Homework #2

Due: 8/19/02

1. In fMRI, we often we wish to acquire a small number of slices with higher temporal resolution in order to examine some fine details in the hemodynamic response. Alternatively, we may wish to acquire more slices with a longer TR in order to acquire the whole brain. For this problem, please assume that the in all cases the voxel volume will remain the same as we change TR (V is constant). [You will also need this formula $\alpha_{Ernst} = \arccos\left(e^{-TR/T1}\right)$.]
   a. As we go to shorter TR's, we have less T1 recovery. Assuming at the T1 of the tissue of interest is 1200 ms. Determine the signal strength for TR = 500, 1000, 2000 and 10,000 ms with a 90 degree flip angle. (Let TE =0.)
   b. When using a short TR, it is advantageous to use less than a 90 degree flip angle in order to save magnetization for subsequent RF pulses. Determine the optimal flip angle, α_{Ernst}, and the magnitude of the signal for TR = 500, 1000, 2000 and 10,000 ms. (Let TE=0.)
   c. Suppose each image entails $T_{A/D}$ = 30 ms of acquisition time and that the total duration of the fMRI study is 100 seconds. Determine the total $T_{A/D}$ for TR = 500, 1000, 2000 and 10,000 ms.
   d. Determine the SNR for a 90 degree flip angle. Which TR is best?
   e. Determine the SNR for the α_{Ernst} flip angle. Which TR is best?

2. Suppose an activation study results in a 10% increase in CMRO2.
   a. Use Fick's principle to determine the level of oxygenation in the venous system (Y_a) for flow rate (f) changes of 0, 10, 20, and 40% and Y_b=0.5.
   b. Using Grubb's relationship, $\frac{V_a}{V_b} = \left(\frac{f_a}{f_b}\right)^{0.38}$, determine the volume changes for the above flow rate changes. Let V_b = 0.05.
   c. Determine the change in R2' (ΔR2') for the above flow rate changes. Let
      Hct = 0.4
      B_0 = 1.5 T
      κ (constant) = 0.5
      γ = 2.675x10^5 T^{-1}ms^{-1}
   d. Determine the percentage signal changes for the above flow rate changes. Let
      TE = 40 ms.

3. Suppose you wanted to carry out a study of olfaction. The primary olfactory cortex is in the inferior part of the prefrontal cortex above several large air spaces. Please describe three or four artifacts and sources of variation would be of most concern to you and why (I know you may have limited experience, that is why "why" is important in your response).

4. You wish to study primary motor activation any you think 5 min. of scanning will be enough. Please describe what is wrong with the following experimental designs and how you might improve them.
   a. You have your subject perform a complex finger movement task continuously for 5 min. and you collect T2*-weighted images.
   b. You have your subject perform a complex finger movement task for 2.5 min and rest for 2.5 min.
   c. You have your subject perform a protocol alternating between 20 seconds of a complex finger movement task and 20 seconds of thinking about strenuous exercise (you may use you imagination for this part).
   d. You have your subject wag their index finger in an accusing manner once every 5 seconds.
   e. You have your subject wag their index finger in an accusing manner once every 60 seconds.
   f. You decide that jittering is the way to go so you have your subject wag their index finger whenever the spirit moves them.
   g. You construct a parametric design in which you subject first moves no fingers, 1 finger, then 2, then 3, and so on.
   h. Briefly describe a good blocked design to look at primary hand movement cortex. Why did make the choices you made?
   i. Briefly describe a good event-related design to look at primary hand movement cortex. Why did make the choices you made?