

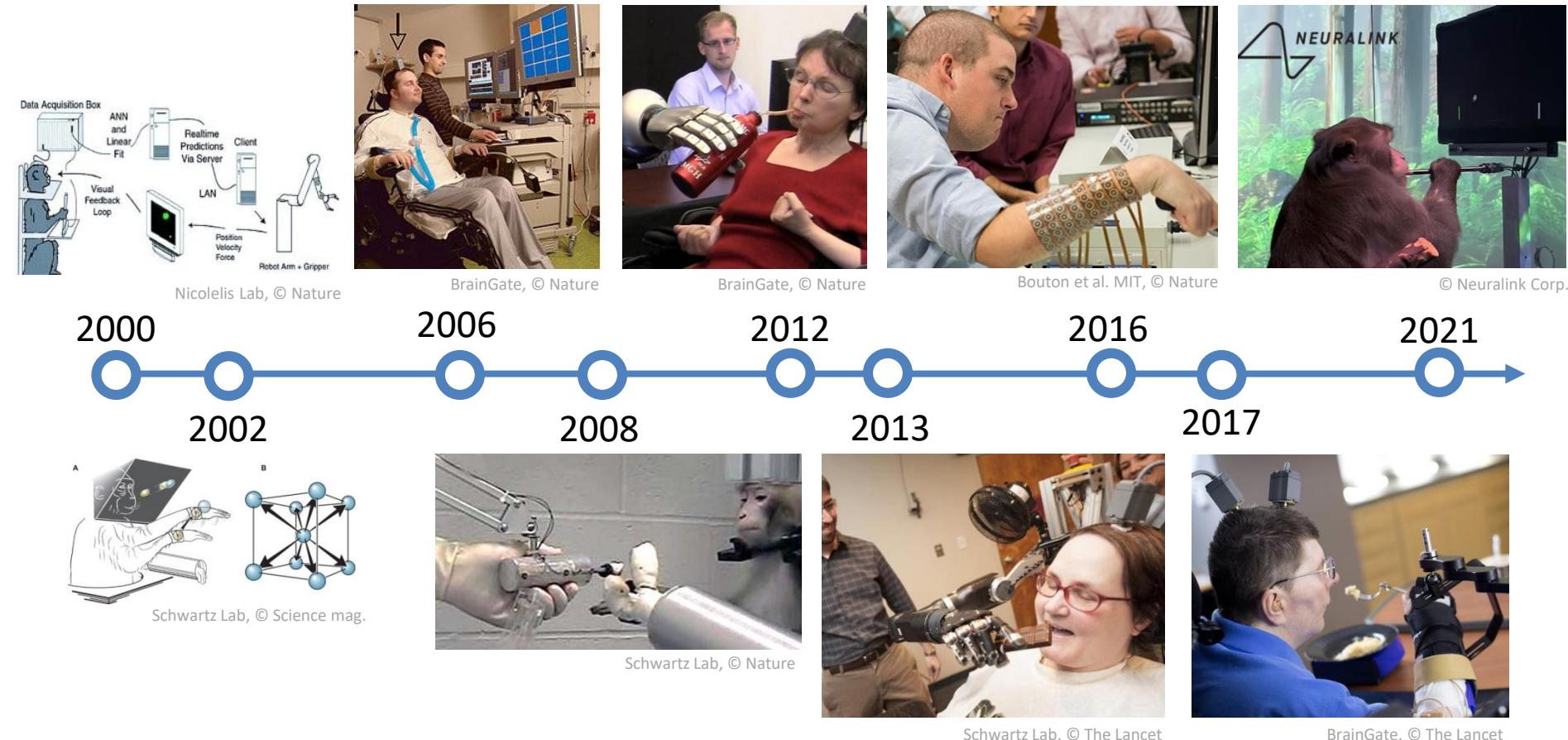
Intention is all you need (to train a high-accuracy grasping iBCI)

Andres Agudelo-Toro

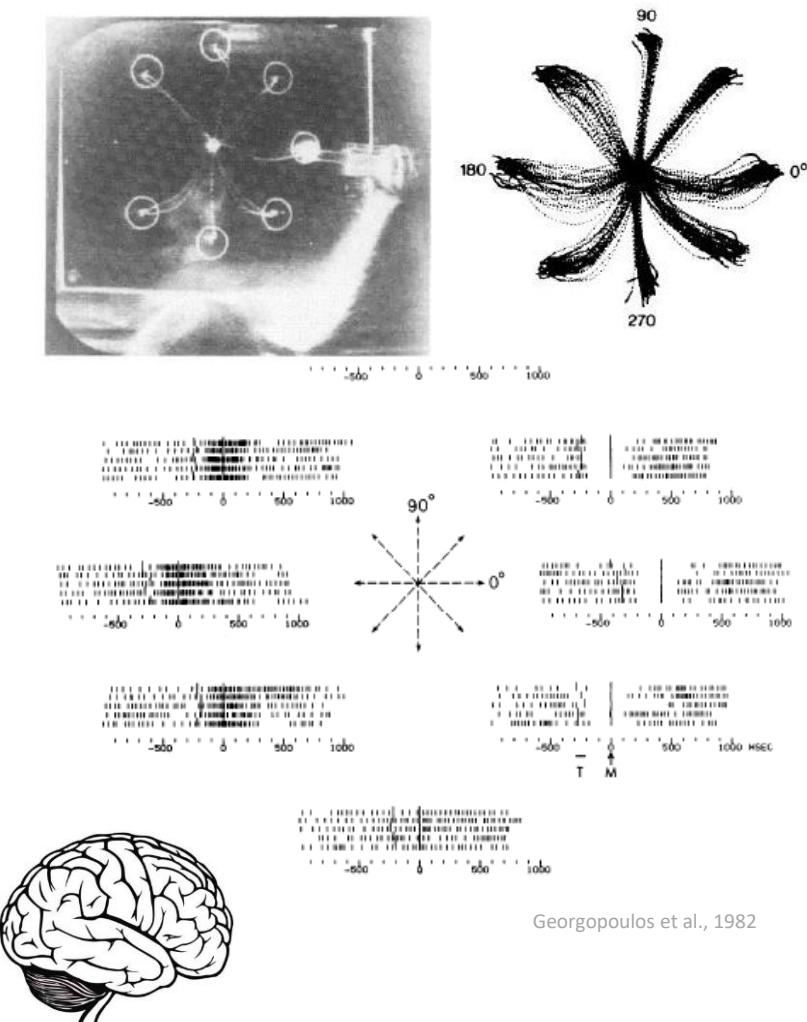
(with Jonathan A. Michaels, Wei-An Sheng, and
Hansjörg Scherberger)

**3rd BCI Un-Conference, Online
January 27th, 2022**

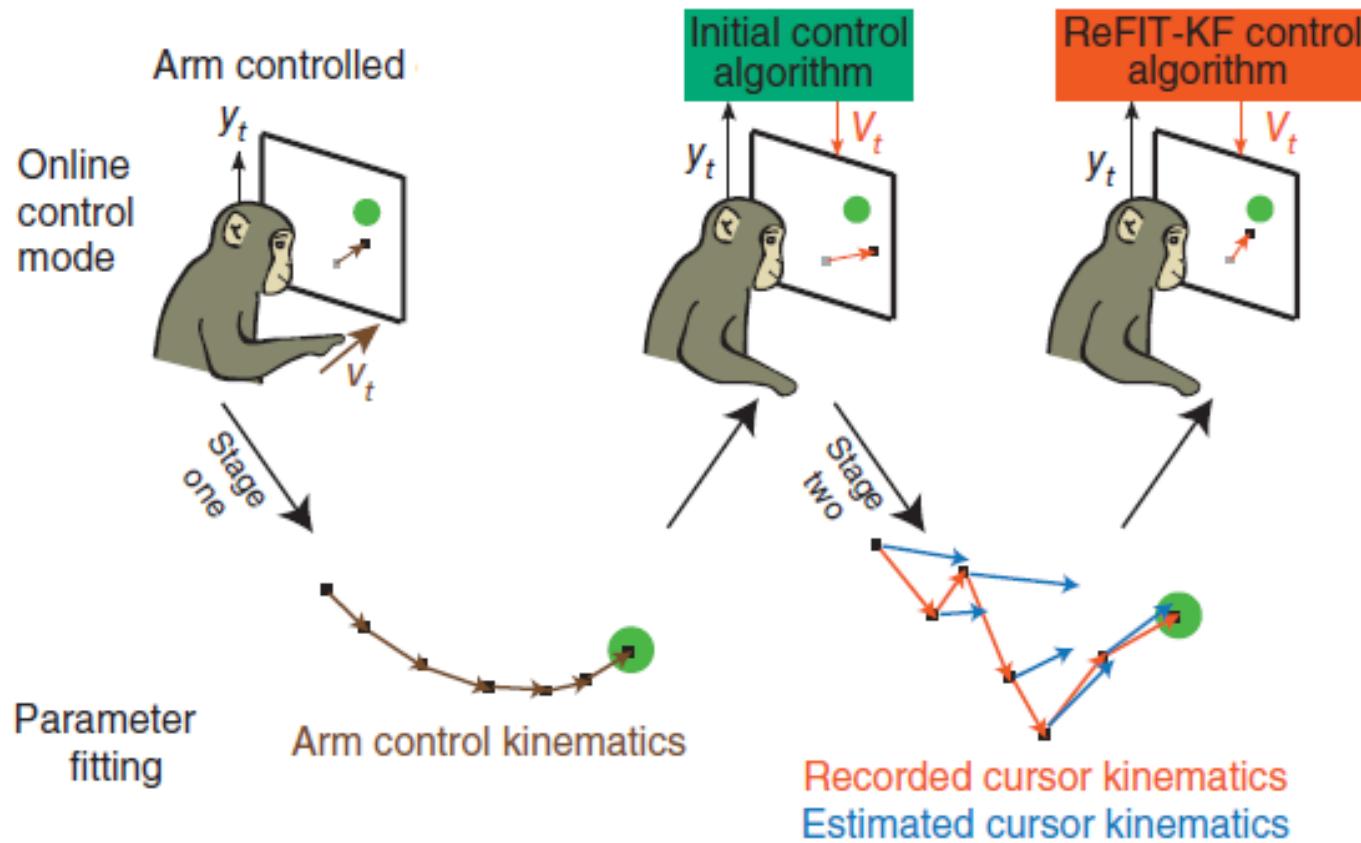
Impressive progress of intracortical Brain Computer Interfaces



Brain activity during reaching correlates to velocity



Motor cortical representations correlate to arm velocity



Gilja et al., 2012

ReFIT: Recalibrated Feedback
Intention–Trained Kalman filter

Can we use the same methods on grasping iBCIs?



Reaching:
velocity control

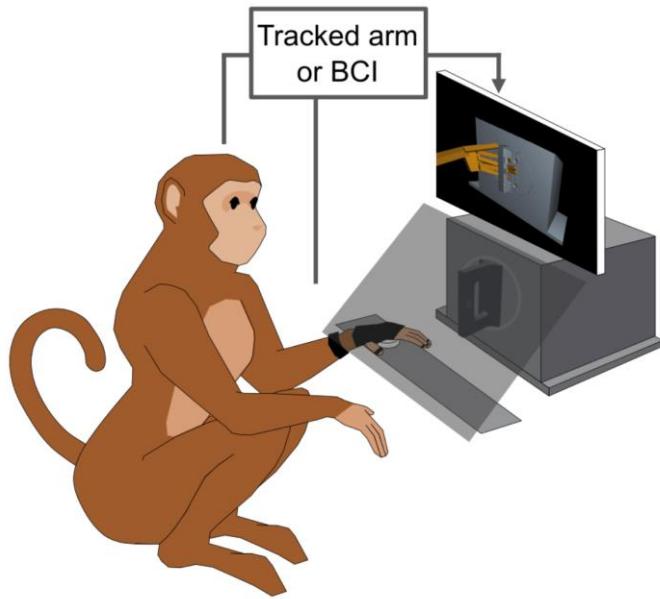


Grasping: also
velocity control?

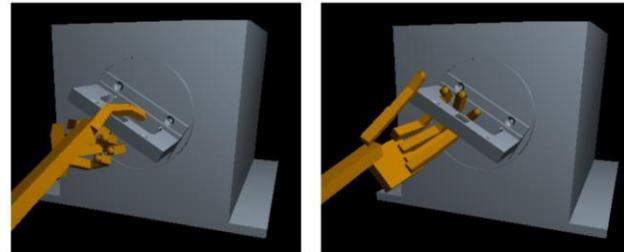


- Grasping circuit activity correlates more to position
- Trajectory based fit strategies work best

Virtual Reality (VR) delayed grasping task

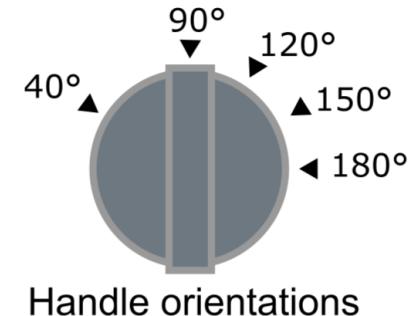
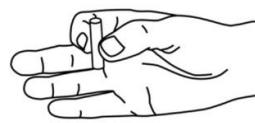


Monkey BR
Monkey BT

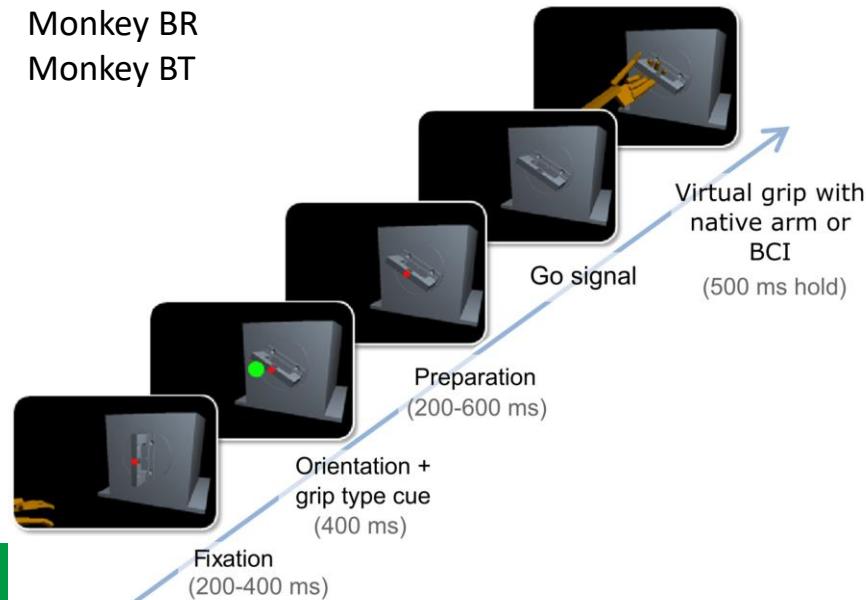


Precision grip

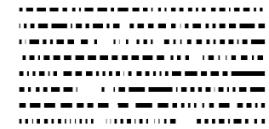
Power grip



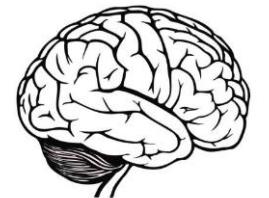
Handle orientations



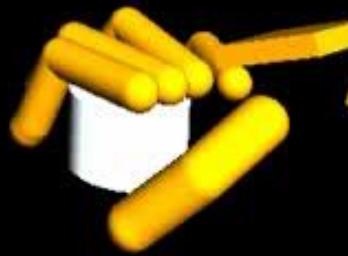
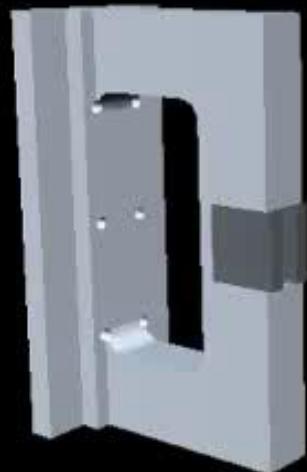
Native Task



BCI Task

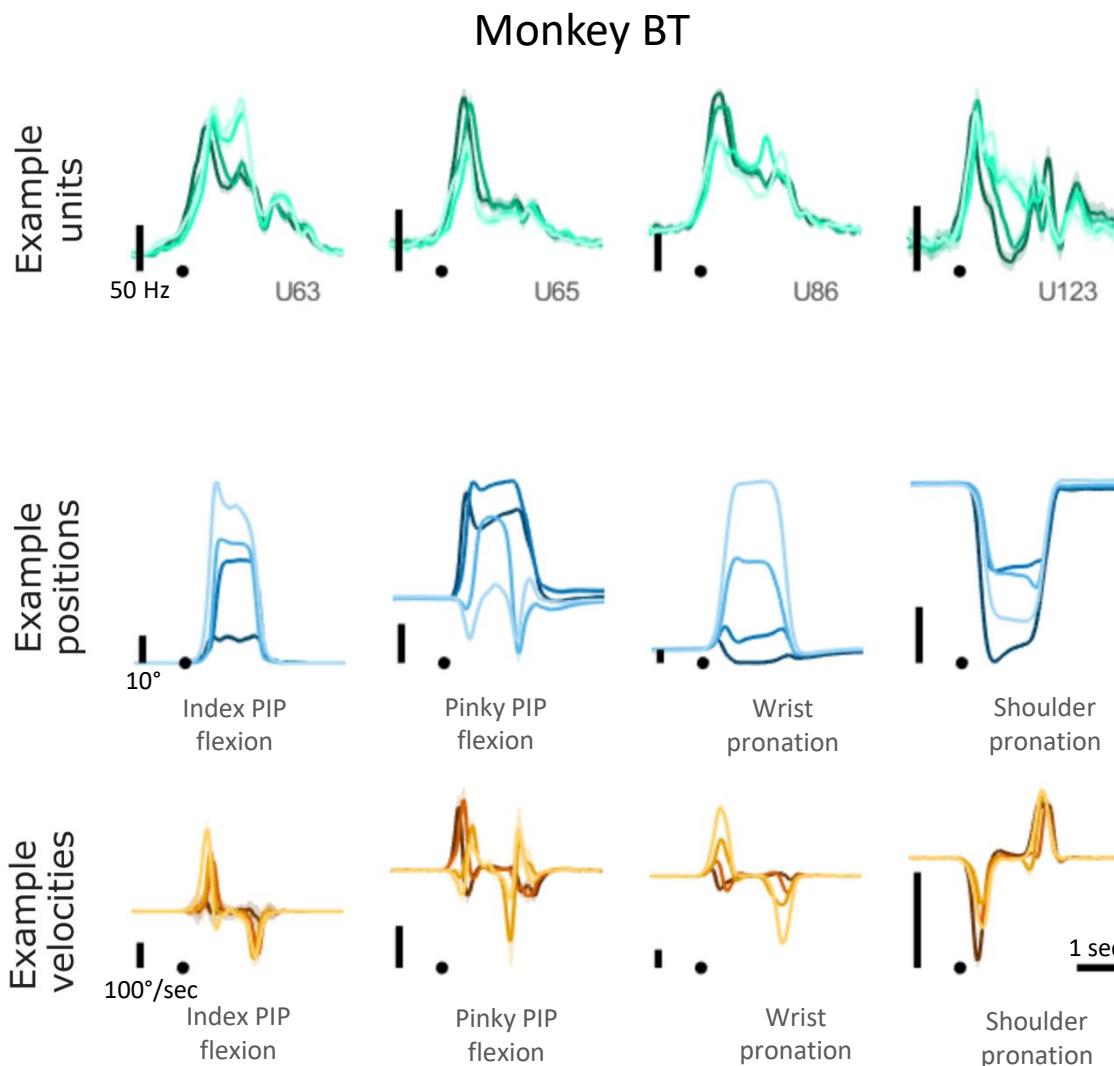
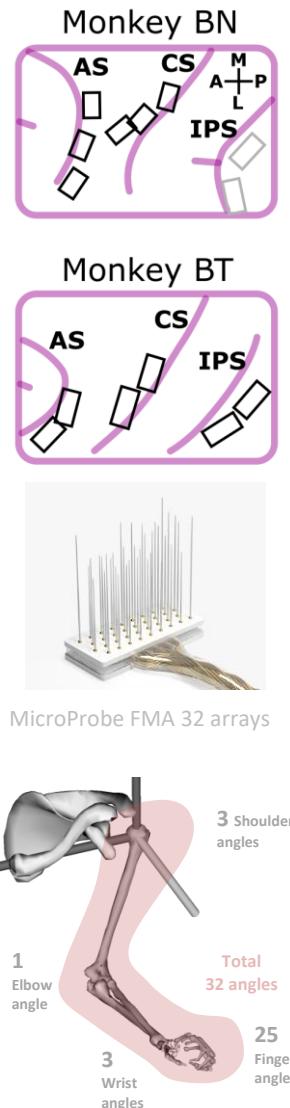


Collisions in VR environment (Monkey BT)

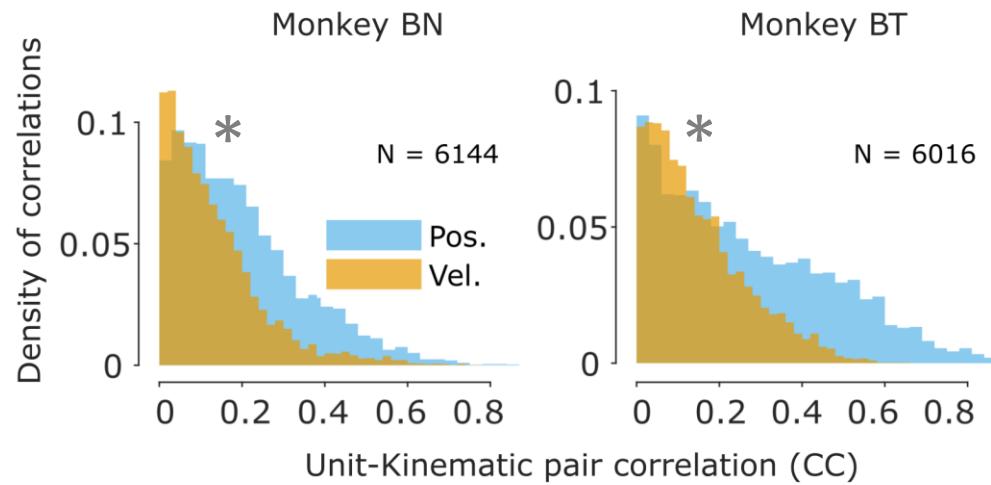
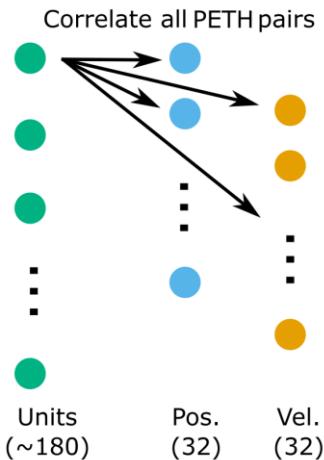
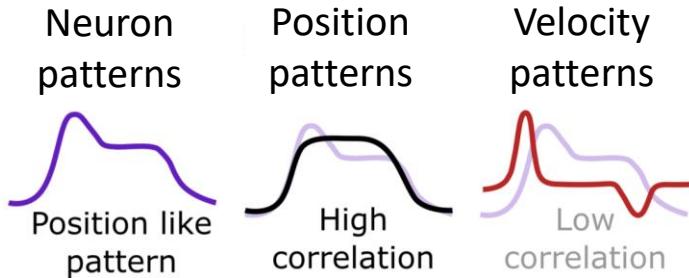


MuJoCo Physics engine (Google DeepMind)

Example units and grasp kinematics

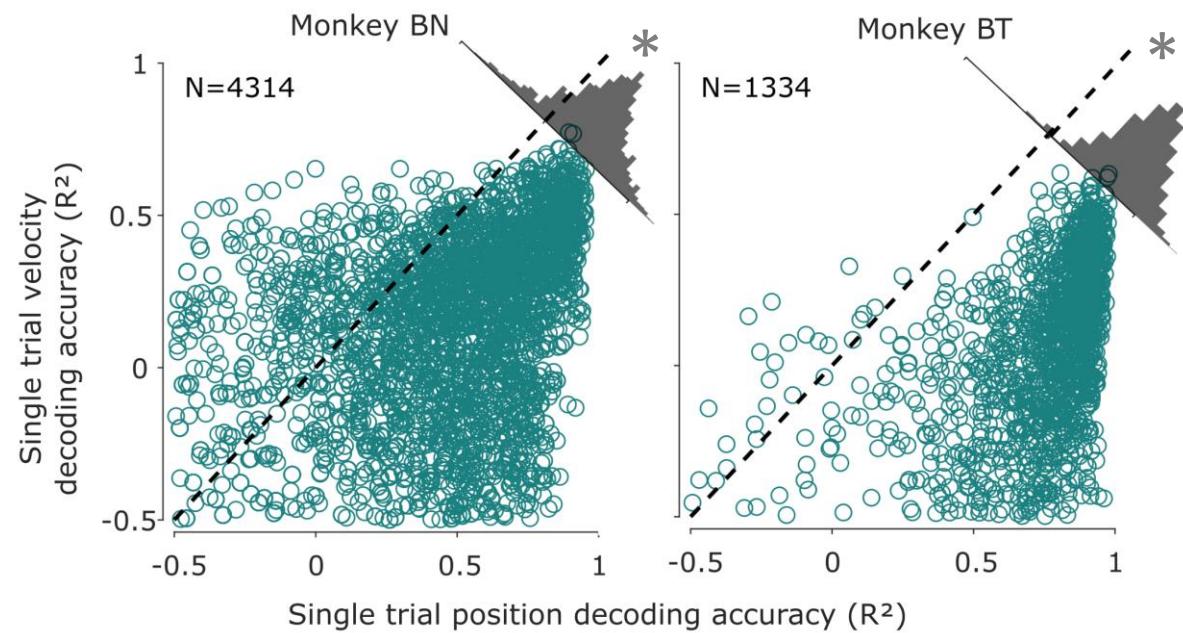
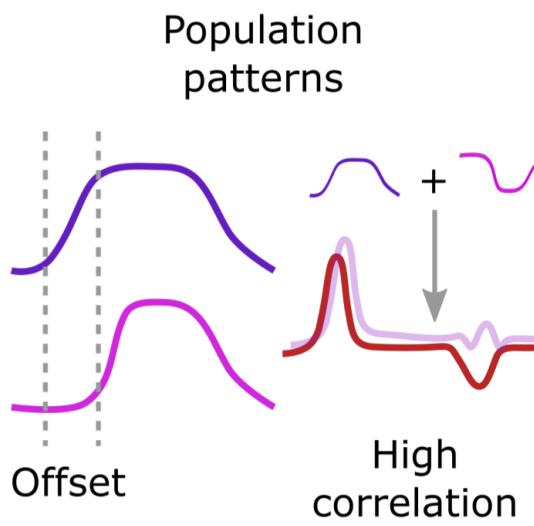


Neural patterns correlate better to position



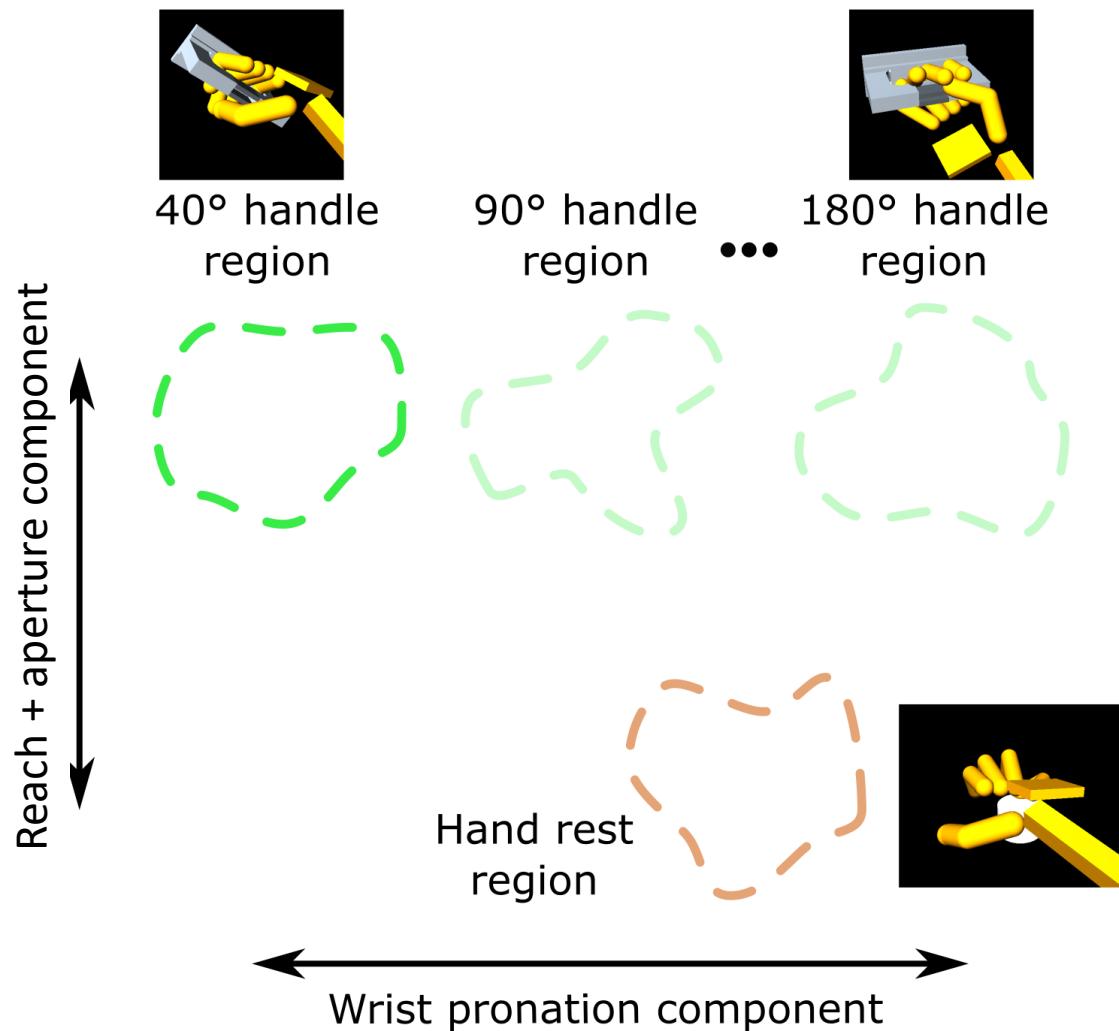
*Wilcoxon's signed-rank $p < 1e-5$

Decoders predict positions better than velocity offline

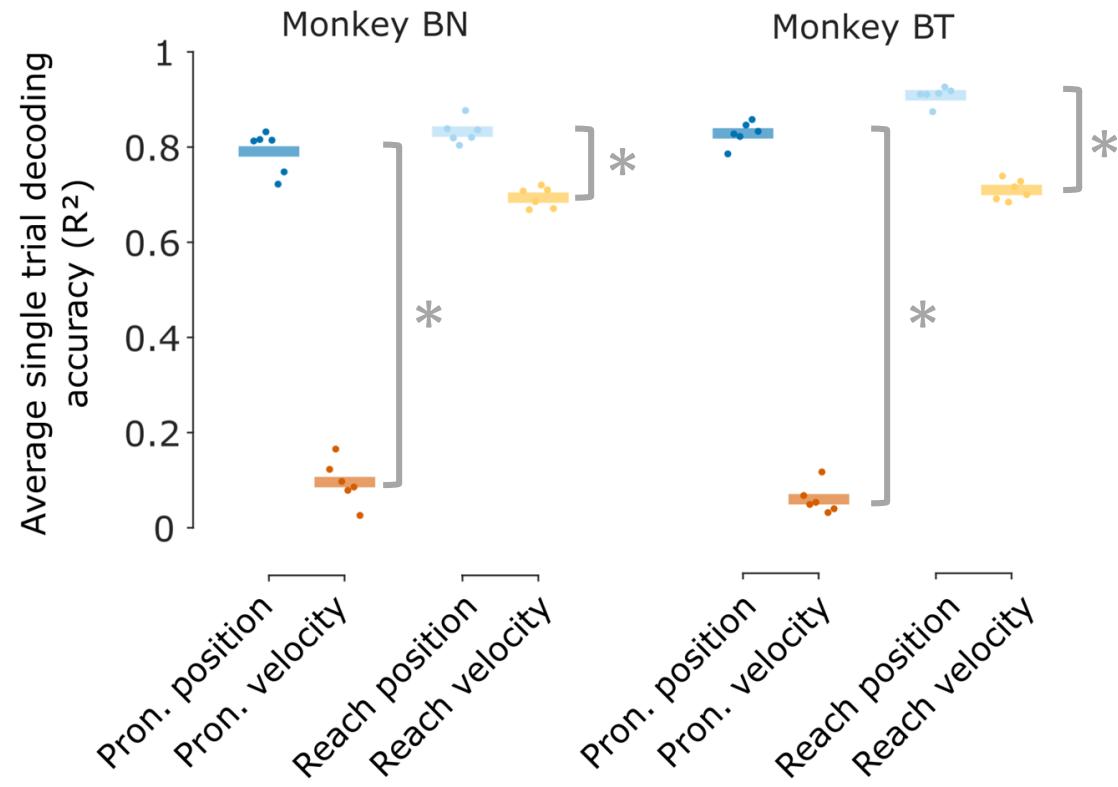
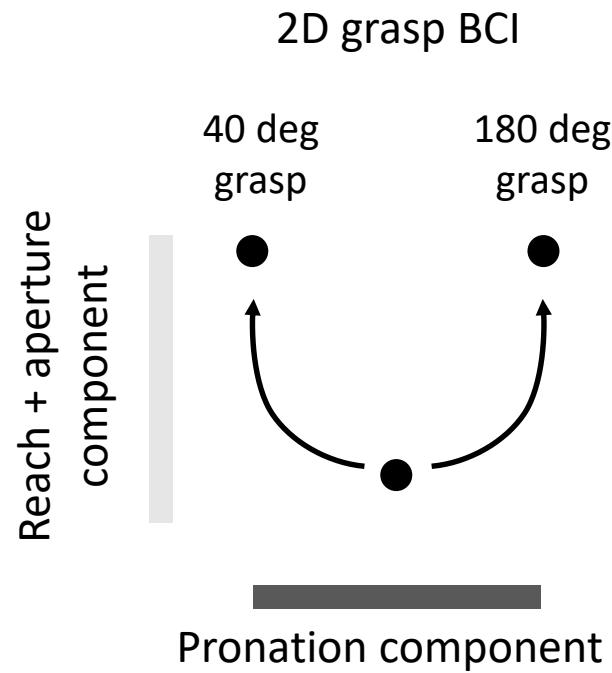


*Paired t-test $p < 0.001$

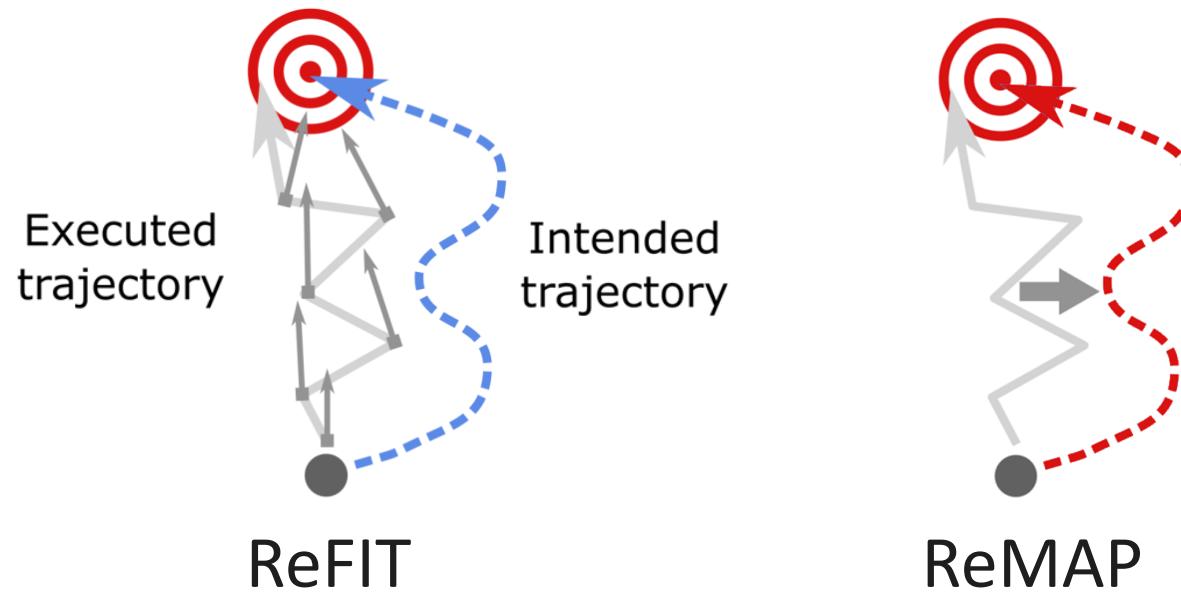
2D iBCI online grasping task



During BCI control position is decoded better than velocity



A strategy to train grasping BCIs

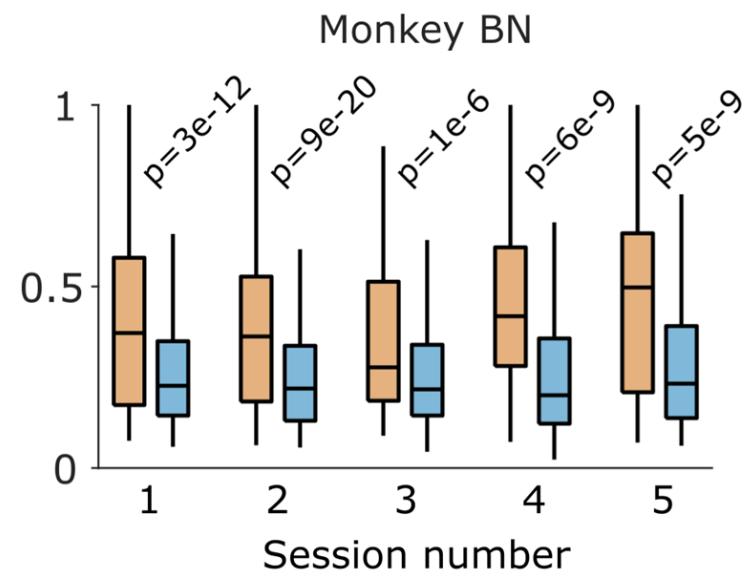
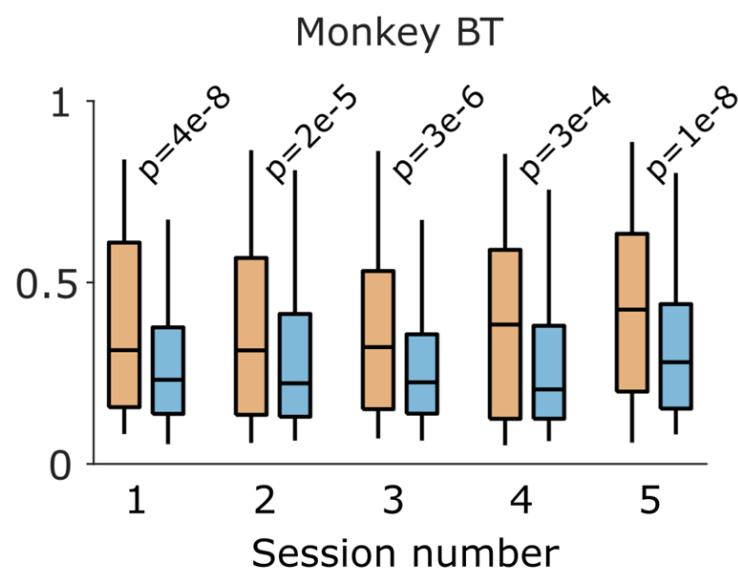


Gilja et al., 2012

Recalibrated Map
to Attempted Path

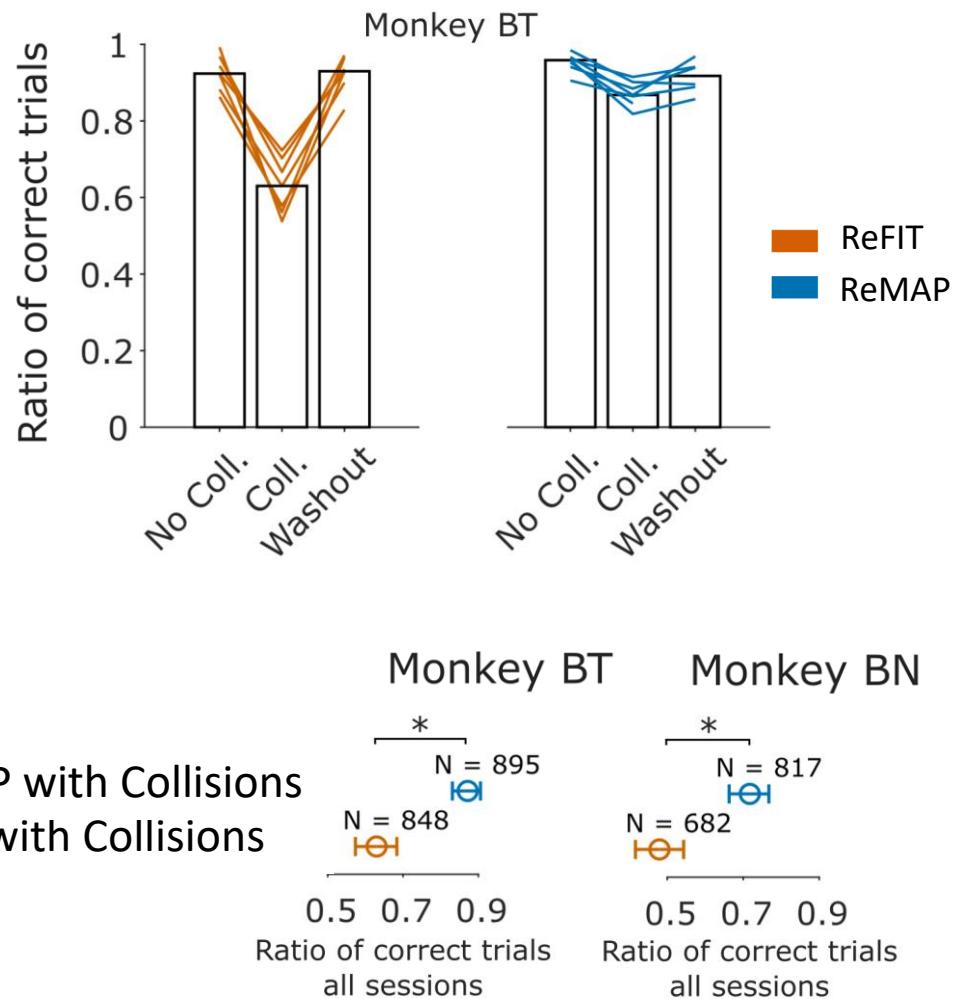
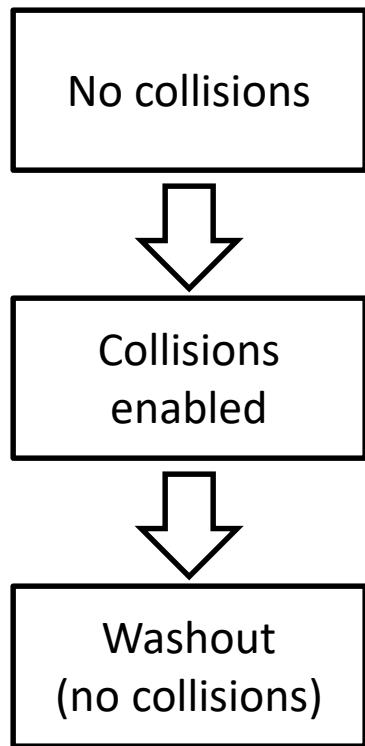
ReMAP increases accuracy

Error respect to intended trajectory (RMSE)



 ReFIT
 ReMAP

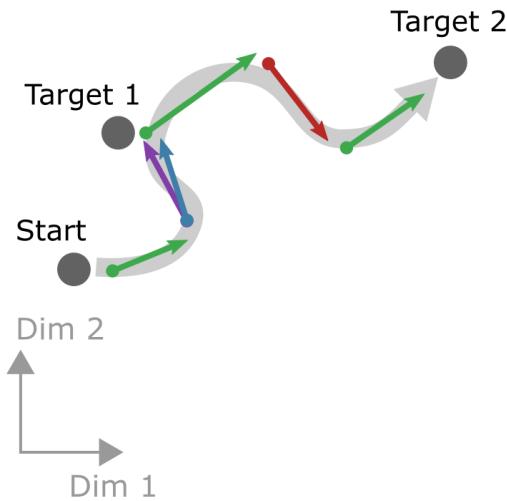
ReMAP increases performance under collisions



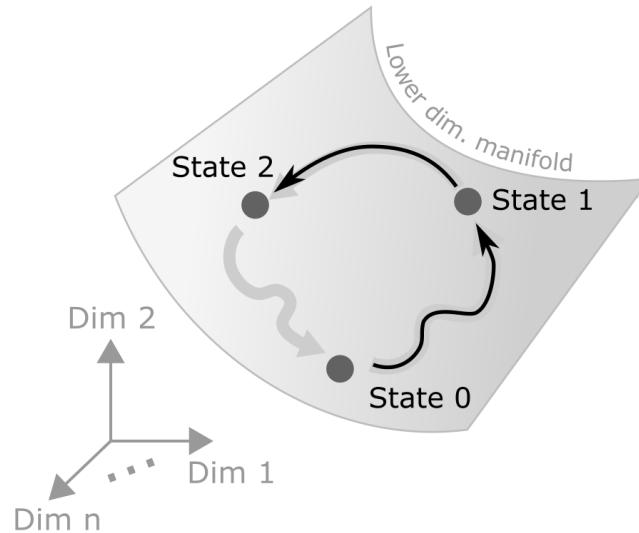
*0.999 Clopper-Pearson confidence intervals for the Bernoulli process, BT: 7 sessions, BN: 5 sessions

Maybe grasping is special

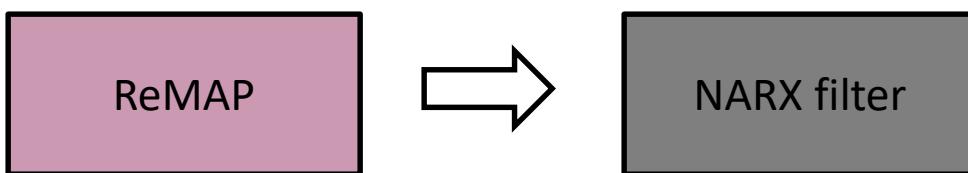
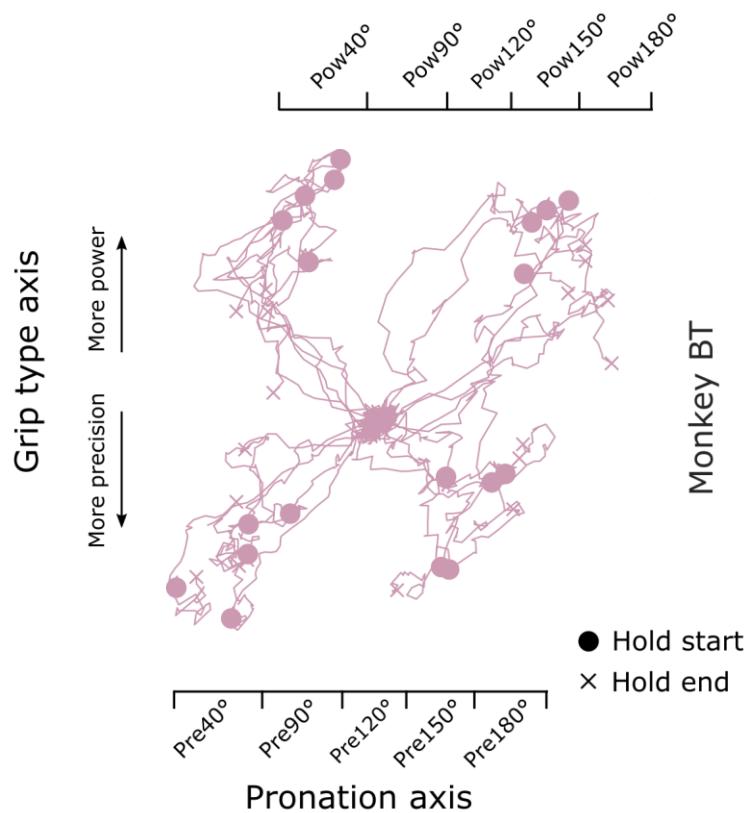
Reaching:
Velocity control



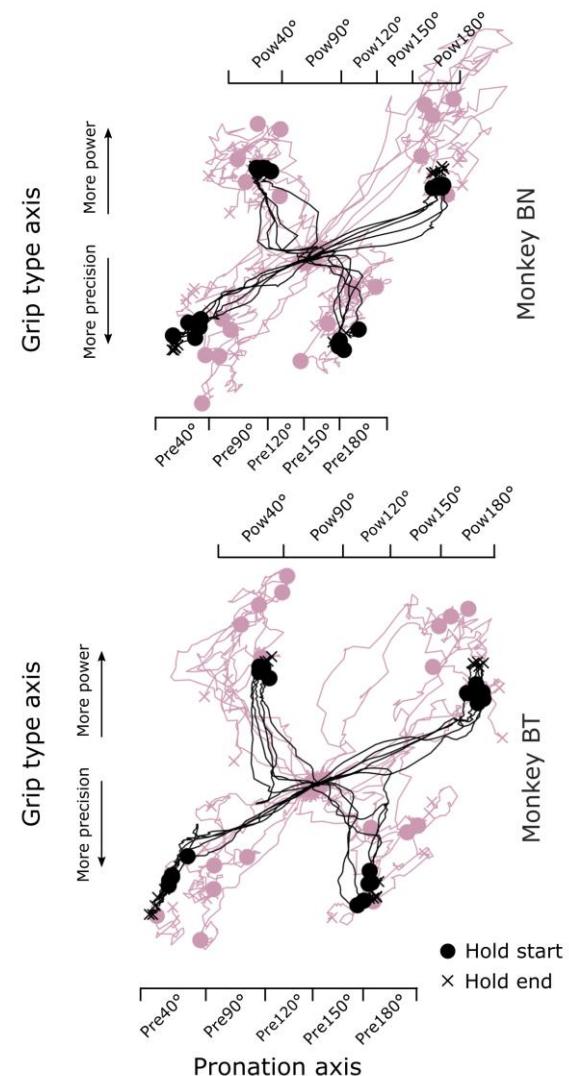
Grasping:
Position control?



Addition of a non-linear filter can increase precision



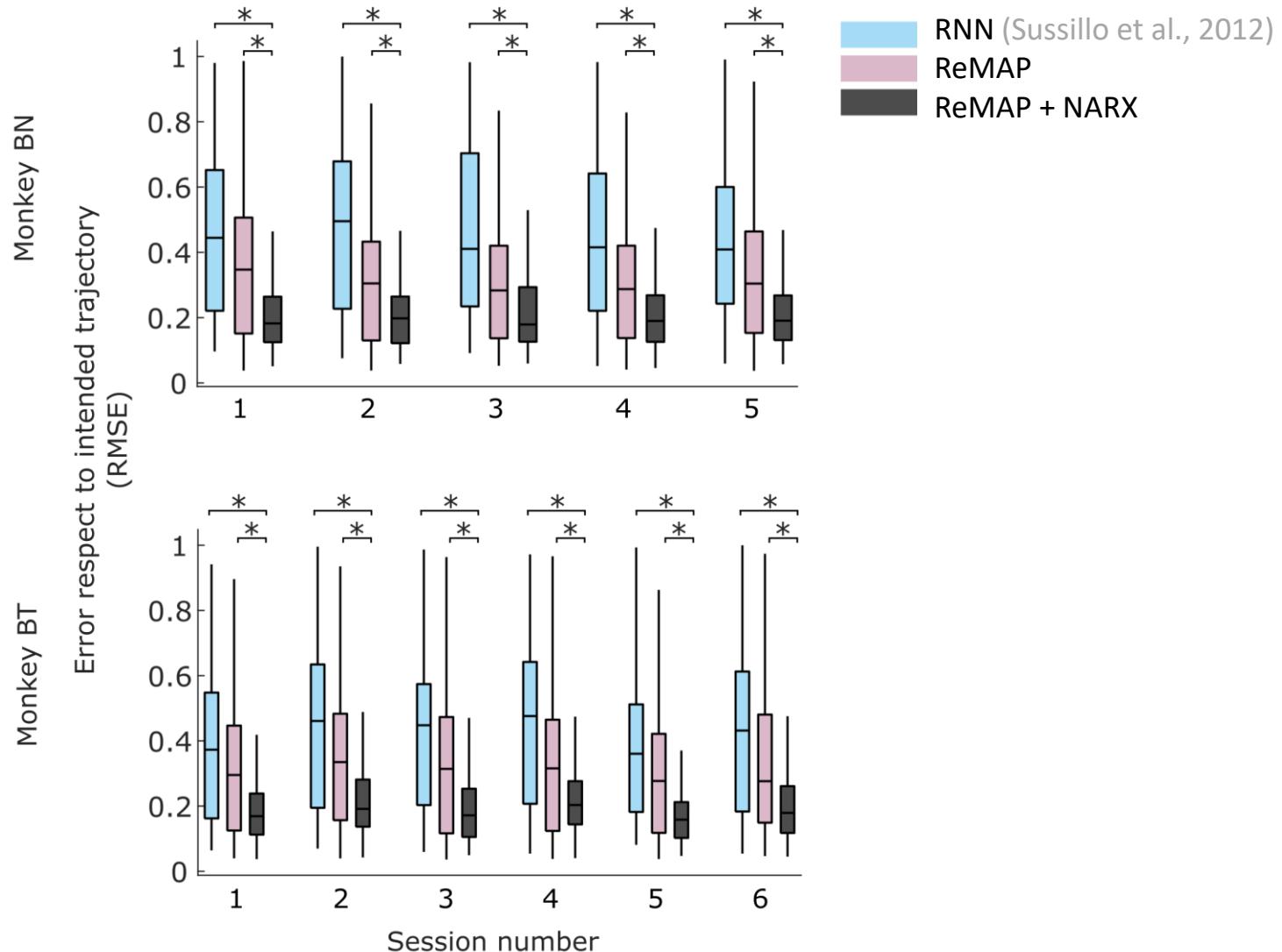
NARX: Nonlinear Auto-Regressive with
eXternal input network



ReMAP KF vs. ReMAP KF+NARX

Only Kalman Filter

NARX adds precision to ReMAP



* $p<0.001$, two-sided Wilcoxon rank-sum test

Conclusion



- iBCIs still lack the capacity to do complex interactions
- Reaching control uses velocity
- The grasping circuit represents position more than velocity
- A trajectory preserving strategy increases performance during iBCI grasping

Thanks for your attention!



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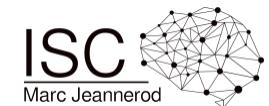
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