Perception and Cognition

Perception and Cognition

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

Detection

Just-Noticable 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

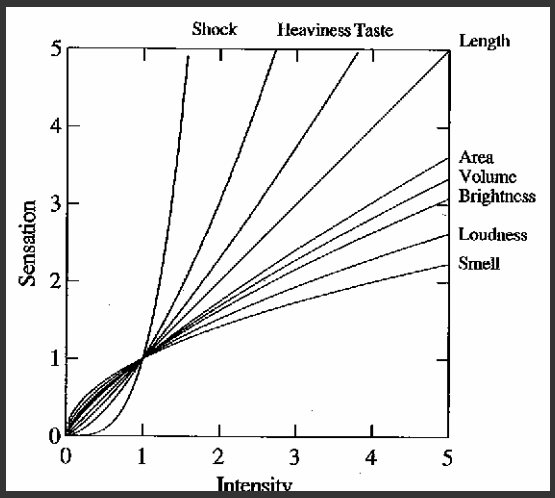
Steps in size and orientation

- Orientation columns roughly 30 deg
- 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

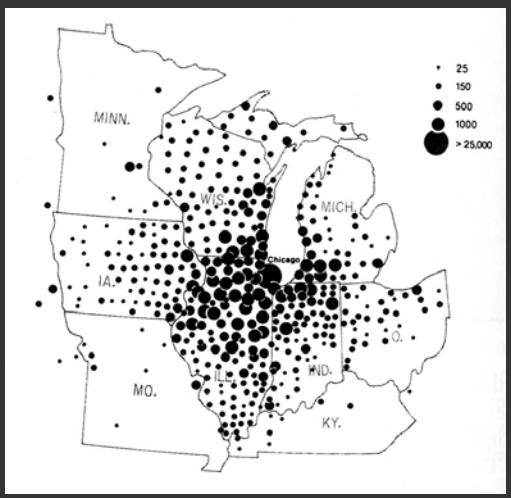
Sensation	Exponent
Loudness	0.6
Brightness	0.33
Smell	0.55 (Coffee) - 0.6 (Heptane)
Taste	0.6 (Saccharine) -1.3 (Salt)
Temperature	1.0 (Cold) – 1.6 (Warm)
Vibration	0.6 (250 Hz) – 0.95 (60 Hz)
Duration	1.1
Pressure	1.1
Heaviness	1.45
Electic Shock	3.5

From Table 2.

S. S. Stevens, Psychophysics of Sensory Function,

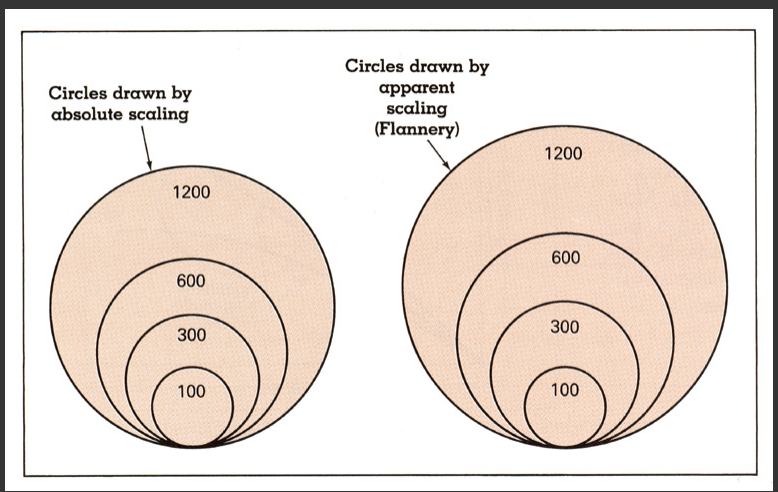
Proportional Symbol Map

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

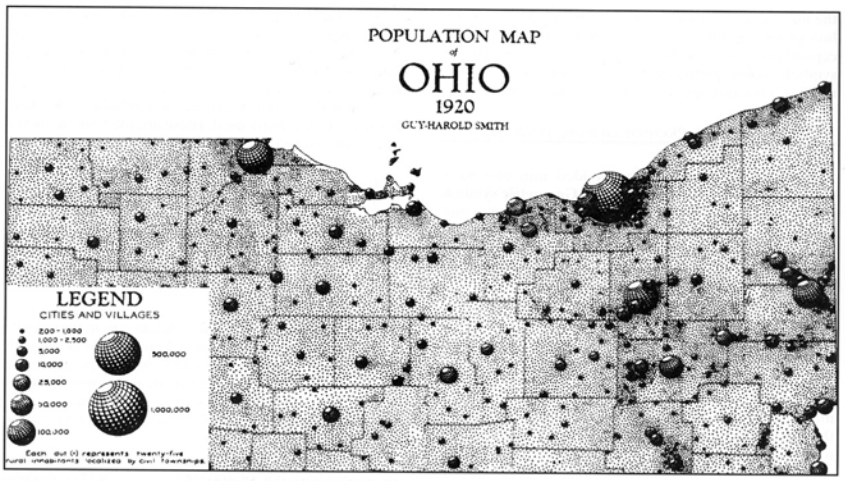


FIGURE 7.4. An eye-catching map created using three-dimensional geometric symbols. (After Smith, 1928. First published in *The Geographical Review,* 18(3), plate 4. Reprinted with permission of the American Geographical Society.)

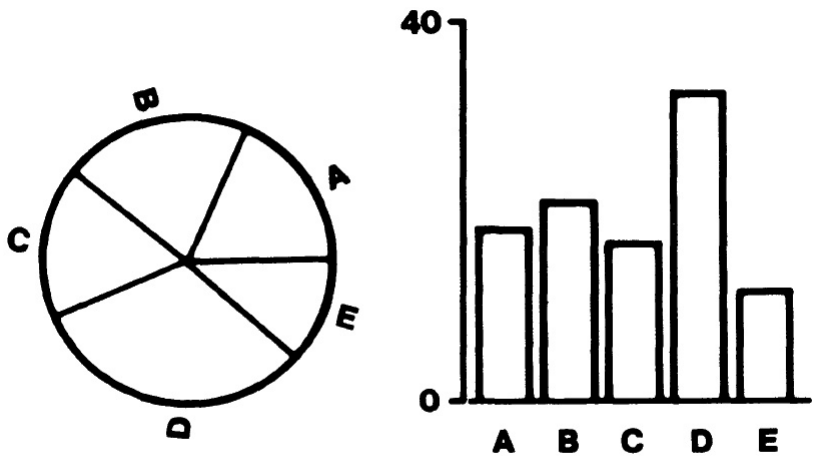


Figure 3. Graphs from position–angle experiment.

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

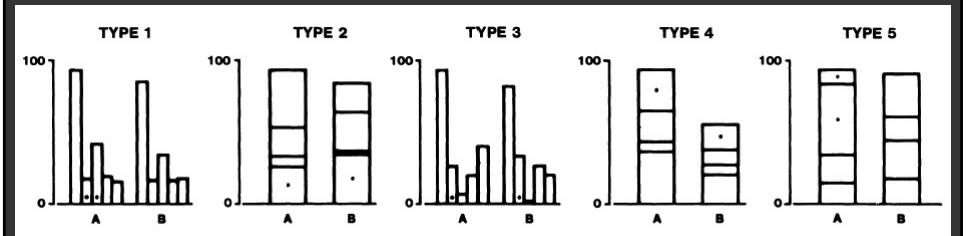


Figure 4. Graphs from position–length experiment.

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

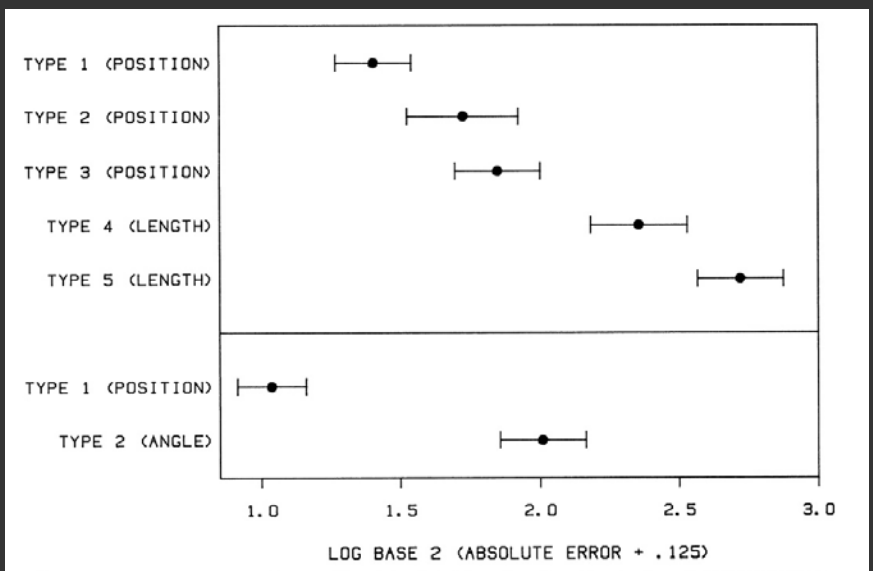


Figure 16. Log absolute error means and 95% confidence intervals for judgment types in position–length experiment (top) and position–angle experiment (bottom).

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

Least accurate

Position (common) scale

Position (non-aligned) scale

Length

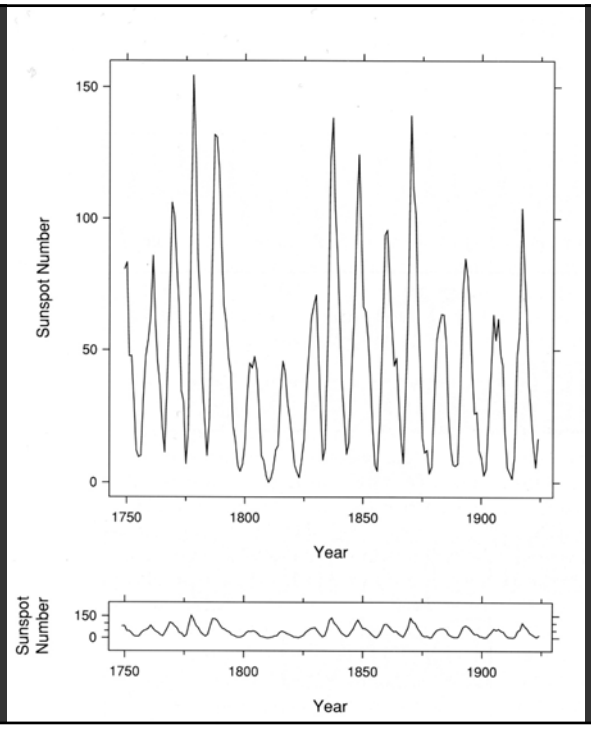
Slope

Angle

Area

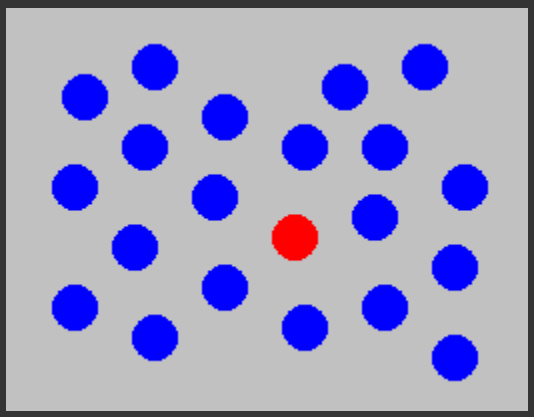
Volume

Color hue-saturation-density



Preattentive vs. Attentive

Visual Pop-Out



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

More Pre-Attentive Features

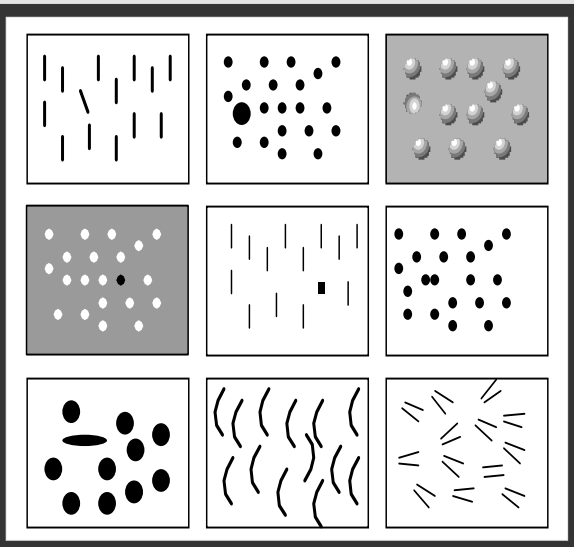
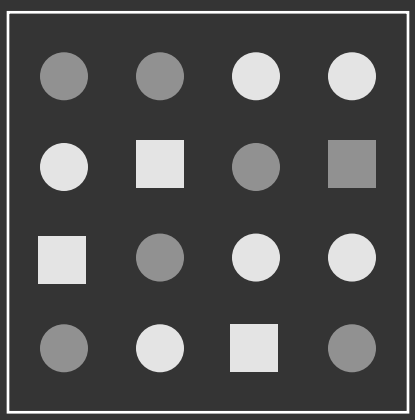


Figure 5. 5, p. 166, Ware, 2000

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 [1985]
Colour (hue)	Nagy & Sanchez [1990, 1992]; D'Zmura [1991]; Kawai et al. [1995]; Bauer et al. [1996]
Intensity	Beck et al. [1983]; Triesman & Gormican [1988]
Flicker	Julesz [1971]
Direction of motion	Nakayama & Silverman [1986]; Driver & McLeod [1992]
Binocular lustre	Wolfe & Franzel [1988]
Stereoscopic depth	Nakayama & Silverman [1986]
3-D depth cues	Enns [1990]
Lighting direction	Enns [1990]

Preattentive Conjunctions



Shape and Lightnesss

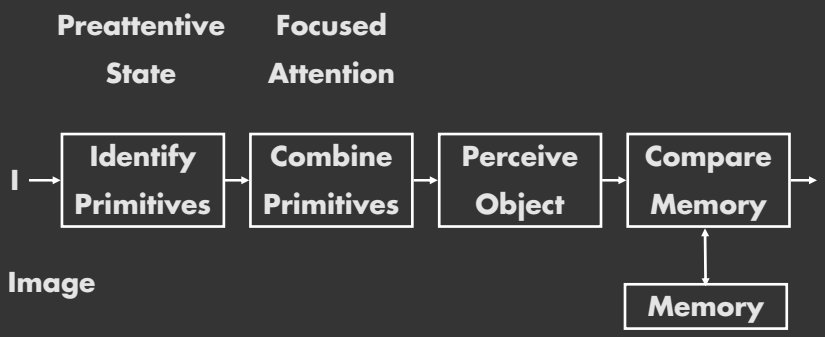
Preattentive Conjunctions

Motion and disparity is conjunctive

Motion is separable with color and shape

Disparity is separable with color and shape

Feature-Integration Theory



Visual Pathways

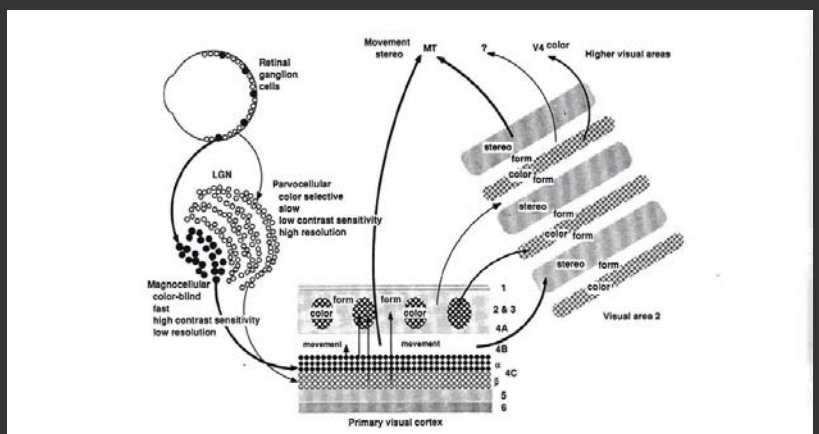
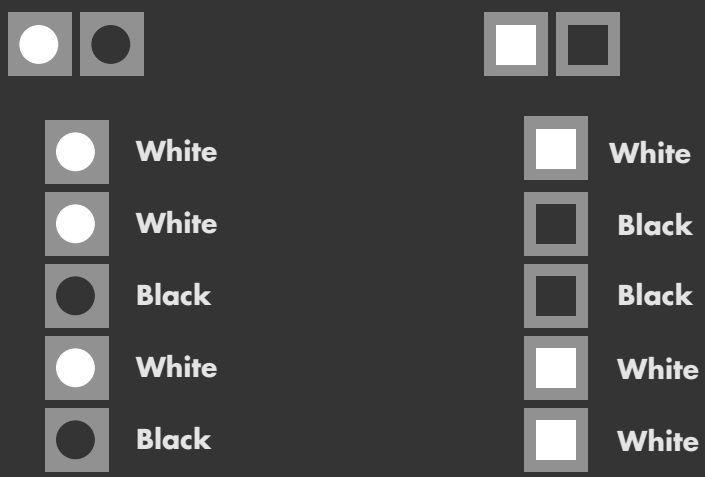


Figure 4.4.1 A theory of separate functional pathways in the primate visual system. Livingstone and Hubel suggested that form, color, motion, and stereo information become increasingly differentiated from retina to extrastriate visual cortex. (LGN = lateral geniculate nucleus; MT = medial temporal lobe; V4 = visual area 4.) (From Livingstone & Hubel, 1988.)

Multiple Attributes

One-dimensional: Lightness



One-dimensional: Shape

Square
Circle
Circle
Square
Circle

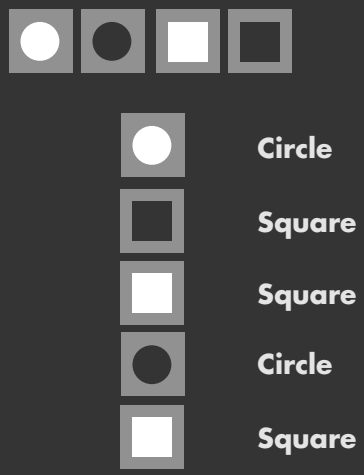
Circle
Circle
Square
Circle
Circle

Correlated Dims: Shape or Lightness

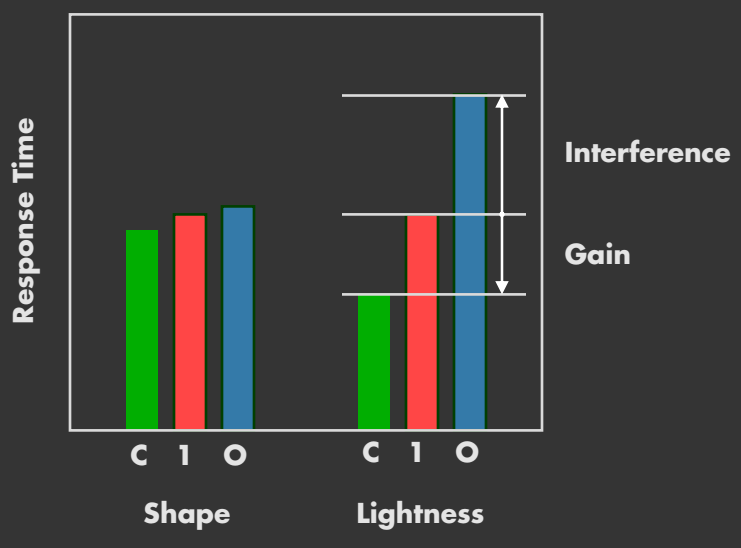
Circle
Square
Square
Circle
Square

Circle
Square
Square
Square
Circle

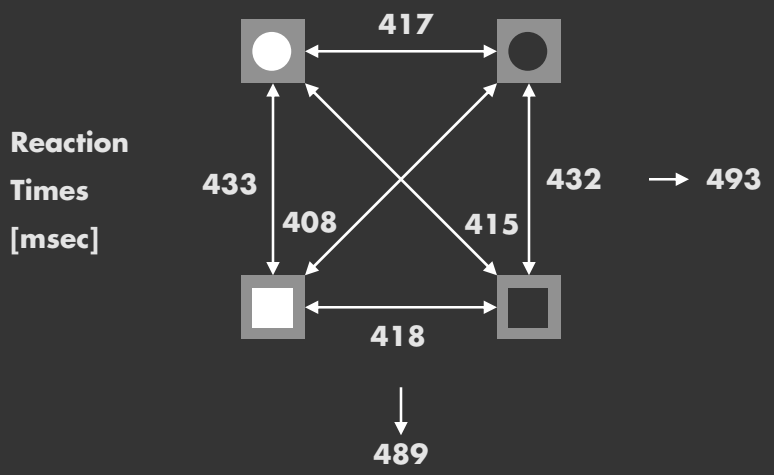
Orthogonal Dims: Shape and Lightness



Speeded Classification



Speeded Classification



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

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

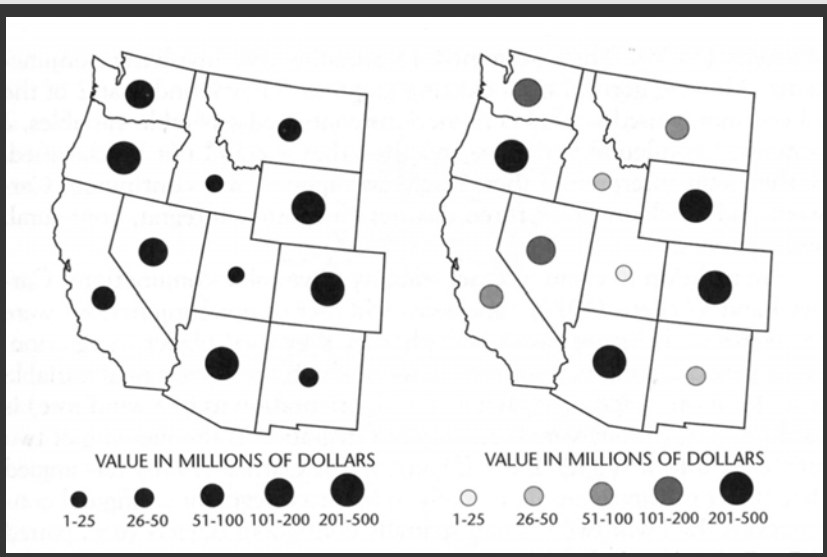
Separable

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

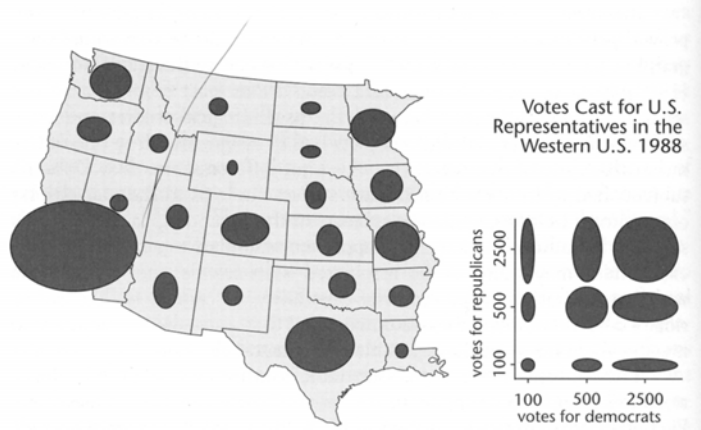
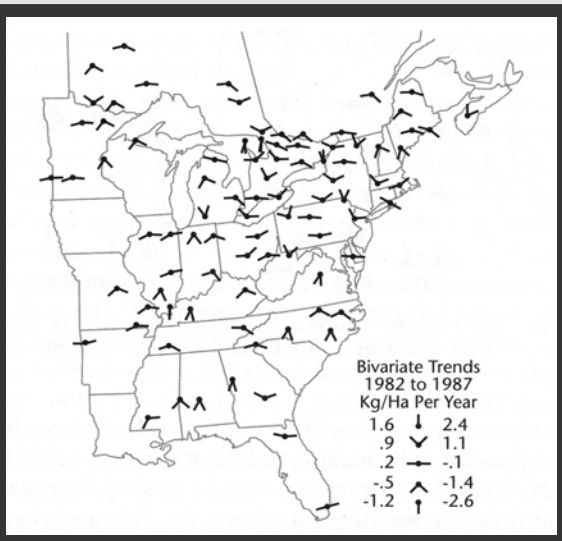


FIGURE 3.38. An example of the use of an ellipse as a map symbol in which the horizontal and vertical axes represent different (but presumably related) variables.

MacEachren, 1995

Bivariate Map



NO_3-SO_2

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

Bivariate Map

Temperature and precipitation

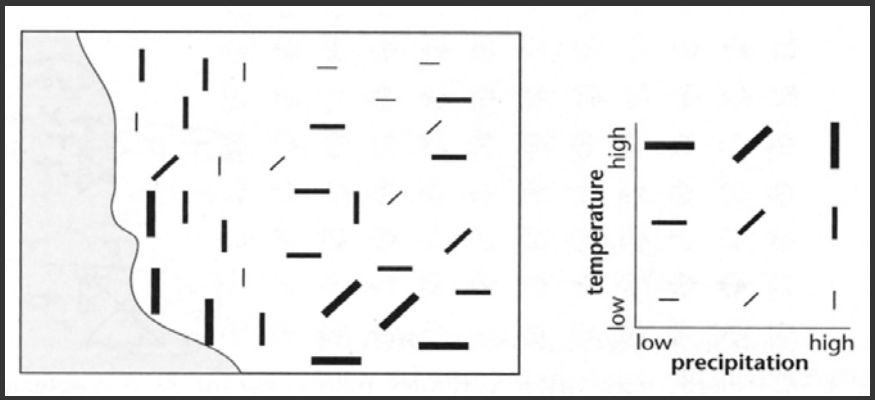


Figure 3.36, p. 86 MacEachren, 1995

Bivariate Map

Temperature and precipitation

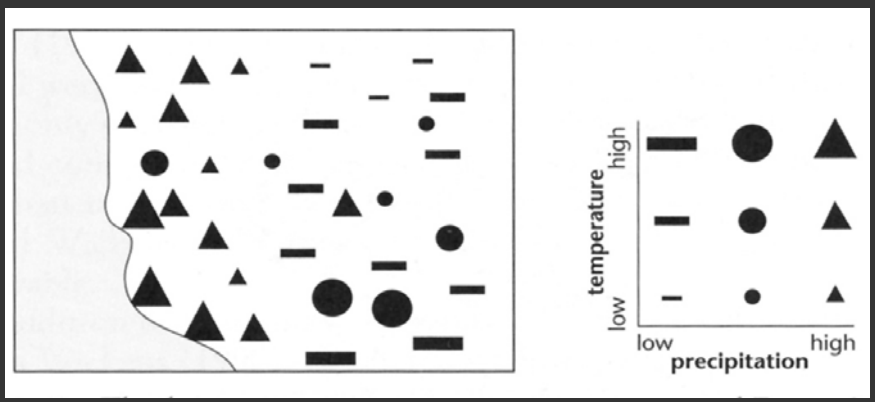
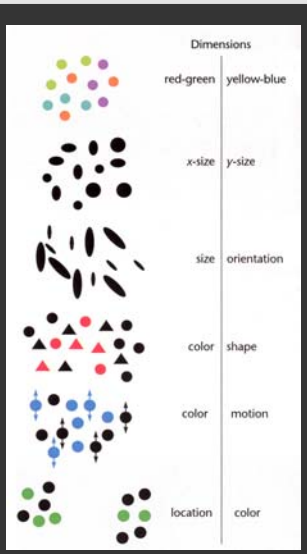


Figure 3.40, p. 92 MacEachren, 1995

Summary of Integral-Separable



Integral

Separable

Figure 5.25, Color Plate 10, Ware, 2000

Grouping

Small Multiples

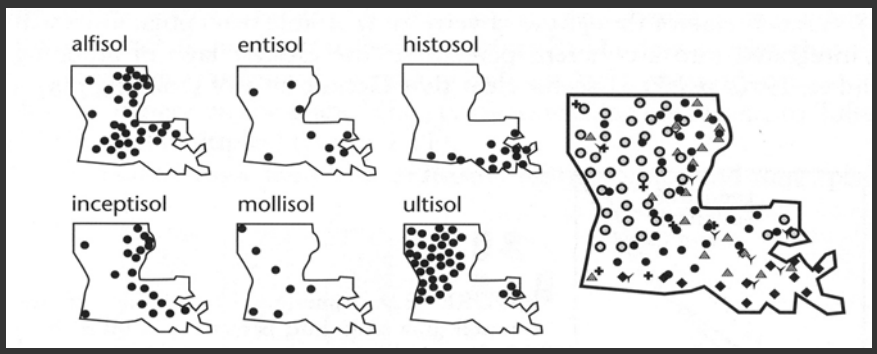


Figure 2.11, p. 38, MacEachren, 1995

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**