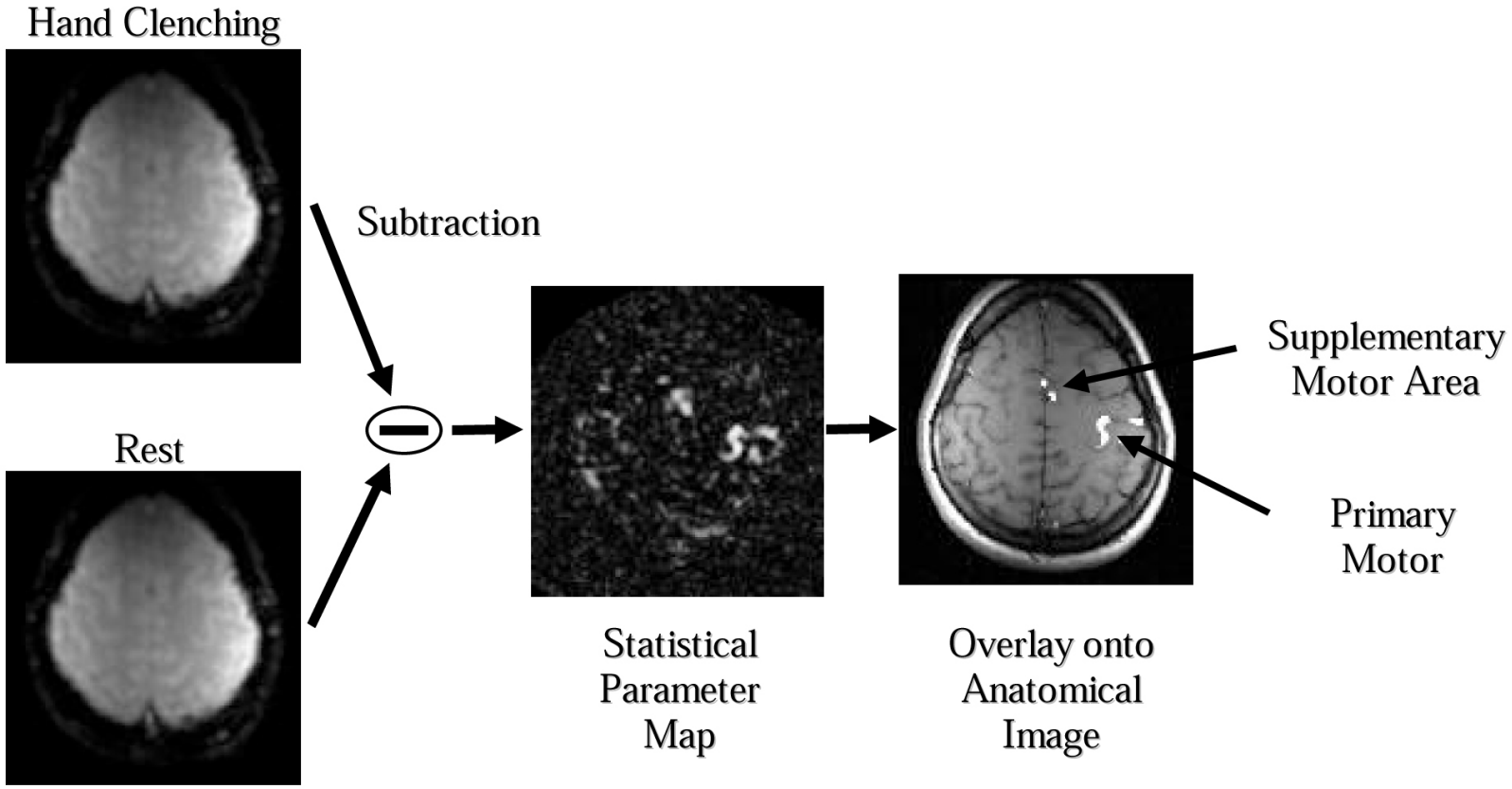


Figure 9. Graphical description of a functional MRI experiment: images from two behavioral conditions are subtracted to yield regions of brain activity. In this case, a hand clenching task was used to define the primary and supplementary motor control areas in the brain.

fMRI pros and cons

PROs

- No radioactive tracers are needed.
- Good spatial resolution: 3-6mm (in most applications).

CONs

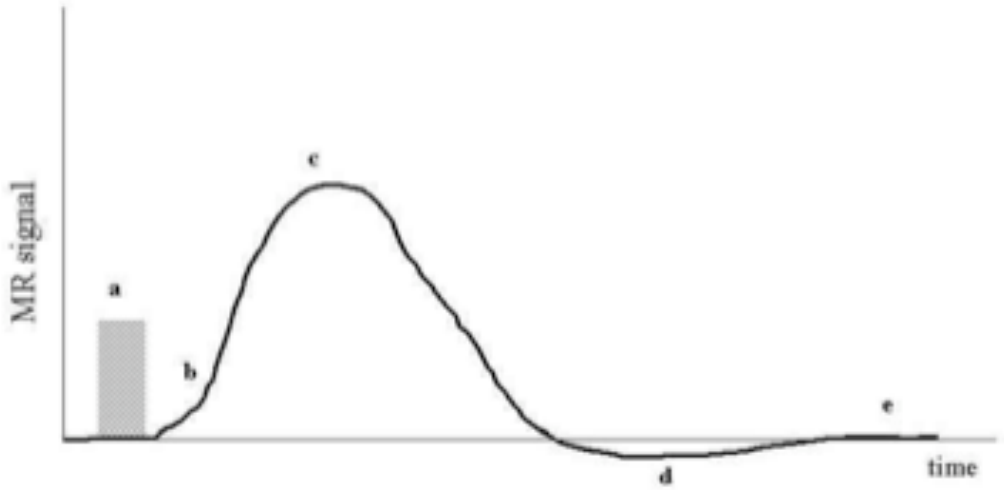
- Strong magnetic field necessitates strict safety protocols.
- Noisy. On and off currents cause loud clicking sounds.

  - https://www.elliothospital.org/website/diagnostic-imaging-mri-faqs-why-does-the-mri-machine-make-so-much-noise.php

- Temporal resolution: in the order of seconds.
  - **Fast enough to distinguish between trials (i.e. event-related designs and randomization are possible)**
  - **Not fast enough to distinguish between the activation patterns associated with different stages of stimulus processing.**

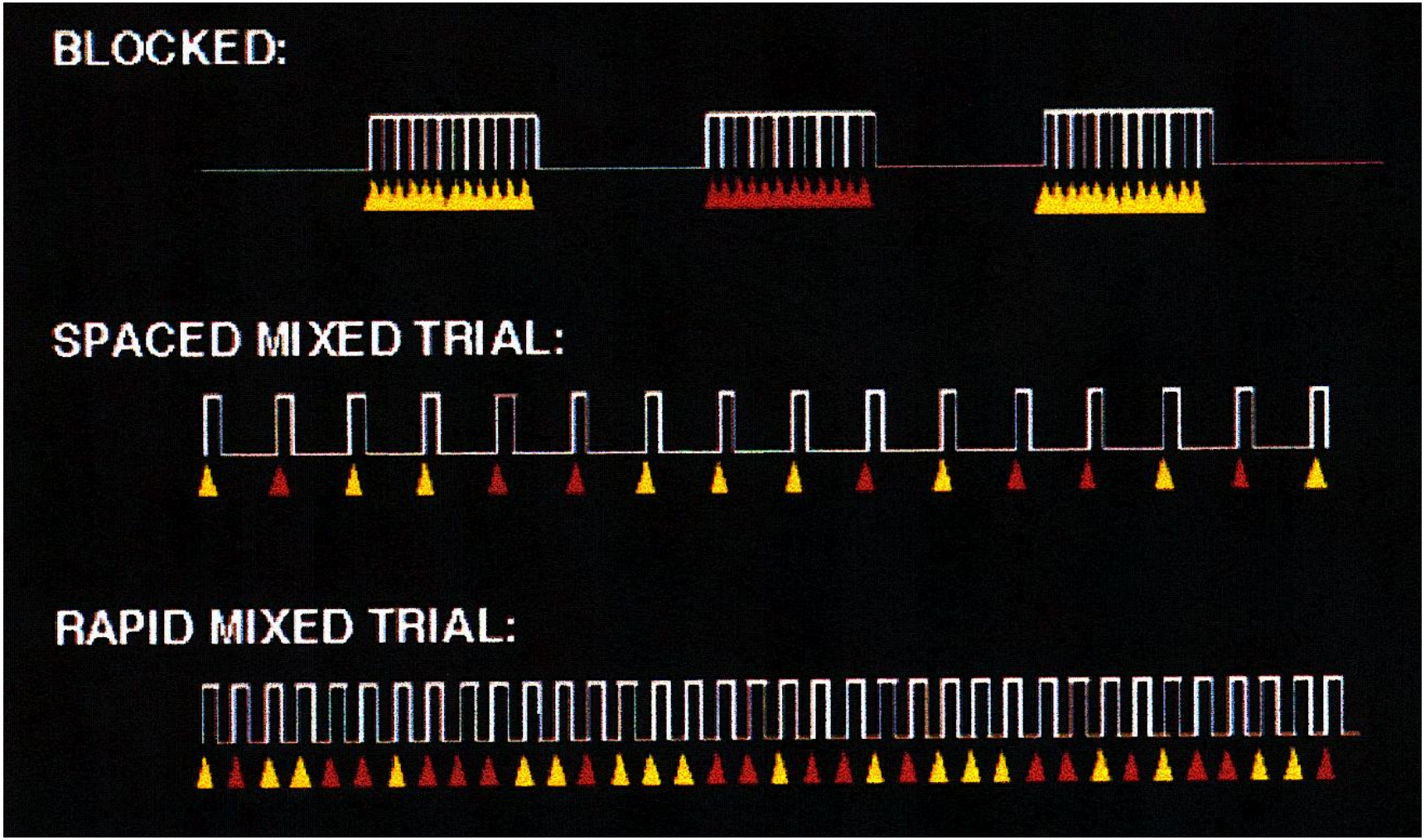
Hemodynamic lag

a: short stimulus
b. rise, 6-9 sec
c. return to baseline, 8-20sec
d. undershoot



Hemodynamic response to a stimulus

Experimental designs for hemodynamic techniques



Buckner, 1998, *HBM*