behavioral effect in the primate arm-motor system. Stimulation delivered $>$200ms before the movement cue (early-stimulation) did not affect RTs, suggesting that PMd can recover from optogenetic disruption on a rapid timescale. We computed the difference in PMd/M1 population firing rates on stimulated versus non-stimulated trials. Both early- and late-stimulation pushed neural state significantly away from non-stimulated trajectories. By movement onset, neural differences largely (though not completely) decayed for early stimulation trials, whereas these differences persisted into the movement time for late-stimulation trials. Therefore, targeted optogenetic perturbation of premotor cortical activity can disrupt motor preparation by diverting neural activity onto a distinct, presumably less-beneficial peri-movement trajectory.

III-61. Characterization of dynamical activity in motor cortex

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There has been increasing interest recently in understanding the role that internal dynamics play in the response of neural populations, in both sensory [1] and motor systems [2]. In particular, [2] has recently shown evidence of consistent, internally-driven dynamical activity in populations of motor cortical neurons by focusing on rotations in the neural state space. However, that work stopped short of exploring other dynamical features or characterizing their dominance. Here we characterize the structure of neural population dynamics by studying canonical features including: i) expansive vs. rotational structure (the two building blocks of simple linear systems); ii) time invariance vs. variance (to examine the temporal complexity of data); and iii) normality vs. nonnormality (a feature of theoretical importance due to its connection to Hebbian vs. balanced amplification [3]). Here we present algorithms that enable analysis of all these dynamical features. While time invariance vs. variance can be studied with simple least squares, the other features require novel contributions. Expansive systems are fit using new extensions to the method in [2], and fitting normal systems requires extensions to and combinations of classic results from differential geometry and linear algebra, which we derive below. We use these novel methods to analyze data from motor cortex. Despite the simplicity of the linear time invariant model, we show that activity across many different experimental conditions has consistently strong dynamics fitting this model (48.5% of the data variance is explained), and furthermore that the linear time invariant component is highly normal and rotational (93.2% and 91.3% of the time invariant system, respectively). In contrast, the time invariant system has trivial expansive component (8.7%). In all, this work deepens the characterization of dynamics in motor cortex and introduces analyses that can be used similarly across other cortical areas.

III-62. Decoding arm movements from hybrid spike-field potentials in human motor cortex

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Action potentials recorded in motor cortex offer an information-rich input to motor prosthetic applications, yet recording stable spiking activity from the same neuronal population across months to years is an unresolved