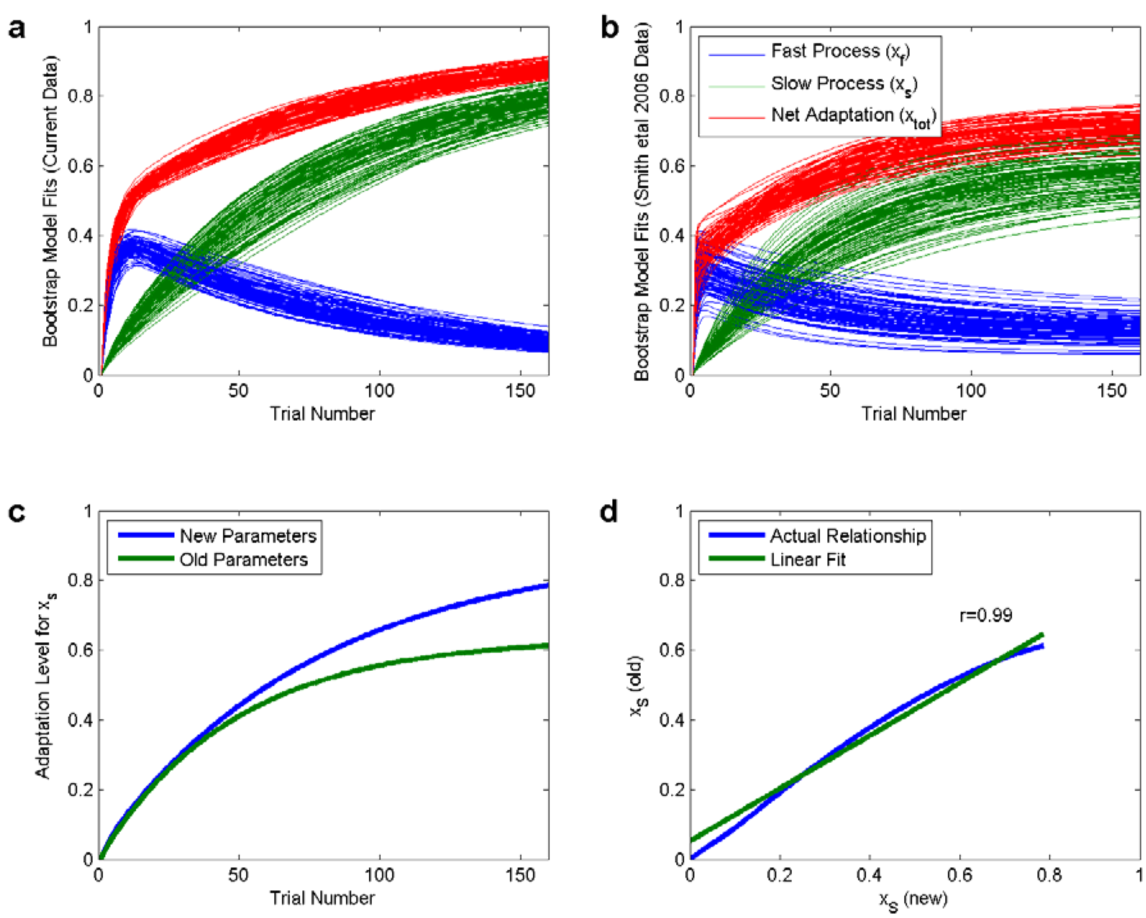
Supplementary Materials:

(1) The effect of using parameter estimates for the multi-rate model based on the current data set versus the Smith et al 2006 data set:

In this paper we showed that the level of the 24-hour retention associated with a single training session for a motor adaptation was well-predicted by the level achieved by a specific component in a multi-rate model of motor adaptation – the so-called slow learning process. This model is parameterized by two learning rates and two retention factors which were fit to the learning curves during the initial adaptation period shown in figure 2c. However, the parameters derived from this fit do differ from the parameters that were fit to the data from Smith el. al 2006 (full citation appears in the main paper) - the paper in which this model was proposed. Figure S1 shows a comparison of model simulations of a single training session that were run with parameter sets bootstrapped from the two data sets mentioned above. Note that both sets of simulations display similar qualitative behavior – a rapid initial rise in the overall learning followed by a slower more prolonged improvement. The fast process accounts for the initial rapid phase of the overall learning and the slow process accounts for the slower secondary improvement. However, these parameter sets differ in the level of learning achieved. The parameter set based on the current data produces about a 15% increase in adaptation compared to the previous parameter estimates. Of course, this stems from the fact that the adaptation data in the current paper appear to show about 15% greater adaptation levels during he force-field training block than the data from Smith et al 2006. Interestingly, however, although the slow process levels display different magnitudes, they possess remarkably similar shapes - i.e. each one is very close to a scaled version of the other (r=0.99). This is shown in panels c & d of figure S1. The similarity between these shapes suggests that the strength of the relationship between our 24-hour retention data and the level of the slow process associated with

Figure S1

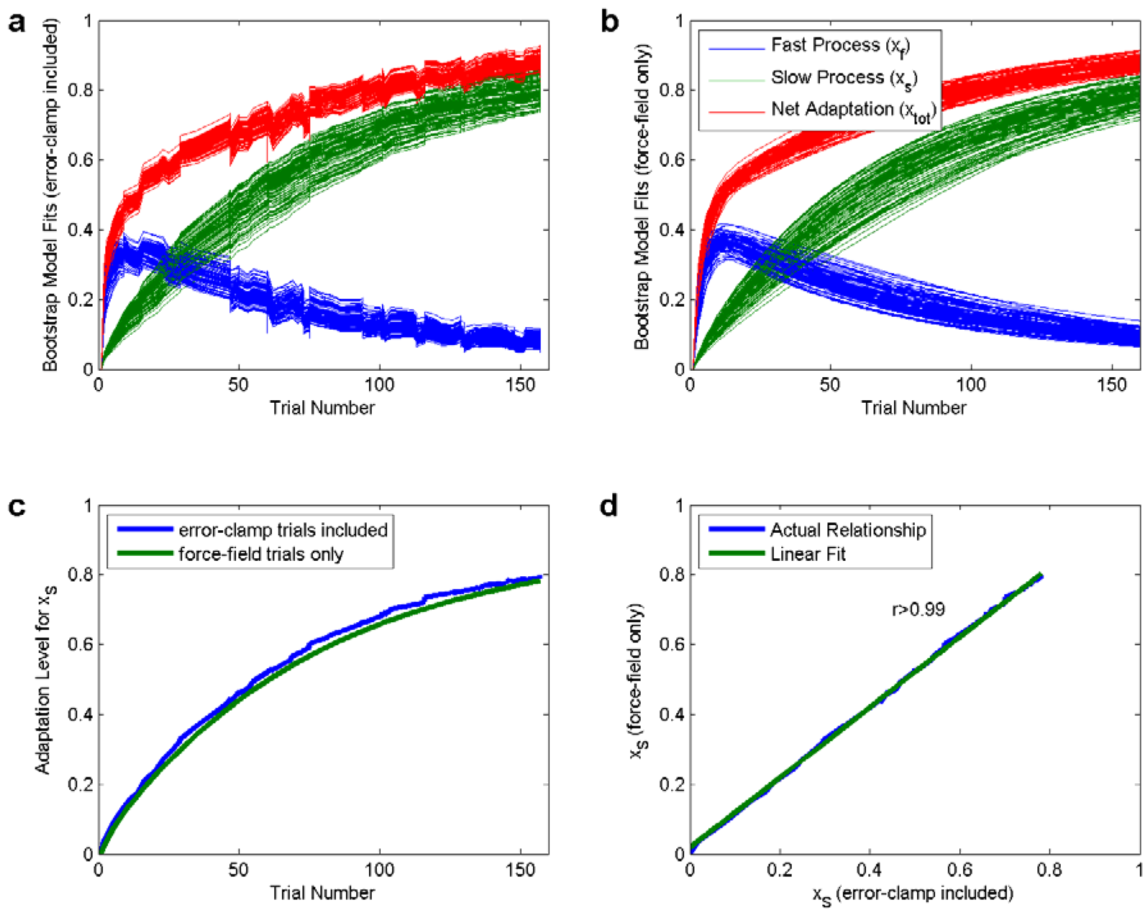


the new model parameters should be quite similar to that seen when the previous model parameters were used – the relationship could be *slightly* stronger or weaker, but only *slightly*. Correspondingly, we find that the correlation between the slow process level predicted from the model and our 24-hour retention data is quite similar for both sets of parameter estimates, and both parameters sets yield a strong linear relationship between these variables (r^2=0.991 (current parameters) versus r^2=0.985 (previous parameters)).

(2) The effect of including occasionally interspersed error-clamp trials when simulating adaptation during a training session using the multi-rate model.

For simplicity of presentation, the multi-rate model simulations shown in figure 3 included force-field training trials only, although during the actual training regimen error-clamp measurement trials were occasionally interspersed (20% of trials) between force-field training trials (80% of trials). We felt comfortable with this simplification because the error-clamp measurement trials are essentially benign since essentially no lateral errors are experienced that would drive adaptation. Note this is different from catch-trials which are often used as measurement trials, because large lateral errors are often experienced on catch-trials and substantial unlearning often occurs as a result. However, these error clamp trials do have a small effect on the model predictions related to the retention factors, and so we performed a comparison of the simulation results obtained with and without the interspersed error-clamp trials. Figure S2 follows the format of figure S1, but instead of comparing simulations with different parameter sets, only parameters derived from the current data are used and simulations with and without inclusion of the error clamp measurement trials are performed. The slow process levels are quite similar to one another (S2c) and the linear correlation between them is greater than 99% as shown in figure S2d.

Figure S2



(3) Interpretation of the error equation that couples to the multi-rate learning model:

The error equation (given in the Methods section) used with the multi-rate learning model is:

$$e(n) = f(n) - x(n)$$

Note that in the methods section the terms in this equation are described in very general terms (pun intended):

$e(n)$ - Error on trial n

$f(n)$ - Strength of force-field disturbance on trial n

$x(n)$ - State of learned motor output on trial n

It is important to note that (1) for the equation to hold the units for each of these terms must agree, and (2) there are several different reasonable interpretations for each of these terms. In particular, the each of these terms can be interpreted as being either kinematic, force-based, or field-field environment based. As a result, there are several reasonable ways to interpret the equation that would reconcile the units of the different terms. The three we think most relavant are shown below:

The 1st interpretation is that all of these quantities reflect forces:
ForceError = PertubingForce – LearnedForceOutput

The 2nd interpretation is that all of these quantities reflect kinematics (i.e. position):
KinematicError = KinematicEffectOfPertubingForce – KinematicEffectofLearnedForceOutput

The 3rd interpretation is that a constant stiffness (K) is implied and normalized out of the equation:
KinematicError = (1/K) * [PertubingForce – LearnedForceOutput]

If this equation (interpretation 3) is divided by (**PerturbingForceMagnitude/K**) it yields:
KinematicError / (PerturbingForceMagnitude/K) = NormalizedError = [1-NormalizedForceOutput]

Which of these interpretions is best/correct falls outside the scope of the current study, but it's worth pointing out some issues related to these interpretations. One key difference between these interpretations is whether kinematic error or force error (as defined here) drives adaptation. This is currently an open question. Note that the adaptation coefficients that we use to estimate $x(n)$ are force-based (and normalized by the size of the force-field). Thus interpretations 1 and 3 are most compatible with the learning metric we chose, however a nearly linear relationship between learned-force-output and the kinematic effect of learned-force-output is highly likely over the range of forces relavant to he task we studied. If so, interpretation 2 would also be compatible. Note that the normalization for the 3rd interpretation works as long as stiffness (K) is constant from one trial to the next. Of course, this may not exactly be the case and there is some evidence that stiffness is adaptively modified - although the details of this have not been worked out. The fact that the multi-rate model accounts for adaptation data pretty well without taking stiffness variations into account suggests that these variations have relatively minor effects on adaptation – at least over the course of the tasks in which the model has been applied.