New neural activity patterns emerge with long-term learning

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Flexible Learning Reading Group
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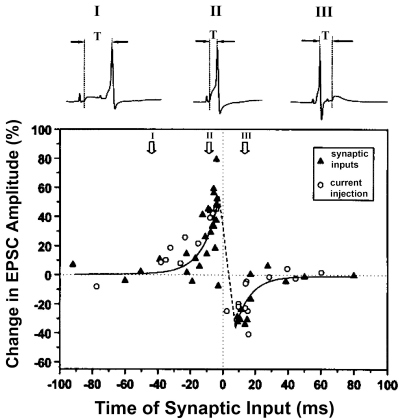
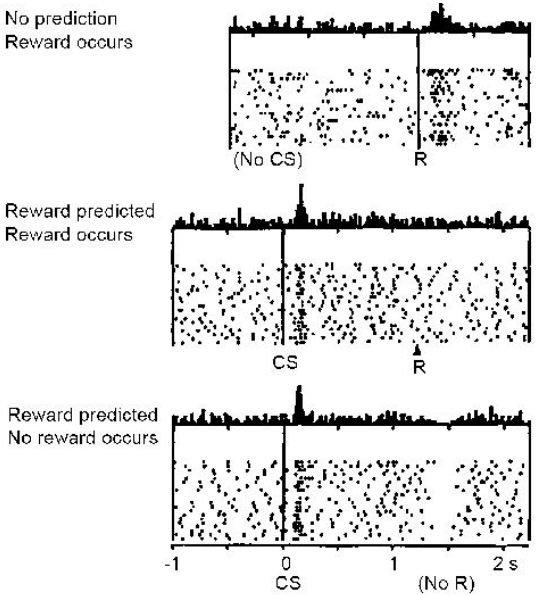
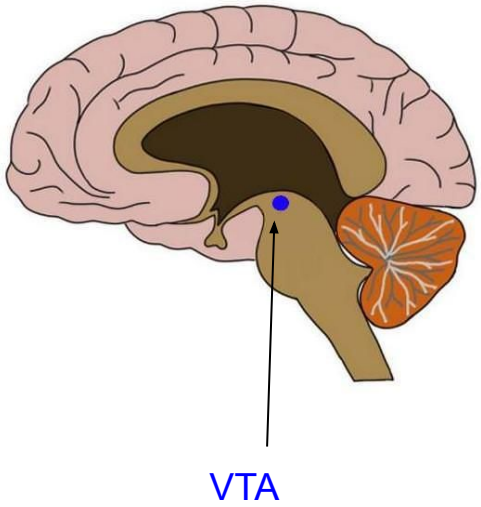
The neuroscience of learning



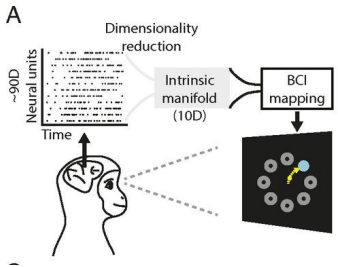
Dan & Poo ‘14



Schultz et al. ‘97



Brain-Computer Interface (BCI) directly links neural activity to behavior



Spikes u → Factors z → Velocities v

Dimensionality reduction with **Factor Analysis:**

Low-d factors: $z_t \sim N(0, I)$

Neural activity $u_t | z_t \sim N(\Lambda z_t, \psi)$

Intrinsic Manifold: span($\mathbf{\Lambda}$)

BCI mapping with **Kalman Filter**:

Hidden velocity:

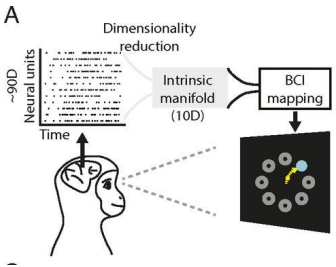
$$v_t | v_{t-1} \sim N(A v_{t-1}, Q)$$

$$\hat{v}_t = M_1 \hat{v}_{t-1} + M_2 u_t + m_0$$

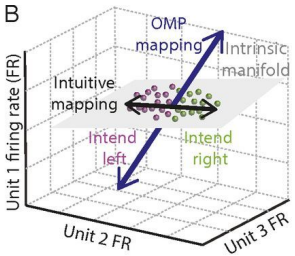
Inferred factors:

$$\hat{z}_t | v_t \sim N(C v_t + d, R)$$

Encourage learning by perturbing the BCI mapping



Spikes u → (OMP) → Factors z → (WMP) → Velocities v

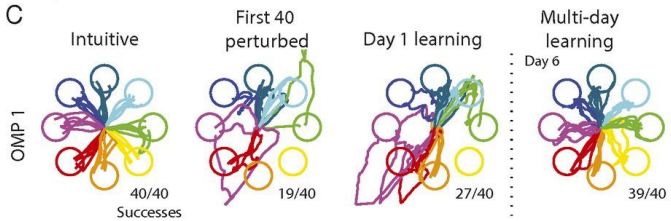


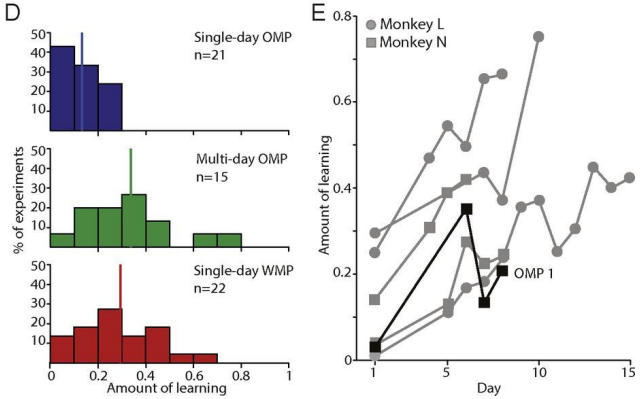
Outside Manifold Perturbation (OMP)

$$\hat{v}_t = M_1 \hat{v}_{t-1} + M_2 \eta_{OM} u_t + m_0$$

Within Manifold Perturbation (OMP)

Learning outside Manifold Perturbations (OMPs) requires multiple days

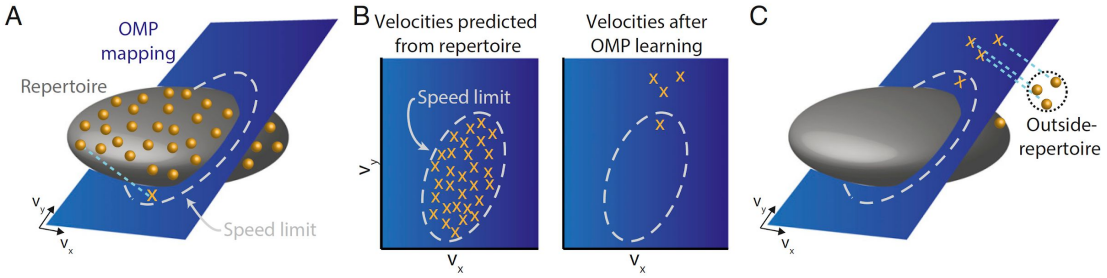




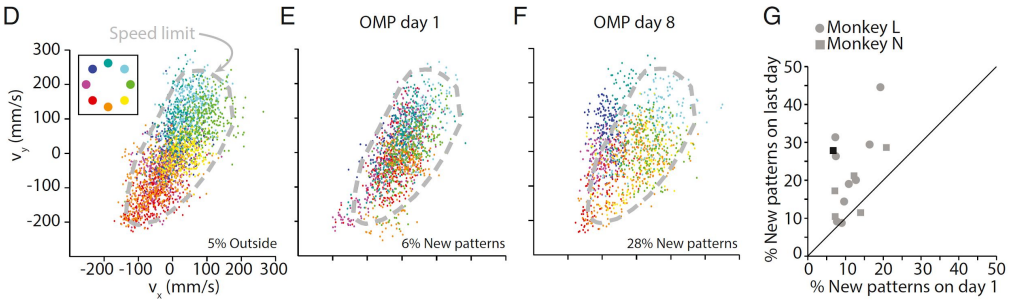
Video!

New activity patterns emerge with multi-day learning

Schematic

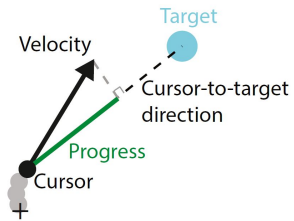


Data

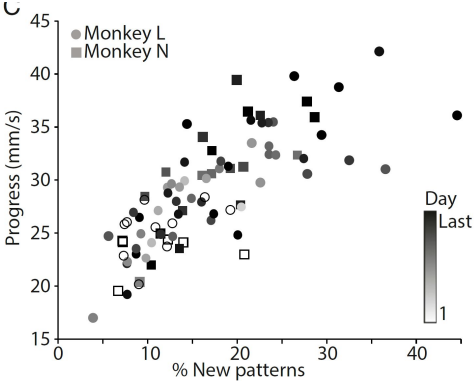


Controls to test if new patterns cause behavior

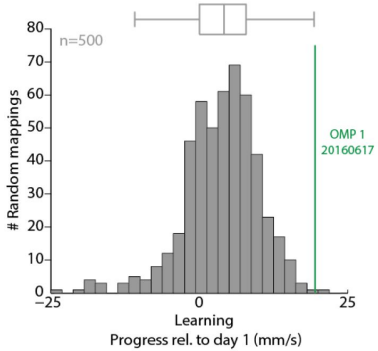
Progress: movement to target



New patterns correlated with improvement



New patterns specific to OMP



Learning partly happens by changes in the neural correlation structure