Talk 303

Variation, signal, and noise in sensory-motor processiong

(NEI R01-EY017210 FY 05)

Stephen G. Lisberger
University of California, San Francisco

William Bialek
Princeton University

Even Tiger Woods cannot replicate the same perfect golf swing over and over. Some motor variation is inevitable, even in well-practiced movements, which can be remarkably consistent over repeated trials. In contrast, the responses of individual neurons to identical presentations of the same stimulus are conspicuously variable, and this has led to the notion that the activity of many neurons must be pooled to average out the noise. How the brain achieves "reliable computation with unreliable components"[8] will depend on the response variation of individual neurons, and more importantly, on how much of the variation carries information versus how much reflects neural noise. To evaluate the sources of neural variation at an intermediate stage in sensory-motor processing, we have recorded the trial-by-trial responses of individual Purkinje cells in the floccular complex of the cerebellum while monkeys generated smooth pursuit eye movements to repeatedly track a moving stimulus. We found that the contribution of signal, variation, and noise to Purkinje cell variation is dynamically modulated across the different phases of the pursuit movement. During the initiation of pursuit, a provocatively large fraction of neural variation was related to small trial-by-trial variation in the eye movements, suggesting that activity across the population of Purkinje cells might become transiently correlated at movement initiation due to a shared, sensory-related, noise source. During the steady-state phase of pursuit, in contrast, the trial-by-trial co-variation of neural and behavioral responses was much weaker. The latter data suggest the existence of a mechanism for de-correlating Purkinje cell activity after pursuit initiation, in parallel with the development of a larger contribution to overall neural variation from the accumulation of motor noise.

Publications

1. Medina, J. and Lisberger, S.G. Trial-to-trial correlation between eye movements and the firing of Purkinje cells in the floccular complex of rhesus monkeys Society for Neuroscience Abstracts, 2005.