Week 5 Exercises

This week we will discuss some concepts related to the idea of fMRI data as sets of numbers that can be manipulated computationally. We will also introduce the concept of "statistical maps" (or "overlays"). We will be working with statistical maps throughout the course, so we are introducing them early in the laboratories.

We will talk about automated ways of loading data, processing, and viewing data using the **BIAC XML header** format ("*.bxh"). You will use the same basic viewing tool, Showsrs2, but with a new way of loading the data.

Exercise 1: Understanding overlays

In this next exercise, you will work with data collected in a biological motion paradigm. Subjects watched three types of motion (of cartoon figures): mouth, eye, and hand. The data are stored in the directory \\Huxley\data\Class.01\Examples\BIOMOT . The AVI files in this directory show the stimuli that were used. Each of the ####_overlay files indicates the value of a statistical test (*t*) at each voxel.

If you have not already done so, you will need to **create a directory** for your group under Class.01\Students. You will not need to copy any files to your new directory in this lesson; you will just use it for storing the headers that you create. Then **change to that directory** in MATLAB.

1.1 Create BXH files for each image type

You will need to create four BXH files. Each should point to the data in the examples directory. To create the BXH file, you will need to:

- Change to your group's directory in MATLAB (cd command)
- Use command **bxhabsorb** . Once you type bxabsorb, a graphic user interface will pop up. You then select the file you want; remember that you may need to change file type in the dialog to make it visible. You will need to put in the parameters for the data you want to load.
- The four BXH files you should create in your directory are:
  1) base.bxh : for the "base.img" file.
  2) mouth.bxh : for the mouth_overlay.img file
  3) eye.bxh : for the eye_overlay.img file
  4) hand.bxh : for the hand_overlay.img file

All have parameters: Voxel dimensions: 90 * 108 * 78, Voxel size: 1.5mm * 1.5mm * 1.5mm, Data type: float, Orientation: Axial (S=>I).

After you have created these files, load in the data to MATLAB. You should end up with four variables (base, mouth, eye, and hand). Note that you can load the data, once a BXH file has been created, either by using the readmr interface or by just typing the following (if 'base.bxh' was in your current directory).

base = readmr('base.bxh'); % repeat for the other files

1.2 Display the data using Showsrs2

To display the data, you can just type:

showsrs2(base, mouth, eye, hand)

You should change to the "3 Orthogonal Planes" view under the Orientation menu.

Q1. Describe the data. What do you see as you move around the brain?

Q2. What do you think that the different values in the bottom right window represent? Are they generally similar or different across the three conditions?

1.3 Understanding overlays

These color maps are often called "overlays" because they are laid on top of the original anatomical data. **The single most important thing to understand about such overlays is that they represent statistical tests of whether the data are consistent/inconsistent with an experimental hypothesis. They are not "snapshots" of brain activity.** To illustrate this point, look at the data in showsrs2, with all thresholds set to the default values (as loaded automatically).

Q3. How many discrete areas are active in the brain? Give a rough estimate of the number of large clusters that you see. Also, about what percentage of the brain is active?

Now, lower all of your thresholds for the different overlays to a **lower limit of 1.0**. To do so, you can 1) click on the W+L button and select the different overlays using the pull-down menu at upper right, or 2) click on the Config menu and select "adjust colormaps and clipping".

Q4. After adjusting the threshold downward, how did the brain activity change from the previous threshold?

Finally, raise all of the thresholds to a **lower limit of 6.5**.

Q5. After adjusting the threshold upward, how many areas are now active? What is different about the activity?

Note that the same brain overlays were used in every case. The only difference was in the statistical value that we called "significant".

1.4 Quantifying the effects of threshold

We can very quickly count how many voxels have significance values above different threshold levels in MATLAB. Suppose that you want to count how many voxels have a *t* value > 0.5, a *t* value > 1.0, a *t* value > 1.5, and so forth. You could define a set of such steps (0.5, 1.0, 1.5, …, 7.5, 8.0) using the command:

steps = [0.5: 0.5 : 8];

Then you could set up a place to store data:

a=zeros(length(steps),1);

Finally, you can quickly count how many voxels had significance values greater than each step. (You can plot the output using the **figure** and **plot** commands).

for i = 1:length(steps);a(i)=length(find(mouth.data>steps(i)));end

Q6. How does the number of active voxels change with significance value?

BONUS Exercise: You could also plot how many voxels are within small ranges (e.g., from 0 to 0.2, from 0.2 to 0.4, etc.) in order to map out the distribution of significance values across voxels.

1.5 Finding the maximum and minimum values

You should next find points in the brain with the maximum values for each overlay (note that there may be more than one point with a given value). Hint: adjust the thresholds in the configuration window so that you display one overlay at a time, and adjust the range for that overlay so that you only see the top of the range. The movement keys (A&D, W&S, and Q&E) may be useful. Write those values below:

Q7. What are the coordinates of the maximum significance values, estimated visually:
eye_overlay: maximum (X,Y,Z): ________________ *t* = _______________
hand_overlay: maximum (X,Y,Z): ________________ *t* = _______________
mouth_overlay: maximum (X,Y,Z): ________________ *t* = _______________

1.6 Using transparencies

Using the transparency function on the "W+L" screen, determine whether each of your maxima are found in gray matter or white matter. Put a G or W next to the points listed above.

1.7 Check your answer

You can also quickly find out the minimum and maximum values in each image:

mm = minmax(mouth.data)

To determine the X, Y, and Z coordinates of these values, use the following:

mm_min = find(mouth.data == mm(1))
mm_max = find(mouth.data == mm(2))
[x,y,z]= ind2sub(size(mouth.data), mm_min)
[x,y,z]= ind2sub(size(mouth.data), mm_max)

Q8. What are the coordinates of the minimum and maximum significance values, determined in MATLAB? What are the actual t values?

eye_overlay: min: ______________ *t* = _________max: ______________ *t* = _________
hand_overlay: min: ______________ *t* = _________max: ______________ *t* = _________
mouth_overlay: min: ______________ *t* = _________max: ______________ *t* = _________

Exercise 2: Working with Time Series of data

2.1. Creating BXH files for time series

A "time series" of data is a sequence of similar images showing changes in the brain over time. You are going to work with "averaged epochs", which indicate the changes in the brain time-locked to the occurrence of the different stimuli. These data consist of 12 time points, from 3 time points before (6s) through 8 time points after the stimulus (16 sec). The data are saved in the same directory as files in the form : Eye_0001.img.

You will need to create BXH files for each of the three time series. The only thing that you need to do differently is to select "use wildcard read"; if you then select one file in a series, it will associate that BXH file with all of them. The examples below will assume that you use the file convention: **eye_all.bxh** . When you are finished creating the BXH files, 1) load all three time series into MATLAB and 2) display them in showsrs2.

NOTE: WHEN SELECTING THE IMAGES FOR THE TIME SERIES, CLICK ON THE FIRST ONE IN THE SEQUENCE, THEN SELECT "USE WILDCARD READ". AFTER YOU'VE DONE THAT, YOU'LL SEE THAT IT TRIES TO LOAD 13 IMAGES. TO FIX, JUST PUT A 0 BEFORE THE "*.IMG"; E.G., "Eye_0*.img".

showsrs2(base, mouth_all, eye_all, hand_all)

2.2. Changing the colormap limits

You will need to change the values displayed on the colormap, as we will now be dealing with relative MR signal change instead of *t* values. Change the lower limit of each overlay to 2.0 and the upper limit to 3.5.

2.3. Looking at time series of data

Find the points that you identified as being active in all three conditions. What does the time course of activation look like at those points? You can view the data in the window at bottom right, and/or play the data using the controls at bottom left.

Q9. Write a short description of the time course of activity at the “most active voxels” in the space below.

2.4. Finding the peak response

Q10. At what point does the brain response peak? Is this similar for all of the conditions? Is it similar across all of the points? Write a short description of your findings in the space below.

2.5. Looking at the spatial pattern of activation

Q11. How does the spatial pattern of activation change across time points? At what time point is there the most activation? Write down your findings in the space below.

Summary:

Q12. Write a general summary of the data below. You looked at (real) data showing patterns and time courses of activity when the subjects were watching eye, hand, and mouth movements. What brain areas were activated by these stimuli? How did the activation pattern in those areas change over time? How similar were the activation patterns for the different conditions?

Questions:

Q1. Describe the data. What do you see as you move around the brain?

Q2. What do you think that the different values in the bottom right window represent? Are they generally similar or different across the three conditions?

Q3. How many discrete areas are active in the brain? Give a rough estimate of the number of large clusters that you see. Also, about what percentage of the brain is active?

Q4. After adjusting the threshold downward, how did the brain activity change from the previous threshold?

Q5. After adjusting the threshold upward, how many areas are now active? What is different about the activity?

Q6. How does the number of active voxels change with significance value?

Q7. What are the coordinates of the maximum significance values, estimated visually:
eye_overlay: maximum (X,Y,Z): __________________ *t* = ________________
hand_overlay: maximum (X,Y,Z): __________________ *t* = ________________
mouth_overlay: maximum (X,Y,Z): __________________ *t* = ________________

Q8. What are the coordinates of the minimum and maximum significance values, determined in MATLAB? What are the actual t values?

eye_overlay: min: _______________*t* = __________max: _______________ *t* = __________
hand_overlay: min: _______________*t* = __________max: ______________ *t* = __________
mouth_overlay: min: ______________*t* = __________max: ______________ *t* = __________

Q9. Write a short description of the time course of activity at the "most active voxels" in the space below.

Q10. At what point does the brain response peak? Is this similar for all of the conditions? Is it similar across all of the points? Write a short description of your findings in the space below.

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