**Shadmehr and Holcomb (1997, Science)**

Subjects adapted to velocity-dependent force fields while being PET(H2O15)-scanned.

* Comparison between baseline and random force field: bilateral sensorimotor cortex, R putamen.
* Comparison between early exposure to a fixed force field and a random (unlearnable) force field: increased rCBF in the pulvinar thalamus, medial occipital gyrus and DLPFC
* Recalled of the pre-learned force field after 5.5 hours: increased activation in the L posterior parietal cortex (BA7), L dorsal premotor cortex (BA6) and the R anterior CBM cortex. Note that the posterior part of the cerebellum was not covered in their scans.   
  As a control, exposure to a new force field (called field B) didn’t elicit increased activity in those areas.

These changes after the initial motor learning was interpreted as evidence for a re-organization of the representation of the motor skill shortly after initial learning.

**Clower et al. (1996, Nature)**

Nature of the adaptation: adaptation to prismatic shift of visual targets during reaching inside a PET scanner. Because the adaptation occurs rather quickly (saturates after 5 – 10 trials of exposure), blocks alternated between left and right shifts to keep the subject in a state of continuous adaptation.

The control condition was the performance of the same type of reaching, but with online target jumps randomized in direction (left or right) on a trial-by-trial basis. Because of the randomness of the visual target jumps, this condition was not “adaptable”. But it involves the same kind of error and attention, and performance conditions as the adaptation condition. Therefore the authors used it as a control.

PET results: Compared to the control condition, the adaptation condition showed a focal increase in activity in the left (contralateral) posterior parietal cortex. This region was on the lateral bank of the intraparietal cortex, and corresponded to the cytoarchitectonic area of “PET”.

The authors acknowledge that the lack of a cerebellar activation under this contrast was surprising. But they interpreted this as a suggestion that the CBM is primarily involved in error detection, whereas the remapping between visual and proprioceptive coordinates is performed in the PPC.

Critiques: 1) because of the adaptation that occurs in the fixed prism condition, it is possible that the amount of total error is not matched between the adaptation condition and the baseline condition. This can potentially mask activations in certain regions (e.g., the cerebellum).

2) One cannot rule out the possibility that adaptation also occurs in the control condition. Since the order of the left and right target jumps were randomized, once in a while there would be consecutive trials with the same direction of jump. This may also explain the paucity (only one region: PPC) of activation under the adaptation – conrol contrast.

Inspirations for the SAS study: 1) look carefully at those parietal activations.

**Danckert et al. (2008, EJN)**

Nature of the adaptation: short-term (10 trials / block) adaptation to prismatic shifting of visual targets during pointing.

Design: alternating blocks of (1) pointing with no prism, and (2) pointing with prism. Non-sparse sampling fMRI.

The statistical analysis of this paper appears to be rather liberal. Another shortcoming of the methodology: the behavioral performance of the subjects inside the scanner was not measured. The authors relied on the subjects’ subjective report to decide that the performance in the first three trials of a prism-on block is worse (less accurate) than that in the last three of the bock.

Main results: the left (contralateral) M1, anterior cingulate cortex and anterior intraparietal (AIP) cortex showed greater activation in the first three trials than in the last three trials in the prism-on blocks. In addition, a vermal region of the cerebellum also showed this pattern of activation decrease from the first three trial to the last three trial of the prism-on blocks. Another region of the cerebellum, the right (ipsilateral) culmen showed increases in activity during the pointing movement, however, the activity in this cerebellar region didn’t change from the first three trials to the last three trials in the prism-on blocks.

Inspiration to our project: 1) try comparing the early-Stay phase to the late-Stay phase to see which brain areas show decrease activation level from early to late.

**Anguera et al. (2007)**

**Inoue et al. (2000, NeuroImage)**

**Imamizu et al. (2000, Nature). Learning of visuomotor rotation and the recruitment of the internal model in the cerebellum.**

Nature of learning: 120-degree when moving a mouse to control a cursor on the screen. The cursor was used to track a moving visual target on the screen. Eleven training sessions were given (24 trials/session). Simultaneous fMRI was performed.

This paper only examined activations in the cerebellum.

There are widespread regions in the cerebellum that showed increased activation under the visuomotor rotation condition. However, these activations decreased with the progression of the training and were correlated positively with the error of visuomotor tracking. In the last training session, the spatial extent of the activation in the cerebellum was greatly reduced relative to the activation at the first training session

The region of the cerebellum in which the activation didn’t decrease significantly with practice (i.e., adaptation to the visuomotor rotation) was near the “posterior superior fissure” (where is it? To figure out). By using subtraction of the substantially decreasing pattern from the time course in this specific region, they showed an asymptotically increasing time course that fit their interpretation of the internal model (IM). They were also very careful in ruling out the possibility that the activation in the cerebellar regions thought to related to IM was activated simply because changes in the absolute amount of error from the baseline to the visuomotor rotation condition. They achieved this by using a faster visuomotor tracking condition that was associated with an amount of visuomotor error about equal (not significantly different from) that of the last training session.

One major problem of this paper is that, you can tell from the d.o.f. of their t-tests that they used a fixed-effect analysis in their fMRI data analysis, despite the fact that they corrected for multiple comparisons using GRF.

The second problem is that the matching of absolute error of tracking may not be a perfect match (or control). Because presumably, the kinds of errors are different between the training condition and this matched control condition. The errors should be predominantly directional in the former; whereas in the latter, there should be predominantly extent (linear) errors.

Inspirations for the SAS study: again: compare the early Stay phase with the late Stay phase, preferably across “good adapters” and “bad adapters”