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Presentation Abstract

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Abstract: In order to act, we must make decisions about what action to take. Our choices may be 'forced' when only one action is available, or we may have 'free choices' when multiple good options present themselves. Moreover, we may acquire additional information mid-decision, prompting a change of mind. Behavioral observations of changes of mind have previously been made by Resulaj et al. (Nature 2009); we examined the covert neural processes that occur during decision-making by combining a novel 'decision-maze' paradigm with large-scale simultaneous neural recordings and recently developed single-trial analytical tools. The task was a variant of the delayed-reach 'maze' task, described previously (Kaufman et al., J Neurophys 2010; Churchland et al., Neuron 2010). Monkeys initiated each trial at a central fixation spot, and were then presented with two targets and intervening virtual barriers. After a random delay period, a go cue was given and the monkeys had to make curved reaches around the barriers to reach either of the targets. The barriers on each side could be in easy, difficult, or impossible configurations, and one barrier could move at a random point in the trial. This task therefore allowed us to examine the course of neural events in forced, free, impossible, and change trials. Single- and multi-unit activity was recorded with dual 96-electrode Utah arrays in each of two monkeys, with one array placed in dorsal premotor cortex and one in primary motor cortex. Gaussian

Process Factor Analysis (Yu et al., J Neurophys 2009) was used to extract low-dimensional single-trial neural trajectories. Choice prediction from neural data appears reliable using simple methods even at fine timescales: using a single time point 100 ms post-Go (before movement activity begins), 97% of forced-choice trials were correctly predicted in leave-one-out cross-validation; 91% of free-choice trials were correctly predicted. On single trials, we have been able to visualize the neural correlates of 'changes of mind' when biasing changes occur, where previously they could only have been inferred statistically. On 'free-choice' (no-change) trials, evidence for vacillation during the delay period is present on 6-13% of trials. Since vacillation is a fully covert process, it had not previously been known whether it was present in monkeys in the absence of additional external information. This combination of rich behavioral task, array recordings, and single-trial analysis methods opens the doors to better observing the dynamics of unique events, such as decision-making, changes of mind, and error trials.

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