

Information Visualization

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1

Visual Perception (1)

2

Semiotics

- The study of symbols and how they convey meaning
- Sensory vs. Arbitrary symbols
- Sensory representation
 - Understanding without training
 - Resistance to instructional bias
 - Sensory immediacy
 - Cross-cultural validity
- Arbitrary representation
 - Hard to learn
 - Easy to forget
 - Embedded in culture and applications
 - Formally powerful
 - Capable of rapid change
- Most visualizations are hybrids!

3

Related Disciplines

- Psychophysics
 - Applying methods of physics to measuring human perceptual systems
 - How fast must light flicker until we perceive it as constant?
 - What change in brightness can we perceive?
- Cognitive psychology
 - Understanding how people think, here, how it relates to perception

- Dr. John Stasko, Slides of CS7500 at Gatech

4

Visual Perception

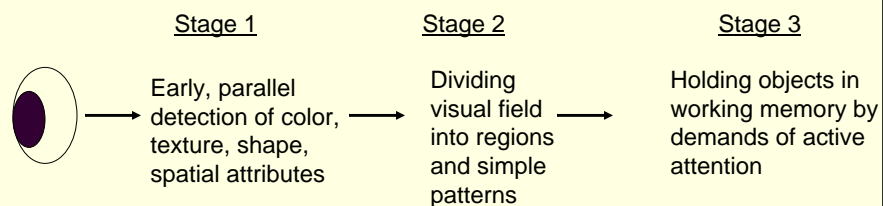
- What is visual perception?
 - process of knowing or being aware of information through the eyes.
 - process of acquiring, interpreting, selecting, and organizing sensory information.

<http://en.wikipedia.org/wiki/Perception>

5

One Simple Model of Perceptual Processing

- Three stage process
 - Parallel extraction of low-level properties of scene
 - Pattern perception
 - Sequential goal-directed processing



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6

Stage 1 - Low-level, Parallel

- Neurons in eye & brain responsible for different kinds of information
 - Orientation, color, texture, movement, etc.
- Arrays of neurons work in parallel
- Occurs “automatically”
- Rapid
- Information is transitory, briefly held in iconic store
- Bottom-up data-driven model of processing
- Often called “pre-attentive” processing

- Dr. John Stasko, Slides of CS7500 at Gatech

7

Stage 2 – Pattern Perception

- Slow serial processing
- Involves working and long-term memory
- A combination of bottom-up feature processing and top-down attentional mechanisms
- Different visual systems for object recognition and visually guided motion

8

Stage 3 – Sequential Goal-Directed

- A few objects are constructed from the available patterns to provide answers to visual queries
- Top-down attention-driven model of processing
- Slow serial processing

9

Pre-attentive Processing

- The most important contribution of vision science to data visualization is that:
 - A limited set of visual properties can be detected very rapidly and accurately by the low-level visual system
- Tasks that can be performed on large multi-element displays in less than 200 to 250 milliseconds (msec) are considered **pre-attentive**. (Eye movements: 200 msec)

<http://www.csc.ncsu.edu/faculty/healey/PP/index.html>

10

Count 3s

```
1281768756138976546984506985604982826762
9809858458224509856458945098450980943585
9091030209905959595772564675050678904567
8845789809821677654876364908560912949686
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1281768756138976546984506985604982826762
9809858458224509856458945098450980943585
9091030209905959595772564675050678904567
8845789809821677654876364908560912949686
```

Tasks

- Target detection
 - Is something there?
- Boundary detection
 - Can the elements be grouped?
- Counting
 - How many elements of a certain type are present?

Pre-attentive Features

- Form
 - Line orientation
 - Line length
 - Line width
 - Line collinearity
 - Size
 - Curvature
 - Spatial grouping
 - Blur
 - Added marks
 - Numerosity
- Color
 - Hue
 - Intensity
- Motion
 - Flicker
 - Direction of motion
- Spatial Position
 - 2D position
 - Stereoscopic depth
 - Convex/concave shape from shading

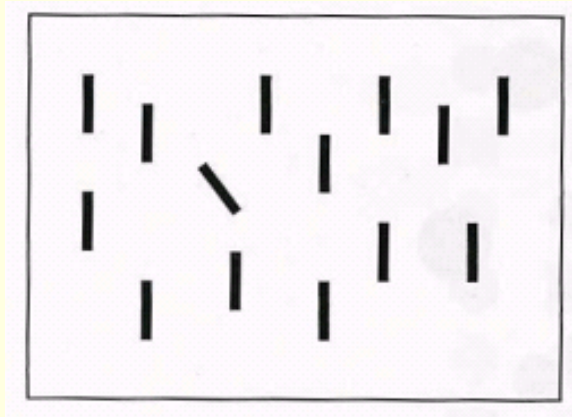
13

Example

- Find the distinct one

14

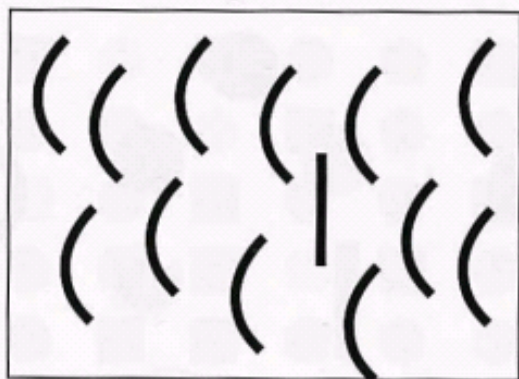
Orientation



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15

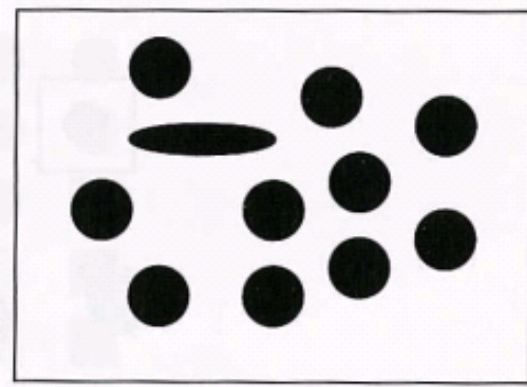
Curved/Straight



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16

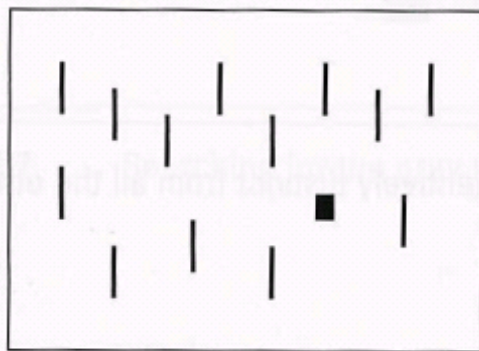
Shape



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17

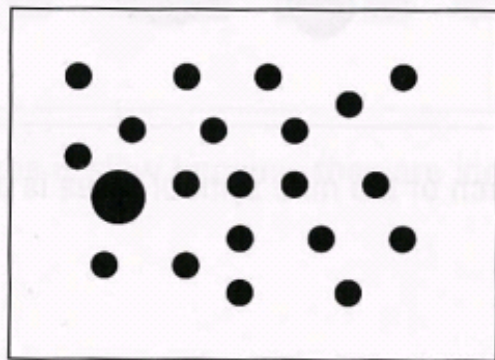
Shape



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18

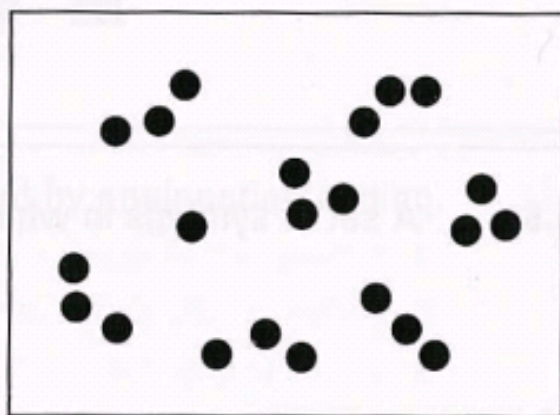
Size



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19

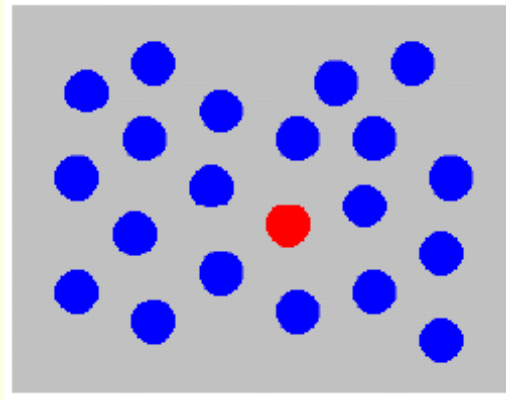
Number



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20

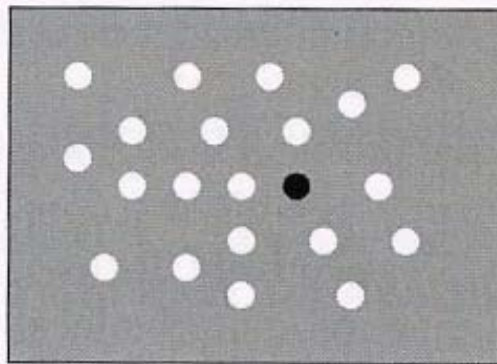
Hue



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21

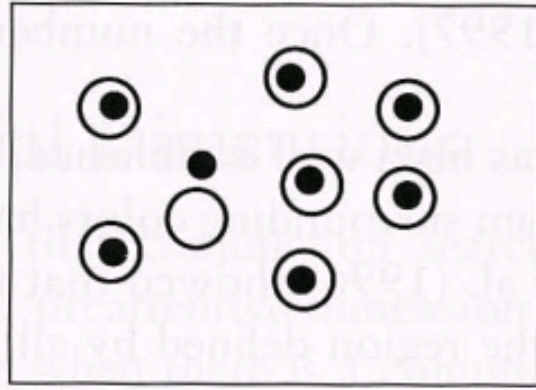
Gray/Value



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22

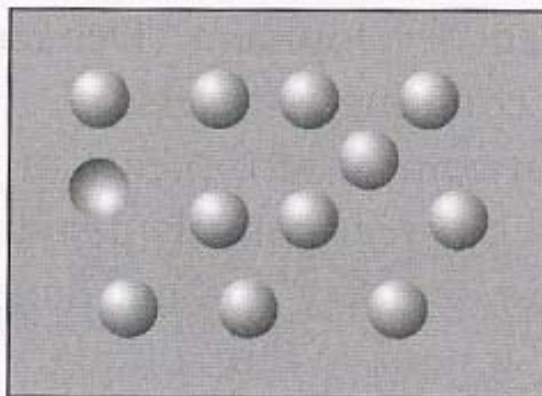
Enclosure



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23

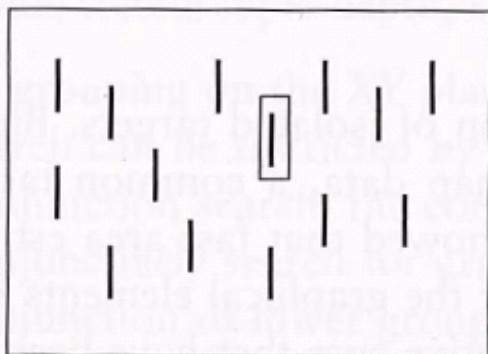
Covexity/Concavity



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24

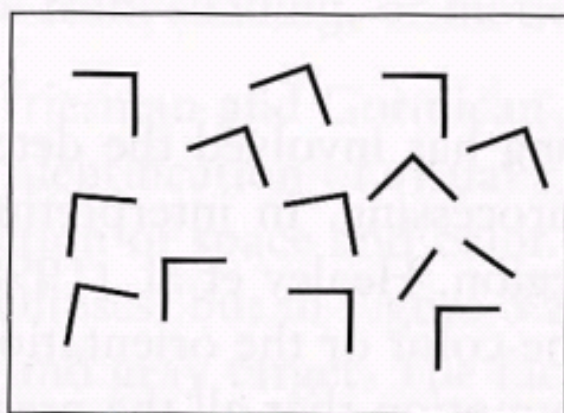
Addition



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25

Juncture

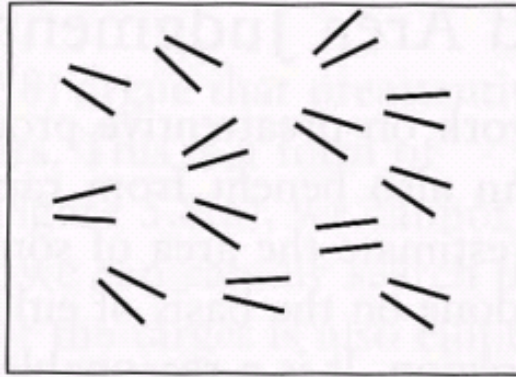


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Not!

26

Parallelism



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Not!

27

Multiple Symbol Types



- Pre-attentive symbols become less distinct as the variety of distracters increase
- Two factors
 - Degree of difference of target from nontargets
 - Degree of difference of nontargets from each other

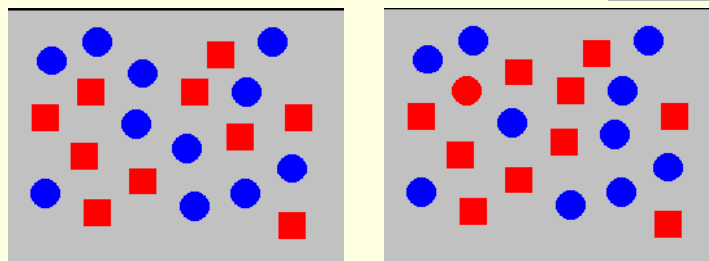
28

Example

- Determine if a red circle is present

29

Conjunction of Features



- Cannot be done pre-attentively
- Must perform a sequential search
- Conjunction of features (shape and hue) causes it

- Dr. John Stasko, Slides of CS7500 at Gatech

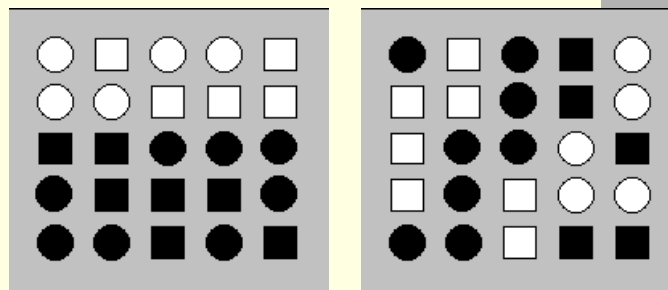
30

Example

- Is there a boundary in the display?

31

Mixed Features



- Left can be done pre-attentively since each group contains one unique feature
- Right cannot (there is a boundary!) since the two features are mixed (fill and shape)

- Dr. John Stasko, Slides of CS7500 at Gatech

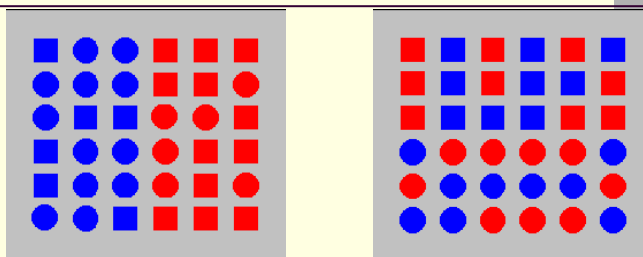
32

Example

- Is there a boundary in the display?

33

Feature Hierarchy: Hue vs. Shape

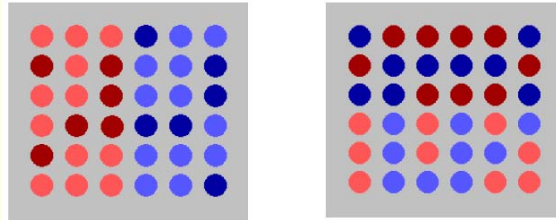


- Left: Boundary detected pre-attentively based on hue regardless of shape
- Right: a horizontal form boundary cannot be pre-attentively identified when hue varies randomly in the background
- Visual systems favor hue over shape

<http://www.csc.ncsu.edu/faculty/healey/PP/index.html>

34

Feature Hierarchy: Hue vs. Brightness

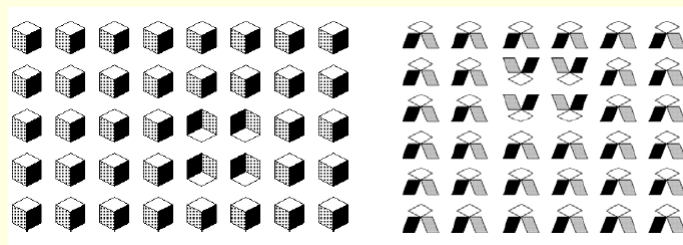


- Left: Boundary detected pre-attentively based on hue regardless of brightness
- Right: a horizontal form boundary cannot be pre-attentively identified when hue varies randomly in the background
- Visual systems favor hue over brightness

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35

3-D Figures



36

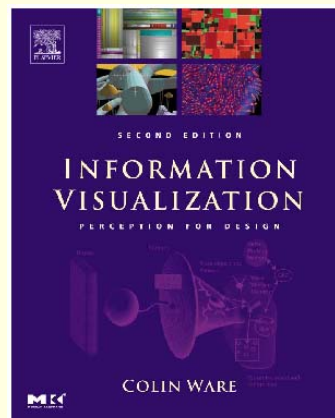
Discussion

- What can we do using pre-attentive features?

37

Book

- Dr. Colin Ware



38