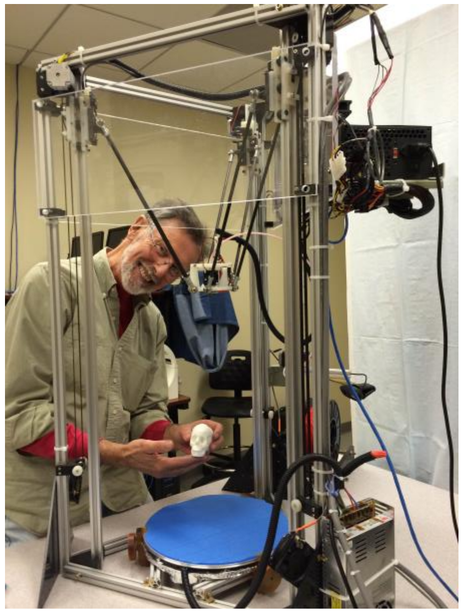
**2015 – BIC Highlights**

This year we got to play with puppies in the name of science! Greg Berns brought his (human) team from Emory to perform dog fMRI at BIC. The subjects were all service dogs in training at Canine Companions for Independence (CCI), based in Santa Rosa. Although these dogs are close to fully grown and around a year old by the time they are in serious training at CCI, they are still exceedingly boisterous. So, how do you scan a dog that treats everything like a game? More training! Greg's team had a mock scanner constructed at CCI, and the dogs received extracurricular training on a task to be used in an fMRI experiment, and on how to remain still inside the scanner when requested. How well did they perform? In many cases, better than humans. You can read all about the project in this blog post and see some of the training videos there, too.

The BIC was selected for a second time to conduct MRI scans on the Oakland cohort of participants enrolled in the nationwide CARDIA study. In 2010-11, we had scanned nearly 300 participants for Year 25 of the CARDIA study, which was the first time that MRI was included. Many of the participants scanned this year – CARDIA Year 30 - were repeats from last time, although some new participants were also enrolled. Physiological monitoring wasn't required for the study, but as in 2010-11 we took advantage of our BIOPAC setup to record respiratory and heart rate data. These traces allow assessment of compliance with the breath-holding task for cerebrovascular reactivity, and permit deeper consideration of physiological confounds in the resting-state fMRI data.

The big project behind the scenes this year was completion of a custom 3D printer. Rick and Miguel spent many months tinkering and adjusting this or that hardware or software component, assisted with expert advice from James Gao in the Gallant Lab, until they were finally (reasonably) happy with their device. Naturally, this being BIC, the iterations have continued, but the printer functions well enough to produce printed head cases for all the BIC staff. No mean feat!



Rick displays a miniature “Yorick,” printed from polylactic acid (PLA) using the new custom-designed, custom-built 3D printer in the foreground.

Daniel designed and built a hard real-time interface to control our MRI-compatible TMS unit. The TMS pulses are timed to occur during crusher gradient episodes in the EPI sequence, allowing repetitive TMS up to the slice repetition rate of approximately 18-20 Hz (depending on the spatial resolution of the EPI scans). Theta burst TMS with a pulse rate of 50 Hz is the goal, however, but this will require further modifications to the EPI pulse sequence as well as a more complete understanding of residual artifacts produced by the TMS system. There are “hangover” effects from TMS that may arise in the EPI scans via several mechanisms, including eddy currents in the magnet cryostat (or other metallic components close to the TMS coil), leakage current from the TMS control hardware, rebound movement of the TMS coil relative to the subject’s head, or some combination of all of them. A thorough characterization of the TMS system performance is next on the agenda.

Rick used his traditional shop skills rather than the new 3D printer to manufacture a prototype TMS coil holder for use in our custom birdcage RF coil. The integrated unit will provide the range of motion required for experimental setup, but then ensure the TMS coil remains static once the experiment has commenced.

Rick also revised the EyeLink eye tracker, adding a new light source and changing the configuration to permit improved line of sight for the camera as well as less visual obstruction for subjects viewing a screen. It was found that shadows from the upper section of the RF coil obscured visual images for users of our 32-channel head coil. Rick’s solution was to purchase an array of IR-LEDs and replace the product’s light source. The new array illuminates the target eye from both sides, eliminating shadows. Now we have optimal visual display as well as optimal eye tracking.

In May, the NorCal SNUG convened for its second meeting, this time at the Center for Imaging of Neurodegenerative Diseases (CIND) at the SF VAMC. Organized by Pratik Mukherjee, the emphasis was on 7 T and MRS issues. There was an excellent turnout, with attendees from the Martinez VA, UC Davis, UC Berkeley, UCSF and Siemens, including John Grinstead, the Siemens applications scientist based at OHSU in Portland, OR. Clearly, the momentum is building with the NorCal SNUG, and if we're not careful we will have to rename it the West Coast SNUG.

Assessing head motion effects in fMRI is difficult because so many factors can change at once. Furthermore, there is no "ground truth" against which to assess a post hoc correction. Daniel programmed a simulated motion pulse sequence, SimPACE, that allows the imaging gradients to be moved slightly, relative to the starting (prescribed) positions, once per TR while the subject remains stationary. It is based on a pulse sequence conceived and written by Erik Beall of the Cleveland Clinic, for use on a cadaver. At BIC, we intend to use the sequence with live humans held firmly in place with custom head cases printed on the new 3D printer. For the motion time series, Daniel solicited some real head motion data from a group at Stanford who had been using optical tracking inside their scanner. Driving the imaging gradients with these perturbations produces many, but not all, of the motion effects that real head motion imparts to an EPI time series, the most important of which is $T_1$ effects. The driving modulations can also be scaled to produce a target RMS motion amount that would match typical real fMRI data. The custom head restraint ensures that the baseline (real) head motion is reduced to a practical minimum. In early tests, we found that even low levels of simulated motion – levels that would be considered very low motion in a real fMRI experiment using foam padding as restraint – are many times larger than the remaining real motion, indicating that, as intended, the simulated motion dominates when using a printed head case. The next step is to acquire several data sets on the same subjects and begin to compare post hoc motion correction strategies, using the injected motion trace as the reference waveform.

Also on the pulse sequence front, this year we installed a new diffusion-weighted imaging sequence for scanning post mortem brains. The sequence, DW-SSFP, was provided by Karla Miller's group at Oxford. With their remote assistance to overcome some local technical limitations, the sequence was tested on several cetacean (whale) brain specimens provided by Terry Deacon's group in Anthropology. The goal is to conduct tractography on a range of cetacean species, and to do comparative anatomical studies against primate and other higher mammalian brains. But we can also scan post mortem human brains, if anyone is interested!

In October, JB and Ben participated in a Brain Imaging AMA (Ask Me Anything) session as part of the PLOS Science Wednesday series on Reddit. The topic, ostensibly, was "Orthogonalization of Regressors in fMRI Models," the title of an article that JB had published recently in PLOS ONE. There were definitely a few questions on this, but there were many other questions from imaging experts seeking acquisition advice, as well as from members of the public trying to separate truth from fiction on how brain imaging is portrayed in the mainstream media. Fun and interesting? Maybe. It was marginally less chaotic than the average Twitter discussion, let's put it that way. For an AMA it helps to be able to type very fast indeed.