Motion Perception

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Why Motion?

- Detect prey/predators
- Greater consequences for moving things
- Leibold Gisela (LM), cerebral akinetopsia/ motion blindness

How We See Things that Move:

The Strange Symptoms of Blindness to Motion

The patient had great difficulty pouring coffee into a cup. She could clearly see the cup's shape, color, and position on the table, she told her doctor. She was able to pour the coffee from the pot.

But the column of fluid flowing from the spout appeared frozen, like a waterfall turned to ice. She could not see its motion. So the coffee would rise in the cup and spill over the sides.

More dangerous problems arose when she went outdoors. She could not cross a street, for instance, because the motion of cars was invisible to her: a car was up the street and then upon her, without ever seeming to occupy the intervening space.

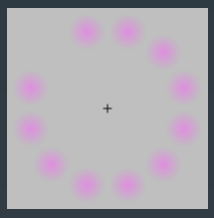
Even people milling through a room made her feel very uneasy, she complained to Josef Zihl, a neuropsychologist who saw her at the Max Planck Institute for Psychiatry in Munich, Germany, in 1980, because "the people were suddenly here or there but I did not see them moving."

Unable to see motion, Gisela Leibold feels anxious as she rides down an escalator in Munich.

Outline

1. Basic Phenomena, Neural Mechanisms
2. Observer-Environment Interaction
3. Properties of Objects from Motion
4. Applications for Visual Design

Sources:
Sekuler et al., Motion Perception
Palmer, Vision Science: 5.4, 10.1-10.3
Bartram, "Perceptual and Interpretive Properties of Motion for Information Visualization"
Huber & Healey, "Visualizing Data with Motion"

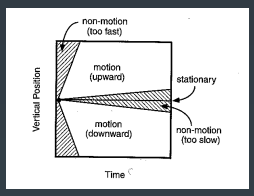


1. Basic Phenomena, Neural Mechanisms

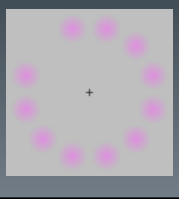
Image Sources:
-Wikipedia, Phi Phenomenon
-David Heeger, NYU, http://www.cns.nyu.edu/~david/courses/perception/lecturenotes/motion/motion.html

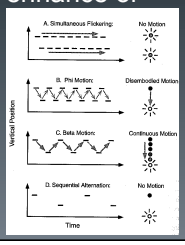
1.1 Physical stimuli for motion

- Continuous motion (relative motion, e.g., gridlines in background=lower threshold)



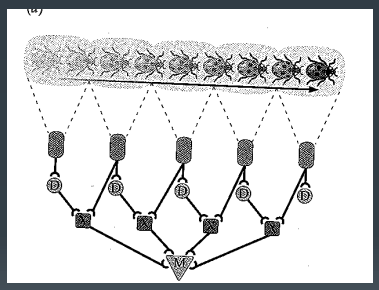
- Apparent motion: flicker 40 Hz (no motion), phi, beta 10 Hz, sequential alternation 2 Hz (no motion)
- Korte's laws: separation, rate, and intensity can enhance or reduce apparent motion perception





1.2 Reichardt motion detectors

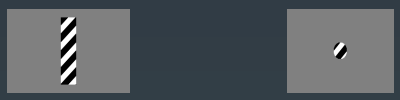
- Apparent motion: Change in position of image on retina ≠ motion perception
- Reichardt detectors can account for real and apparent motion, spatiotemporal window of visibility (Sekuler et al., 148)

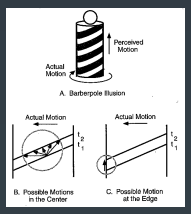


- "… not yet possible to trace out specific circuits… to test the theories" (Palmer, 486), but plausible as low level motion detector
- e.g., V1 cells show directional selectivity (Hubel & Weisel, 1968); waterfall motion aftereffect demonstrates this property

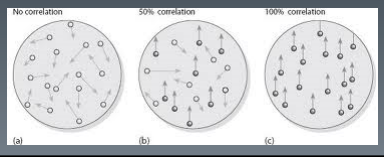
1.3 MT cortex

- First-order (luminance-based) motion vs. second-order (e.g., texture-based) motion= non-reichardt (Sekuler et al., 148-9)
- Aperture problem- small receptive field means motion direction is ambiguous, e.g., barberpole illusion



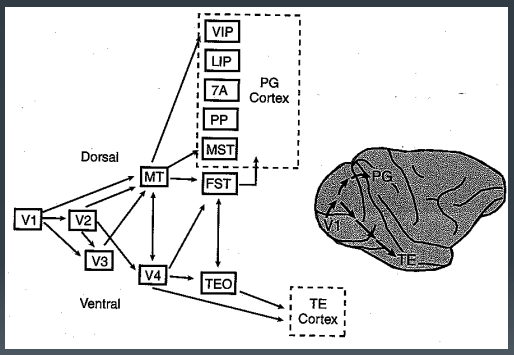


- Thus, local directional motion signals from V1 neurons must be integrated at "higher" cortical area
- Random Dot Kinematograms: macaque's perception of motion closely corresponds to firing of MT cells

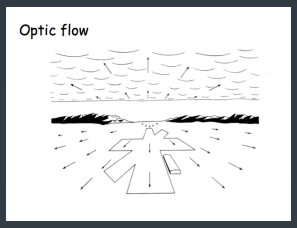


1.4 Higher motion areas in cortex

- V1 feeds directly and indirectly to MT; also feedback (resonance = conscious perception of motion? Sekuler et al., 125)



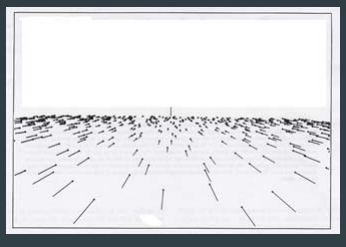
- MST= rotation and expansion/contraction, i.e., spirals; optic flow
- STS= biological motion module?



2. Observer-Environment Interaction

2.1 Optic Flow

- Instantaneous velocity field (direction and speed in retinal image) ; Role of optic flow in steering & wayfinding



- Optic-flow field can be reduced to basic types of movement: translation, isotropic expansion, rigid rotation, and shear
- Recall MST neurons: direct stimulation in monkeys alters judgments of heading direction (Sekuler et al., 138)

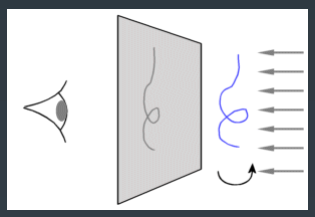
2.2 Optic Flow in Humans

- People do make use of optic flow to guide themselves
- Task: head-mounted display, walk as quickly as possible to visible target, e.g., doorway
- Egocentric coordinates and optic flow usually coupled, but when subjects are fed contradictory information, they follow the misleading optic flow
- Aging diminishes capacity to use optic flow, poorer spatial navigation ability in Alzheimer's patients

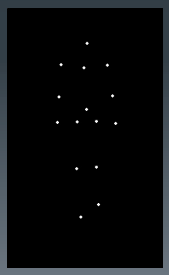
2.3 Collision Perception

- Time to collision: Travel distance / travel rate

- Tau: current retinal image size / rate of change in image size
- E.g., diving Gannets' wing tuck
- However, this fails to predict collision under certain conditions (e.g., gravity-induced acceleration, very slow approach)

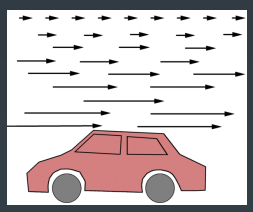


3. Properties of Objects from Motion

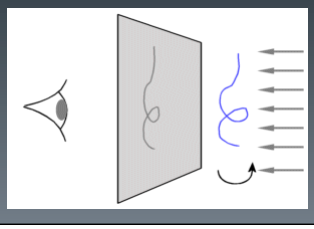


3.1 Depth from Motion

- Motion Parallax: closer objects traverse retina at faster pace than farther objects
- Used by Praying Mantids



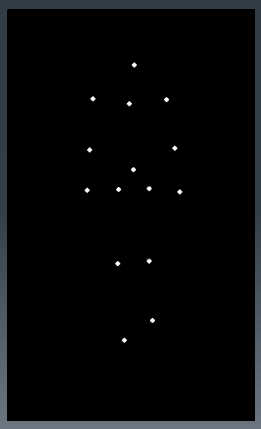
- Rotating objects: rigidity heuristic allows us to see wire as 3-d object when projected onto 2-d screen



3.2 Biological Motion

- Specialized ability to perceive biological motion, brain area: STS
- Double dissociation between translational and biological motion

- Brief view: gender, activity, emotional state
- 3 month olds can discriminate
- Not only first-order (luminance-defined) motion, also texture-defined



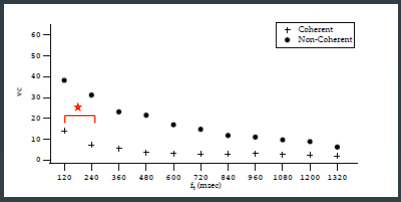
4. Applications for Visual Design

4.1 Bartram

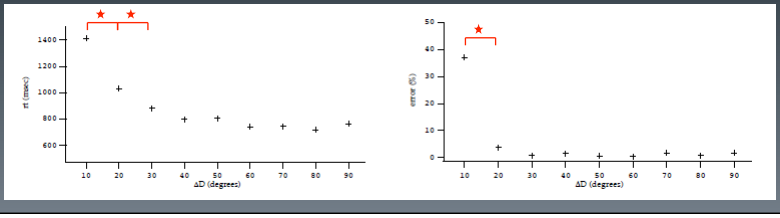
- Motion to represent abstract meaning
- Motion may be used to alter user to important changes and to track values without increasing cognitive overhead, especially in the periphery
- Gestalt grouping principle of common fate for multiple similar motions
- Data relationships: causality (based on social psychology research)

4.2 Huber & Healey

- Response Time and Accuracy to differences in motion properties (Flicker rate, Direction, Velocity) between target and background items
- Target flicker rate (120 msec):

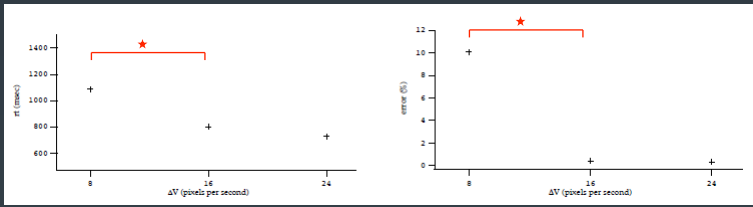


- Direction difference (RTs ≤ 20 degrees, Acc = 10 degrees):



4.3 Huber & Healey (Cont'd)

- Velocity difference (8 pixels per second):



- Conclusion: use at least minimum difference to distinguish target from background motion in order to ensure efficient (quick and accurate) target search

Conclusion

- Changes in retinal image contribute to motion perception, but it is ultimately a construction of the cortex
- Observer in action benefits from optic flow
- Optic flow is helpful for navigation
- Motion allows us to perceive other characteristics of objects
- Biological motion is particularly informative
- Motion underutilized as encoder of information in visual displays
- Be sure to exceed threshold for detecting target motion