2014 – BIC Highlights

For the second time since changing from December to January, we began the year with a review of many of the highlights of the past twelve months, at the 13th Annual BIC Research Day. In best BIC tradition, talks covered a wide range of methods and applications, from TMS and MRS to fMRI and PET. There was also a proposal from BIC's Matthew Brett and JB Poline to change the way we train new neuroimaging researchers in the future. And Fernando Perez, former BIC coding stalwart now a professor in the Statistics Department, returned to give us an overview of the new Berkeley Institute for Data Science. "Big data" is a hot topic, and fMRI certainly qualifies given that we can acquire 8 MB/sec with new simultaneous multi-slice (SMS) acquisitions.

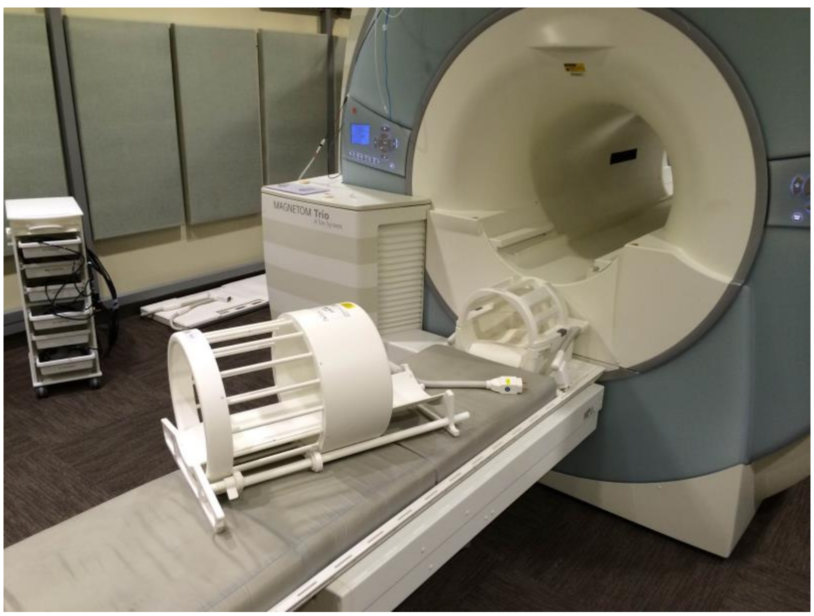
This year saw the creation of a northern California Siemens Neuro User Group, the NorCal SNUG. With so many research sites around the greater Bay Area using Siemens MRI scanners, almost all pursuing neuroimaging applications that are broadly similar, it makes sense to share tips and tricks, and to help each other with problems that might have been encountered and overcome locally. Little, if any, of the low level technical knowledge ever makes it into research papers, or for that matter into any public forum. The NorCal SNUG is an attempt to ensure that whatever one site learns is quickly disseminated across the region. Supported by a new e-mail list, the inaugural NorCal SNUG meeting was held at Berkeley in March. There were presentations by researchers from UCSF (NIC), the SF VA (CIND), UC Davis (IRC) and Siemens, and of course from Berkeley. Future meetings will rotate around the Bay Area so that each research site gets to present its local applications and issues.

On the maintenance front, 2014 exposed a few problems. The 3 T scanner's gradient set developed a cooling water leak and had to be replaced by Siemens. During the investigation into gradient wear and tear, Rick installed some temperature sensors on the gradient cables and filters, and this led to the discovery that at least one of the gradient cables had a changing resistance with use. So, Siemens replaced all three gradient cables for good measure.

The scanner's nominal 480 V supply continued to present concerns, with high voltages (near 500 V) observed occasionally. Rick has installed a recording monitor to log voltage and current, allowing us to investigate any scanner performance issues in case power instability is suspected to be the underlying cause. Voltage fluctuations produce instability for EPI since the gradient amplifiers see the power directly. Furthermore, excessively high voltages (>500 V) can cause errors in RF amplifier control, an instability that so far has affected the pseudo-continuous (PC)ASL sequence most often, since it has the most intricate RF pulse sequence we use. The plan is to purchase a power conditioner when the scanner is upgraded.

In April, Miguel and Rick installed a new EyeLink 1000 eye tracker. Since we have a rear projection system already installed whereas the EyeLink was designed for use with a front screen or goggles, it meant customization, of course. Rather than mount the camera at the bottom, rear of the magnet, as designed, Rick reversed its configuration to be top, front, completely out of the way of our projector screen. Over the summer, he then produced a frame to hold the camera off the magnet bore, to reduce vibration effects. There are a few remaining issues related to our RF coils, but eye tracking is already far more reliable than with the aging Avotec unit.

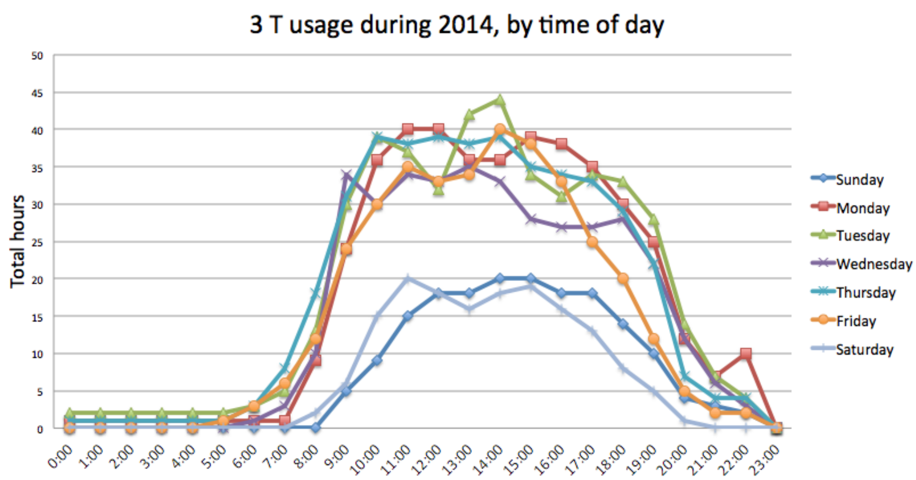
In December, we took delivery of a receive-only birdcage coil that was custom-built for us by Rapid Biomed. There are two main uses for this new coil. Firstly, it has an inner diameter that is 32 cm, 6 cm larger than the Siemens 12-channel coil. It is also open front and rear. The additional space is designed for use with a TMS coil and should allow placement of the TMS coil over any cortical region with a subject aligned as normal in the magnet. The second use for the new birdcage coil is exploratory. Daniel has been investigating the impact of lab-frame contrast, including receive field heterogeneity, on the ability to correct head motion *post hoc* in fMRI, *e.g.* with volume realignment. He has coined two terms for the interaction of head motion with the receive field: RFC-MoCo, and anchoring. The first effect, RFC-MoCo, means that even perfect motion correction (MoCo) leaves residual errors in the time series due to receive field contrast (RFC). This was the focus of a simulation study presented at a conference last year. Anchoring refers to the tendency of a volume realignment algorithm to under report (and under correct) actual head motion because of a conflict between brain-based and lab-based contrast. The cost function cannot distinguish between the two. The stronger the lab-based contrast, the worse the anchoring effect. A solution to both receive field contrast effects is to acquire with a homogeneous receive field, as provided by a birdcage coil. Use of a quadrature birdcage coil rather than a phased-array coil does mean that it is not possible to perform simultaneous multi-slice (SMS) imaging, however, but Daniel has conceived a new coil design for that. We will be working on this new coil design in the coming year.



The new receive-only birdcage coil (front) and Siemens 12-channel coil (rear).

At the request of two different users, Daniel modified our workhorse *ep2d_neuro* pulse sequence to allow proper sparse sampling. There are two approaches to sparse sampling. The default is to allow a quiet delay for each volume of EPI data, one for one. This is inefficient if stimuli are not required in every quiet period. Typically, given the 5-6 sec hemodynamic response, a stimulus during one quiet period is followed by two or more volumes of EPI. However, shutting off all RF and gradient episodes during the quiet period perturbs the T_1 steady state and causes changes in image intensity in the two or three blocks of EPI acquired thereafter, most likely leading to errors in fMRI analyses. The solution is to disable only the frequency- and phase-encoding gradients, leaving the slice select gradients and RF pulses running during the quiet periods. The T_1 steady state is maintained at the cost of a low clicking sound – the slice select gradients – during the quiet period. Which approach you use – one silent period per TR, or one reasonably quiet period per *n* TRs - is now under your control.

One of the benefits of the Calpendo online scheduler is an ability to produce reports that can inform management decisions. Here's the 3 T usage by time of day for 2014:



We see that there is a preference for people to scan late into the evening rather than starting early in the morning, most likely a preference that is created by subject availability. It means that if you are interested in relatively unfettered access to the scanner, early mornings are by far your best bet! Only Rick gets in routinely before 7 am! Scanner usage patterns also allow us to plan QA testing, schedule maintenance, *etc.* We don't always want to stay completely out of your way. We would like to assess hardware performance both when the scanner has been driven hard, as well as when it is convenient to run QA tests. So-called time-of-day effects are notorious in system failures; usage patterns can make a big difference to when and how failures will first show up. So, don't be surprised if you find one of us running QA on a Friday evening. There's a method to the madness.