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Letters

Illusory motion reversal in tune with motion detectors

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Occasionally during prolonged viewing, a continuously illuminated moving pattern seems to reverse direction [1]. Kline *et al.* suggested that this illusory motion reversal (IMR) could originate in spurious responses of classical Reichardt motion detectors[2]; however, others consider the phenomenon to be an analogue of the wagon wheel illusion and take it as evidence that the visual system processes the world using discrete samples [1,3–5]. In their recent article supporting the discrete sampling theory, Andrews and Purves [3] highlight a recent finding that IMR occurs most often for stimuli with a particular temporal frequency rather than a particular velocity. In other words, IMR appears to be temporal-frequency tuned. According to Andrews and Purves, this contradicts the theory that the illusion results from spurious responses of Reichardt motion detectors because, they claim, 'Reichardt motion detectors are tuned to velocity rather than temporal frequency' (p.263).

This last claim, a crucial one for their argument, is erroneous. Only the delay-and-correlate subcomponent of the Reichardt motion unit is velocity-tuned [6]. Full Reichardt detectors, which compute the difference between subcomponents preferring opposite directions of motion, are temporal-frequency tuned [7]. Furthermore, although the subcomponents are indeed tuned to the velocity of a pattern moving in the correct direction, they do not show velocity tuning when responding to a pattern moving in the wrong direction. To see why, imagine that the delay-and-correlate subcomponent is presented with a moving periodic pattern of dots (as in Figure 1A of [2]). First, a dot stimulates the delayed input line of the correlator. Next, although the pattern moves in the 'non-preferred' direction, a second, trailing dot stimulates the undelayed input line at exactly the time necessary to activate the correlator. If the spatial frequency of this hypothetical dot pattern were lowered, the stimulus velocity would have to be increased in order to continue stimulating the detector. This demonstrates that the correlator's activity is not velocity-tuned for motion in the 'non-preferred' direction.

A separate discrete sampling process is therefore not necessary to explain the IMR. The 10–15 Hz tuning of the illusion [4] coincides with the overall frequency tuning of normal human motion sensitivity [8]. This is compatible with the Kline *et al.* theory of rivalry between oppositely-tuned motion detectors [2]. Prolonged stimulation would lead to extreme adaptation of motion units, especially when that stimulation is presented at the temporal frequency for which the system is most sensitive. In turn, this could occasionally allow relatively unadapted detectors selective for the reverse direction to drive the percept.

References

1 Purves, D. *et al*. (1996) The wagon wheel illusion in movies and reality. *Proc. Natl. Acad. Sci. U. S. A.* 93, 3693–3697
2 Kline, K. *et al*. (2004) Illusory motion reversal is caused by rivalry, not by perceptual snapshots of the visual field. *Vis. Res.* 44, 2653–2658
3 Andrews, T. and Purves, D. (2005) The wagon-wheel illusion in continuous light. *Trends Cogn. Sci.* 9, 261–263
4 VanRullen, R. *et al*. (2005) Attention-driven discrete sampling of motion perception. *Proc. Natl. Acad. Sci. U. S. A.* 102, 5291–5296
5 VanRullen, R. and Koch, C. (2003) Is perception discrete or continuous? *Trends Cogn. Sci.* 7, 207–213
6 Zanker, J.M. *et al*. (1999) Speed tuning in elementary motion detectors of the correlation type. *Biol. Cybern.* 80, 109–116
7 Reichardt, W. (1961) Autocorrelation, a principle for the evaluation of sensory information by the central nervous system. In *Sensory Communication* (Rosenblith, W.A., ed.), pp. 303–317, Wiley
8 Snowden, R.J. and Hess, R.F. (1992) Temporal frequency filters in the human peripheral visual field. *Vis. Res.* 32, 61–72

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