Initial Version: March 28, 2003 by Greg Lee (grlee@umich.edu)
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How To Run A 2-coil ASL Experiment

In the Scan Room:

1.) Attach the neck coil around the subjects neck via the velcro strap (for subject comfort, do not tighten). It should rest just under the chin. Make sure that the side with the BNC jack is pointing toward the feet. This end will be connected to the RF pannel.
2.) When situating the subject in the scanner, do not pull the head coil down so far that the neck coil is inside of it. This may result in undesirable interactions between the coils leading to image distortions.
3.) After setting the landmark at the desired location, measure the distance along the axis of the bore in cm from the landmark location to the center of the neck coil. (This number will be entered as a CV later with possible adjustment for any shift in table position due to a Rx not centered at the landmark)
4.) Once the subject is in the bore, undo any loops or kinks in the 2-coil ASL cable before leaving the room.

In the Console Room:

1.) Make sure the power to the frequency source is turned plugged in and then make sure to turn ON the source. Set the power level to read between 0 and 3dB. (**DO NOT INCREASE IT FURTHER**. The amplifier will be maxed at this setting and may be damaged if the input power is increased further)
2.) Set the frequency source to the center frequency of the scanner (you can check this frequency under the manual prescan screen) minus the offset frequency chosen in opuser20 of the userCVs screen (default = 10000Hz). (e.g. center frequency of 128073000Hz-10000Hz offset=128063000Hz desired frequency)
3.) Make sure the power cord to the amplifier circuit is plugged in. There is no power button on the amplifier itself. It is always ON when plugged in. (Amplification is effectively attenuated except when the scanner sends a high signal to J12 to allow RF amplification)
4.) Make sure that the TTL input jack of the amplifier circuit is connected via a BNC cable to J12 on the RF cabinet of the scanner (located in the equipment room).
5.) Verify that the output of the amplifying circuit is attached to the control room side of the RF panel. Then attach the long ASL BNC cable (labelled as 2-coil ASL cable and stored in the scan room under the sink) from the same BNC port at the other side of the RF panel to the neck coil (stored in a cabinet in the scan room). **IMPORTANT**: One end of the 2-coil ASL cable is magnetic. This end should be connected to the RF panel in the scan room. Make sure that the nonmagnetic end is connected to the coil since this will go in the bore. Getting this backwards will result in image distortions.
6.) Use the pulse sequence **cast_double2** (forward spiral version) or **cast_double_r** (reverse spiral version) for scanning the patient.
Some important CVs specific to the CASL sequences:
t_tag = the duration to apply the RF label for during each TR

t_delay = an optional delay between the end of the RF label and the time image acquisition begins
opuser19 = tagging plane distance in cm
opuser20 = RF frequency source offset (in Hz)
opuser21 = toggle for crushing OFF or ON (0 or 1 respectively)
opuser22 = toggle the type of control case. (0 = alternate between RF off or on each TR. 1 = leave the RF on every TR but flip the gradient each TR so that the adiabatic condition is not satisfied half of the time)

Guidelines:

- For the forward spiral SE, a TE of 12ms is a pretty good value to use. (The absolute minmum is around 10.5ms)
- For reverse spiral GE, minte can be selected. (For a FOV of 20cm this ends up being 25.256ms)
- Make sure to lengthen the TE appropriately if you select the flow crushing option or the download will fail.
- **opuser1** will be the number of images acquired. This must be a multiple of 2 since we want control/tag pairs. Thus the number of averages for the perfusion images will equal opuser1/2
- **IMPORTANT:** If your Rx is not centered at 0.0 in the S/I direction, you will need to adjust opuser19 (tagging plane distance) accordingly. For example, if you measured a distance of 20cm from the landmark to the neck coil and the Rx is centered at S20 (mm) then you should set opuser19 to be 22 not 20. (Note: Unfortunately, in practice it usually seems that I need to reduce the expected opuser19 value by a couple of cm. It is probably best to just do a few short 50s scans at opuser19 values of maybe 22, 21, and 20cm in the example above to verify which gives the most signal)
- You may want to switch OFF the RF source and/or unplug the amplifer circuit during the acquisition of the anatomical images because despite our efforts a small amount of artifact due to the amplifier circuit can occur. (Make sure to plug it back in before scanning ASL stuff, though!)

CVs for the flow crushing:

- SE case: the crusher gradients are gzsp1 and gzsp2. The decay ramp of gzsp1 and the attack ramp of gzsp2 are separated by delta1. These crushers surround the 180 pulse so a_gzsp3 and a_gzsp4 should be set to the same value. (so δ is pw_gzsp1/2 and Δ is delta1)
- GE case: the crusher gradients are gzsp3 and gzsp4 with the attack ramps spaced by distance delta1. a_gzsp3 and a_gzsp4 should be set to opposite polarity. (so δ is pw_gzsp3/4 and Δ is delta1)

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Processing the data:

The data are acquired via spiral scanning just as in splx2 or splx3rf so Doug's gsp18 or gsp19b scripts can be used to do the reconstruction for the forward and reverse spiral cases respectively. The control and tag states are alternated every TR. Thus the control images will be 1,3,5,7…etc and the tag images will be 2,4,6,8….etc. Pairwise subtractions of the magnitude images (1-2,3-4,5-6, …etc) will give perfusion images. (Complex subtractions are not generally recommended)

Troubleshooting:

Why do my control/tag images look noisy before subtraction?
If the image you acquire looks very noisy before subtraction of control/tag pairs, this is most likely because J12 is not connected via BNC to the TTL input jack of the amplifier circuit. When disconnected the amplifier is always in the high state, so it will be amplifying noise of all frequencies by 40dB resulting in poor images. This noise is attenuated when this input is held to the low state by the scanner J12 output.
Other possible sources of distortion are connecting the wrong (magnetic) end of the 2-coil ASL cable to the neck coil or having the head coil pulled down over the neck coil.

I don't see anything in the subtractions!
Possible causes:

- RF source and RF amplifier not plugged in.
- RF source not switched on
- wrong frequency setting on the RF source
- wrong tagging plane distance entered (opuser19)
- J12 not properly connected
- Output of amplifier not connected to RF panel
- t_tag and/or t_delay is too short for the tag to arrive at the imaging plane (Transit time from the neck to the cortex is approximately 1.5s)
- The coil is really out of tune. (This can be checked via the network analyzer, but it is necessary to calibrate it properly. Please do not just change the tuning of the coil unless you ask first as it tends to work well as is for most subjects I've scanned.)

If none of the above resolves the issue it is time to start using the oscilloscope and possibly a network analyzer to verify that the desired signals are where they should be. Also test the integrity of the BNC connectors with a voltmeter. (flaky connections are especially likely on homemade BNC connectors) **DO NOT MODIFY ANY ASPECT OF THE HARDWARE!** Notify either Luis Hernandez or Greg Lee if you think there is a hardware problem.

Other questions:

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Please contact Greg Lee (grlee@umich.edu) or Luis Hernandez (hernan@umich.edu)