Cognitive Neuroscience for AI Developers (CNAID)

SS 2023

Week 6, Imaging Techniques (MRI, fMRI, PET, online lecture of Prof. Maier)

Exercise sheet by Achim Schilling

Multiple Choice Exercise

(Please mark the right answer with a cross. Only one answer is correct!)

Q1: Which statement on imaging techniques is correct?

- fMRI has a temporal resolution of approximately 100 Hz
- EEG has a better spatial resolution than fMRI
- fMRI measures neural activity and is well suited to measure gamma-waves
- In fMRI studies the blood oxygenation level is measured in order to draw conclusions on the underlying neural activity
- PET was developed to measure small currents in the brain

Q2: Which statement on imaging techniques is **not** correct?

- CT (computed tomography) and MRI are used to measure the structure of the brain and take advantage of the different physical properties of the brain tissue
- fMRI in contrast to standard MRI is used to draw conclusions on neural processing
- In CT, a 3D volume is reconstructed from 2D x-ray images
- MRI exploits the effect that hydrogen nuclei have a spin that creates a tiny magnetic dipole
- The magnetic field strength in MRI scanners is approximately 10 fT

Q3: Which statement on PET is **not** correct?

- PET like MRI relies on the spin of hydrogen nuclei
- For PET measurements a radioactive tracer is injected
- The tracer decays and emits positrons that annihilate with the electrons of the tissue to be measured
- The annihilation of an electron and a positron emits two photons that move in opposite directions
- PET can be used to draw conclusion on neural activity as it measures local variations in cerebral blood flow which are correlated to mental activity

Q4: Which statement on fMRI is correct?

- BOLD stands for blood overcompensation duration
- fMRI exploits the magnetic properties of acetylcholine
- fMRI has a very high temporal resolution comparable to MEG
- in fMRI the fraction of oxygenated and deoxygenated hemoglobin is measured called the blood oxygen level-dependent (BOLD) effect
- fMRI measurements are highly suited for auditory neuroscience as it simple to present auditory stimuli in an MRI scanner

Discussion Exercise

1) Why we need several imaging techniques

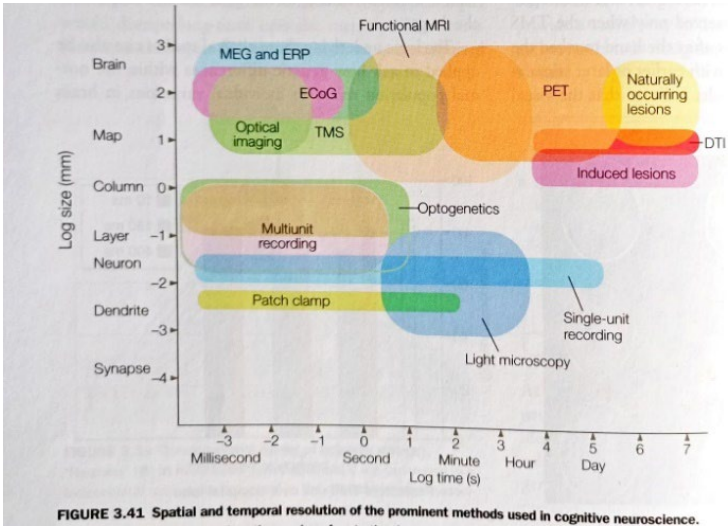


FIGURE 3.41 Spatial and temporal resolution of the prominent methods used in cognitive neuroscience.

from Gazzaniga, Ivry, Mangun, Cognitive Neuroscience, The biology of the mind, 2014

Think about and reason why we need so many different imaging techniques with the help of the following illustration.

2) Diffusion Tensor Imaging

"[…] diffusion tensor imaging (DTI) is performed with an MRI scanner that measures the density and motion of water contained in the axons." (Gazzaniga et al., 2014)

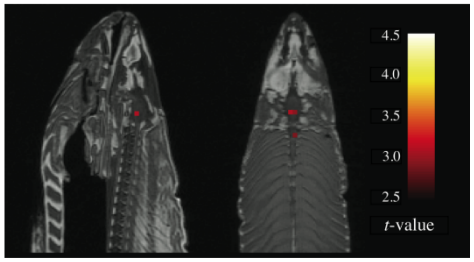
Gazzaniga, Ivry, Mangun, Cognitive Neuroscience, The biology of the mind, 2014

For which purposes DTI can be used in neuroscience and Neurology?

3) The dead salmon and statistics

"Subject. One mature Atlantic Salmon (Salmo salar) participated in the fMRI study. The salmon was approximately 18 inches long, weighed 3.8 lbs, and was not alive at the time of scanning.

Task. The task administered to the salmon involved completing an open-ended mentalizing task. The salmon was shown a series of photographs depicting human individuals in social situations with a specified emotional valence. The salmon was asked to determine what emotion the individual in the photo must have been experiencing.



A *t*-contrast was used to test for regions with significant BOLD signal change during the photo condition compared to rest. The parameters for this comparison were $t(131) > 3.15$, p(uncorrected) < 0.001, 3 voxel extent threshold.

from (Bennett et al., 2009)

Design. Stimuli were presented in a block design with each photo presented for 10 seconds followed by 12 seconds of rest. A total of 15 photos were displayed. Total scan time was 5.5 minutes." (Bennett et al., 2009)

Bennett, C. M., Miller, M. B., & Wolford, G. L. (2009). Neural correlates of interspecies perspective taking in the post-mortem Atlantic Salmon: An argument for multiple comparisons correction. *Neuroimage*, *47*(Suppl 1), S125.

This a is a part of the Methods section of a scientific poster published in 2009.

1) Is this at a first glance funny experiment useful and if yes why?
2) Compare the idea behind this study also with the idea behind the publication. "Could a neuroscientist understand a microprocessor" from Jonas and Kording.

Jonas, E., & Kording, K. P. (2017). Could a neuroscientist understand a microprocessor?. *PLoS computational biology*, *13*(1), e1005268.