Perception and Design I

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Based on slides from John Stasko, GTECH
Disclaimer

I am not a psychologist

A general understanding of these perceptual issues is still important for Information Visualization

For Information Visualization specific discussion, see Information Visualization, Perception for Design by Colin Ware

Relevant Courses: PSY 340, 442
Visual Perception

Sensation

Stimulus

Sensory Organ

Perception

Perceptual Organ

Rapid processing = Preattentive Processing
Fast than 10 ms per item

Iconic ( < 1 s)
Short Term (~3s)
Long Term
Image from: www.prefuse.org

--Card, Mackinlay and Schneiderman 1999
Preattentive Processing

• Automatic and unconscious processing that happens without focused attention
• Fast recognition process
• Only certain things are processed preattentively!
  – Can we take advantage of these??
Preattentive Processing

How many 5’s do you see?

01993004768202084373593884790981123804998
98739847597893974983229384729134095093004
80387609901128048304994864509928293764529
90304784739902720384784576373890283899029
Pretattentive Processing

How many 5’s do you see?

01993004768202084373593884790981123804998
98739847597893974983229384729134095093004
80387609901128048304994864509928293764529
90304784739902720384784576373890283899029
Preattentive Attributes

**Form**
- Orientation
- Line length
- Line Width
- Size
- Shape
- Curvature
- Added Marks
- Enclosure

**Color**
- Hue
- Intensity

**Spatial Position**
- 2D Position
- Convex/concave

**Motion**
- Flicker
- Direction

Line Colinearity
Spatial Grouping
Blur
Numerosity
Stereoscopic Depth
Shape from shading
Examples of Preattentive Attributes

Not preattentive
What Kinds of Tasks

Target detection
   Is something there?

Boundary detection
   Can the elements be grouped?

Counting
   How many elements of a certain type are present?
Example: Is there a red circle?

Images courtesy of Christopher Healey
(http://www.csc.ncsu.edu/faculty/healey/PP/index.html)
Example: Is there a red circle?
Example: Is there a red circle?

Conjunctive targets normally not preattentively detected

Images courtesy of Christopher Healey
(http://www.csc.ncsu.edu/faculty/healey/PP/index.html)
Examples: Find the boundary
Find the Boundary
Preattentive Attribute Demos

http://www.csc.ncsu.edu/faculty/healey/PP/index.html
How can we take advantage of this information?

We know what pops out...BUT...what is good for conveying VALUES for various types of data?
The marks are perceived as PROPORTIONAL to each other.
The marks can be perceived as SIMILAR.
The marks are perceived as DIFFERENT, forming families.
The marks are perceived as ORDERED.
The marks are perceived as ORDERED.
Cleveland and McGill 1984

Accuracy of judgement of quantity

- Position
- Length
- Angle
- Slope
- Area
- Volume
- Colour
- Density

Most accurate to Least accurate.
Mackinlay’s Ranking 1986

**Quantitative**
- Position
- Length
- Angle
- Slope
- Area
- Volume
- Density
- Shape

**Ordinal**
- Position
- Density
- Colour saturation
- Colour hue
- Texture
- Connection
- Containment
- Length
- Angle
- Slope
- Area
- Volume

**Categorical**
- Position
- Colour hue
- Texture
- Connection
- Containment
- Density
- Colour saturation
- Shape
- Length
- Angle
- Slope
- Area
- Volume
Few – Tasks and Preattentive Attr.

• Distinguish nominal (or ordinal) values from one another
  • hue & shape
    • Must use separable colors!
• Order quantitative values
  • length, position [superstars of quant. values!]
  • width, size, intensity, blur
• Less effective as distractors increase!
<table>
<thead>
<tr>
<th>Precision of Quantitative Perception</th>
<th>Attribute</th>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very precise</td>
<td>Length</td>
<td></td>
<td>Longer = greater</td>
</tr>
<tr>
<td>2-D Position</td>
<td></td>
<td>• • • •</td>
<td>Higher or farther to the right = greater</td>
</tr>
<tr>
<td>Not very precise</td>
<td>Width</td>
<td></td>
<td>Wider = greater</td>
</tr>
<tr>
<td></td>
<td>Size</td>
<td>• • • •</td>
<td>Bigger = greater</td>
</tr>
<tr>
<td></td>
<td>Intensity</td>
<td>• • • •</td>
<td>Darker = greater</td>
</tr>
<tr>
<td></td>
<td>Blur</td>
<td>• • • •</td>
<td>Clearer = greater</td>
</tr>
</tbody>
</table>
Few - Memory

- Working memory - 3 chunks?? vs. 7+/−2
- Visual representations allow us to organize large chunks
- Augment chunking with ‘external storage’
  - the screen
  - Avoid fragmenting information
**Preattentive processing:** How to make important things “pop out” at a glance (for certain tasks!)

**Encoding Rankings:** What’s the most effective way to encode various types of data (quantitative ordinal, nominal) for reading ‘values’

How do we make patterns apparent?
Gestalt Principles - 1912

Gestalt theory describes how the mind organizes visual data

Original goal: how we perceive pattern, form, organization

6 Gestalt Principles

Visual attributes that incline us to group the objects that we see in particular ways

- Proximity
- Enclosure
- Continuity
- Similarity
- Closure
- Connection
Gestalt Principles: Proximity
Gestalt Principles: Similarity

We group together objects similar in size, shape, color, and orientation.

Slide courtesy of John Stasko
Gestalt Principles: Enclosure
Gestalt Principle: Closure
Gestalt Principle: Continuity

- blah A
- blah B
- blah C
- blah C
- blah C
- blah E
Gestalt Principle: Connection
Perceptual Design in Minard’s Map

Figurative Map of the successive losses in men of the French Army in the Russian campaign 1812–1813.

Drawn up by M. Minard, Inspector General of Bridges and Roads in retirement.

Paris, November 20, 1869.

The numbers of men present are represented by the widths of the colored zones at the rate of one millimeter for every ten thousand men, they are further written across the zone. The red designates the men who were in Russia, the blue those who have left. The information which has served to draw up the map has been extracted from the works of H. M. Ch. de Bar, of Territorial of Chemins and the unpublished diary of Jacob, theNoSuch of the Army since October 25th.

In order to better judge what the diminution of the army, I have assumed the towns of Danzig, Hildes and Marshal Davoust who had been detached at Munich. The Magdeburg have approximated around Czerni and Wierick, had almost marched with the army.

Graphic Table of the temperature in degrees of the Réaumur thermometer below zero.
Perceptual Design in Snow’s Cholera Map
Perceptual Design: Challenger

(Tufte 1983)
Perceptual Design: Challenger

There is much more to the story: http://people.rit.edu/wlrgsh/FINRobison.pdf