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Presentation Abstract

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Title:	Gaussian process factor analysis for low-dimensional single-trial analysis of neural population activity
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Abstract:	Neural responses are typically studied by averaging noisy spiking activity across multiple trials to obtain firing rates that vary smoothly over time. However, particularly in cognitive tasks (such as motor planning or decision making), the timecourse of the neural responses may differ on nominally identical trials. In such settings, it is critical that the neural data not be averaged across trials, but instead be analyzed on a trial-by-trial basis (Churchland et al., Curr Opin Neurobiol, 2007). With the ability to record simultaneously from a neural population (tens to hundreds of neurons) and building on evidence that firing rates vary smoothly over time (Afshar et al., SFN, 2008), we consider techniques for extracting a smooth low-dimensional "neural trajectory" summarizing the recorded activity on a single trial. A traditional approach is to first estimate a smooth firing rate profile for each neuron on a single trial (e.g., by convolving each spike train with a Gaussian kernel), then apply a static dimensionality reduction technique (e.g., probabilistic principal components analysis, PPCA, or factor analysis, FA). We developed a novel alternative approach, Gaussian process factor analysis (GPFA), which performs the smoothing and dimensionality reduction operations simultaneously rather than serially. This

allows the degree of smoothness and the relationship between the low-dimensional "neural trajectory" and high-dimensional recorded activity to be jointly optimized. We applied these techniques to data recorded simultaneously from 61 single and multi-units in premotor and motor cortices while a rhesus macaque performed a center-out delayed reaching task (monkey G). To evaluate model goodness-of-fit, we left out one unit at a time and asked how well each technique could predict the activity of that unit, given the activity of all other recorded units. Our findings are as follows: (1) GPFA yielded the lowest prediction error, followed by FA and PPCA. (2) The dimensionality of the linear subspace within which the recorded neural activity evolved during reach planning and execution for a single target ranged from 8 to 10. (3) For each of the 14 reach targets, the extracted low-dimensional neural trajectories converged during the delay period, an effect which previously could only be inferred indirectly (Churchland et al., J Neurosci, 2006). The techniques reported here should facilitate studies that involve tracking a subject's instantaneous neural / cognitive state.

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