Patterns of Motor Cortical Activity Described by the First Latent Dimension Predict Presence of an Object

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INTRODUCTION

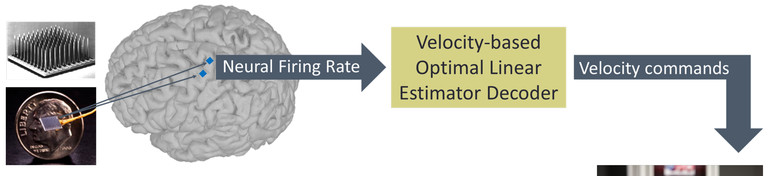
- BCI-controlled robotic neuroprosthetics restore upper-limb function in a laboratory setting. [1]

- Past work has shown difficulties interacting with objects using a BCI.
- We use factor analysis to analyze sources of firing rate variation during reaches to objects.

METHODS

Setup:

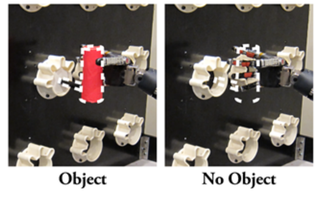
- Two 88-channel intracortical microelectrode arrays were implanted in the hand and arm region of the primary motor cortex in a 28-year-old male with tetraplegia.



- A decoder was trained to transform neural data recorded from the electrode arrays into endpoint velocity commands for a robotic arm.

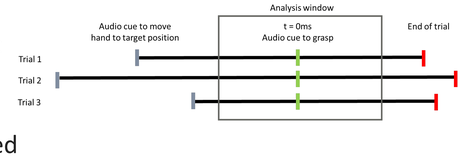
Task:

1. Reach arm to a specified location
2. Grasp object there or close fingers



Analysis:

- Neural spike counts binned into 40 ms time bins
- Trials aligned to start of grasp phase
- Unsuccessful trials excluded
- Factor analysis on binned spike data 2 sec before to 2 sec after start of grasp phase
- First 10 factors identified



RESULTS

Success Rates:

Object	No Object
70.9%	90.0%

Table 1. The participant showed a marked decrease in success on object trials vs. no-object trials.

Condition-Dependent Modulation of Neural Trajectories in a Single Latent Dimension:

- The object trajectory is heavily modulated in the first latent dimension.
- The object and no-object trajectories in the second (or later) latent dimensions modulate together.

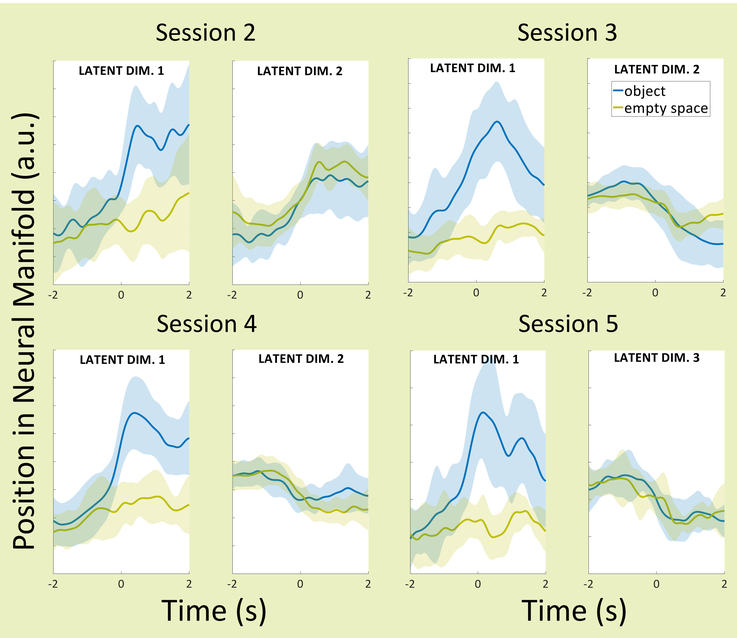


Figure 1. Average single dimensional neural trajectories in the first several latent dimensions ± SD. t=0 ms indicates the start of the grasp phase. Test Session 1 not shown. For test sessions 2 – 5, there was a significant time*condition interaction in the first latent dimension ($p < 0.0001$ for all).

ACKNOWLEDGEMENTS

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RESULTS

Temporal Profile of Neural Trajectory Separation:

The greatest separation between neural trajectories by condition occurred at 460 ms (SD = 80 ms)

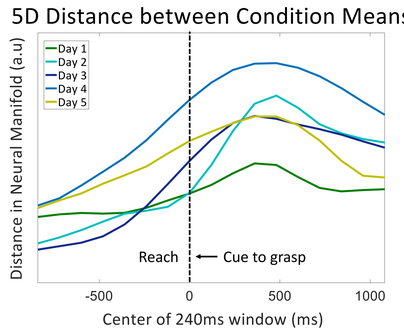
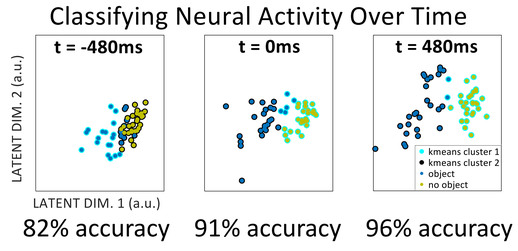


Figure 2. Neural trajectories were broken into 240 ms snippets, which were then averaged to single points. The 5-dimensional Euclidian distance between the centers of the object and no-object point clusters are plotted over time.

Prediction of Task Condition from Latent Neural Activity:

Task condition can be predicted from latent neural activity using Kmeans algorithm with up to 96% accuracy

Figure 3. Averaged 240 ms snippets of neural trajectories were sorted with Kmeans clustering algorithm at different time points. Kmeans classification accuracies are shown below each.



CONCLUSIONS

- There is clear separation of object and no-object conditions in the first latent dimension, suggesting that it functions as an object detector.
- The greatest separation between conditions occurs around 460 ms after the cue to grasp, most likely the time at which the participant actually performed the grasp.
- Task condition can be predicted by latent neural activity.

REFERENCES

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