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# Neuronal responses in the cortical area MSTd during smooth pursuit and ocular following eye movements

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The motion sensitive medial superior temporal (MST) area has been implicated in a variety of functions such as smooth pursuit (SP) generation, self-motion perception, and coding of visual target motion. For self-motion perception, the dorsal part of MST (MSTd) is crucial [1], e.g., neurons in MSTd respond to optic flow simulating self-motion. However, about 35% of MSTd neurons also respond to smooth pursuit eye movements, which is difficult to reconcile in the context of self-motion perception. Here, we examined neuronal responses of 55 pursuit-sensitive MSTd neurons recorded in two awake macaque monkeys [2], and related these responses to a computational model of the smooth pursuit system [3].

Four stimulus conditions were applied: 1) step-ramp SP in response to a moving laser spot (5–20°/s), 2) target blanking (duration 100 ms) during SP, 3) ocular following response to moving visual large-field (LF) stimuli (5–20°/s), 4) visual perturbation (5 Hz sinusoid, ±10°/s) of target or LF motion [2]. Most neurons (n = 49) also responded during LF stimuli, but with different characteristics: 1) the preferred direction for LF was opposite to that of SP, and 2) for LF stimuli, neuronal responses preceded eye movement onset by 34.1 ms, but lagged behind eye movement onset during SP by 128 ms. Target blanking led to a transient decrease in eye velocity, but not to a change in neural responses (n = 22). Perturbations during LF motion or SP consistently caused changes in eye velocity. However, while 93% of the tested neurons (n = 15) responded to LF perturbations, only 33% (of 55) responded during SP. Again, neuronal perturbation responses preceded changes in eye movement for LF, but lagged behind eye movement for SP.

For model simulations, we extended our non-linear pursuit model [3] by appropriate temporal delays. The MST-branch of the model contains an eye-movement related signal, which lags behind the eye by about the same amount as the eye lags behind target motion (120–135 ms vs. 128 ms neuronal delay). This signal, constituting a delayed efferent copy signal, is used to reconstruct target motion in space [4]. Being extra-retinal in origin, it also persists during target blanking, consistent with our data. However, even though these characteristics are in accordance with our model, the major differences between neuronal LF and SP responses despite similar eye movements suggest a different explanation, compatible with earlier findings [5]: if LF motion is interpreted as being caused by self-motion in space, pursuit-sensitive neurons in MSTd would code for gaze velocity in world-centered coordinates.

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