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HST.583 Functional Magnetic Resonance Imaging: Data Acquisition and Analysis
Fall 2008

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Midterm Exam
HST.583
November 5, 2008

Instructions:

There are 7 problems, points for each problem are indicated. Please immediately confirm you have all 5 pages! This is a closed book/ closed notes exam. You have one hour.

Read the whole exam first. **Write legibly.** Describe what you are thinking. Even if the final answer is wrong, you will be given credit for your reasoning and approach to the problem. Be efficient, assess what you can answer right away; divide your time so that you can cover all the problems, allocating less time to the easiest parts. Don't spend too much time on a single question. **Try not to leave questions blank; we cannot give partial credit without something written down.**

Problem 1 (25 points):

Spatial attention has been hypothesized to be an emergent function of a "Tri-nodal Cortical Network".

a) Name each of the three cortical regions that comprise the "Tri-nodal Cortical Network" for spatial attention (5 points)

b) Design your own or describe a published experimental paradigm to probe the attention network. Your answer must include a clearly stated hypothesis (5 points), a briefly, but accurately described paradigm (5 points), and predicted or reported outcome (5 points).

c) Choose an appropriate acquisition sequence for collecting this scan noting type of sequence, and relevant parameters (5 points)

Problem 2 (15 Points):

Standard functional imaging at the Martinos Center uses an echo planar (EPI) imaging paradigm (30 slices, 4 mm slice thickness, TE = 30 ms, TR = 2000 ms, matrix size = 64x64).

- a) What is the phenomenon that causes EPI distortions called? (5 points)

- b) What regions of the brain are most susceptible to these distortions. Explain. (5 points)

- c) What relaxation parameter allows the generation of contrast through the BOLD effect? (5 points)

Problem 3 (20 points):

After a short fMRI scan during which your subject performed a carbon dioxide inhalation task (block design paradigm in which she alternates between breathing room air and breathing room air enriched with 10% carbon dioxide), she takes a coffee break. The caffeine in her coffee is a known vasoconstrictor (i.e. decreases the radius of arterioles).

- a) Will caffeine cause a global increase or decrease in baseline cerebral blood flow (CBF)? Explain. (5 points)

- b) Carbon dioxide inhalation is thought to (increase/ decrease/ not affect) oxygen metabolism (CMRO₂). Explain. (5 points)

Happily caffeinated, she returns to the magnet and you resume scanning using the exact same carbon dioxide inhalation task. Assume that the absolute change in CBF during carbon dioxide inhalation is the same as in the original scan (i.e. before coffee).

c) Do you expect the BOLD percentage change during carbon dioxide inhalation to (increase/ decrease/ stay the same), compared to the original scan (i.e. before coffee)? (10 points)

To help you answer this problem, consider the BOLD/flow relationship derived by Hoge and Davis; feel free to plot this curve if it helps you answer the problem.

Problem 4 (10 points):

The post stimulus undershoot (PSU) is a consistent feature of the BOLD hemodynamic response. Provide a possible explanation for the PSU that considers dynamic changes in physiology during activation. Feel free to use hand drawn diagrams and/or graphs.

Problem 5 (5 points):

What are two different types of experimental manipulation used in fMRI tasks for relating specific mental processes to specific brain regions? For each, give an example from something presented in class or a published study.

1)

2)

Problem 6 (15 points):

It is well known that fMRI data is very noisy. Considerable effort is being made on multiple fronts to improve activation detection sensitivity (improve signal to noise). For each of the domains listed describe one way to improve sensitivity to fMRI signal changes and explain why it would work.

a) Image acquisition

b) experimental design

c) image analysis (post-processing)

Problem 7 (10 points):

Diffusion Weighted Imaging is used to investigate white matter integrity and pathology associated with normal aging and neurological disorders such as multiple sclerosis that are known to disrupt axonal function and/or myelination.

- a) What would you expect to observe about FA values in areas of disruption along a white matter tract, such as the cortico-spinal tract? Explain. (5 points)
- b) What would you expect to observe about FA values in areas of disruption along a white matter tract at the site of crossing with an unaffected tract? Explain. (5 points)

Reference for your further edification:

Ciccarelli O, Werring DJ, Wheeler-Kingshott CA, Barker GJ, Parker GJ, Thompson AJ, Miller DH. Investigation of MS normal-appearing brain using diffusion tensor MRI with clinical correlations. *Neurology*. 2001 Apr 10;56(7):926-33.