

Title: Motion detection mechanisms: Contrasting counter-evidence with evidence to the contrary

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Traditional models of motion detection (Reichardt detector, motion energy model) collect evidence for the occurrence of motion in each of two co-axial directions (e.g., left vs. right) and compare that evidence in an opponency stage. However, an efficient detector should not only collect evidence in favor of a particular direction, but also consider evidence against it. In the 1D case, evidence against one direction equals evidence for the opposite. However, in 2D evidence against one direction corresponds to evidence for all other directions, not necessarily the opposite.

The Bours-Lankheet model, an elaborated Reichardt detector, does collect counter-evidence, namely in the form of spatiotemporal displacements with anti-correlated luminance contrasts. Stimuli rich in such displacements give rise to the reverse-phi motion effect, the reversal of perceived direction when contrast is periodically inverted. The Bours-Lankheet model explains reverse-phi as an inhibition of the detector signaling motion in the direction of the displacement, contrary to earlier efforts that explain the effect as an excitation of detectors tuned to the opposite displacement (e.g., motion energy model).

We present evidence for the use of counter-evidence from extracellular recordings of cells in macaque V1 and MT. We recorded a pair of tuning curves from each cell using single-step lifetime random dot patterns with either constant contrast (CC) or inverted contrast (IC) across the step. The peaks of the CC/IC tuning curve pairs were in opposite directions, confirming that the responses of V1 and MT cells are consistent with the reverse-phi effect. Crucially, in the motion-direction where V1 CC tuning curves had a peak, the IC tuning curves overwhelmingly exhibited a trough of similar width and shape. This is consistent with inhibition by counter-evidence as proposed by Bours and Lankheet and inconsistent with the traditional motion energy and Reichardt models.

In contrast, MT cells displayed a high similarity between the opposite peaks of the CC and IC tuning curves. While this pattern is consistent with the motion energy model when considered in isolation, our findings as a whole suggest that once counter-evidence is taken into account in striate cortex, the outcome of this computation is forwarded to extrastriate motion areas.

Our data provide strong electrophysiological support for the Bours-Lankheet model and show that primate motion mechanisms not only gather evidence for a particular motion direction and its opposite (motion opponency) but also take counter-evidence into account. Presumably the goal of this mechanism is to increase the sensitivity of motion detection.

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