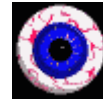
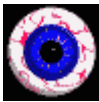


## Crown 85: Visual Perception: A Window to Brain and Behavior



Lecture 7: Processing of Motion and Depth

1

### lecture 7 outline

Crown 85 Winter 2016

Visual Perception: A Window to Brain and Behavior

Lecture 7 Perception of Motion and Depth

**OVERVIEW:** In the final two lectures we will discuss how the visual system enriches perception by adding the dimensions of depth, motion, and color to the canvas of visual information. These lecture will bring more *psycho* in our treatment. Although we will not be able to be as definitive in assigning specific neural networks, we will connect perceptions to the kinds of information processing which neurons can accomplish. Artists are perhaps the most astute “viewers” of the visual world. In the second part of lecture 8 we will look a visual illusion and how artists recognize and take account of visual information processing in their works.

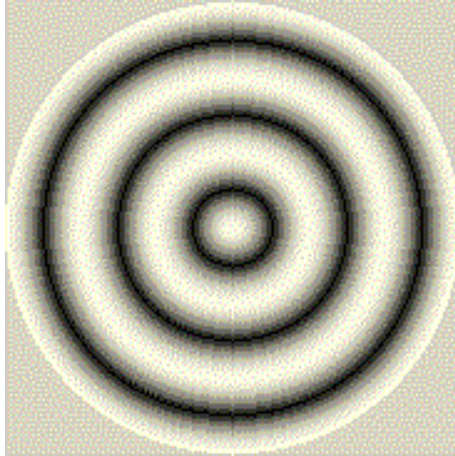
Reading: [Joy of Perception](#) and [Joy of Perception](#)  
[Eye, Brain, and Vision](#) and [Eye, Brain, and Vision](#)

Looking: [Biological Motion](#)  
[Spiral Motion Adaptation](#) (needs JAVA)

2

*temporal (motion, on-off)*

---



*depth*

---



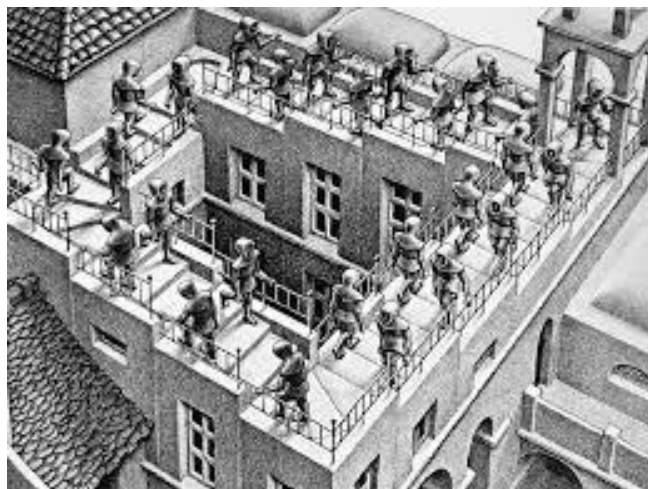
*color*

---



*art and illusion*

---



CROWN 85: Visual Perception:  
A Window to Brain and Behavior  
Lecture 7

*from outline*

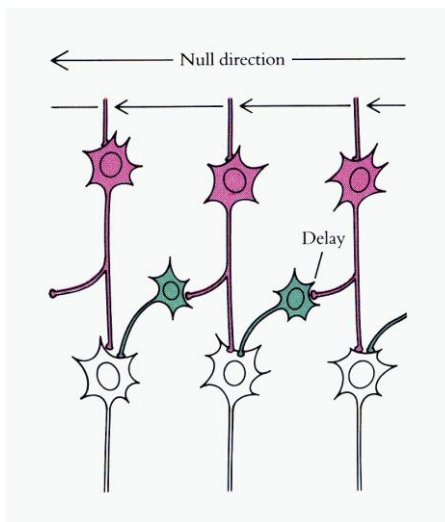
---

1. How might a simple neural network in the cortex signal direction of motion?
2. Know the following terms related to eye movements:
  - a. vestibular-ocular eye movements
  - b. conjugate eye movements
  - c. vergence eye movements
  - d. smooth pursuit eye movements
  - e. saccades
  - f. tremor
  - g. saccadic suppression
  - h. nystagmus

7

*motion detector network*

---

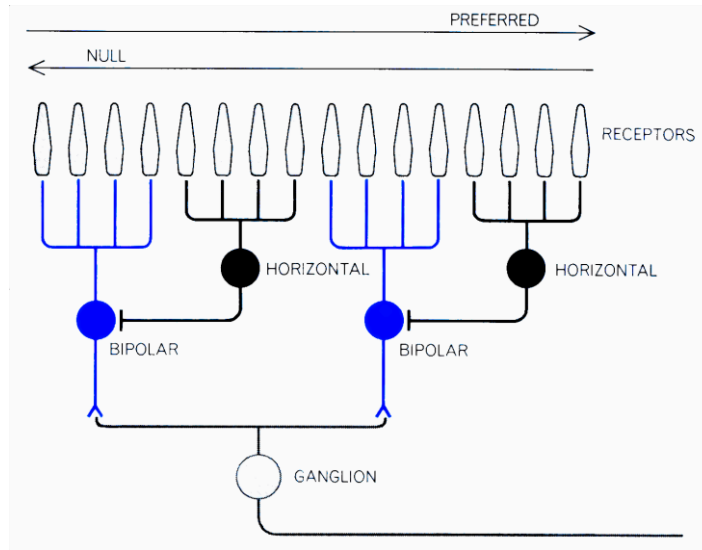


from: *Eye, Brain, and Vision*, by D.Hubel, p19.

8

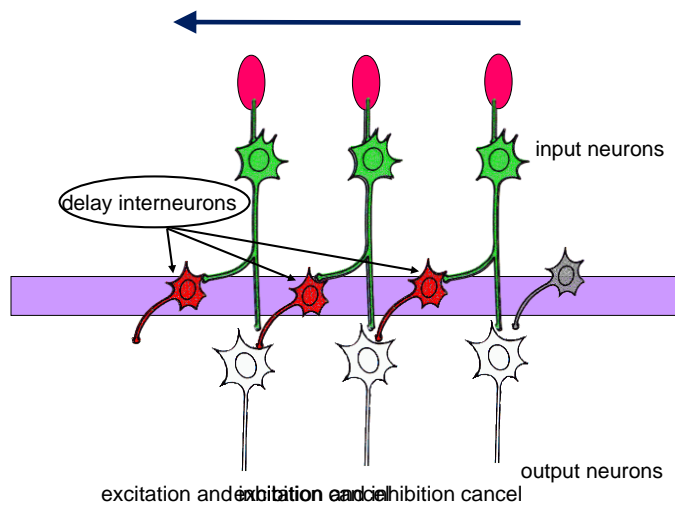
CROWN 85: Visual Perception:  
A Window to Brain and Behavior  
Lecture 7

*neuron selective for direction of motion*



9

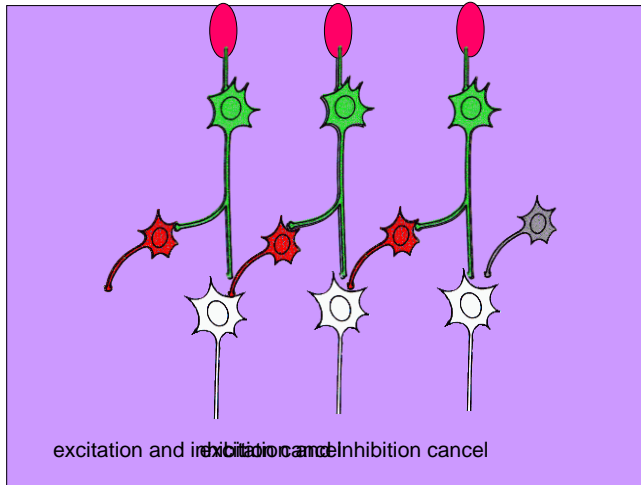
*null direction*



10

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A Window to Brain and Behavior  
Lecture 7

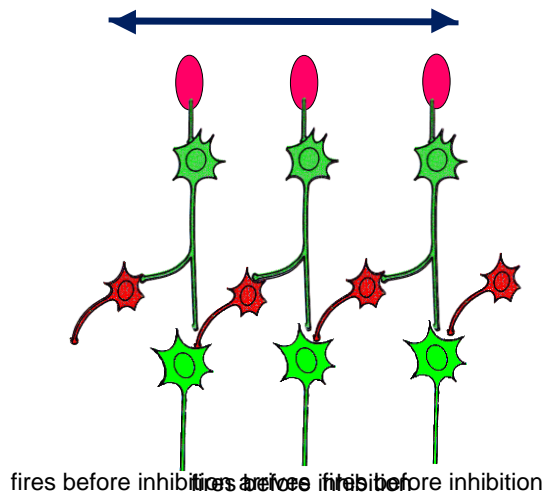
*null direction*



nada

11

*preferred direction*

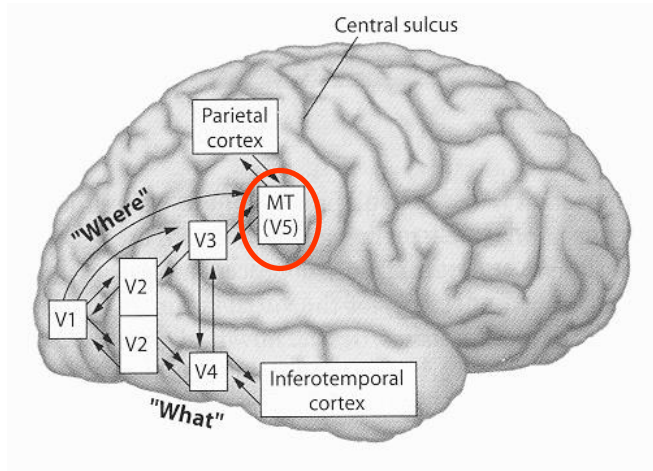


neurons fire

12

CROWN 85: Visual Perception:  
A Window to Brain and Behavior  
Lecture 7

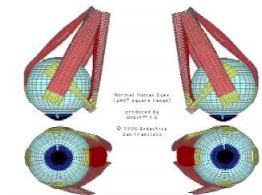
*motion: MT (parietal pathway; mangocellular input)*



13

*from outline*

- ✓ 1. How might a simple neural network in the cortex signal direction of motion?
2. Know the following terms related to eye movements:
  - a. vestibular-ocular eye movements
  - b. conjugate eye movements
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  - d. smooth pursuit eye movements
  - e. saccades
  - f. tremor
  - g. saccadic suppression
  - h. nystagmus



14

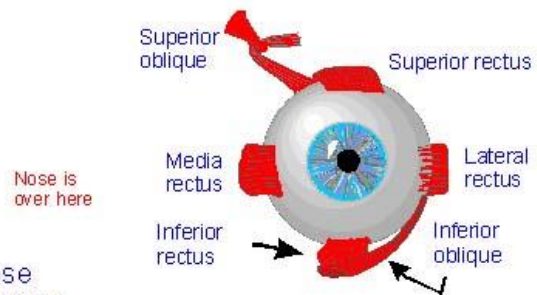
# Eye Movements



Ian Rapoport

## Muscles!!!

- Medial rectus moves the eye towards the nose
- Lateral rectus moves the eye away from the nose
- Superior rectus moves the eye up
- Inferior rectus moves the eye down
- Superior oblique rotates the eye so that the top of the eye moves towards the nose.
- Inferior oblique rotates the eye so that the top of the eye moves away from the nose



The Left Eye

<http://www.yorku.ca/eye/muscle.htm>

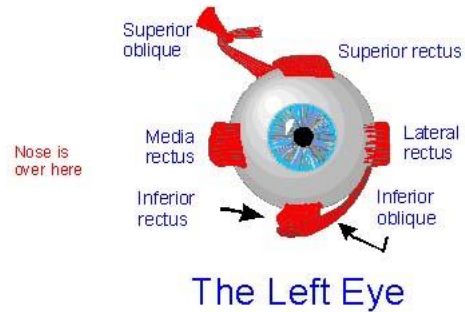


## conjugate eye movements

basic eye movements when the angle between the eyes do not change

left, right, up, down

essentially both eyes are looking in the same direction

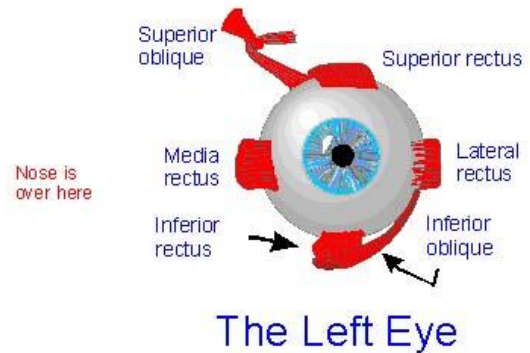


## vergence eye movements

basic eye movements when the angles between the eyes DO change

focus on your finger and move your finger closer to your face and then further away (good job!)

essentially eyes are looking in different directions

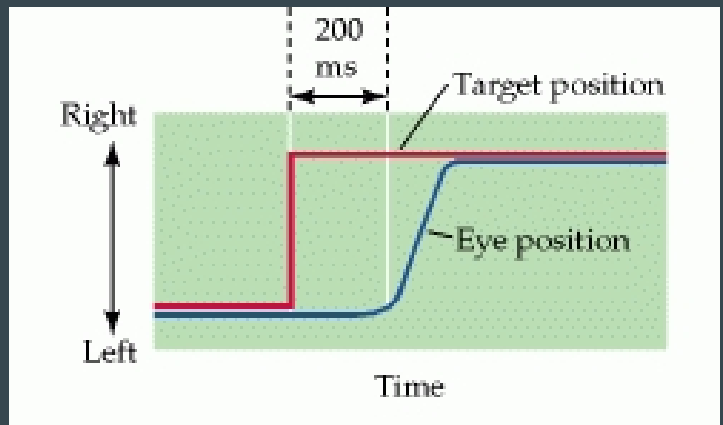


## saccades

quick eye movements from one point to another

look at one thing! now look at another!  
awesome possum!

<http://www.ncbi.nlm.nih.gov/books/NBK10991/>

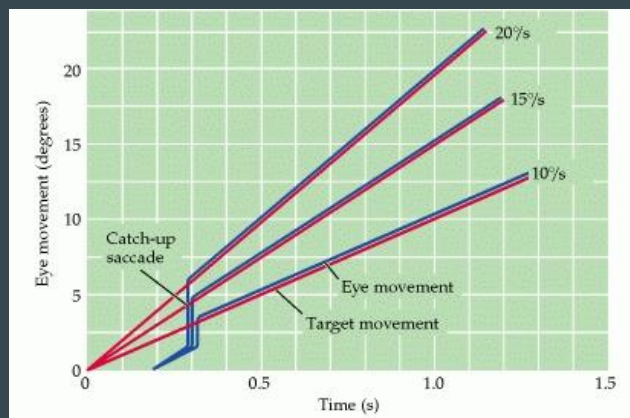


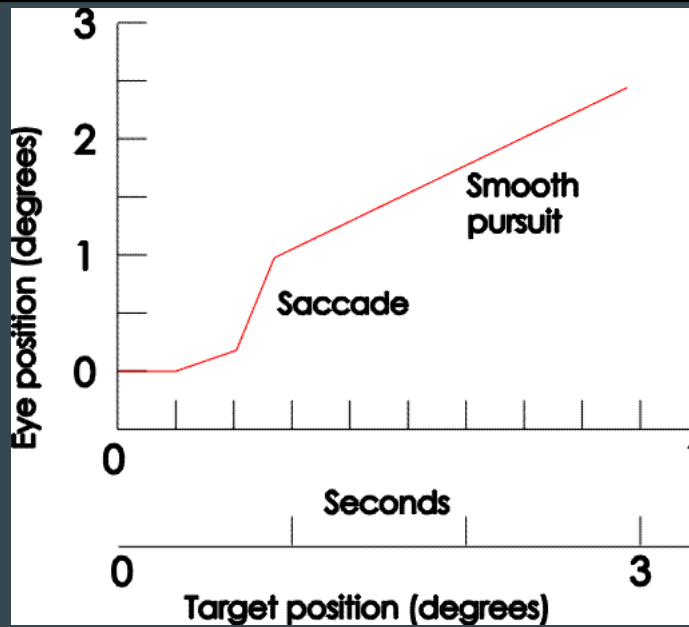
## smooth pursuit eye movements

slow tracking movements that keep a moving image focused on the retina

basically whenever you watch something that is moving

<http://www.ncbi.nlm.nih.gov/books/NBK10991/>





<http://www.yorku.ca/eye/eyemove.htm>

## vestibular-ocular eye movements

stabilizing eye movements relative to the head and outside world

vestibular system detects changes in head movement and produces corrective eye movements

eye moves in opposite direction of head so image doesn't slip

focus on something and move your head around

CONGRATULATIONS!!! YOU JUST MADE A VESTIBULAR-OCULAR EYE MOVEMENT!!!

## tremor

involuntary eye movements caused by muscle contractions

twitching basically

## saccadic suppression

when the brain does not acknowledge eye movements

when you make a saccadic movement, your brain is not processing the image of everything between point A and B

also happens when you blink

## nystagmus

eye condition

inability of eyes to hold steady image, results in  
eye tremors or involuntary eye movements

can be inherited or sometimes temporary

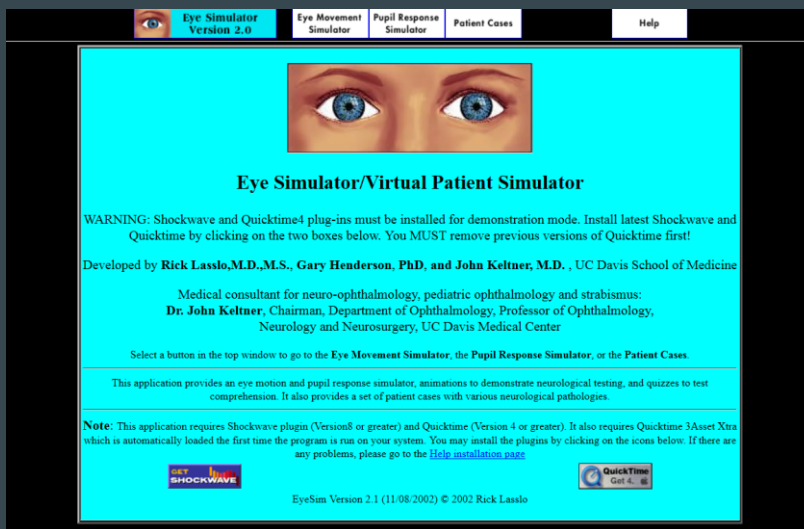
on your own time spin around in a chair and then  
try to focus on something, that spiny image is  
nystagmus

<http://giphy.com/gifs/eye-medical-school-student-fl7fVWr5t3c4>



## HEY CHECK THIS OUT?

<https://cim.ucdmc.ucdavis.edu/eyerelease/Interface/TopFrame.htm>



**Eye Simulator Version 2.0** | Eye Movement Simulator | Pupil Response Simulator | Patient Cases | Help

**Eye Simulator/Virtual Patient Simulator**

WARNING: Shockwave and Quicktime4 plug-ins must be installed for demonstration mode. Install latest Shockwave and Quicktime by clicking on the two boxes below. You MUST remove previous versions of Quicktime first!

Developed by Rick Lasso, M.D., M.S., Gary Henderson, Ph.D., and John Keltner, M.D., UC Davis School of Medicine

Medical consultant for neuro-ophthalmology, pediatric ophthalmology and strabismus:  
**Dr. John Keltner**, Chairman, Department of Ophthalmology, Professor of Ophthalmology,  
Neurology and Neurosurgery, UC Davis Medical Center

Select a button in the top window to go to the Eye Movement Simulator, the Pupil Response Simulator, or the Patient Cases.

This application provides an eye motion and pupil response simulator, animations to demonstrate neurological testing, and quizzes to test comprehension. It also provides a set of patient cases with various neurological pathologies.

Note: This application requires Shockwave plugin (Version 8 or greater) and Quicktime (Version 4 or greater). It also requires Quicktime 3Asset Xtra which is automatically loaded the first time the program is run on your system. You may install the plugins by clicking on the icons below. If there are any problems, please go to the [Help installation page](#).

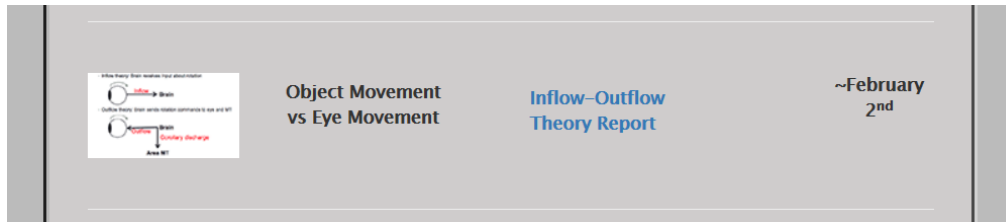
SHOCKWAVE | QuickTime Get 4.0

EyeSim Version 2.1 (11/06/2002) © 2002 Rick Lasso

*head and eye motion vs object motion*

---

3. When the eye moves and an object is stationary the image of the object moves across the retina. When an object moves and the eye is stationary the image of the object moves across the retina. Understand how both the inflow and outflow theories could provide sufficient information to distinguish between these two situations. What experiments show that the visual system actually employs the outflow (corollary discharge) information?



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Inflow-Outflow  
Theory

Ben Smith

## Eye movement vs. Object movement

- Eye fixed: object moves across loci
  - Afferent signals
- Eyes pursue moving target:
  - Still perceive movement
  - Efferent signals
- How to distinguish?

## Inflow theory

- Sherrington
- Eye muscle signals sent to brain
- Cancel out retinal movement signals
- But, muscle signal slower → jolt

## Outflow theory

- Helmholtz
- Corollary signal sent to “comparator”
- Dominant theory

- Corollary discharge model



*spiral after effect and the waterfall illusion*

---

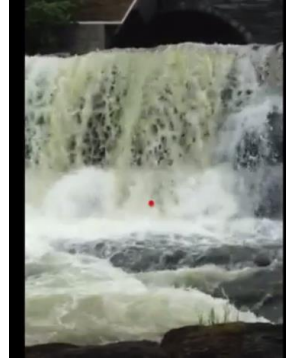
4. What is the explanation of spiral motion adaptation and the waterfall effect?



<https://lindavernon.files.wordpress.com/2012/02/img071.jpg>



<http://www.mtv.com/news/1923605/niagara-falls-honeymoon/>

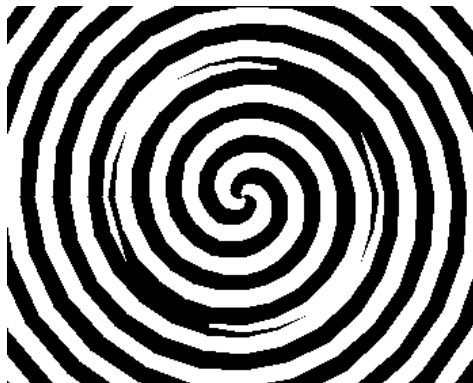


<https://www.youtube.com/watch?v=qLDKcZB8Eaw>

34

*spiral after effect and the waterfall illusion*

---



*adaptation to spiral motion*



35

*grouping by motion and common fate*

---

5. What is 'common fate' in regard to the visual system's ability to utilize motion to extract perceptual grouping?



36

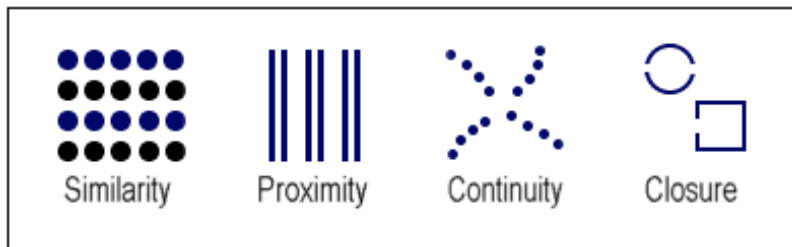
# Common Fate and Motion Perception

Madeleine Buckley

## Gestalt Principles of Grouping

Human perception that organizes images into patterns

Proximity, Similarity, Closure, Good Continuation, Common Fate, Good Form



## Common Fate

Grouping of objects moving in the same direction

The same motion-selective neurons will fire for these objects and not for the background images



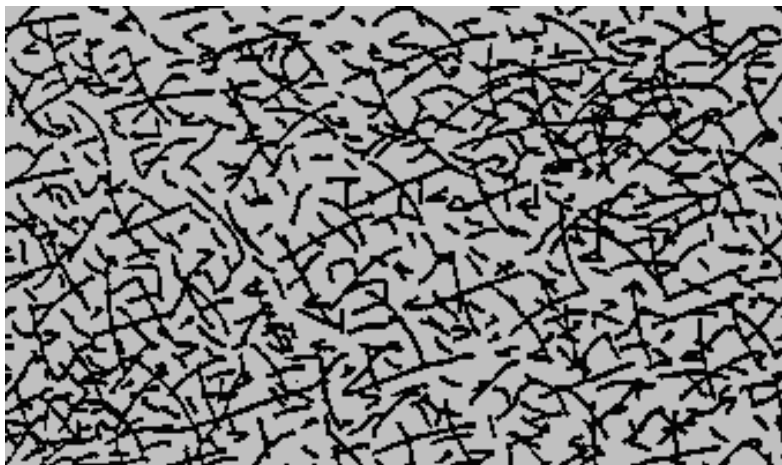
## Examples

<http://switkes.chemistry.ucsc.edu/teaching/CROWN85/Movies/DOTS3.mp4>

[http://psylux.psych.tu-dresden.de/i1/kaw/diverses%20Material/www.illusionworks.com/html/hidden\\_bird.html](http://psylux.psych.tu-dresden.de/i1/kaw/diverses%20Material/www.illusionworks.com/html/hidden_bird.html)

*common fate*

---

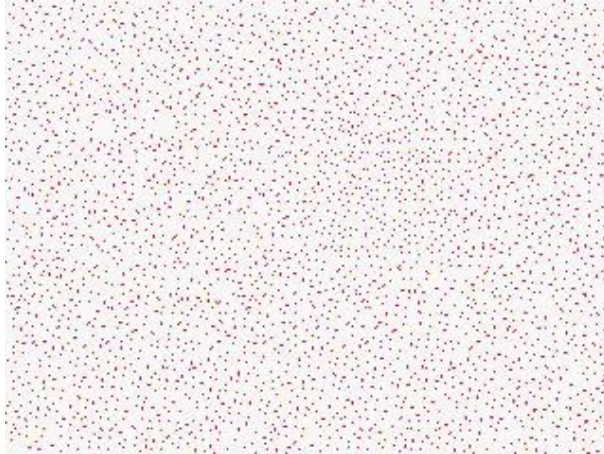


<http://www.illusionworks.com>

41

more common fate

---



42

*biological motion*

---

6. What is 'biological motion' and how does it require the visual system to extract information about both form and motion? Which pathway, parietal or temporal, is implicated in the perception of biological motion



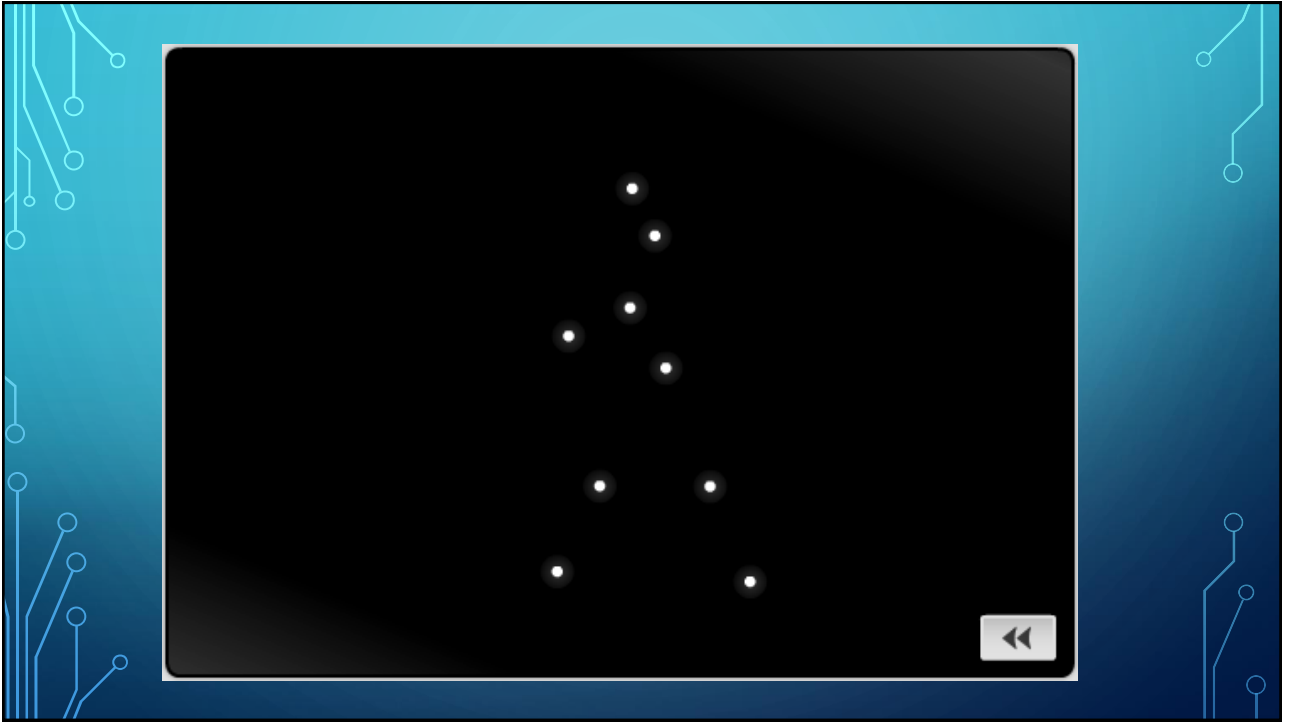
# BIOLOGICAL MOTION

~ WHAT IS 'BIOLOGICAL MOTION'

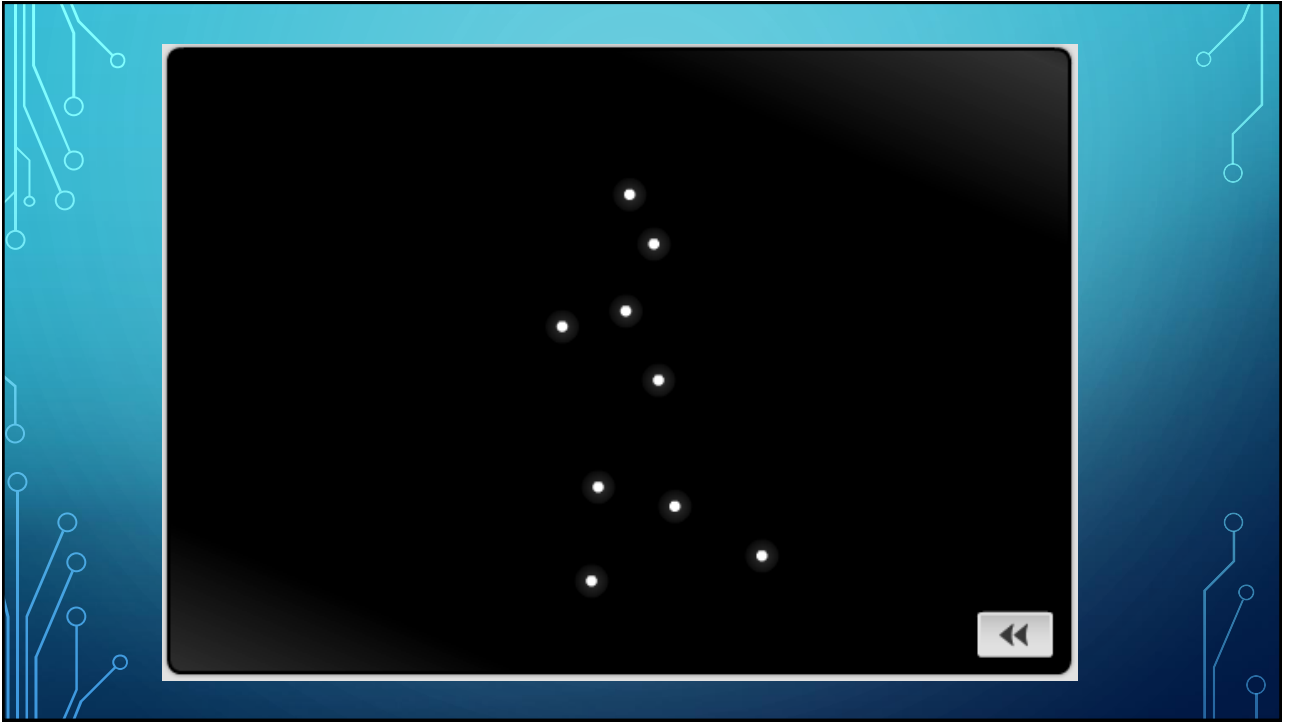
~ AND HOW DOES IT REQUIRE THE VISUAL SYSTEM  
TO EXTRACT INFORMATION ABOUT BOTH FORM  
AND MOTION?

~ WHICH PATHWAY, PARIETAL OR TEMPORAL, IS  
IMPLICATED IN THE PERCEPTION OF BIOLOGICAL  
MOTION

CROWN 85: Visual Perception:  
A Window to Brain and Behavior  
Lecture 7

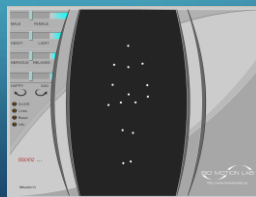


CROWN 85: Visual Perception:  
A Window to Brain and Behavior  
Lecture 7



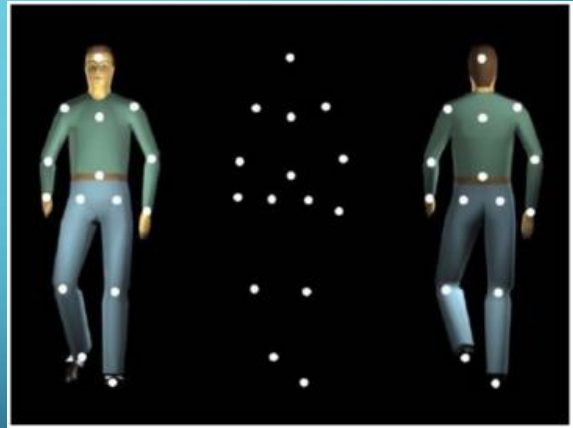
[HTTPS://BRAIN.MADA.ORG.IL/BIOMOTION/BIOMOTION  
WEB.SWF](https://brain.mada.org.il/biomotion/biomotion.web.swf)

[HTTP://WWW.BIOMOTIONLAB.CA/DEMOS/BMLWALKER.  
HTML](http://www.biomotionlab.ca/demos/bmlwalker.html)





Gunnar Johansson (1911–1998) was a Swedish psychophysicist. He was interested in the Gestalt laws of motion perception in vision. He is best known for his investigations of biological motion.



## FORM AND/OR MOTION

What does “recognizing” biological motion involve?

- Brain mechanisms that involve form?
- Brain mechanisms that involve motion?

VENTRAL-  
TEMPORAL

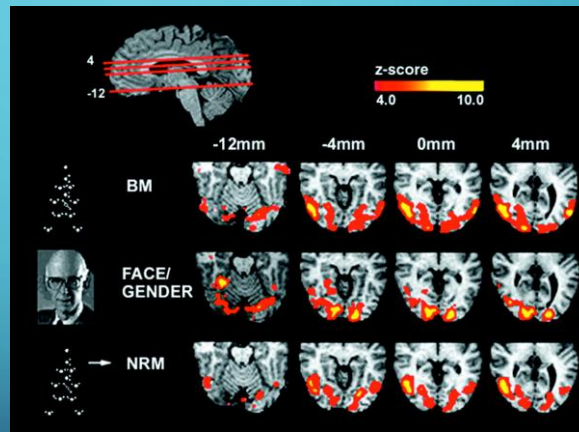
DORSAL-  
PARIETAL

## FMRI STUDY OF NON-RIGID MOTION, FORM, AND BIOLOGICAL MOTION

**Biological motion:**  
**both ventral and dorsal**

Face/Gender identification:  
**ventral**

non-rigid motion (no form):  
**dorsal** (e.g. MT)



Lucia M. Vaina et al. PNAS 2001;98:11656-11661

## CLINICAL OBSERVATIONS

*had dorsal, MT lesion  
used ventral path*

such as patients LM and AF, who were impaired on many aspects of visual motion perception to the extent that they are referred to as almost or completely **"motion-blind"** can **reliably recognize human actions in point-light displays**.

*had ventral lesion  
used dorsal path*

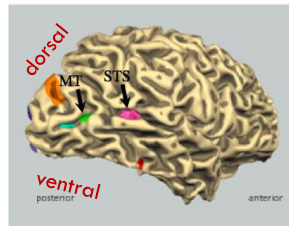
Similarly surprising, patient EW, **with bilateral ventral lesions** involving the posterior temporal lobes, suffered from prosopagnosia and object agnosia, **but could easily and correctly recognize BM**. Thus, inputs from the ventral pathway to STP were not fully available, and we suggest that this patient mostly relied on the dorsal pathway

## EITHER (BOTH) STREAM ACTIVATES SUPERIOR TEMPORAL SULCUS

Thus, we conjecture that, whereas form and face stimuli activate primarily the ventral system and motion stimuli primarily the dorsal system, recognition of

**BM stimuli may activate both systems as well as their confluence in STS**

Visual area STS responds to biological motion



<http://www.cns.nyu.edu/~david/courses/perception/lecturenotes/motion/motion.html>

### *flicker fusion rate*

---

#### 7. What is the flicker-fusion rate?

How rapidly a light can be turned on and off before the percept becomes that of continuous illumination.

*depends on brightness and scotopic or photopic, color, size of source, etc.*

- Incandescent lights 120 Hz (cycles/sec)
- CRT monitors ~60 Hz
- Old time movies ('flicks') recorded at 24 Hz, show each frame twice = 48 Hz

*from lecture outline: DEPTH*

---

8. In the real world what are clues which the brain uses to determine depth?
  - a. monocular
  - b. binocular
  
9. What are Julesz patterns and what do they show about depth perception?

## monocular clues :



James Petnic,  
Crown 85



Monocular Cues  
to Depth

Monocular Cues  
Report

--February  
4<sup>th</sup>

## monocular clues— perspective & texture, size

### Pictorial Cues

- **Relative size** - when objects are equal size, the closer one will take up more of your visual field
- **Perspective convergence** - parallel lines appear to come together in the distance
- **Familiar size** - distance information based on our knowledge of object size



from: [University of Washington Psychology 333](#)

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## monocular clues— perspective & texture

### Pictorial Cues

**Texture gradient** - equally spaced elements are more closely packed as distance increases



taken from: [University of Washington Psychology 333](#)

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## monocular clues— occlusion, height in picture

### Pictorial Cues

**Occlusion** - when one object partially covers another  
**Relative height** - objects that are higher in the field of vision are more distant



from: [University of Washington Psychology 333](#)

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## monocular clues— aerial or atmospheric perspective

### Pictorial Cues

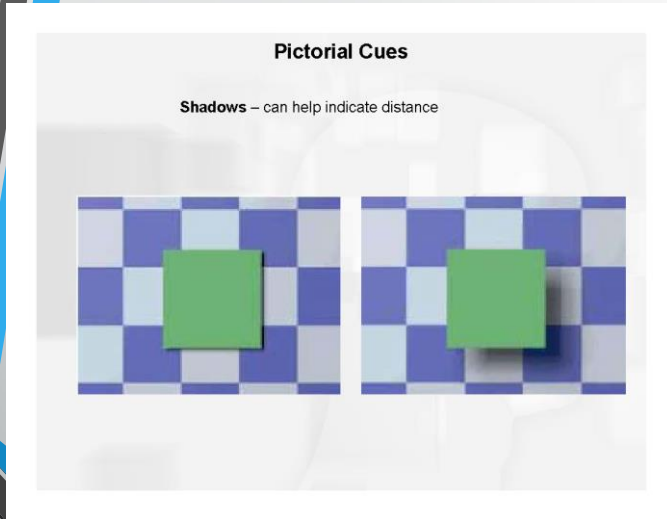
- **Atmospheric perspective** - distance objects are fuzzy and have a blue tint



from: [University of Washington Psychology 333](#)

61

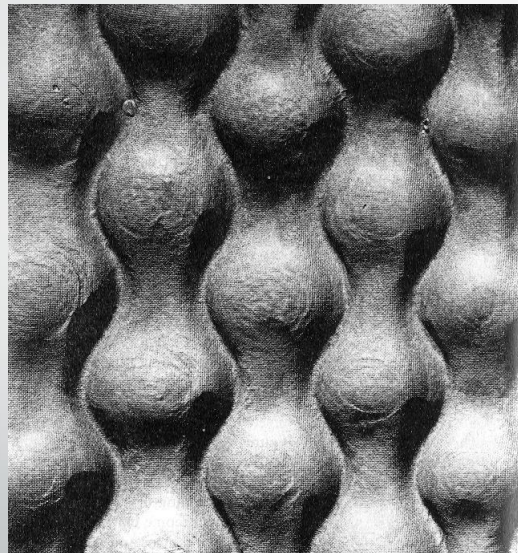
## monocular clues— shadows



from: [University of Washington Psychology 333](#)

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## depth, monocular clue: shadow



## monocular clues— motion

### Motion-Produced Cues

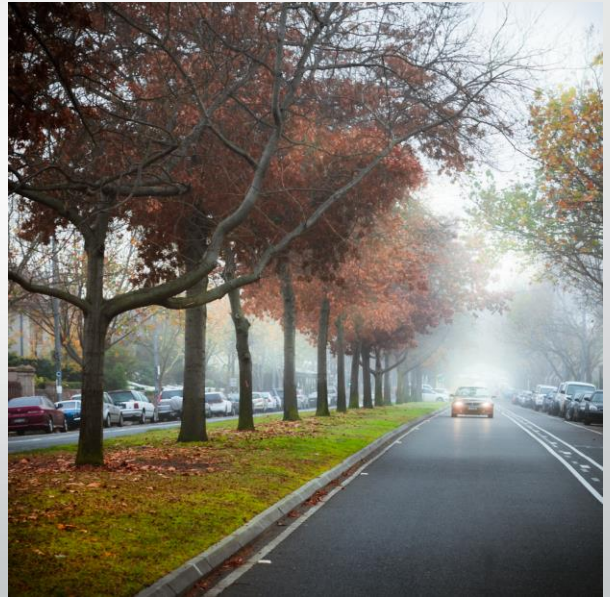
- **Motion parallax** - close objects in direction of movement glide rapidly past but objects in the distance appear to move slowly
- **Deletion and accretion** - objects are covered or uncovered as we move relative to them
  - Also called occlusion-in-motion



taken from: [University of Washington Psychology 333](https://www.uw.edu/psychology/333/)

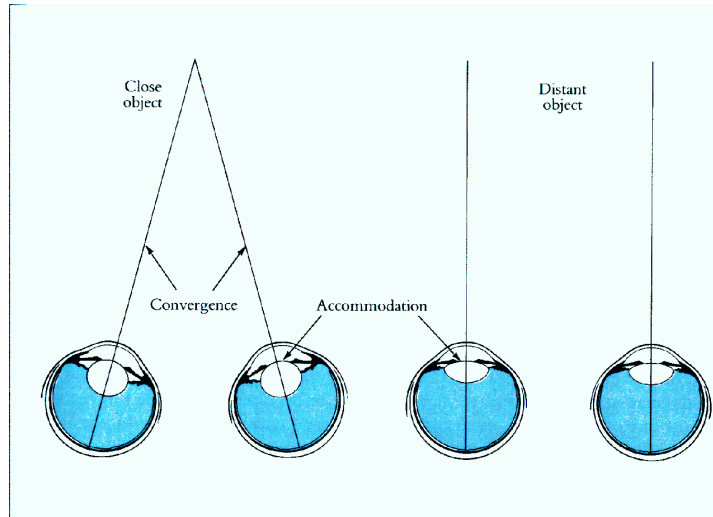
64

## Examples

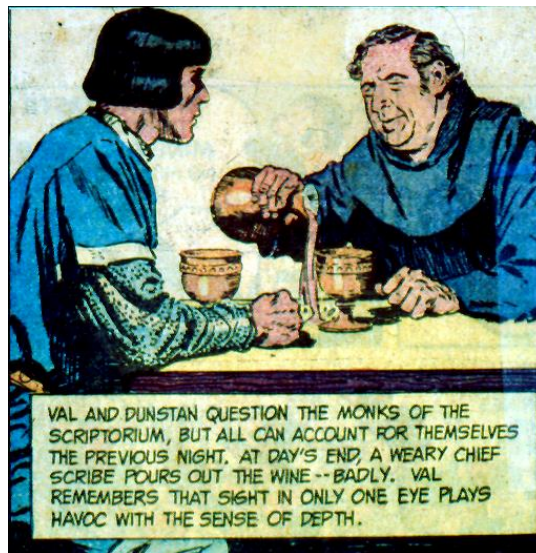




*depth, binocular clues (oculomotor) : convergence and accommodation*



**BAD JOKE !!**



*depth, binocular clue: disparity*

---



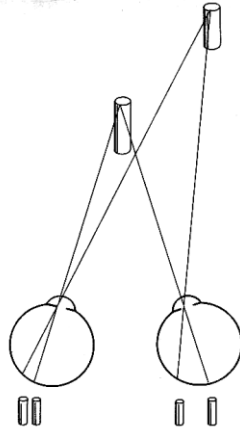
*depth, binocular clue: disparity*

---



*disparity*

---



from: *Perception, The World Transformed* (1979)  
by L. Kaufman, Oxford (New York), p 208.

Figure 7-16. The images of two rods on the left retina are closer together than the corresponding images on the right retina. This difference in separation is the relative binocular disparity of the images. If the left and right eyes were to view such pictures, the observer would see two rods in depth.

*more disparity*

---

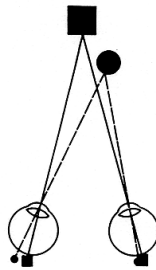
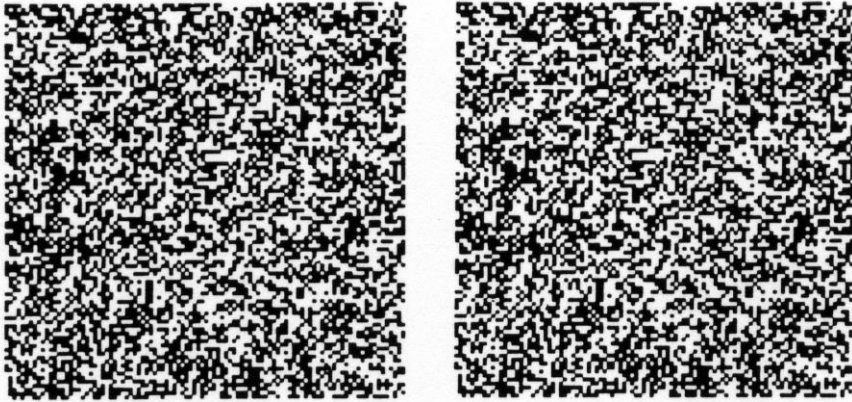


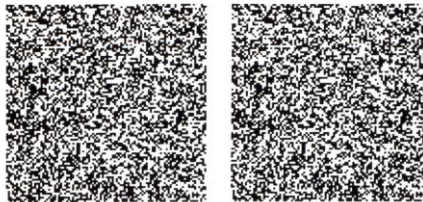
Fig. 11.18. Binocular disparity. The square and circle are imaged quite close together on the right retina, but are imaged considerably farther apart on the left retina. If observer fixates on square, there must be a disparity in the retinal locations of the image of the circle.

*Julesz patterns: depth with disparity as only clue*



*construction of Julesz patterns*

Figure 7-21. The random dot stereogram invented by Julesz. The two halves of the stereogram are identical except that a central portion of one half is shifted toward one side, as illustrated in the accompanying letter matrices.



1	0	1	0	1	0	0	1	0	1		
1	0	0	1	0	1	0	1	0	0		
0	0	1	1	0	1	1	0	1	0		
0	1	0	Y	X	X	B	B	0	0	1	
1	1	1	X	A	A	B	A	0	0	1	
0	0	1	X	A	A	B	A	1	0		
1	1	1	Y	B	B	A	B	0	0	1	
1	0	0	1	1	0	1	1	0	1		
1	1	0	0	1	1	0	1	1	1		
0	1	0	0	0	1	1	1	1	0		

1	0	1	0	1	0	0	1	0	1		
1	0	0	1	0	1	0	1	0	0		
0	0	1	1	0	1	1	0	1	0		
0	1	0	A	A	B	B	0	0	0	1	
1	1	1	B	A	A	A	0	0	0	1	
0	0	1	A	A	B	A	0	1	0		
1	1	1	B	B	A	B	0	0	0	1	
1	0	0	1	1	0	1	1	0	1		
1	1	0	0	1	1	0	1	1	1		
0	1	0	0	0	1	1	1	1	0		

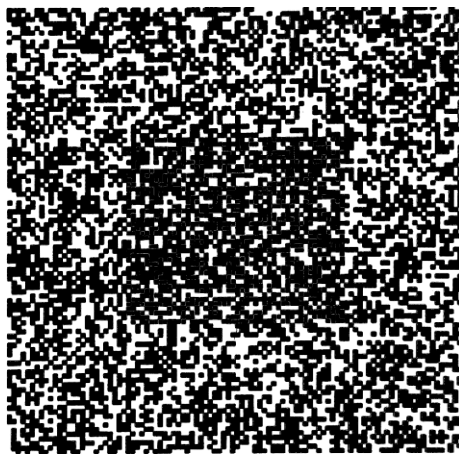
*construction of Julesz patterns*

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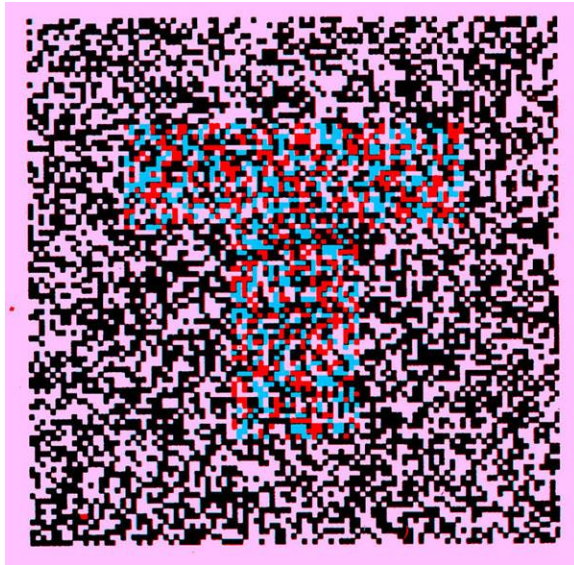
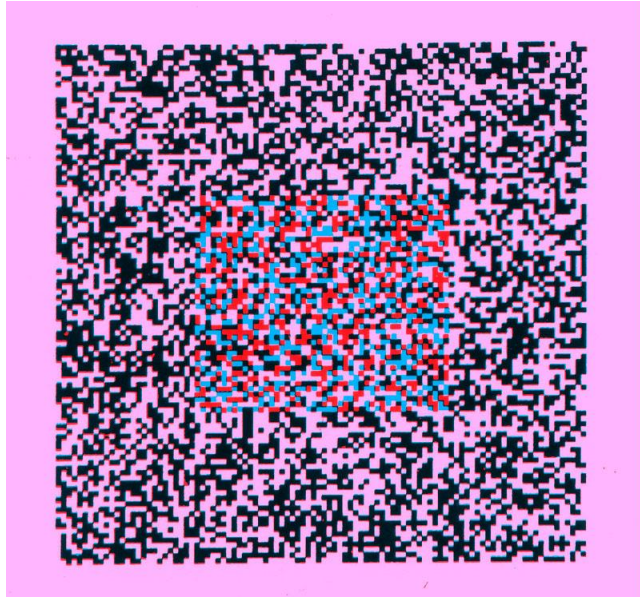


*views for differing eyes*

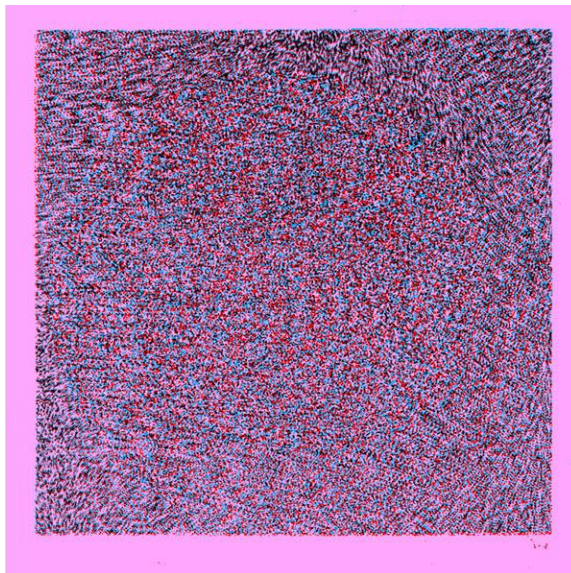
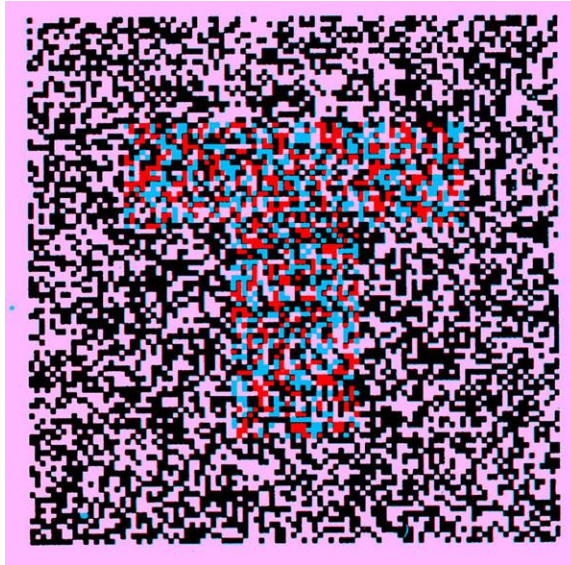
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CROWN 85: Visual Perception:  
A Window to Brain and Behavior  
Lecture 7



CROWN 85: Visual Perception:  
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*from lecture outline: DEPTH*

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- ✓ 8. In the real world what are clues which the brain uses to determine depth?
  - a. monocular
  - b. binocular
  
- ✓ 9. What are Julesz patterns and what do they show about depth perception?

*FINIS*