

## FINAL EXAM

Date assigned: May 3, 2019

Date due: May 10, 2019

Each problem: 5 points

Total exam: 15% of course grade

### Problem 1: Steady-state magnetization, SNR & Bandwidth

A) 1 point. What is the Ernst angle? (Describe what the term means.)

B) 1 point. You develop a sudden interest in functional activation in the basal ganglia, and a colleague mentions that  $T_1$  is different in the caudate nucleus than it is in most gray matter. A PubMed search on "high field  $T_1$ " turns up a paper describing a pulse sequence, DESPOT1-HIFI [Deoni, S. (2007), J. Mag Res Imaging 26:1106], which reports that  $T_1$  in the caudate and putamen -- the 2 subregions of the basal ganglia that you're most interested in -- is 1600ms. What flip angle will you use for an fMRI experiment with a gradient echo EPI pulse sequence that has a TR of 1.5 sec?

What flip angle would you have used for cortex ( $T_1=1100\text{ms}$ )?

C) 0.5 point. Why does the scanner automatically throw away the first 2 or 3 volumes?

D) 0.5 point. Why is the gray/white contrast in the first volume of an EPI series (the one the scanner threw out ...) often better than in subsequent volumes (at steady-state)?

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E) 1 point. You are comparing the SNR between high-resolution and low-resolution acquisitions. If the sampling bandwidth, matrix size and slice thickness are not different, but the field of view was decreased for the high-res acquisition to increase the resolution (decrease the voxel size) by a factor of 2 in *both* the phase-encode and read-out directions, what is the thermal signal-to-noise ratio (SNR) in the new (small) voxels if the SNR in the big voxels was 100. (Hint: you can assume, since the matrix size and bandwidth are unchanged, that the thermal noise is the same in both acquisitions. So the denominator is the same, and the SNR will be determined by the signal strength in each voxel ... which you can assume is proportional to volume.)

F) 1 point. If you increase the bandwidth ...

... is image acquisition faster or slower (ignoring the weird, non-monotonic behavior of the scanner in the real world)?

... does the image have more or less distortion?

... on an EPI acquisition, will the pitch (frequency) of the noise that the scanner makes increase or decrease?

... will SNR get better or worse?

### Problem 2: Distortion & Drop-out

A) 2 points. You run an fMRI experiment and acquire a fieldmap at the end of the hour-long scanning session. The subject has, however, moved her head since the beginning of the session - her chin has rotated down a bit. Will the fieldmap be useful for predicting/correcting distortions in all of the EPI images acquired since the beginning of the scan? Explain/justify your answer.

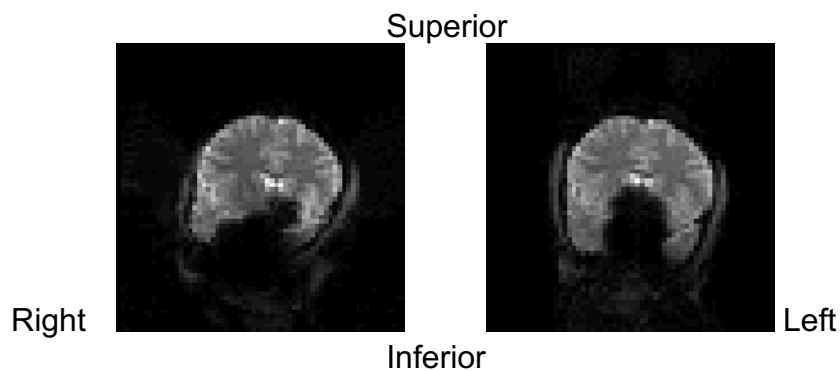
B) 0.75 points. To include fieldmap-based distortion compensation in your data analysis stream (usually considered a pre-processing step), what 3 pieces of information do you

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need, in addition to your EPI images and your fieldmap? Describe briefly what each is used for. (Hint: you can jog your memory by looking at commands you used to do FUGUE, or the slides in Lecture 11.)

C) 0.25 points. If you want to use TOPUP to do distortion compensation, instead of doing fieldmap-based distortion compensation, what kind of image acquisition do you need to include in your scanning session?

D) 0.5 points. Label the phase encode direction on each image.



E) 1.5 points. List 3 strategies for avoiding signal loss due to intra-voxel (usually through-slice) dephasing. Describe a strength and limitation for each approach.

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### Problem 3: Experiment design

A) 1 point. You are investigating a hypothesis about how the brain incorporates spatial information in a decision-making process -- for this you need to cover the *entire* brain (excluding cerebellum, but not missing bits of temporal or parietal cortex) with 1.5 s temporal resolution. With current technology and techniques, what kind of voxel size can you expect? Limit yourself to isotropic sampling and explain how you're going to get it (i.e., if you pick a voxel size smaller than 4 mm, explain how acceleration is contributing to your success).

B) 1.5 points. A colleague of yours is interested in the visual representation of information in inferior temporal cortex. She needs both good spatial accuracy (low distortion) and uniform sensitivity throughout inferior temporal cortex. She is, however, working with a subject population that will not tolerate tricks like filling the auditory canals with saline solution (imagine that ...), and she wants high contrast-to-noise ratio (so she doesn't want to use a spin echo pulse sequence at 3T).

What will you recommend she try in order to minimize or compensate for distortion?

What slice orientation will you recommend she use? Justify your answer (there's no right answer).

What will you recommend she do to minimize trouble with signal loss due to through-slice dephasing?

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C) 2.5 points. Practical application to your data. Your group will run an experiment on April 26 or May 3. During that scanning session, be sure to include an extra scan (either a field map or a phase encode direction-reversed EPI) so you can do distortion compensation. Then, following the templates from HW8 and HW9 ... compute an SNR map and do some distortion compensation. Either paste those images into this document, with an explanation of how they were generated ... or write out the explanation and tell me where I can find the data in /pkg/classes/psy5065/Data/your\_x.500

SNR (1 point). Image and explanation

Distortion compensation (1.5 points). Image and explanation

**Extra credit** (1 point)

Under what circumstances might you be motivated to use parallel imaging? What hardware is required for parallel imaging?