II-56

Preparatory tuning in premotor cortex ‘represents’ upcoming movement activity

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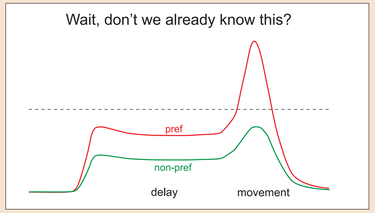
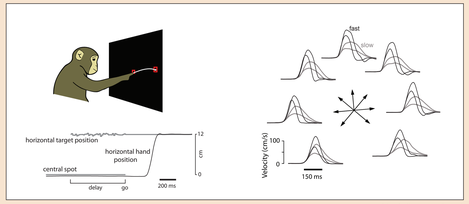
What is preparatory activity in motor and premotor cortex tuned for?

What is the relationship between preparatory and movement-related activity?

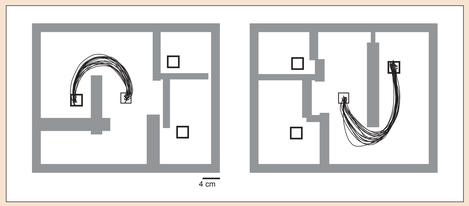


Task



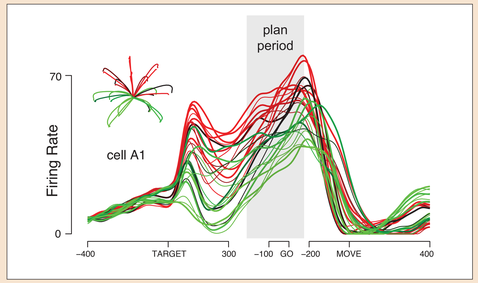
speed task (two monkeys)

or

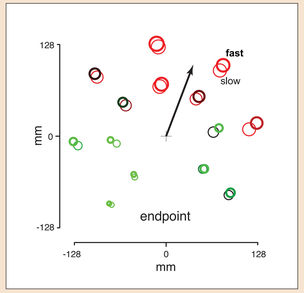


maze task (one monkey)

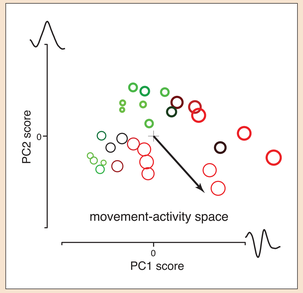
If we wish to use a PD to capture preparatory tuning, what space should it live in?



A traditional space?



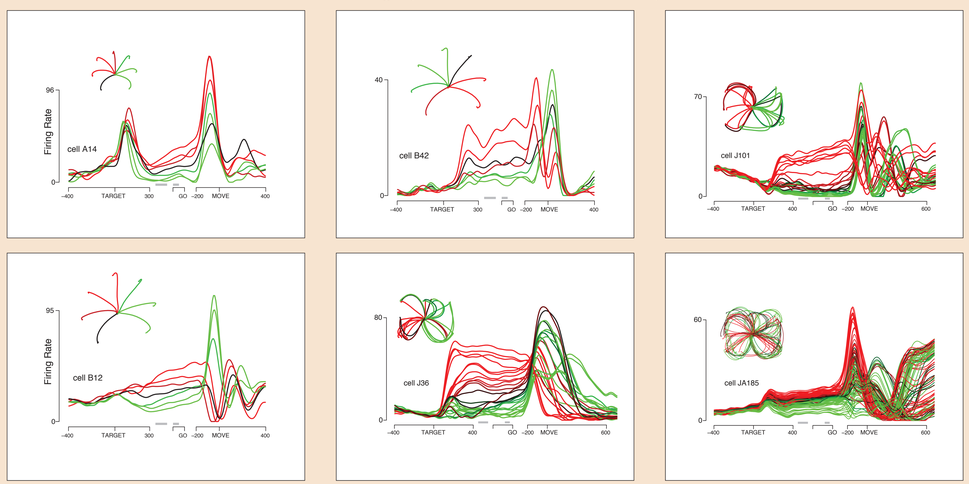
A space that describes population-level movement activity?



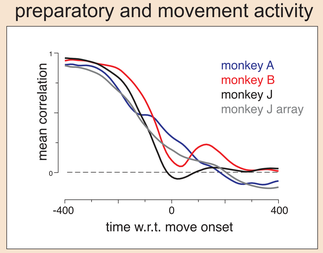
Goals of the rest of this poster:

1) Explain what on earth the ‘movement-activity space’ is.
2) Demonstrate that the PD works best in that space.
3) Illustrate that in retrospect this all makes perfect sense.

Recordings (PMd and M1, ~400 neurons)

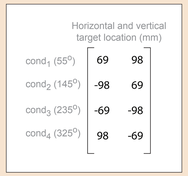


Correlation between preparatory and movement activity



There is no straightforward relationship between a neuron’s preparatory activity and **its own** movement-related activity.

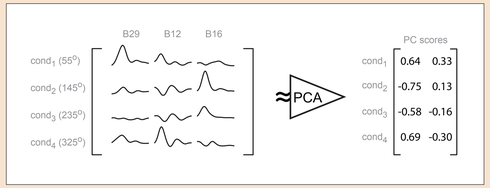
Locating the conditions in different spaces



Easy for the traditional spaces:

Just describe each condition in terms of a few measurements.

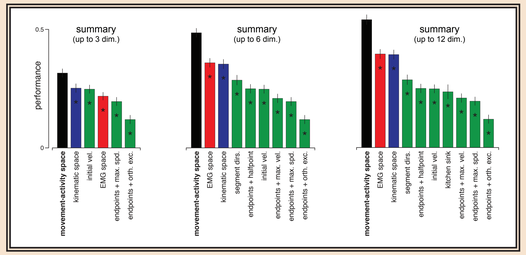
For the movement activity space, we have too many measurements.



The data matrix is c by nt. We reduce its dimensionality to c by k.

The conditions now live in a k dimensional space.

Ability of the PD to capture preparatory tuning

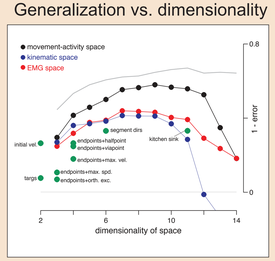


The PD works best when expressed in a space that describes upcoming movement-period population activity.

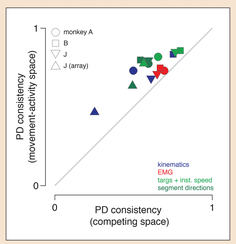
For each neuron, we parameterize the conditions as above, based on a marix derived from all the **other** neurons.

We regress that neuron’s delay-period firing rate against target condition in the k-D space. One condition is left out, and we assess generalization.

Generalization vs. dimensionality



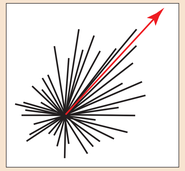
How stable are the PDs?



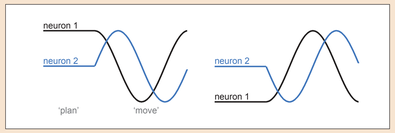
Generalization is best for the movement-activity space.
PD stability is best for the movement-activity space.

Two very different views of preparatory tuning:

View #1: Plan activity represents movement parameters (things like reach direction, distance and speed). This representation is decoded to determine what movement will be made.

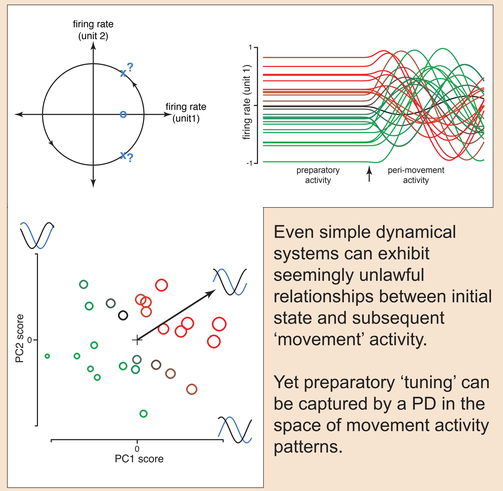


View #2: Plan activity initializes the state of a dynamical system. Nothing is explicitly represented. The ‘readout’ occurs implicitly as the state of the system evolves.



In this view the motor cortices are not an engine for representing movement, they are an engine for generating movement. Motor planning involves the initialization of the state of that engine, not the specification of movement parameters.

An interpretation



Even simple dynamical systems can exhibit seemingly unlawful relationships between initial state and subsequent ‘movement’ activity.

Yet preparatory ‘tuning’ can be captured by a PD in the space of movement activity patterns.

Conclusions

(1) Preparatory activity is lawfully related to movement activity, at the population level.

(2) The nature of this relationship is consistent with the notion that preparatory activity provides the initial state of a dynamical system

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