Hand Localization and Adaptation
People can quickly adapt to visuomotor rotations, which affects estimates of hand position, consisting of proprioception and predicted sensory consequences. We test how quickly these components of hand estimates change by measuring them on a trial-by-trial basis. We fit a two-rate model (Smith et al., 2006) to the reach data to see if the changes in hand estimates match the slow process, which has been linked to implicit learning (McDougle et al., 2015).

Experimental Procedure
All participants alternated between active reaches to the same targets and a different task and all used the same set-up shown below.

Multi-Rate Model
For reaches, we use a standard multi-rate model, where the motor output on trial \( t_1 \) is the sum of the output of a slow and fast process:

\[
X_{t_1} = X_{s,t_1} + X_{f,t_1}
\]

which are each determined by two parameters, a learning rate \( L \) and retention rate \( R \):

\[
X_{s,t_1} = L_s \cdot e_{t_0} + R_s \cdot X_{s,t_0}
\]
\[
X_{f,t_1} = L_f \cdot e_{t_0} + R_f \cdot X_{f,t_0}
\]

Both Processes learn from the error on the previous trial \( (e_{t_0}) \) and retain part of their previous adaptation \( (X_{t_0}) \). Constraints: \( L_s < L_f \) and \( R_s > R_f \).

Reach Training

Reach Models

<table>
<thead>
<tr>
<th>condition</th>
<th>( R_s )</th>
<th>( L_s )</th>
<th>( R_f )</th>
<th>( L_f )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive localization</td>
<td>1.000</td>
<td>0.054</td>
<td>0.750</td>
<td>0.217</td>
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<tr>
<td>Active localization</td>
<td>0.999</td>
<td>0.031</td>
<td>0.768</td>
<td>0.137</td>
</tr>
<tr>
<td>No-cursor</td>
<td>0.991</td>
<td>0.037</td>
<td>0.773</td>
<td>0.127</td>
</tr>
<tr>
<td>Pause</td>
<td>1.000</td>
<td>0.055</td>
<td>0.836</td>
<td>0.225</td>
</tr>
</tbody>
</table>

► Implicit measures such as reach aftereffects and proprioceptive recalibration saturate quickly.
► None of these implicit measures match the fast or slow process.