

## Announcements

- Exam comments
- Perception journal reminder

The Country of the Blind  
Wells, H. G.



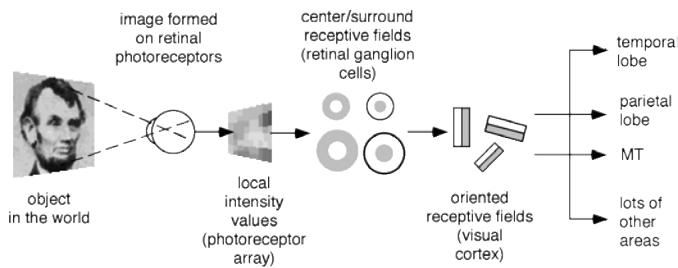
<http://www.youtube.com/watch?v=URLRdcnU6Hk&feature=related>

## Cortical visual processing & form vision

- V1 responses to natural images & the binding problem
- perceptual grouping
- perceptual segregation
- neural mechanisms of grouping and segregation

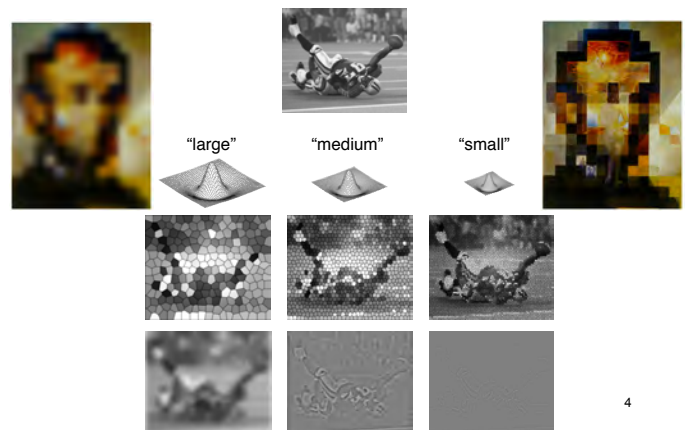
2

## Early visual analysis is LOCAL



3

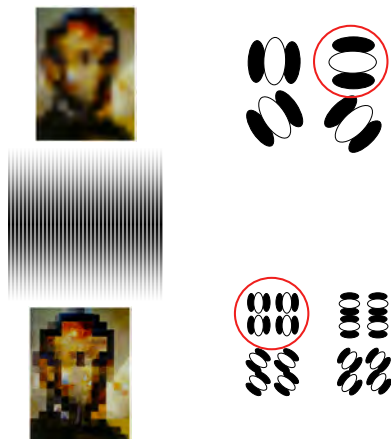
Early visual analysis is **LOCAL**, e.g.,  
visual input is analyzed at different spatial scales (i.e., spatial frequency bands)



4

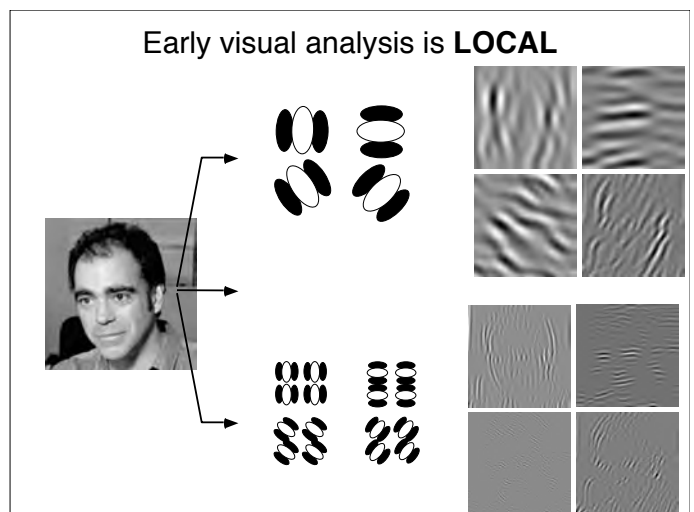
## Early visual analysis is LOCAL

Same holds for other features such as orientation:

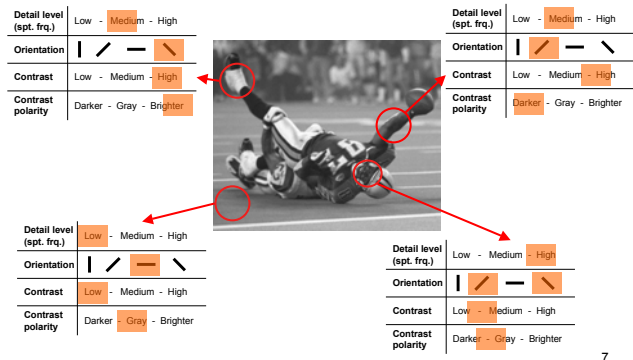


5

## Early visual analysis is LOCAL

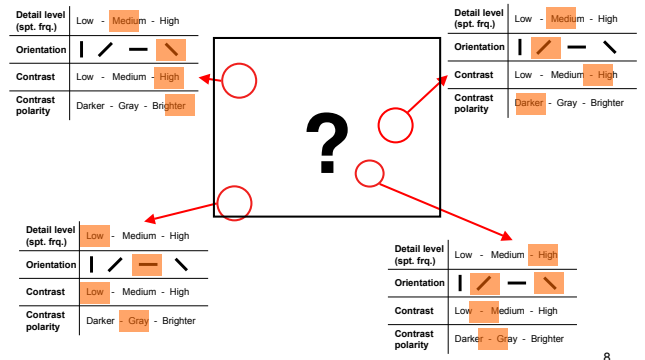


## Early visual analysis is LOCAL

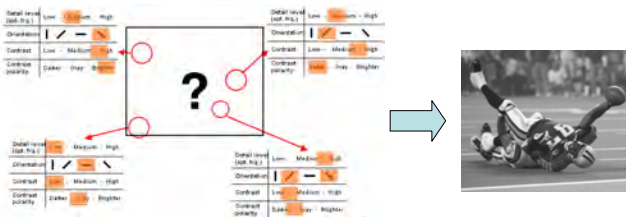


7

## Early visual analysis is LOCAL



8



We see objects and not spatial frequencies, contrasts, etc.

How are local, spatially distributed image descriptions linked to achieve meaningful representations of **objects**?

The “binding” problem

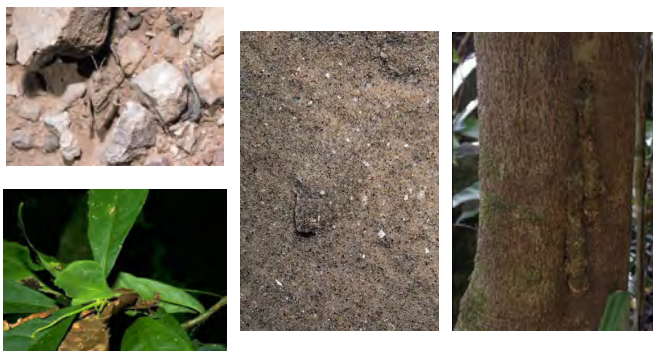


## What's the binding problem?



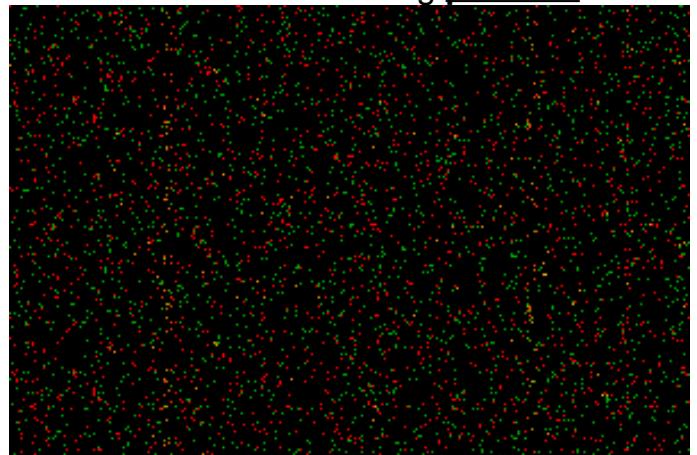
10

## What's the binding problem?



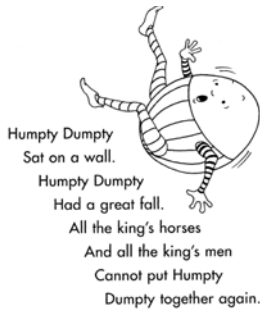
11

## What's the binding problem?



## The “Humpty Dumpty” Problem:

How are local, spatially distributed image descriptions linked to achieve meaningful representations of **objects**?



13

## Solution(s)?

**Gestalt** = organized whole, complete pattern

**Gestalt psychology** = Studies how are local, spatially distributed image descriptions linked to achieve meaningful global representations of objects and events.

**Key message:** “the whole is more than the sum of its parts”

Vision exploits **regularities** in the environment and **knowledge** from experience to “solve” the **binding problem**



14

## Solution(s)?

“What we actually perceive are entities such as things, figures, and also groups of which these entities are members.  
This demonstrates the operation of processes in which the content of certain areas is **unified** and, at the same time, **segregated** from its environment...”

[this] organization depends upon **relations** among local stimuli.”

**unified** = grouping  
**segregated** = figure/ground segmentation



Wolfgang Köhler  
Co-Founder of Gestalt Psychology

15

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16

## Cortical visual processing & form vision

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17

## What Promotes Perceptual Grouping?

**Gestalt principles of grouping:**

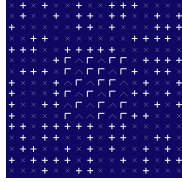
- Similarity
- Proximity
- Common region
- Element connection
- Good continuation
- Symmetry
- Closure
- Simplicity
- **Common fate**

18

Visual grouping from:

similarity - proximity - common region - connection - symmetry - continuation - closure - simplicity

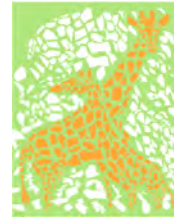
LIGHTNESS  
COLOR  
ORIENTATION  
TEXTURE



19

Visual grouping from:

similarity - proximity - common region - connection - symmetry - continuation - closure - simplicity



20

Visual grouping from:

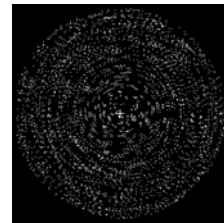
similarity - proximity - common region - connection - symmetry - continuation - closure - simplicity



21

Visual grouping from:

similarity - proximity - common region - connection - symmetry - continuation - closure - simplicity



22

Visual grouping from:

similarity - proximity - common region - connection - symmetry - continuation - closure - simplicity



23

Visual grouping from:

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24

Visual grouping from:

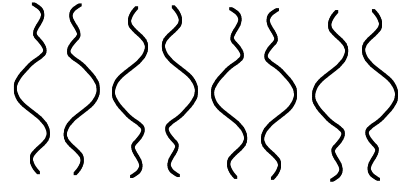
similarity - proximity - common region - connection - symmetry - continuation - closure - simplicity



25

Visual grouping from:

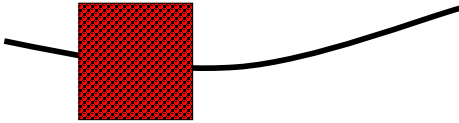
similarity - proximity - common region - connection - symmetry - continuation - closure - simplicity



26

Visual grouping from:

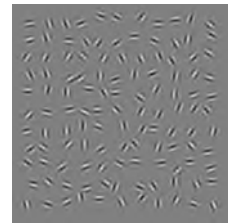
similarity - proximity - common region - connection - symmetry - continuation - closure - simplicity



27

Visual grouping from:

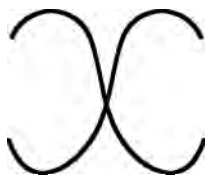
similarity - proximity - common region - connection - symmetry - continuation - closure - simplicity



28

Visual grouping from:

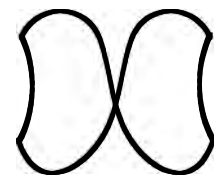
similarity - proximity - common region - connection - symmetry - continuation - closure - simplicity



29

Visual grouping from:

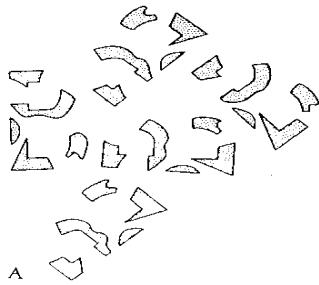
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30

Visual grouping from:

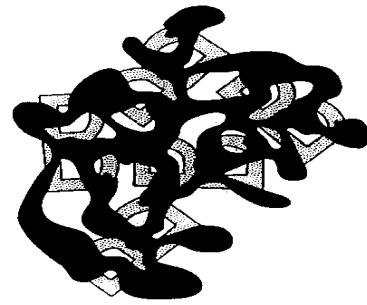
similarity - proximity - common region - connection - symmetry - continuation - closure - simplicity



31

Visual grouping from:

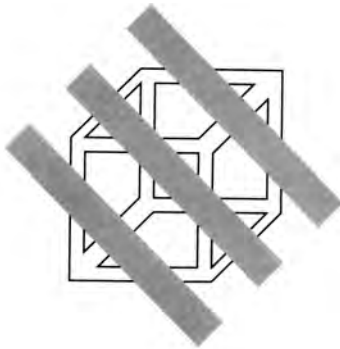
similarity - proximity - common region - connection - symmetry - continuation - closure - simplicity



32

Visual grouping from:

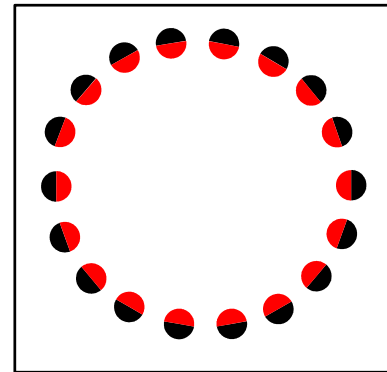
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33

Visual grouping from:

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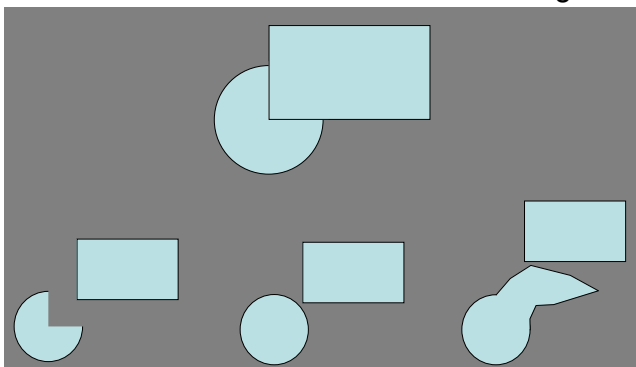


34

Visual grouping from:

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Pragnanz

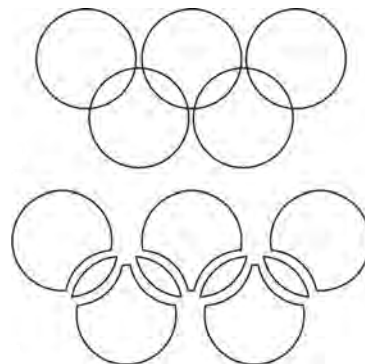


35

Visual grouping from:

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Pragnanz

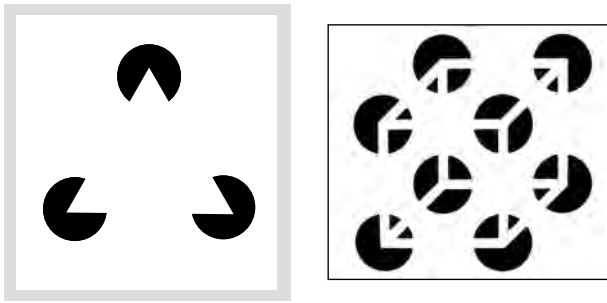


36

Visual grouping from:

similarity - proximity - common region - connection - symmetry - continuation - closure - simplicity

Pragnanz



Grouping from dynamic visual input:  
"Common Fate"

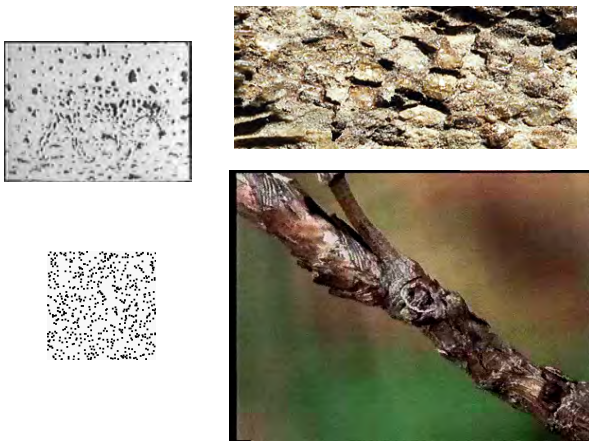


Wolfgang Kohler

"One can easily show that the factors on which grouping depends in time are about the same as those on which it depends in space."



Common fate: Things that move together group together

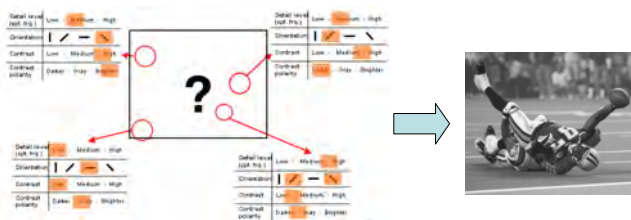


Role of Learning in Grouping



Grouping Cues At Work

similarity - proximity - common region - connection - symmetry - continuation - closure - simplicity



Cortical visual processing & form vision

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43

## Figure/Ground Segmentation



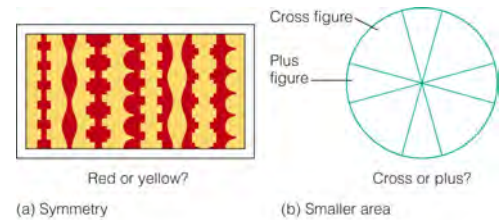
Can you find the 13 faces in this picture?  
"The forest has eyes" by Bev Doolittle

44

## Figure/Ground Segmentation

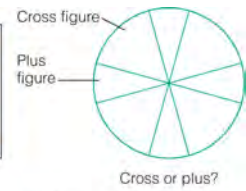
- **Figure-ground segregation** - determining what part of environment is the figure so that it 'stands out' from the background
- Properties of figure and [back]ground
  - The figure is more "thinglike" and more memorable than ground.
  - The figure is seen in front of the ground.
  - The ground is more uniform and extends behind figure.
  - The contour separating figure from ground belongs to the figure (border ownership).
- Factors that determine which area is **figure**:
  - Elements located in the lower part of displays
  - Elements that are symmetrical
  - Elements that are convex
  - Elements that are small
  - Elements that are oriented vertically
  - Elements that have meaning, etc...

45



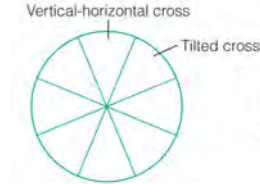
Red or yellow?

(a) Symmetry



Cross or plus?

(b) Smaller area



Vertical-horizontal or tilted?

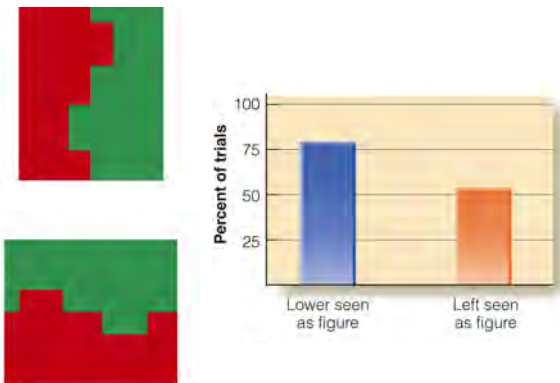
(c) Vertical or horizontal orientation



Dark or light?

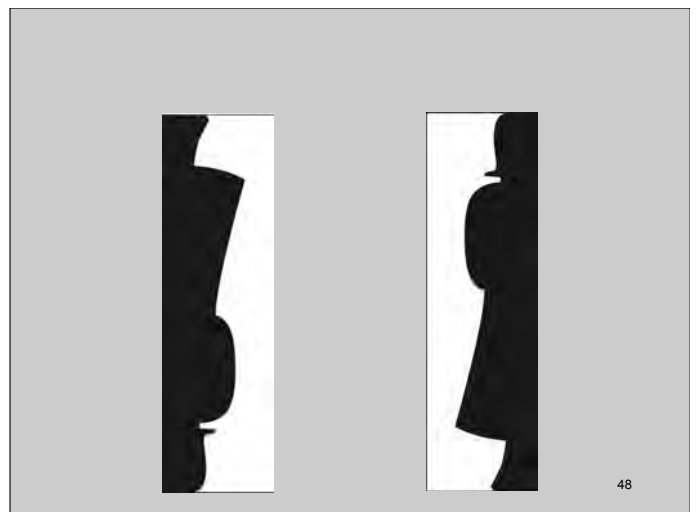
(d) Meaningful (waves)

46



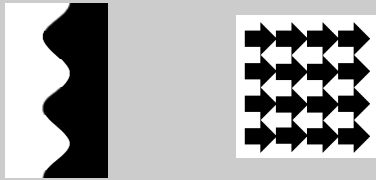
Stimuli and results from Vecera et al. (2002)

47



48

## Figure/Ground Ambiguity



49

## Figure/Ground Ambiguity



(a)

(b)

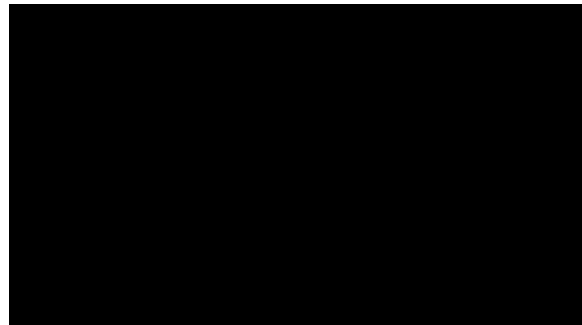
50

## Figure/Ground Ambiguity



51

## Figure/Ground Ambiguity



[http://www.youtube.com/watch?v=a91eiu\\_eer4](http://www.youtube.com/watch?v=a91eiu_eer4)

52

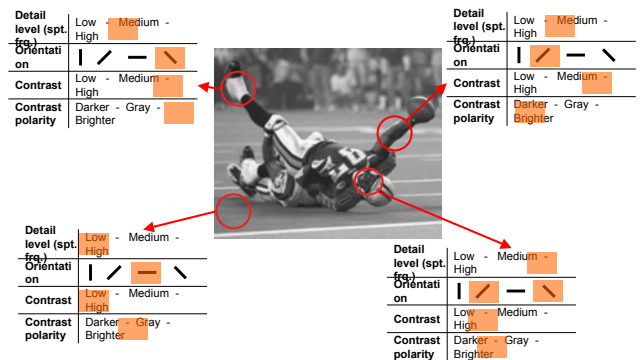
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53

**BUT,**

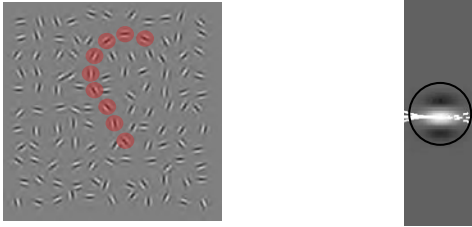
how are grouping, segmentation, etc. implemented in the brain?



54

Visual grouping from:

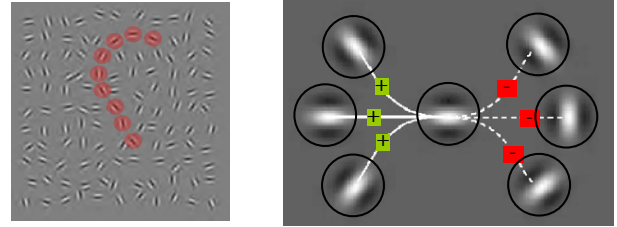
similarity - proximity - common region - connection - symmetry - continuation - closure - simplicity



55

Visual grouping from:

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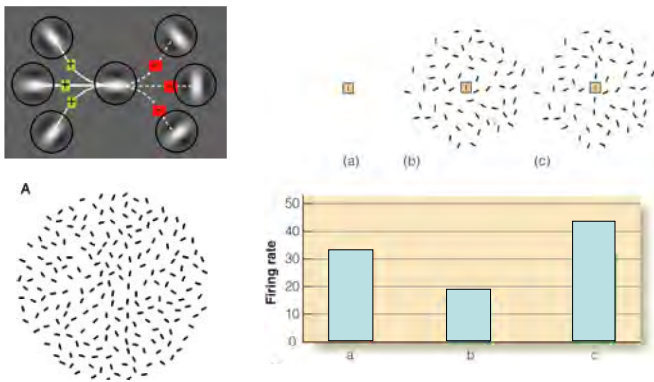


**Contextual modulation** - stimuli outside of a neuron's receptive field can affect neural firing

56

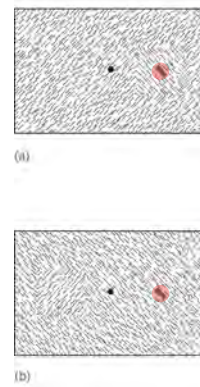
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57

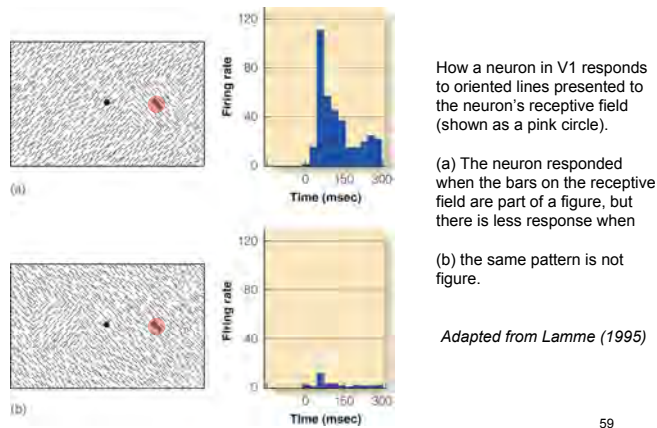
Figure/Ground Segmentation in V1



How a neuron in V1 responds to oriented lines presented to the neuron's receptive field (shown as a pink circle).

58

Figure/Ground Segmentation in V1



How a neuron in V1 responds to oriented lines presented to the neuron's receptive field (shown as a pink circle).

(a) The neuron responded when the bars on the receptive field are part of a figure, but there is less response when

(b) the same pattern is not figure.

*Adapted from Lamme (1995)*

59