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◆ **First-order, second-order, and third-order motion systems**

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This focussed review of computational theories of the psychophysics of human motion-direction discrimination begins in the 1980s with the introduction of Fourier, Reichardt. and motion-energy models by Watson and Ahumada. van Santen and Sperling, Adelson and Bergen, and others for what is now regarded as first-order motion.

Exceptions to first-order motion theories were noted by Braddick, Cavanagh, Derrington, Kncnclcrink. and many others. Chubb and Sperling (1988) used drift-balanced stimuli to derive a formal theory to differentiate Fourier from non-Fourier motion phenomena (now called first-order and second-order motion). Lu and Sperling (1995) proposed a functional architecture of motion perception that further incorporated a third-order motion system.

All three motion systems receive an input that is a function of x, y, t, and all utilise a similar motion-energy algorithm. The inputs are: for first-order, point-contrast (the deviation of point luminance from mean luminance): for second-order, local feature density (the output of circularly symmetric 'texture grabbers'); for third-order, local salience (whether x, y, t, is figure or ground).

Besides the type of stimuli processed, characteristics that differentiate the systems are: temporal cutoff frequency (first and second 10- 12 Hz, third, 3-5 Hz), eye of origin (first and second are monocular, third is indifferent to alternation of stimuli between eyes); and the selective effects of brain lesions, gain-control, motion adaptation, attention (influences only third order). and which nonmotion tasks interfere with motion perception.

A phase independence paradigm in which superimposed same-direction motion stimuli cancel each other when they are processed in the same motion system is used to establish system independence. Finally, successful resolutions of some challenges to the three-systems theory arc considered as well as its relation to the subsequent presentations.