Different pooling of motion information for perceptual speed discrimination and behavioral speed estimation.

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1. INTRODUCTION

The cortical motion system pools information about speed and direction of moving objects across different spatio-temporal channels. We investigated how frequency channels are adaptively pooled for two different methods using textured stimuli where distribution of spatio-temporal frequencies were varied. First, we measured ocular following response (OFR) which are reflexive eye movements driven by speed information extracted by population of speed-tuned neurons in primate areas MT/MST. In the same subjects, we compared OFR performance with perception using a speed discrimination task using the same stimuli.

2. METHODS & STIMULI.

Stimuli: Short presentation (250 msec) of “Motion Clouds” stimuli (Schrater et al. 2000). Stimuli were displayed on a CRT monitor (1280x1024@100Hz) and covered 47° of visual angle. We varied three variables:

* Velocity = 20, 40, 80°/sec;
* Frequency = 0.1, 0.3, 0.4, 0.8;
* Stimulus duration = 0.025, 0.05, 0.1, 0.2, 0.4, 0.8

(Standard deviation around the base frequency; Figure 1 & 2)

Ocular following: Eye movements were recorded through EyeLink1000, using classical paradigm for ocular following Figure 3A (Masson et al 2002). Speed discrimination task: We use a classical paradigm (constant stimuli) with reference velocity (51) at 20°/sec and target velocity (52) at +/- 1, 2, 4, 8, 16 °/sec. The stimulus target is associated to red fixation point but the order of presentation (reference/target) is randomly inverted for every trial Figure 4.

We measured magnitude of OFR as a function of these three variables, to elucidate the spatio-temporal channel characteristics for perceptual speed detection. In parallel, we compared these behavioral results with the effects of the same parameters on speed discrimination thresholds and sensitivity. See Figure 2 & 3.

3. OCULAR FOLLOWING: SPEED DETECTION

Contrary to gratings that are completely represented by a single Fourier component parametrized by its central frequency (spatial and temporal), and phase, we use texture-like motion stimuli. These are generated by a dense mixing of drifting gratings with random phases (using FT) which produces cloud-like patterns. These “Motion Clouds” are represented in Fourier space by the same central frequency (and therefore the same motion) but with a given Gaussian spread in the speed and spatial frequency domains respectively parametrized by \( \sigma_\nu \) and \( \sigma_f \). Motion energy of these stimuli is therefore perfectly tuned and provides an optimal control of the pooling of noisy information by the visual system. This model allows to vary the bandwidth \( \sigma_f \) of the motion cloud.

Detection vs Discrimination

Experiment setup

4. PSYCHOPHYSICS: SPEED DISCRIMINATION

5. COMPARING SPEED DISCRIMINATION & OFR

6. CONCLUSION

We found that stronger and more reliable OFR when increasing spatial frequency bandwidth of the motion clouds. This suggests that the mechanism driving OFR pools information over a larger set of spatiotemporal channels. Interestingly varying the bandwidth had opposite effects upon speed discrimination performance. This suggests that activating more spatio-temporal channels has a detrimental effect. We propose that motion perception avoids to pool information across overlapping distributions in the speed domain. Thus, outputs of spatiotemporal channels are adaptively pooled for different tasks. Future work will explore the consequences of speed bandwidth upon these motion integration mechanisms.

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