Perception and Cognition

1. Discrimination and steps
2. Judging magnitude
3. Preattentive features and serial search
4. Multiple visual attributes
Detection

Just-Noticible Difference

JND

\[ \Delta S = k \frac{\Delta I}{I} \]

Steps in value
- 100:1 contrast

Ratios more important than magnitude
Steps

Most variations in values are perceived as steps

Steps in value
- For example: contour map

Steps in size and orientation
- Orientation columns roughly 30°
- Receptive fields increase by roughly a factor of 2

Estimating Magnitude
Steven’s Power Laws

\[ S = I^p \]

\( p < 1 \) : underestimate
\( p > 1 \) : overestimate

Exponents of Power Law

<table>
<thead>
<tr>
<th>Sensation</th>
<th>Exponent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loudness</td>
<td>0.6</td>
</tr>
<tr>
<td>Brightness</td>
<td>0.33</td>
</tr>
<tr>
<td>Smell</td>
<td>0.55 (Coffee) - 0.6 (Heptane)</td>
</tr>
<tr>
<td>Taste</td>
<td>0.6 (Saccharine) - 1.3 (Salt)</td>
</tr>
<tr>
<td>Temperature</td>
<td>1.0 (Cold) - 1.6 (Warm)</td>
</tr>
<tr>
<td>Vibration</td>
<td>0.6 (250 Hz) - 0.95 (60 Hz)</td>
</tr>
<tr>
<td>Duration</td>
<td>1.1</td>
</tr>
<tr>
<td>Pressure</td>
<td>1.1</td>
</tr>
<tr>
<td>Heaviness</td>
<td>1.45</td>
</tr>
<tr>
<td>Electric Shock</td>
<td>3.5</td>
</tr>
</tbody>
</table>

From Table 2.
S. S. Stevens, Psychophysics of Sensory Function,
Proportional Symbol Map

Newspaper Circulation

B. D. Dent, Cartography: Thematic Map Design, Figure 8.8, p. 172

Apparent Magnitude Scaling

B. D. Dent, Cartography: Thematic Map Design, Figure 8.6, p. 170, 1996
Based on Flannery, 1956
Graduated Sphere Map

**Figure 7.4.** An eye-catching map created using three-dimensional geometric symbols. (After Smith, 1928. First published in *The Geographical Review*, 18(3), plate 4. Reprinted with permission of the American Geographical Society.)

**Figure 3.** Graphs from position–angle experiment.

W. S. Cleveland, R. McGill, Graphical perception: Theory, experiments and application to the development of graphical methods, JASA 39, pp. 531-554, 1984
Figure 4. Graphs from position–length experiment.

W. S. Cleveland, R. McGill, Graphical perception: Theory, experiments and application to the development of graphical methods, JASA 39, pp. 531-554, 1984
Relative Magnitude Estimation

Most accurate

Position (common) scale
Position (non-aligned) scale
Length
Slope
Angle
Area
Volume

Least accurate

Color hue-saturation-density
Preattentive vs. Attentive

Visual Pop-Out

http://www.csc.ncsu.edu/faculty/healey/PP/index.html
More Pre-Attentive Features

Figure 5. S. p. 166, Ware, 2000

Preattentive Features

- Line (blob) orientation: Julesz & Bergen [1983]; Wolfe et al. [1992]
- Length: Triesman & Gormican [1988]
- Width: Julesz [1985]
- Size: Triesman & Gelade [1980]
- Curvature: Triesman & Gormican [1988]
- Number: Julesz [1985]; Trick & Pylyshyn [1994]
- Terminators: Julesz & Bergen [1983]
- Intersection: Julesz & Bergen [1983]
- Closure: Enns [1986]; Triesman & Souther [1983]
- Intensity: Beck et al. [1983]; Triesman & Gormican [1988]
- Flicker: Julesz [1971]
- Binocular lustre: Wolfe & Franzel [1988]
- Stereoscopic depth: Nakayama & Silverman [1986]
- 3-D depth cues: Enns [1990]
- Lighting direction: Enns [1990]
Preattentive Conjunctions

Motion and disparity is conjunctive
Motion is separable with color and shape
Disparity is separable with color and shape
Feature-Integration Theory

Preattentive State

Focused Attention

Identify Primitives
Combine Primitives
Perceive Object
Compare Memory

Image

Memory

Visual Pathways

Figure 4.4.1 A density of separate functional pathways in the primate visual system. Livingstone and Hubel suggested that form, color, motion, and stereo information become increasingly differentiated from retina to extrastriate visual cortex. (LOV = lateral occipital visual; MT = medial temporal; V1 = visual area 1) From Livingstone & Hubel, 1988.)
Multiple Attributes

One-dimensional: Lightness

White  White  White
Black  White  Black
Black  White  White
One-dimensional: Shape

Correlated Dims: Shape or Lightness
Orthogonal Dims: Shape and Lightness

Speeded Classification
Redrawn from Garner, The processing of information and Structure, Erlbaum, 1974 (Figure 6.6, p. 140)

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**Speeded Classification**

**Filtering interference**
- Difficulty in ignoring one dimension while attending to the other

**Redundancy gain**
- Facilitation in reading one dimension when the other provides redundant information
Types of Dimensions

Integral
Filtering interference and redundancy gain

Separable
No interference or gain

Configural
Only interference, but no redundancy gain

Correlated Dim.: Size and Value

W. S. Dobson, Visual information processing and cartographic communication: The role of redundant stimulus dimensions, 1983 (reprinted in MacEachren, 1995)
Configural Dim.: Aspect Ratio

FIGURE 3.38. An example of the use of an ellipse as a map symbol in which the horizontal and vertical axes represent different (but presumably related) variables.

MacEachren, 1995

Bivariate Map

MacEachren, 1995, (From D. B. Carr, A. R. Olsen, D. White, Hexagon mosaic maps for display of bivariate geographic data, Cartography and GIS, 19(4), 228-236, 1992)
Bivariate Map

Temperature and precipitation

Figure 3.36, p. 86 MacEachren, 1995

Bivariate Map

Temperature and precipitation

Figure 3.40, p. 92 MacEachren, 1995
Summary of Integral-Separable

Grouping
Small Multiples

Envisioning Information, E. Tufte
- Operation of trains, p. 68
- Historical and cultural atlas of China, p. 74
Layering

Envisioning Information, E. Tufte
- IBM Copier, p. 54
- Stravinsky score, p. 59