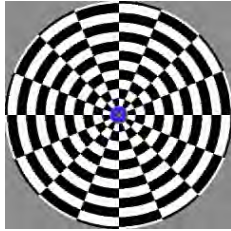
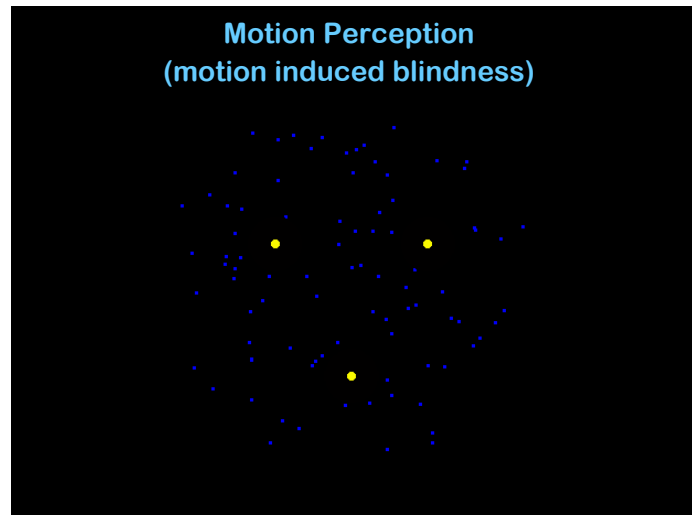


Motion Perception



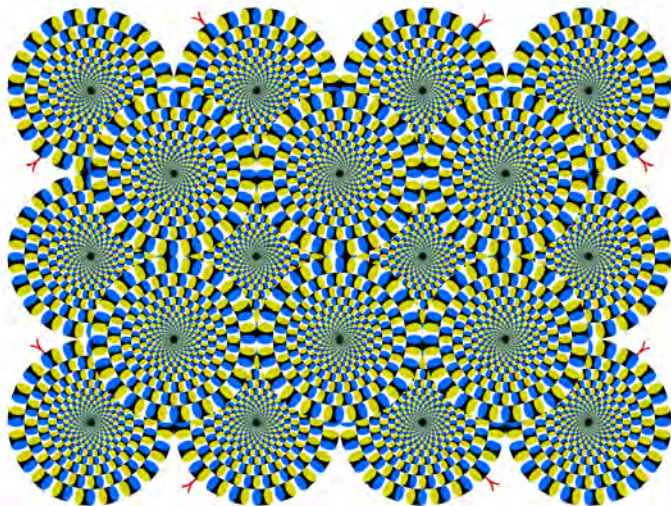
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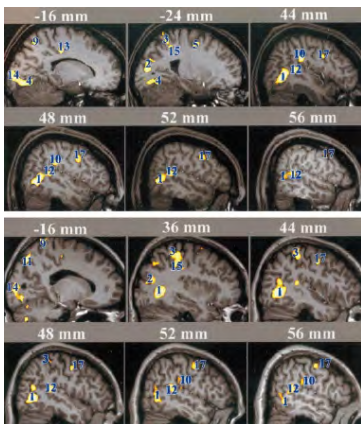
Motion is critical for visual perception

- Without motion there is no vision!
- Motion breaks even perfect camouflage
 - Distinguishing objects from their backgrounds (figure-ground segregation)
- Perception of 3D layout of objects in the world
- Judging heading as we move through the environment, and perceiving “time to collision”
- Perceiving actions and intentions of other biological creatures
- Guiding balance and posture
- Oh yeah, perception of moving objects

4



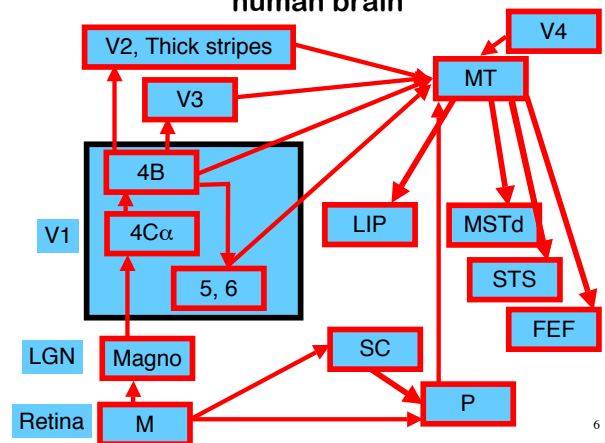
30+ Motion-responsive regions of the human brain



Sunaret et al., 1999, Exp. Brain. Res.

5

Some of motion-responsive regions of the human brain



6

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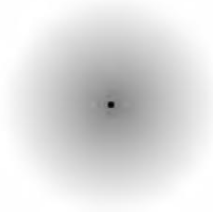
Without motion there is no vision!



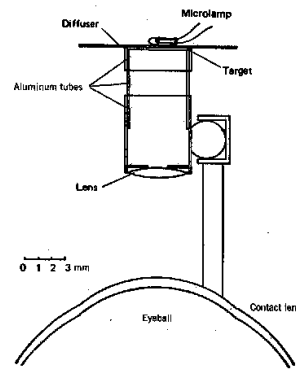
Retinal image is **constantly** moving or jittering:
- saccades & microsaccades

8

Keep staring at the black dot. After a while the gray haze around it will appear to shrink.



Without motion there is no vision!



If retinal image is stabilized, vision fades away in seconds!

retinal image stabilization

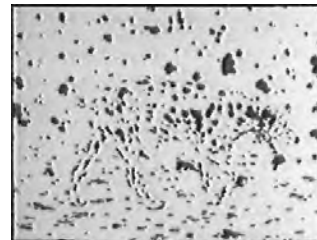
10

Motion is critical for visual perception

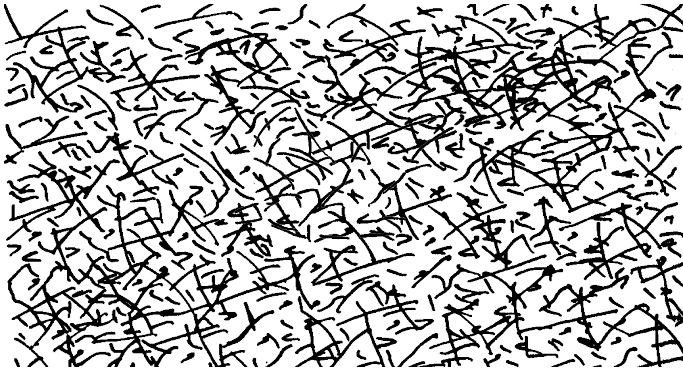
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11

Motion breaks even perfect camouflage



Where is the bird?



Relative Motion Breaks Camouflage
from Regan (2000) Human Perception of Objects

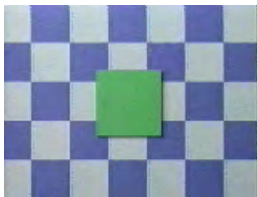
13

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14

•Perception of 3D layout of objects in the world



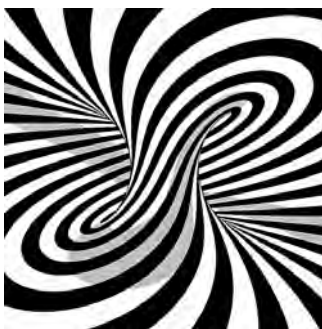
15

•Perception of 3D layout of objects in the world



16

•Perception of 3D layout of objects in the world



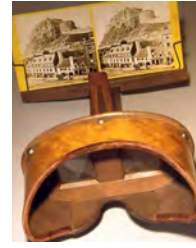
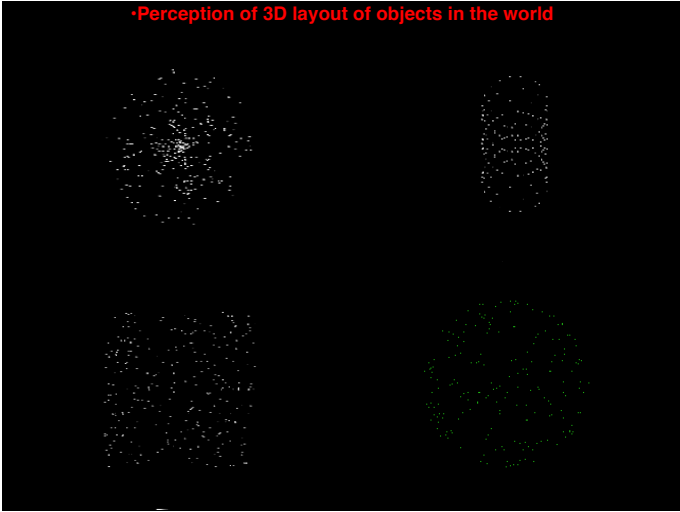
17

•Perception of 3D layout of objects in the world



18

•Perception of 3D layout of objects in the world



LAST WEEK:
Perception of stereo depth requires **two 2D images taken from slightly different positions**, and presented one to each eye

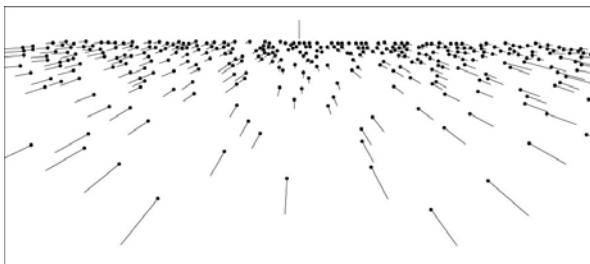
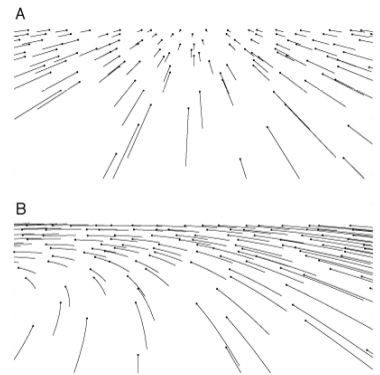
THIS WEEK:
Perception of depth can also be achieved by **two 2D images taken from slightly different positions that are presented in rapid succession (in motion)**



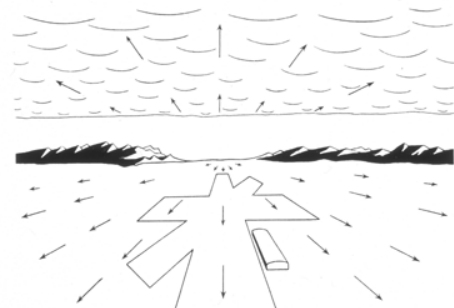
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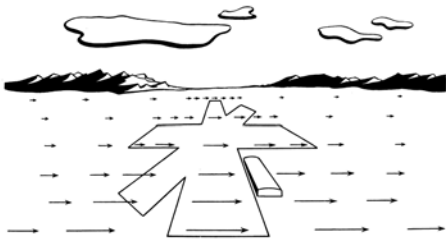
Optic flow



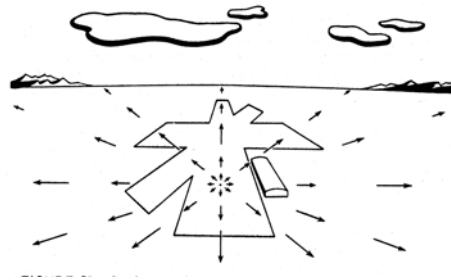
Flow pattern for level flight over the ground in a forward direction



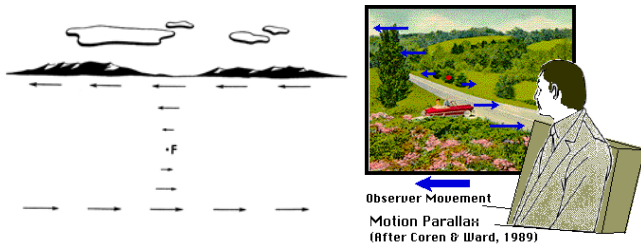
Flow pattern for level flight over the ground in a lateral direction



Flow pattern during airplane landing



Flow pattern for level flight over the ground in a lateral direction while the eye stays focused on a stationary object on the ground



Motion parallax

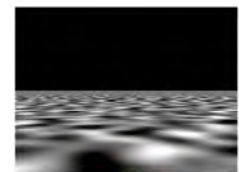
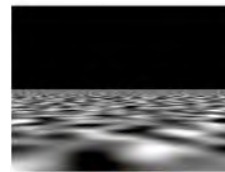
The optic flow pattern can be used to negotiate curves while steering a car.



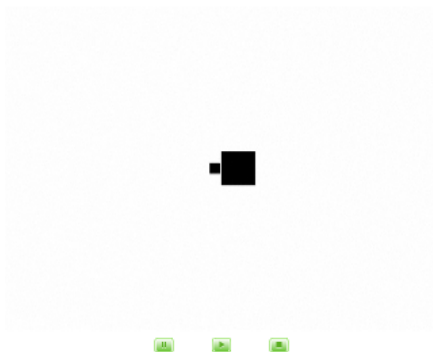
Movement along a straight stretch of road.

Correct negotiation of a curved stretch of road.

Incorrect negotiation of a curved stretch of road. The car will go off the road unless a steering correction is made.



Motion can provide "time to contact" information



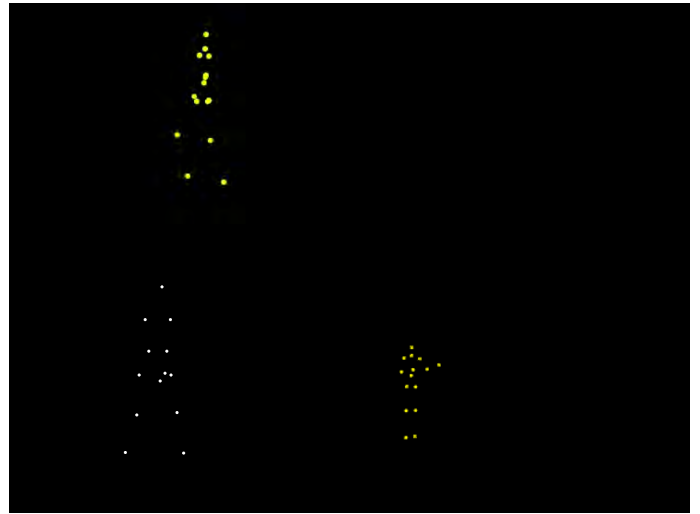
Motion is critical for visual perception

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- Perceiving actions and intentions of other biological creatures
- Guiding balance and posture
- Oh yeah, perception of moving objects

Perceiving actions and intentions of other biological creatures



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Perceiving actions and intentions of other biological creatures



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<http://www.biomotionlab.ca/Demos/BMLwalker.html>

DEMO &
EXPERIMENT

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Motion is critical for visual perception

- Without motion there is no vision!
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- Perception of 3D layout of objects in the world
- Judging heading as we move through the environment, and perceiving "time to collision"
- Perceiving actions and intentions of other biological creatures
- Guiding balance and posture**
 - **together with the vestibular system**
- Oh yeah, perception of moving objects

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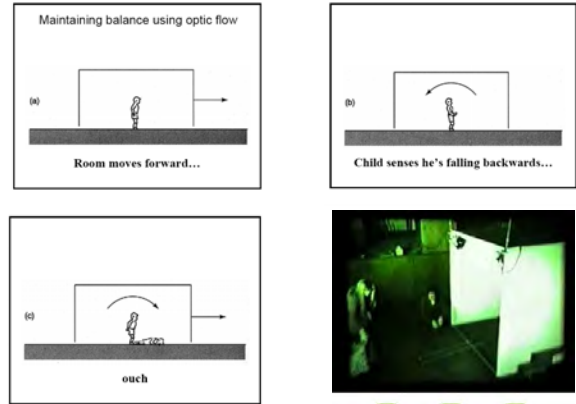
Moving room studies: motion sickness



37

The optic flow pattern is used to maintain balance while standing upright.

Moving room studies



38

Motion is critical for visual perception

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- **Oh yeah, perception of moving objects**

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Basic issues in motion perception

- What is motion?
- Apparent motion
- Contextual effects in motion perception
- Representing motion in space-time plots
- Eye-movements & motion perception
- In-class MAE experiment

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What is motion?



Aristotle:
Motion is a property independent from "location" and "time."



Democritus:
Motion is a nothing more than presence of objects in certain "locations" at certain "times."

41

What is motion in physics?

Sir Isaac Newton:
Motion is a change in position over time.
It seems that Democritus' idea won in physics!



42

What is motion in perception?

- There are several conditions that we perceive motion without any change in location!
- There are pathological conditions in which the patient can perceive locations but cannot perceive motion!



43

Basic issues in motion perception

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Producing motion perception from successively exposed static images: Apparent Motion

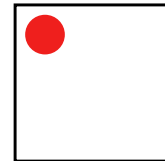


45



Democritus

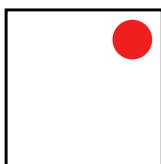
Apparent Motion



frame 1

46

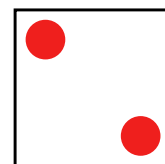
Apparent Motion



frame 2

47

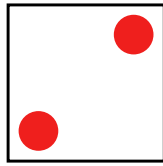
Apparent Motion: two possible paths



frame 1

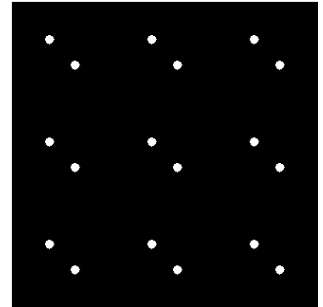
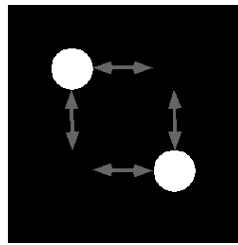
48

Apparent Motion: two possible paths



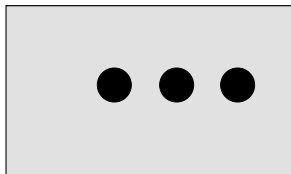
frame 2

Apparent Motion: ambiguous motion paths



Ambiguous Apparent Motion: The Ternus effect

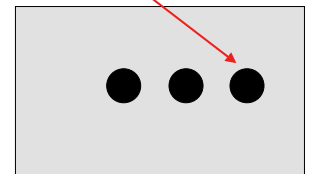
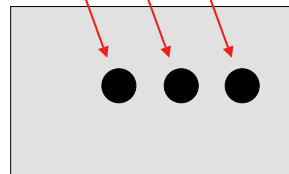
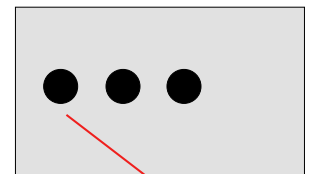
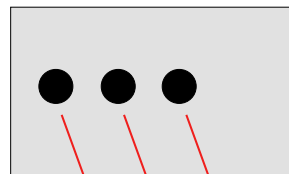
Frame 12



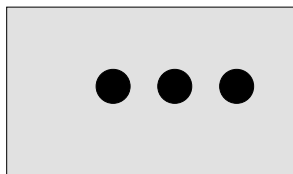
Ambiguous Apparent Motion: The Ternus effect

group motion

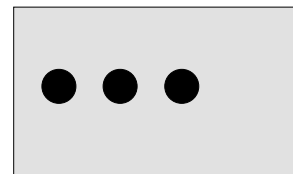
element motion



Ambiguous Apparent Motion: The Ternus effect



Ambiguous Apparent Motion: The Ternus effect

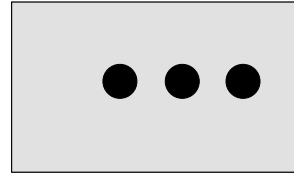


**Ambiguous Apparent Motion:
The Ternus effect**



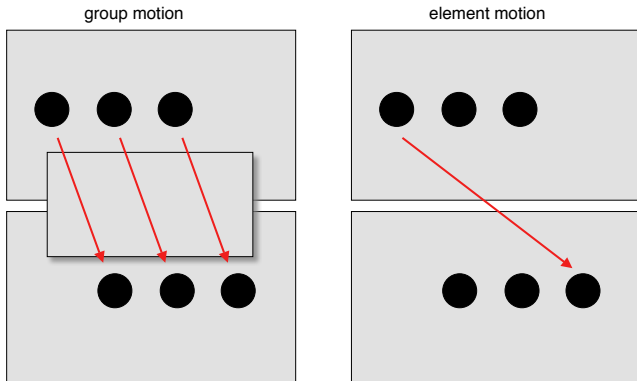
55

**Ambiguous Apparent Motion:
The Ternus effect**

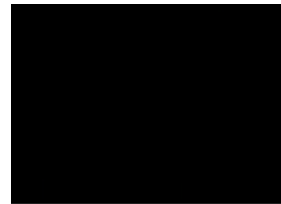


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**Ambiguous Apparent Motion:
The Ternus effect**



Apparent Motion

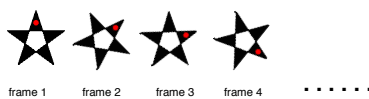


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**Sampling real motion
to produce apparent motion**

Imagine taking a series of photographs of
a smoothly rotating object



<http://www.npr.org/templates/story/story.php?storyId=6668533>



**Sampling real motion:
Wagon wheel illusion**

Sampling is a discrete observation or measurement,
while *Aliasing* is an illusion, appearance of something
that is NOT, due to shortcomings of sampling.



The wagon wheel illusion

If these frames were played in succession, which way would the wheel appear to be rolling - clockwise or anticlockwise?



In a movie this wheel would appear to be moving anticlockwise, when in fact it is rolling clockwise.

Each frame captured by the camera shows the wheel after just under a quarter of a revolution. The brain assumes the wheel has moved the smaller distance - a slight angle anticlockwise with each frame, rather than the bigger rotation clockwise.

The illusion, often seen in old westerns, can be created in real life too, with no camera present, suggesting that the brain creates the perception of continuity from a series of discrete frames, just like a film reel.



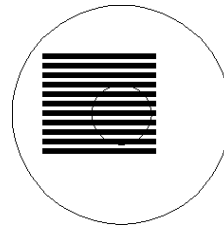
60

Basic issues in motion perception

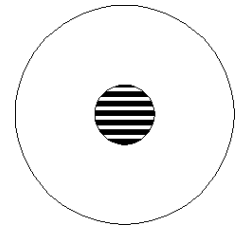
- What is motion?
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Motion perception depends on context: the “aperture” problem



No aperture



aperture

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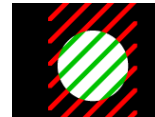
Motion perception depends on context: the “aperture” problem



Barber pole illusion

63

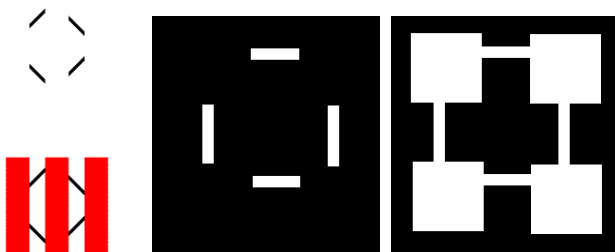
Motion perception depends on context: the “aperture” problem



<http://www.purveslab.net/seeforyourself/>

64

Motion perception depends on context: occlusion illusion



65

Basic issues in motion perception

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66

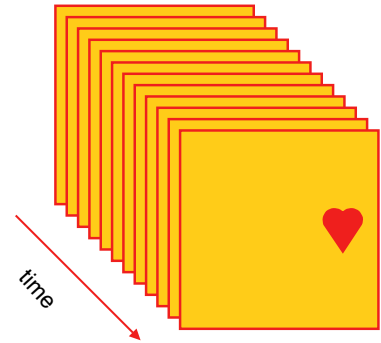
A simple way to think about motion:
The space/time plot



Apparent motion

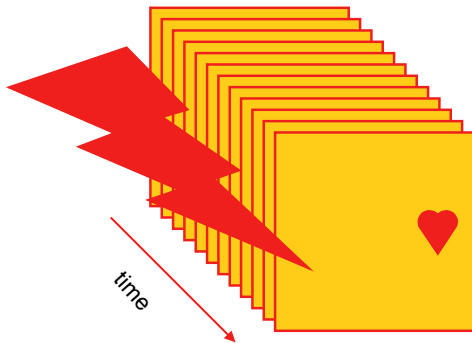
67

The space/time plot



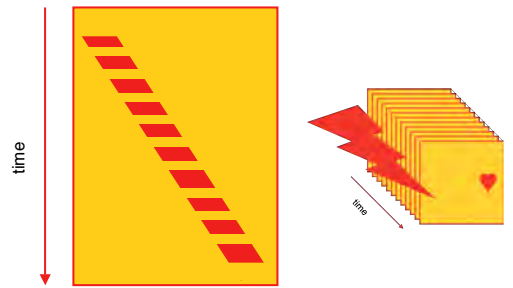
68

The space/time plot



69

The space/time plot



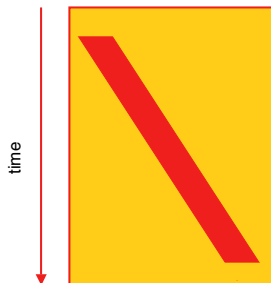
Space

70



Real motion

The space/time plot



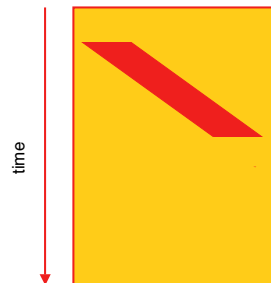
Space

71



Real motion

The space/time plot



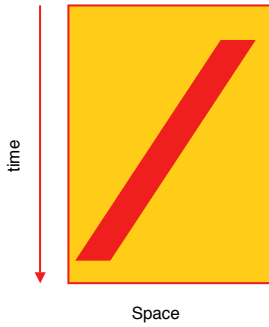
Space

72



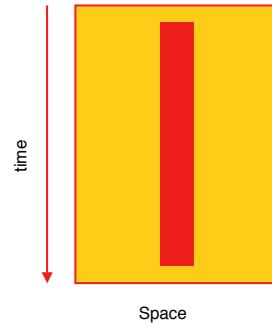
Real motion

The space/time plot



No motion

The space/time plot



How can the visual system detect the “Orientation” of motion energy in space/time?



Does this remind you of another aspect of neural processing that the visual system accomplishes?

Basic issues in motion perception

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“eye” movements a problem for motion perception

Our eyes (and bodies) are inconstant motion. Consequently, the presence of motion on the retina does not require that motion actually occurred in the real world



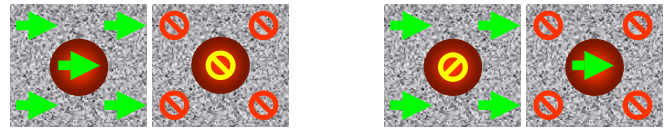
How does the brain sort out **real** motion signals from “fake” motion signals?

NO motion perceived	Motion perceived	retinal motion
Motion perceived	NO motion perceived	No retinal motion
“Eyes” Moving	“Eyes” “Stationary”	

“eye” movements a problem for motion perception

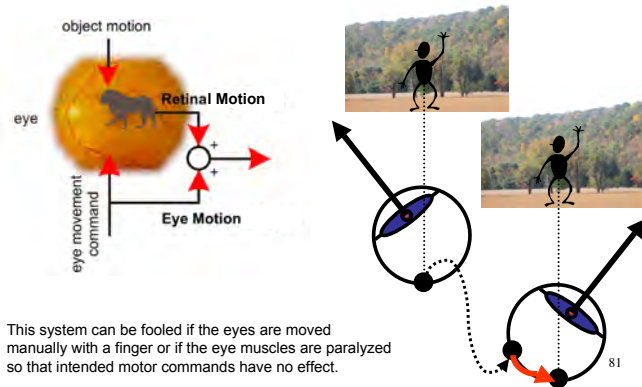
Two solutions:

- insensitivity to large uniform motions
- correcting for eye-movement induced motion
 - corollary discharge: A brain mechanism that allows one to distinguish between self-generated and external stimuli or perceptions.



NO motion perceived 	Motion perceived 	retinal motion
Motion perceived 	NO motion perceived 	
“Eyes” Moving	“Eyes” “Stationary”	Why is the brain not confused by this?

One way of addressing this problem is to exploit information from neural signals to the eye muscles. These signals produce a **corollary discharge** that is compared with the outputs of motion detectors. **If the retinal motion is as expected due to eye movements, then NO motion is perceived.**



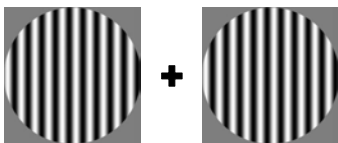
This system can be fooled if the eyes are moved manually with a finger or if the eye muscles are paralyzed so that intended motor commands have no effect.

Basic issues in motion perception

- What is motion?
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MAE experiment

Adapt



Test

