The Ottawa Hospital | L'Hôpital d'Ottawa

RESEARCH INSTITUTE | INSTITUT DE RECHERCHE

uOttawa | Institut de recherche sur le cerveau

Brain and Mind Research Institute

Workshop on Applied Deep Learning in Intracranial Neurophysiology

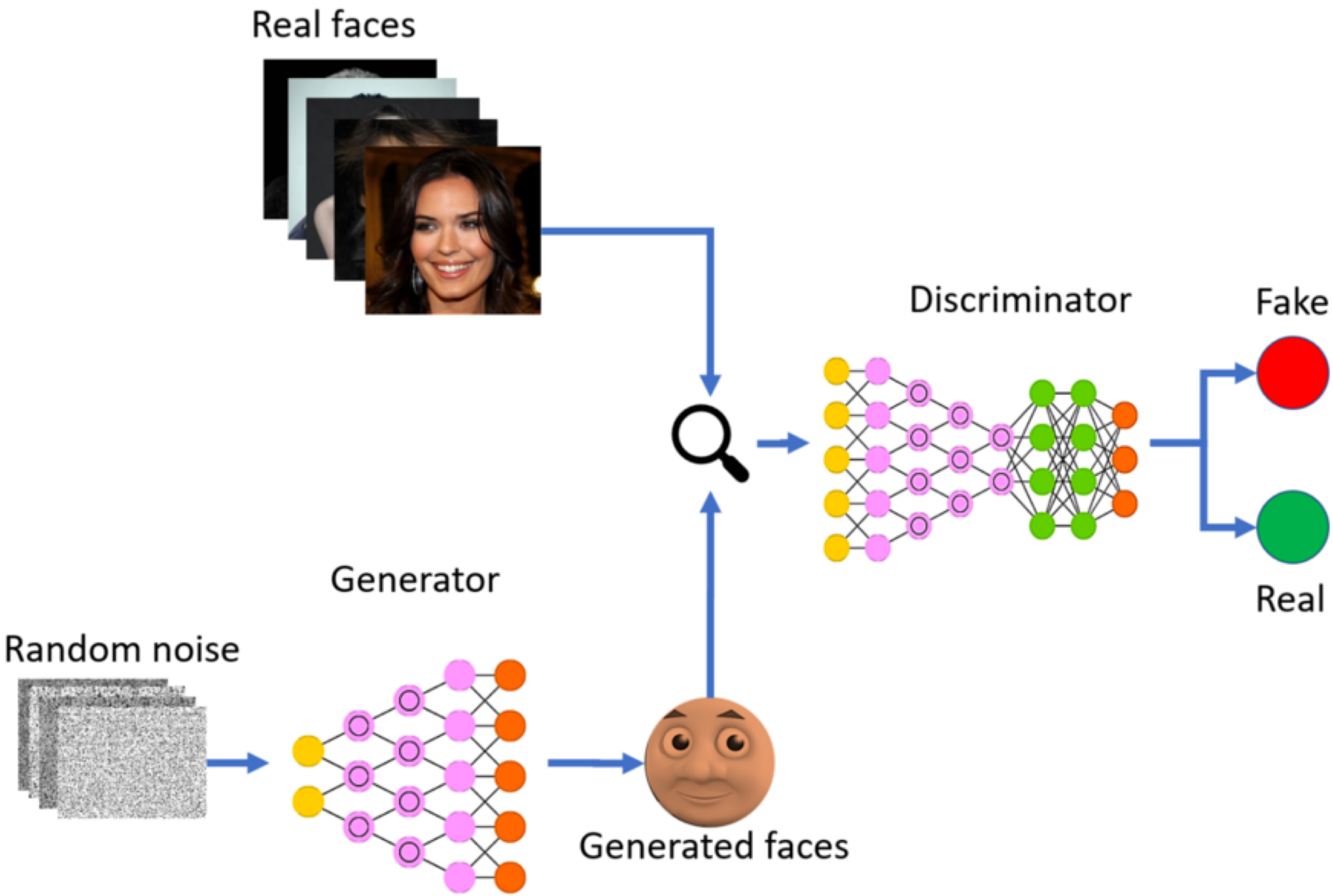
Part 8 – Adversarial Domain Adaptation

September 17, 2019

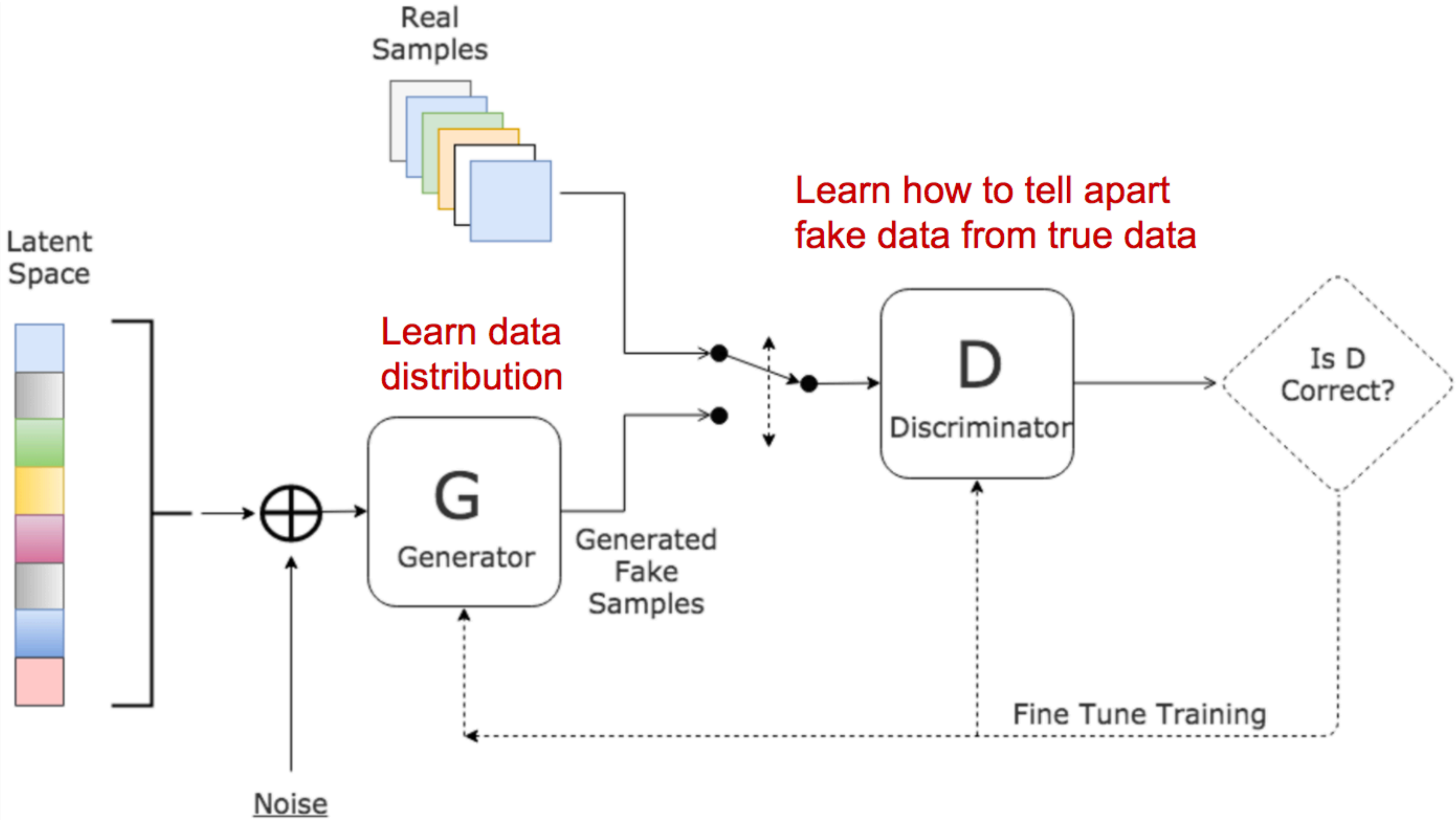
Presented by Chadwick Boulay, MSc, PhD

Sachs Lab

Intro to GANs



Intro to GANs



Ian Goodfellow
@goodfellow_ian

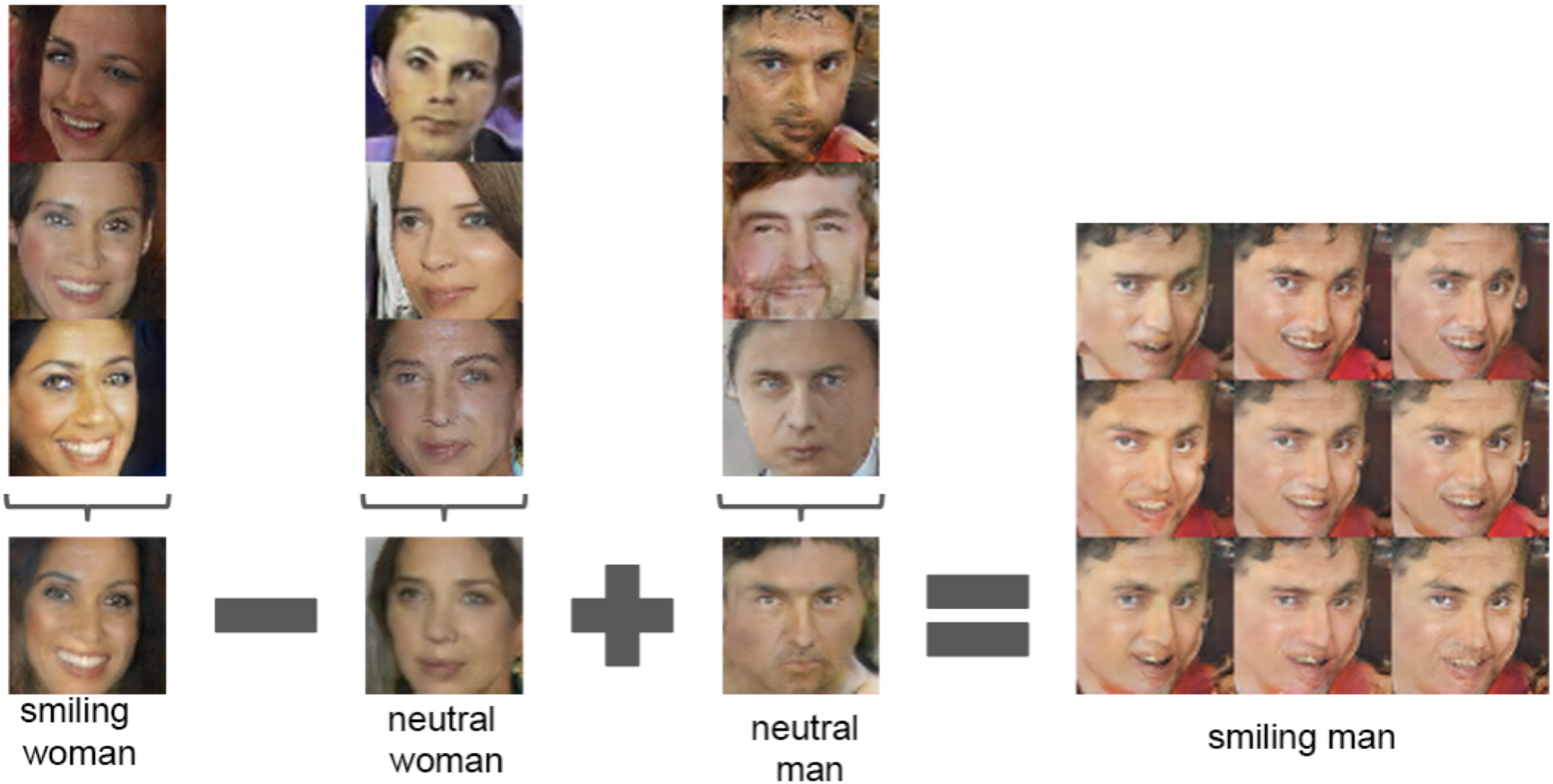
4.5 years of GAN progress on face generation.
arxiv.org/abs/1406.2661 arxiv.org/abs/1511.06434 arxiv.org/abs/1606.07536 arxiv.org/abs/1710.10196 arxiv.org/abs/1812.04948

1:40 AM · Jan 15, 2019 · Twitter Web Client

- thispersondoesnotexist.com

Trained generative model has representation of real data structure.
We can then explore the model latent space.

Interpolation in Latent Space

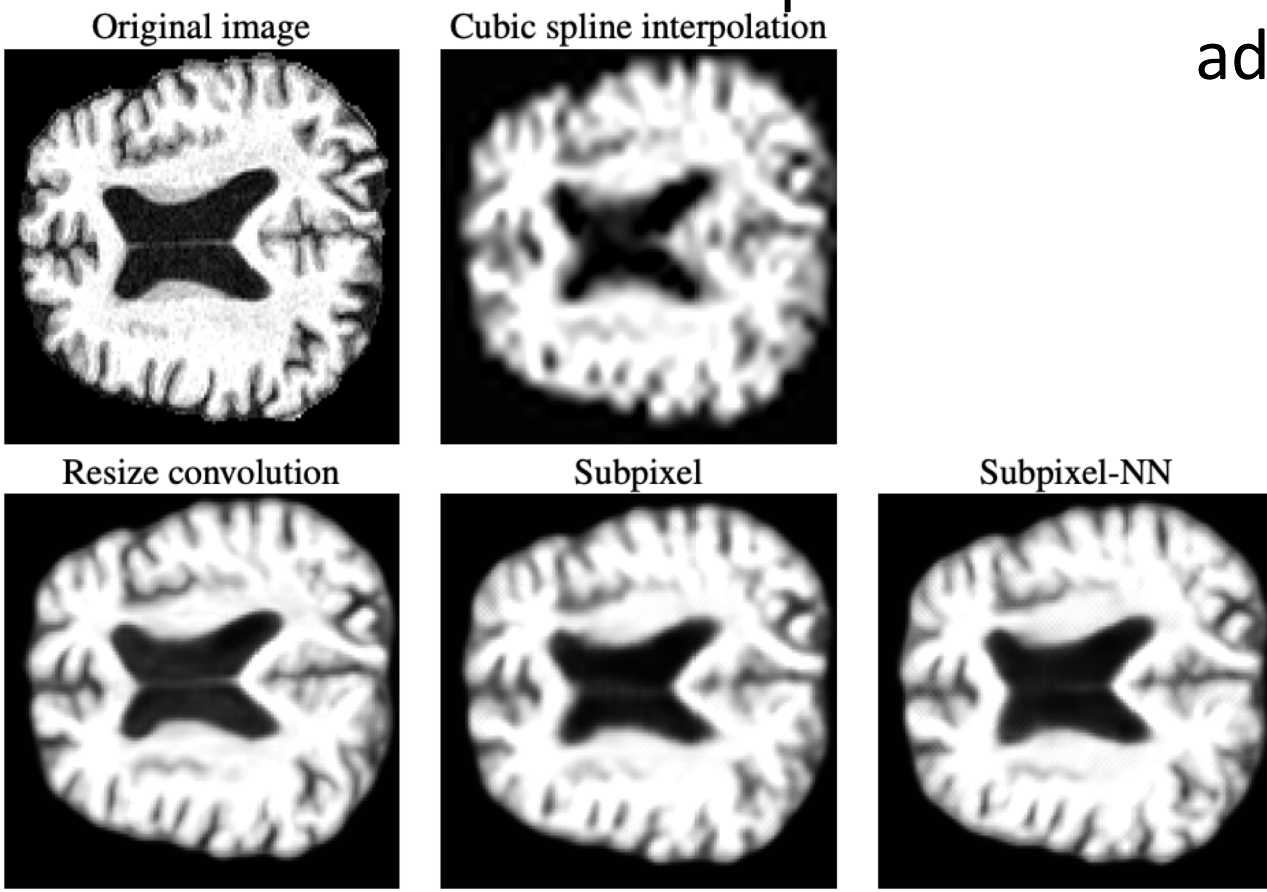


smiling woman
neutral woman
neutral man
smiling man

Style-GAN

- https://youtu.be/kSLJriaOumA?t=28

- A Brief Review on: MRI Images Reconstruction using GAN
- Generative Adversarial Networks for the Creation of Realistic Artificial Brain Magnetic Resonance Images
- Brain MRI super-resolution using 3D generative adversarial networks



- Excellent youtube video here:
  - https://www.youtube.com/watch?v=dCKbRCUyop8
- Along with notebook:
  - https://drive.google.com/drive/folders/1LBWcmnUPoHDeaYlRiHokGyjywIdyhAQb?usp=drive_open

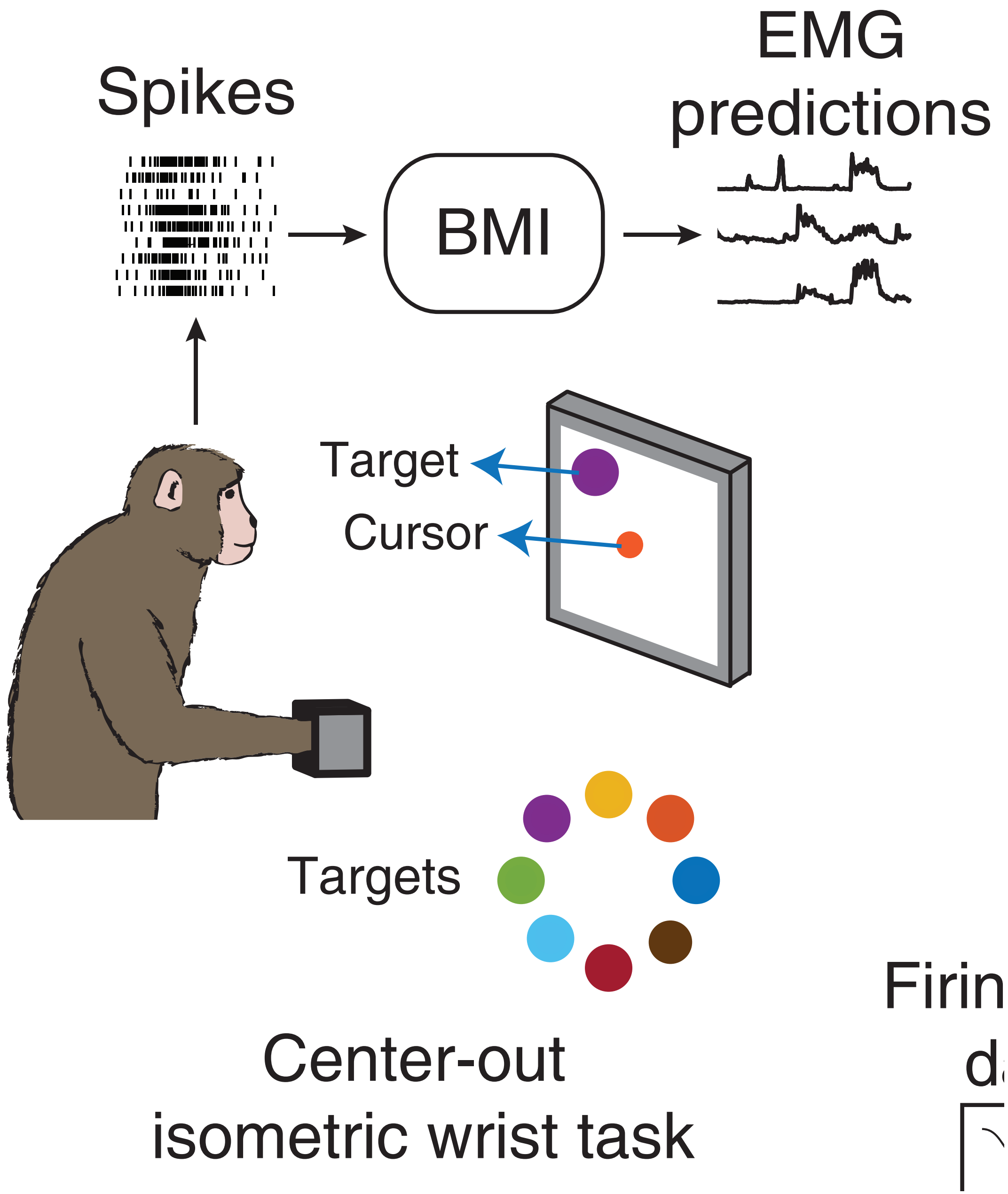
ADVERSARIAL DOMAIN ADAPTATION FOR STABLE BRAIN-MACHINE INTERFACES

Ali Farshchian, Juan A. Gallego, Lee E. Miller & Sara A. Solla
Northwestern University, Evanston, IL, USA
{a-farshchiansadegh,juan.gallego,lm,solla}@northwestern.edu

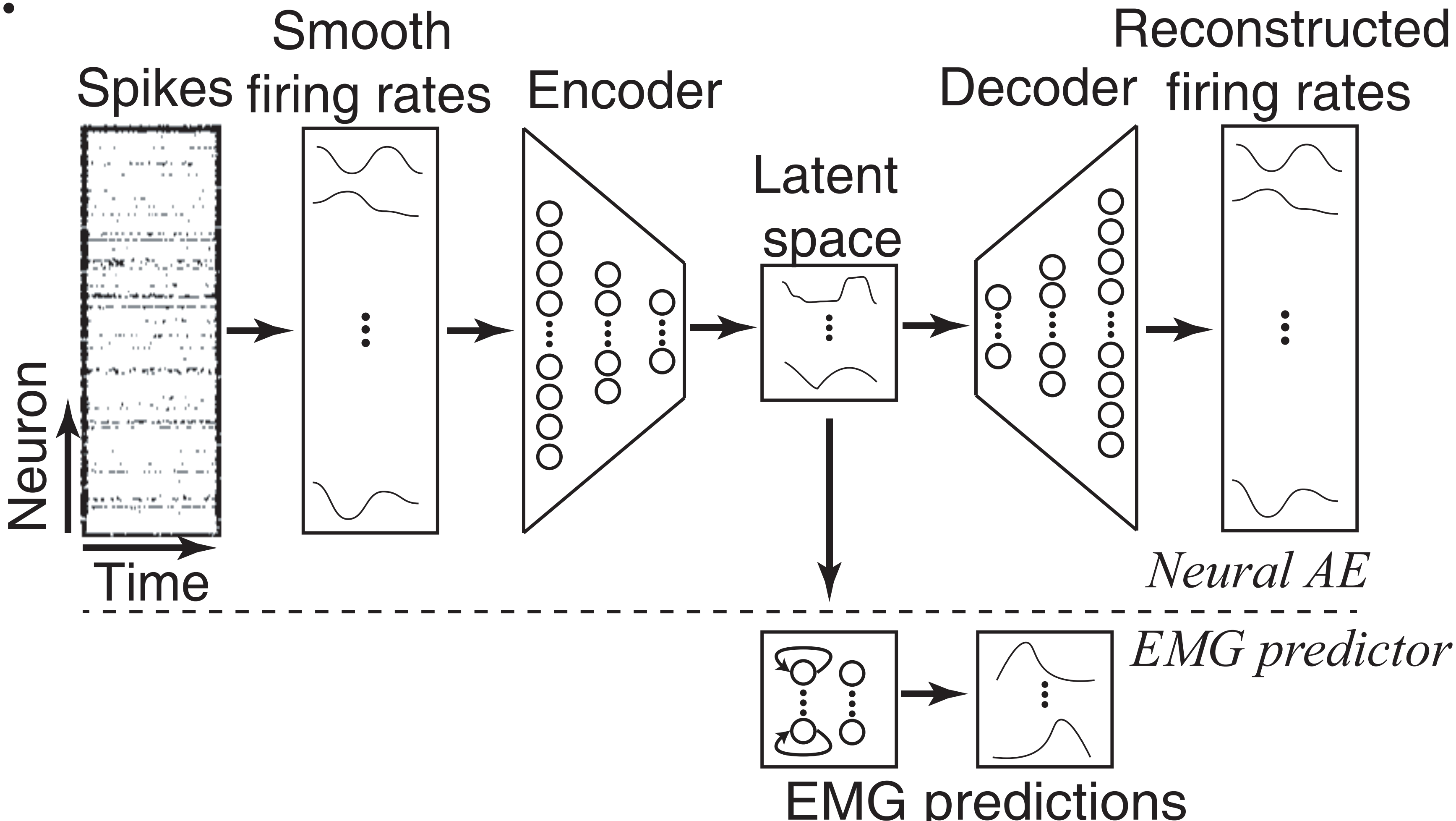
Joseph P. Cohen & Yoshua Bengio
University of Montreal, Montreal, Canada
cohenjos@iro.umontreal.ca,yoshua.bengio@umontreal.ca

ADAN Motivation

- 40% turnover in recorded neurons per week
- Old and new neurons alike participate in same low-dimensional manifold.
- Train DNN: (V)AE; latent space → motor commands
  - Similar to LFADS with different implementation details
- Align PDFs of reconstructed signal residuals on day k with PDF of day 1.
  - Results in alignment of neural latent space.
- Assumes relationship between latent space and movement remains constant across days.


Spikes
BMI
EMG
predictions
Target
Cursor
Targets
Center-out
isometric wrist task

B.



$$\mathcal{L} = \lambda \mathcal{L}^{\boldsymbol{x}} + \mathcal{L}^{\boldsymbol{y}} = \frac{1}{T} \sum_{t=1}^{T} \left(\lambda ||\widehat{\boldsymbol{x}}_t - \boldsymbol{x}_t||^2 + ||\widehat{\boldsymbol{y}}_t - \boldsymbol{y}_t||^2 \right)$$

$$\lambda = \frac{\mathcal{L}^{\boldsymbol{y}}}{\mathcal{L}^{\boldsymbol{x}}}$$

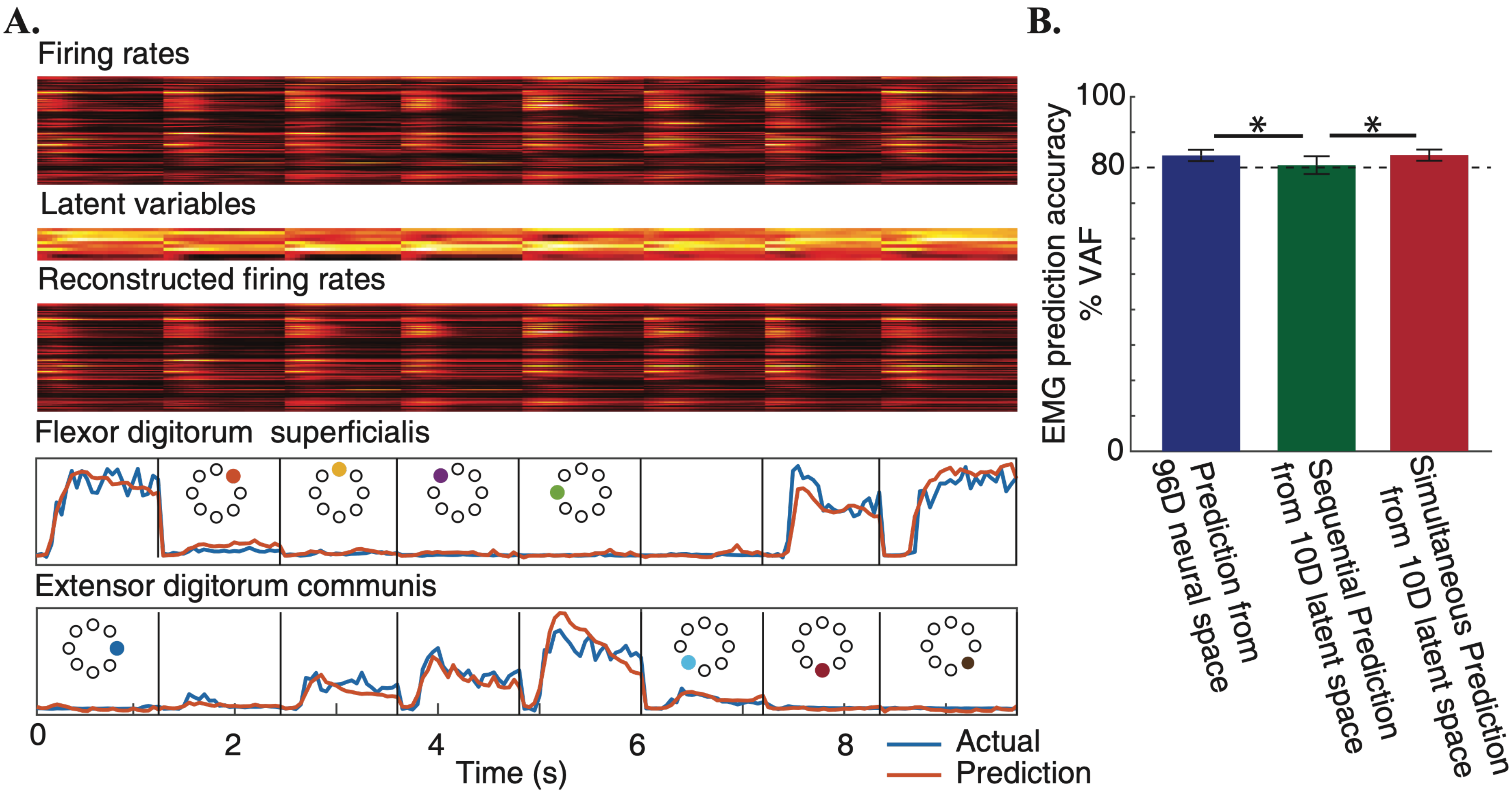
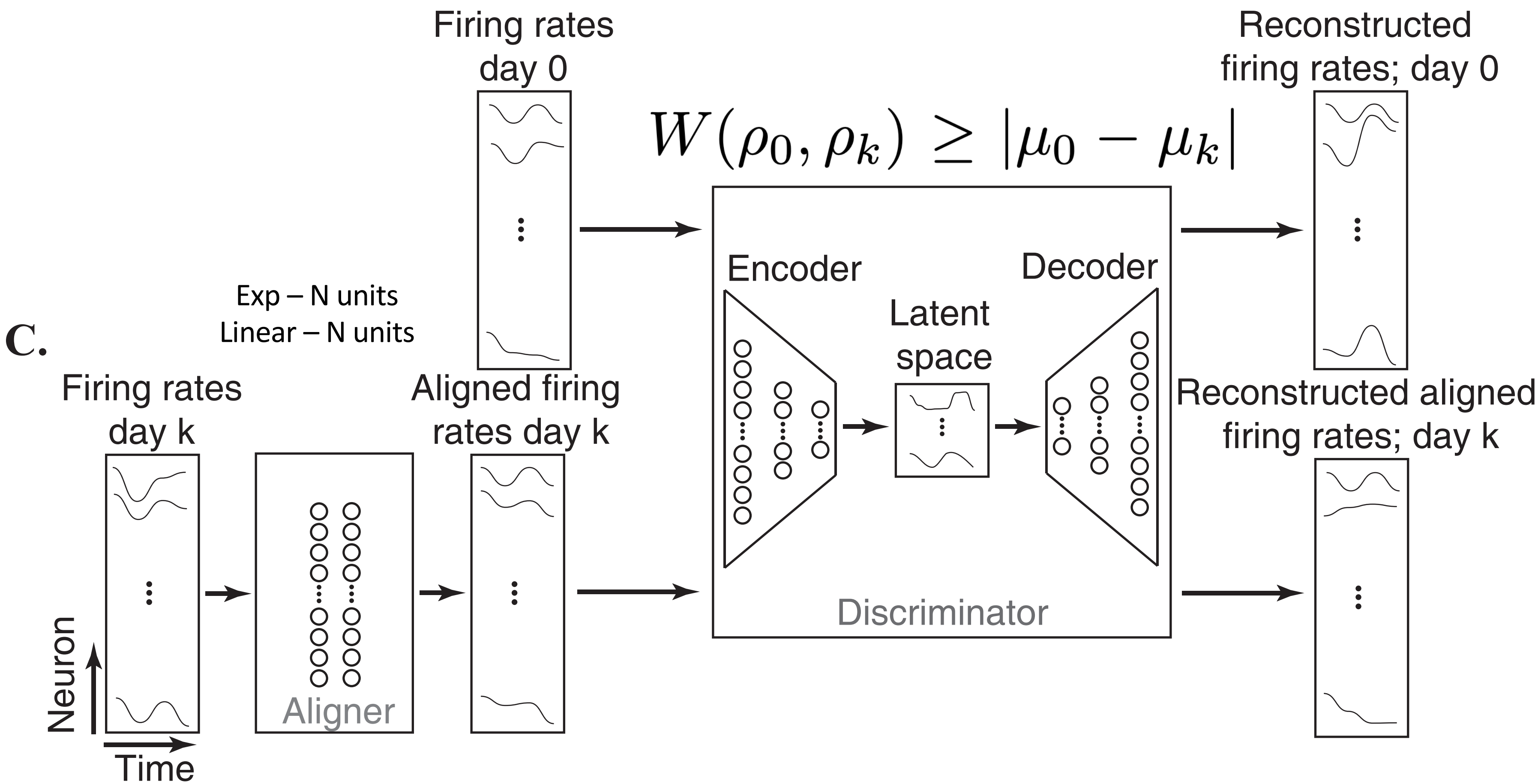


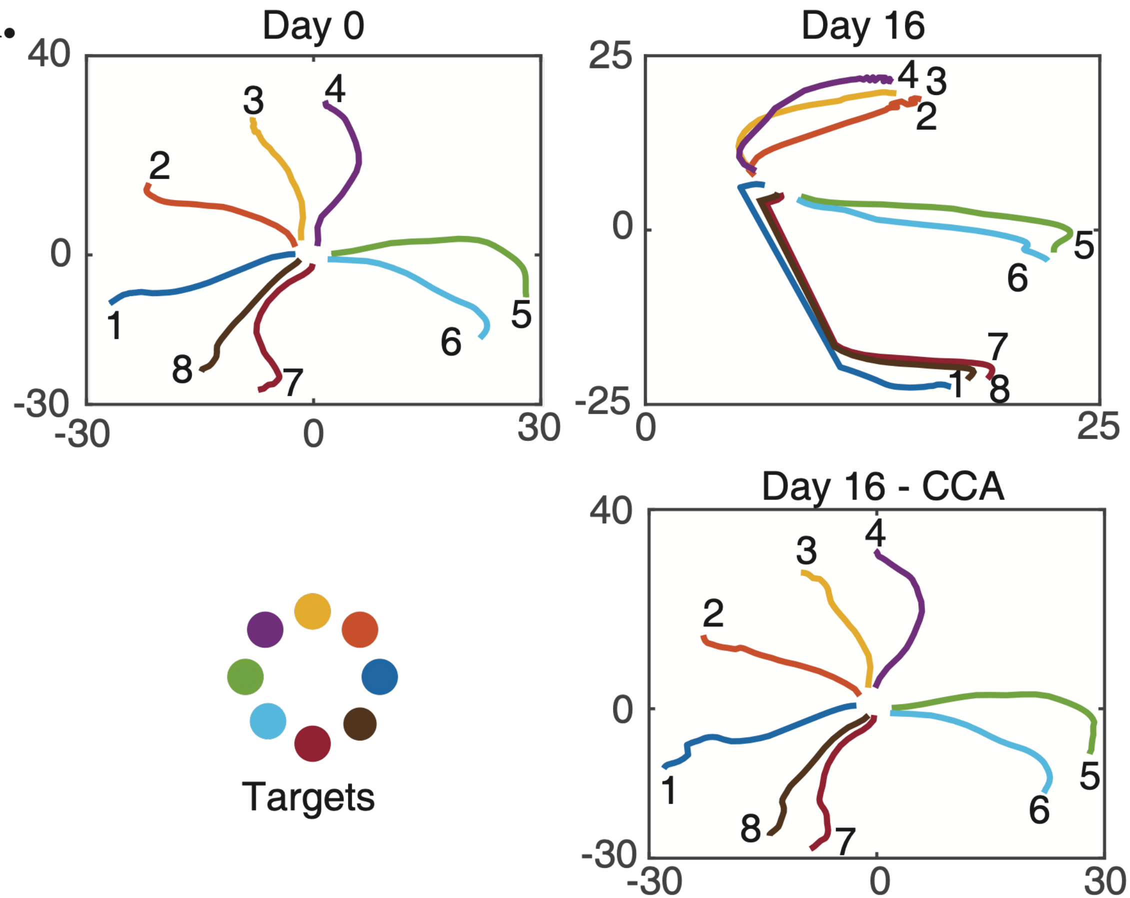
Figure 2: Neural to muscle BMI. **A.** Example firing rates recorded from the hand area of primary motor cortex while the monkey performed the isometric wrist task; we also show latent variables and reconstructed firing rates. The quality of EMG predictions is illustrated by comparison to actual EMGs for two representative muscles, for each of the eight target directions. **B.** Performance comparison between EMG predictions from n-dimensional firing rates (blue) and EMG predictions from l-dimensional latent variables, obtained either by training the predictor sequentially (green) or simultaneously (red) with the neural AE. Error bars represent standard deviation of the mean.

ρ_0, ρ_k : Distributions of scalar losses

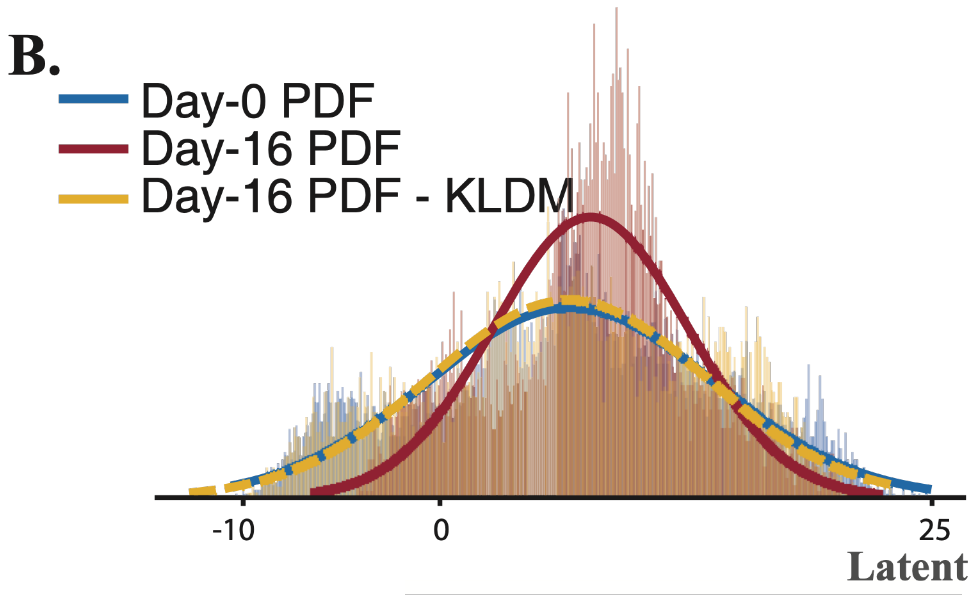


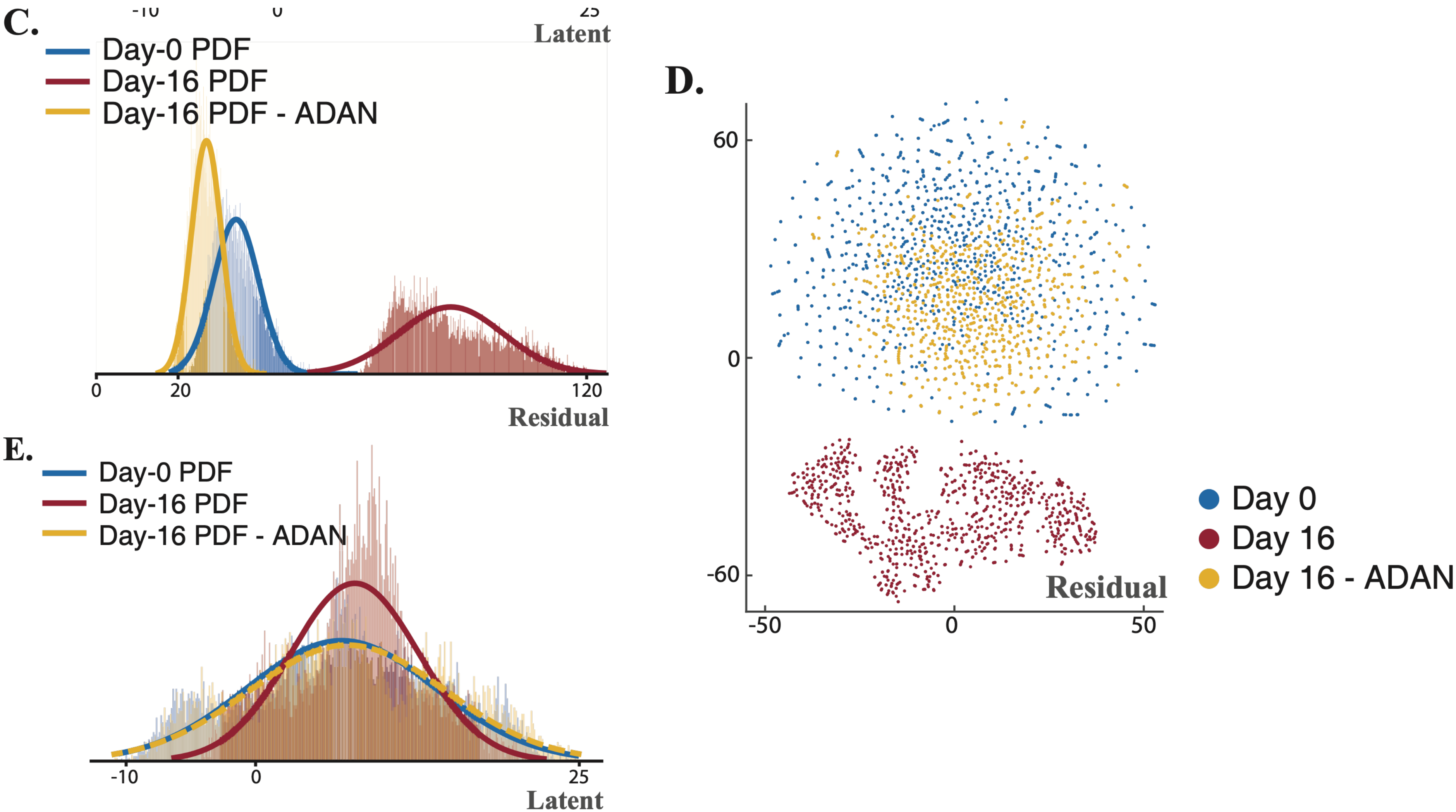
$$\begin{cases} \mathcal{L}_D = \mu_0(\boldsymbol{X}_0; \theta_D) - \mu_k(A(\boldsymbol{X}_k; \theta_A); \theta_D) & \text{for } \theta_D \\ \mathcal{L}_A = \mu_k(A(\boldsymbol{X}_k; \theta_A); \theta_D) & \text{for } \theta_A \end{cases}$$

A.

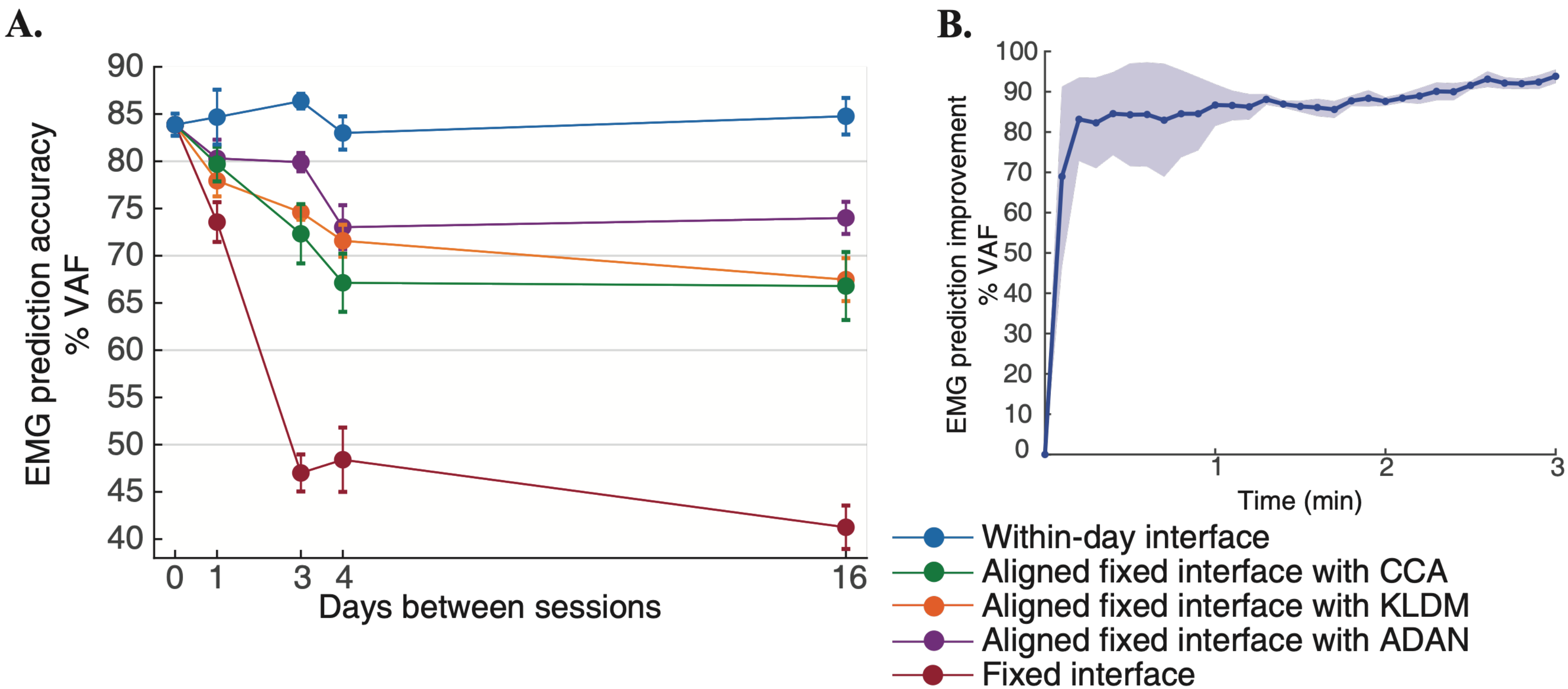


t-SNE of latent neural trajectories
CCA alignment requires many labeled trials on day 16.


B.
Day-0 PDF
Day-16 PDF
Day-16 PDF - KLDM
-10
0
25
Latent



C.
-10
0
25
Latent
Day-0 PDF
Day-16 PDF
Day-16 PDF - ADAN
0
20
120
Residual
D.
60
0
-60
-50
0
50
Residual
Day 0
Day 16
Day 16 - ADAN
E.
Day-0 PDF
Day-16 PDF
Day-16 PDF - ADAN
-10
0
25
Latent


A.
B.
EMG prediction accuracy
% VAF
90
85
80
75
70
65
60
55
50
45
40
0
1
3
4
16
Days between sessions
EMG prediction improvement
% VAF
100
90
80
70
60
50
40
30
20
10
0
1
2
3
Time (min)
Within-day interface
Aligned fixed interface with CCA
Aligned fixed interface with KLDM
Aligned fixed interface with ADAN
Fixed interface

- Notebook 08_01_ADAN.ipynb