DSCI 554 LECTURE 10

PATTERNS, GESTALT AND SEMIOLOGY

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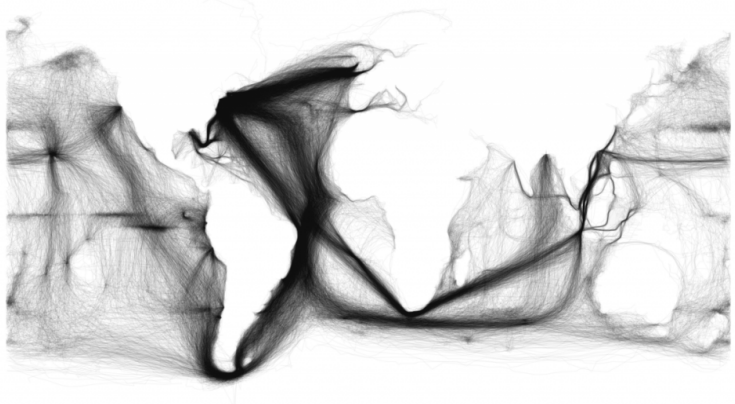
OUTLINE

- Patterns
- Gestalt
- Semiology

PATTERN RECOGNITION

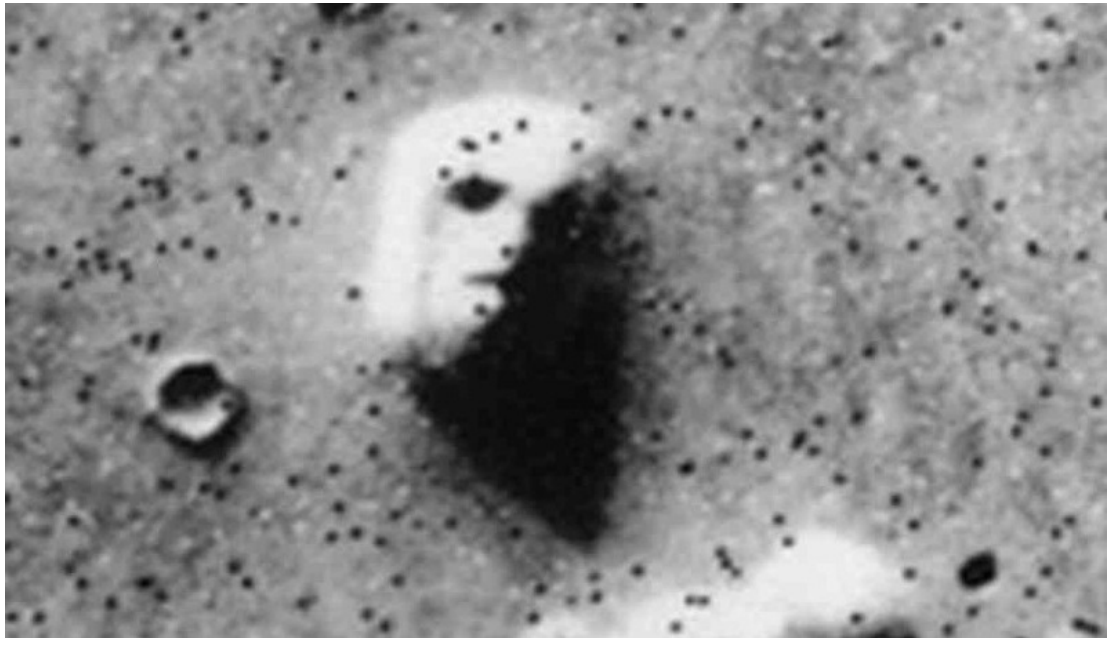
- Linking information from a stimulus to information from memory
- Subconscious
- Top-down and bottom-up process
- Involves the *"What"* visual pathway



Benjamin M. Schmidt Visualizing ship paths from the US Maury Collection (ICOADS deck 701)

APOPHENIA

- Perception of images or sounds in random stimuli
- *"Priming"* increases likelihood of seeing the pattern
- Likely evolutionary process from Type I (false positive) and Type II (false negatives) errors



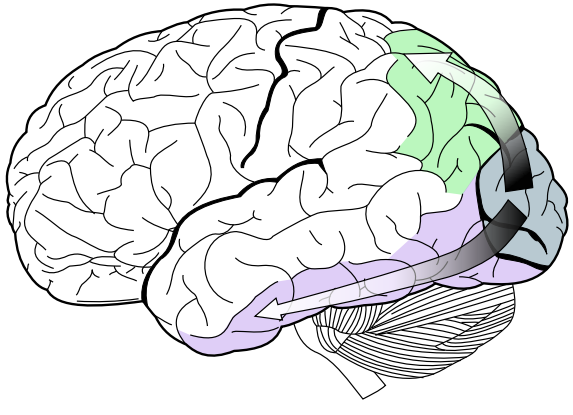
Part of the Cydonia (Mars) region, taken by the Viking 1 orbiter and released by NASA/JPL on July 25, 1976

PRIMING

Effect in which exposure to one stimulus influences a response to a later stimulus. Works on VLTM.

VISUAL PATHWAYS

- Two stream hypothesis: **where** and **what** pathways
- Pathways can work without visual input
- Visual aids needed for visual thinking due to:
  - Limited memory resources
  - Limited attention

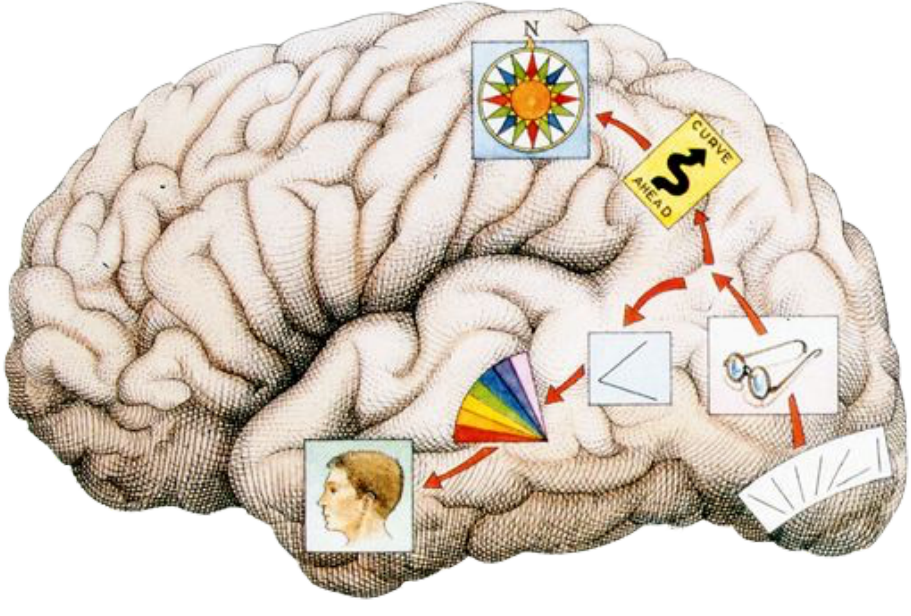


Where / Dorsal
relative object location for motor tasks

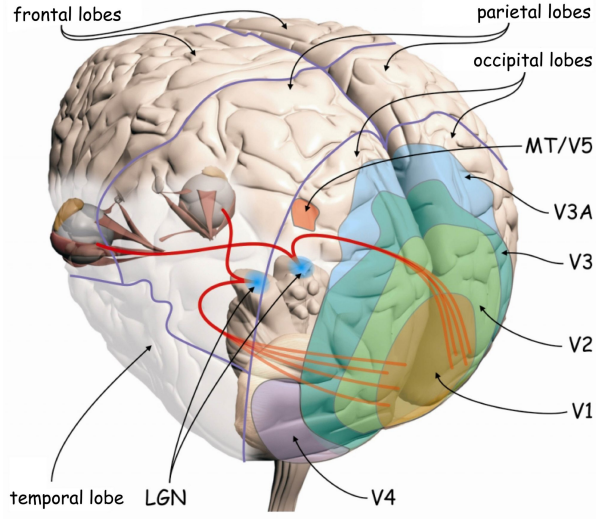
What / Ventral
object identification and recognition

VISUAL CORTEX & FEATURES PROCESSED

Simple features are detected in earlier visual areas, large patterns and shapes in higher visual areas



Visual cortex areas V1, V2, V3, V4, V5/MT (middle temporal)



Visual cortex and other cortical structures involved in vision. Graphic design: P.A. based on Logothetis (1999) and Zeki (2003)

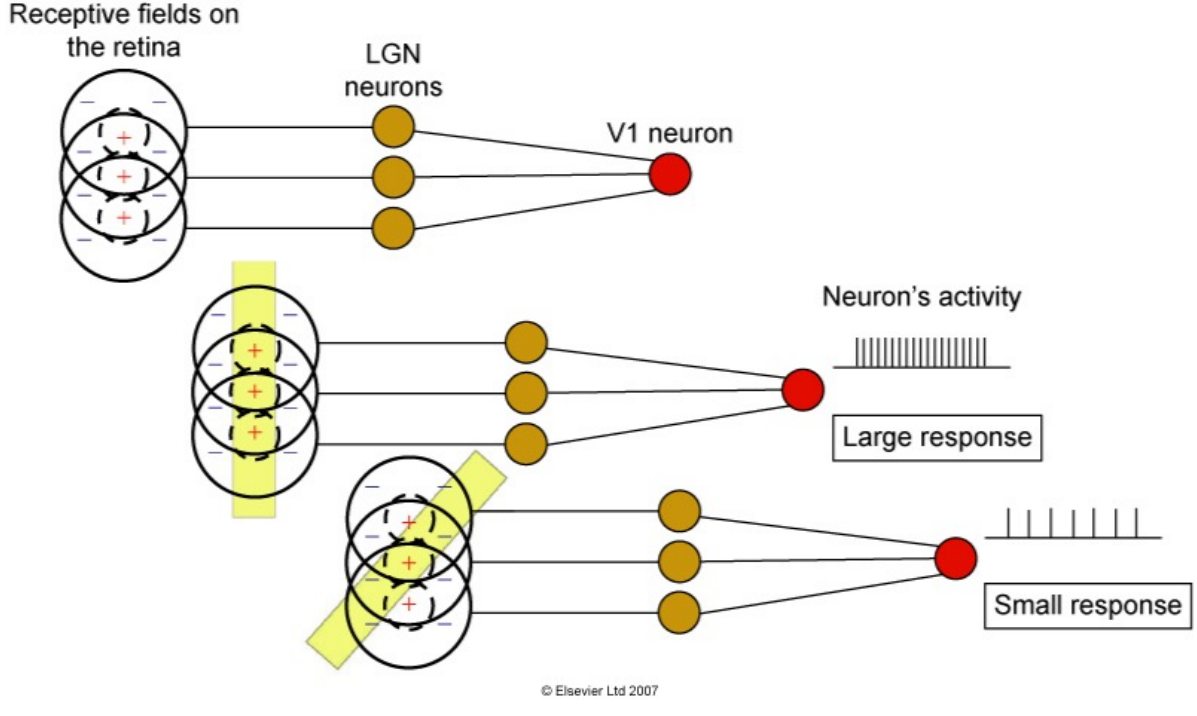
VISUAL CORTEX & INFORMATION

Visual cortex	Areas	Features processed	Example
Lower	V1, V2	Simpler features	V1 neurons may fire to any vertical stimulus†
Higher	V4, MT, and IT	Complex patterns	IT neurons may fire only to a specific face‡

	Lower visual cortex	Higher visual cortex
Information	Low	High
Localization	High	Low
Specificity	Low†	High‡
Experience	Universal	Individual

V1 NEURONAL TUNING

- Single V1 neurons are generally tuned to a particular characteristic
- Results from convergence (group of cells form a receptive field for one neuron)

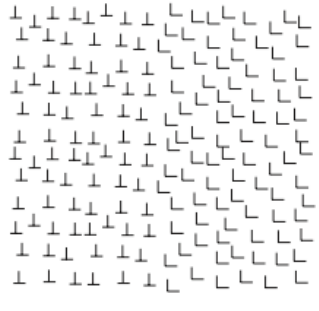


Some neurons of V1 are tuned to vertical lines, others to diagonal lines

LOWER VISUAL CORTEX

- Very fast processing ~ 40ms (pre-attentive ≤ 200ms, saccades: ~ 200ms to initiate, last 20-200ms)
- Strong tuning to orientation, spatial frequency and color
- Extremely sensitive tuning for horizontal and vertical lines

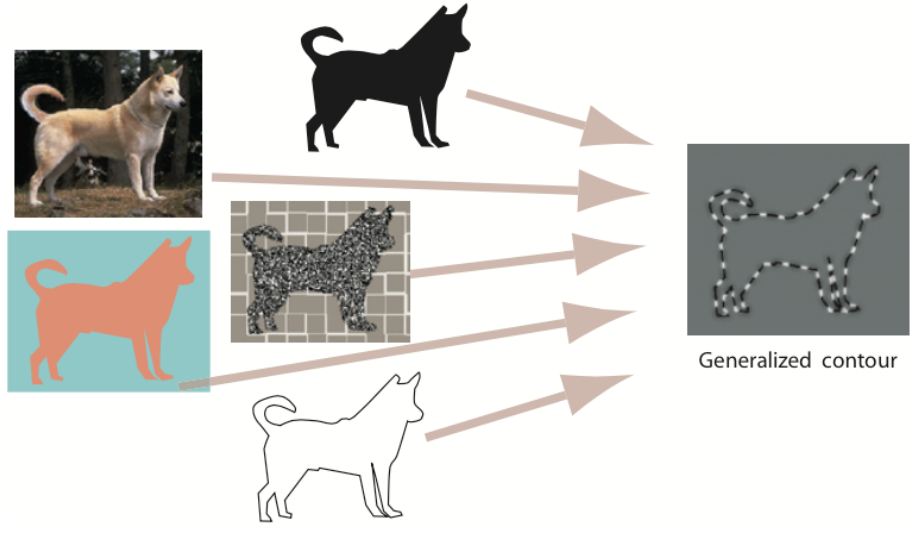
- Feature hierarchy, e.g., corners generate more powerful responses than edges



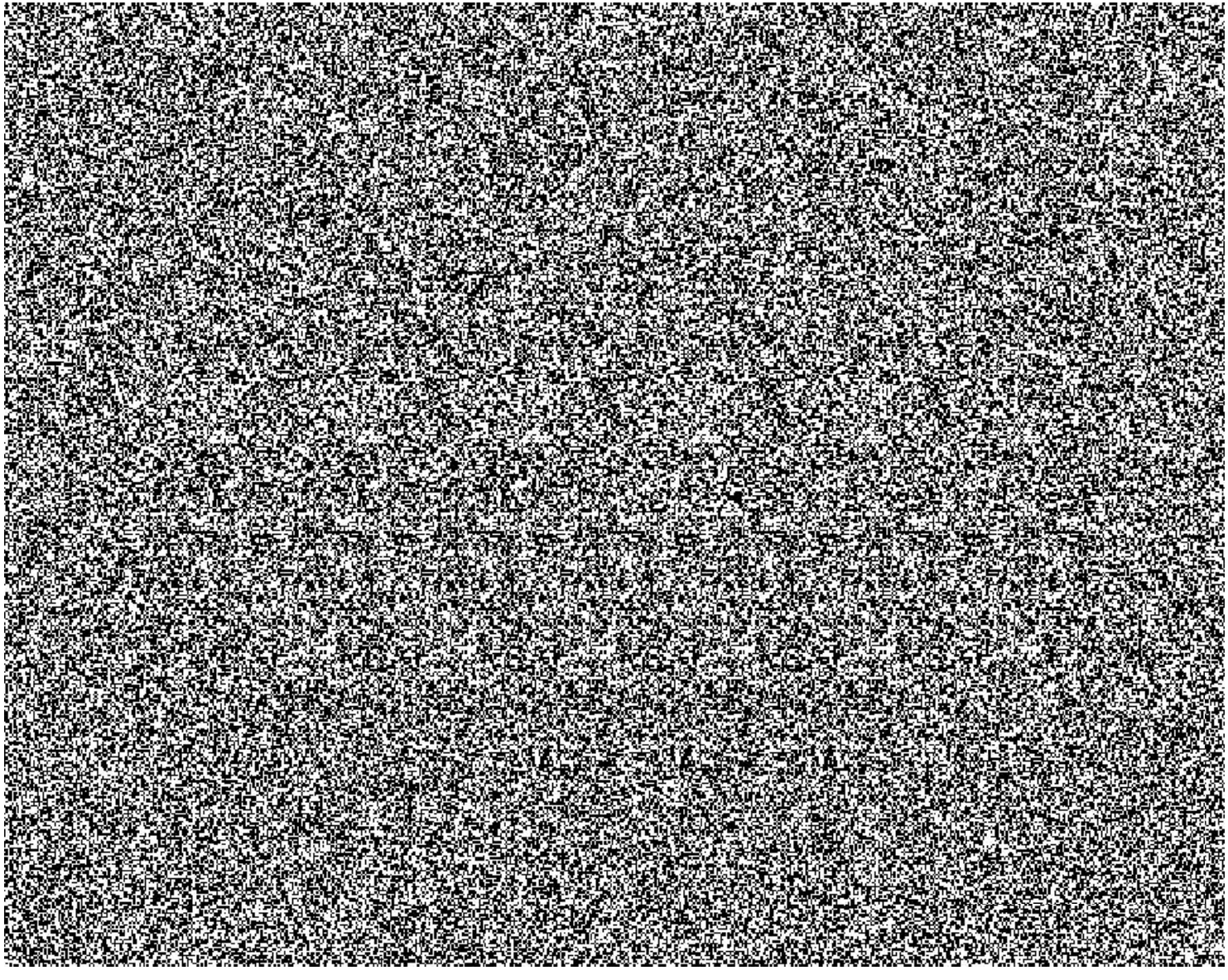
Ware, Colin, Visual queries: The foundation of visual thinking, 2005.

HIGHER VISUAL CORTEX

- Processing takes ≥ 100ms
- Increased sensitivity to more global organization of the scene
- Tuning to groups of patterns, motion patterns of large patterns
- Specialized regions extract and represent generalized object structure, e.g., **generalized contours** are easily understood in sketches



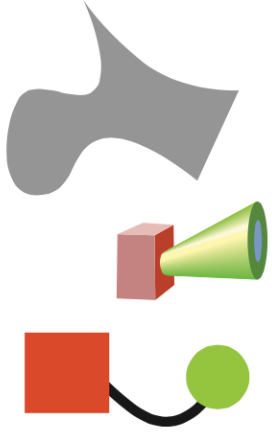
Ware, Colin, Visual queries: The foundation of visual thinking, 2005.



V4 response to motion of a large pattern.
Likely adaptation to tracking camouflaged objects.

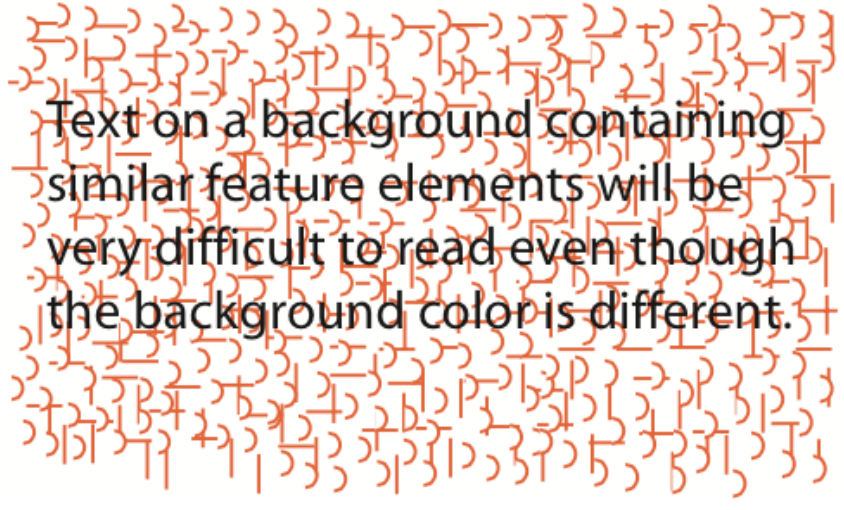
APPREHENDABLE CHUNK

- Learnable composite pattern
- Unlearned patterns that can be apprehended in one fixation
- Consist of about three components



Ware, Colin, Visual queries: The foundation of visual thinking, 2005.

SELECTIVE ATTENTIONAL TUNING



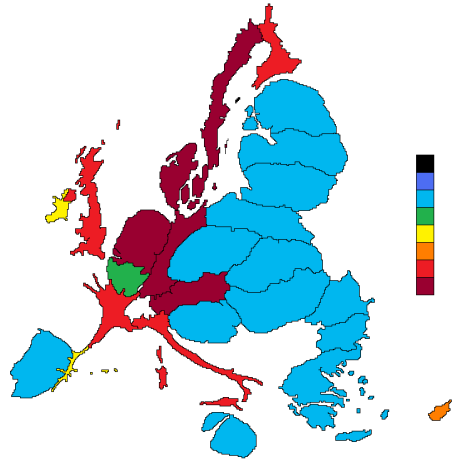
Can focus on a layer of a set of superposed layers. Used in thematic maps to display data on different layers.

Disrupted when patterns are too similar. This is similar to a conjunction search in pre-attentive features.

Images from Ware, Colin, Visual queries: The foundation of visual thinking, 2005.

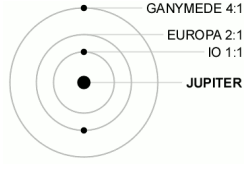
GROUPS OF PATTERNS

Robust to distortions: neurons in higher visual cortex respond strongly despite distortions

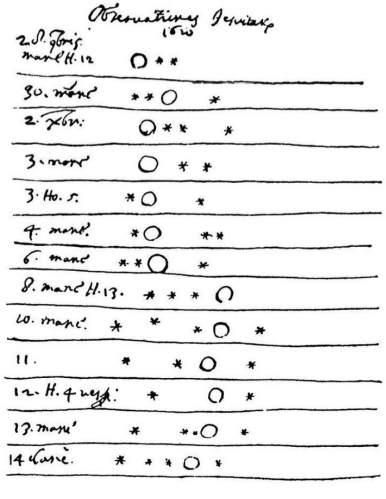


SKETCHES

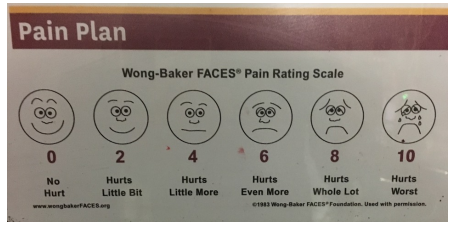
- Easily understood complex patterns
- Require less work than full-color, textured images



Galilean moons.



Drawing by Galileo.



Wong-Baker Faces Pain Rating Scale

Happy-or-not Smiley Terminal™

ICONS & SPATIAL METAPHORS

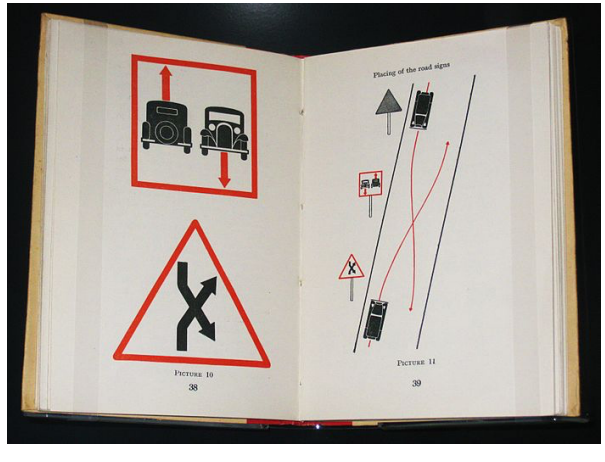
address-card	address-card-o
anchor	archive
arrows-h	arrows-v
asterisk	at
balance-scale	ban
bar-chart-o (alias)	barcode
bathtub (alias)	battery (alias)
battery-2 (alias)	battery-3 (alias)
battery-full	battery-half
bed	beer

Font Awesome icons

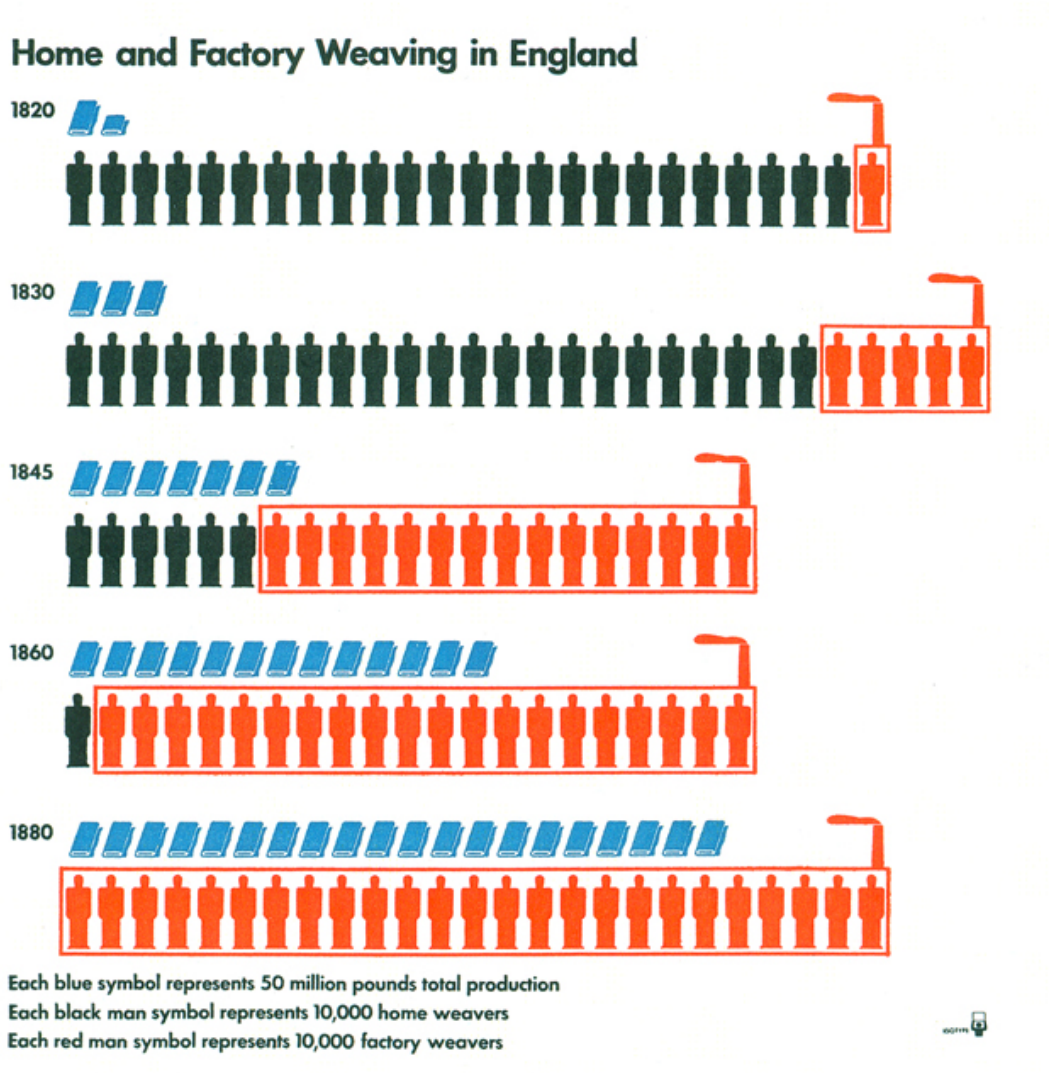
Ware, Colin, Visual queries: The foundation of visual thinking, 2005.

ISOTYPE* [OTTO & MARIE NEURATH - 1935]

- IsoTYPE: International System Of TYpographic Picture Education
- Symbolic representation of qualitative and quantitative information via easily interpretable icons



Neurath's International picture language, 1936



O. Neurath, Modern Man in the Making, 1939. Home and Factory Weaving in England

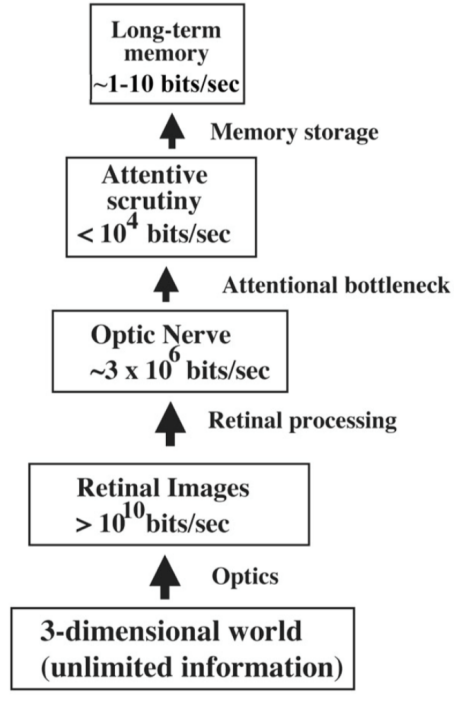
VISUAL MEMORY

← Visual Persistance Information Persistance →

Iconic Memory	Visual Short-term Memory (VSTM)	Visual Long-term Memory (VLTM)
Unlimited capacity	Limited capacity	Large capacity
Retention: $\leq 1s$	Retention: $\leq 30s$	Retention: *indefinite*
◦ High bandwidth ◦ Works unconsciously ◦ Provides temporal integration ◦ Continuity during saccades	◦ Buffer that stores temporary information ◦ Constructs and manipulate visual images	◦ Capacity increases over childhood, declines with old age. ◦ Encodes information semantically for long term storage ◦ Subject to fading, recalls help preserve it

ATTENTIONAL BOTTLENECK

Result of limited VSTM capacity



AN INFORMATION PYRAMID

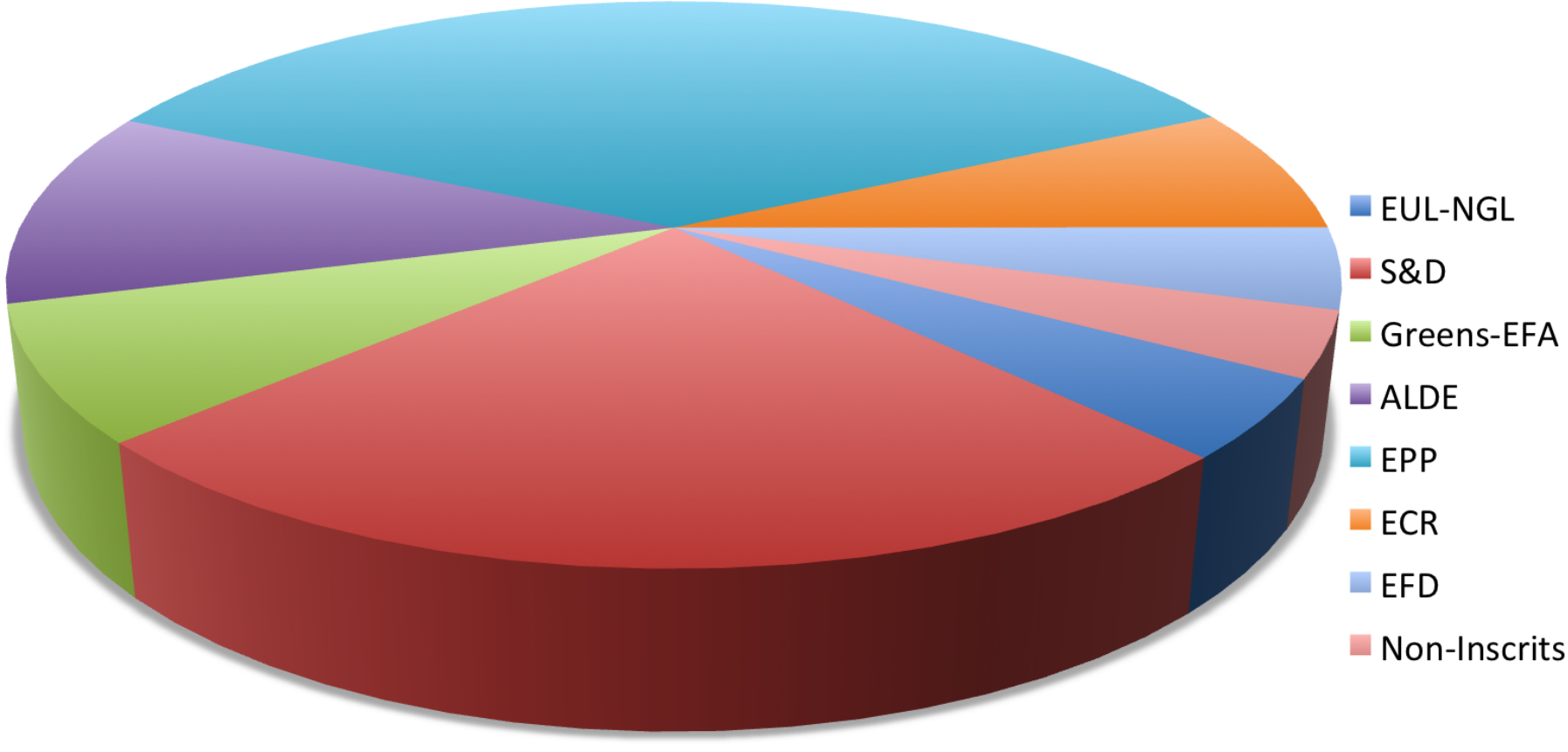
Anderson C., Van Essen D., and Olshausen A, Directed visual attention and the dynamic control of information flow, 2005.

MILLER'S LAW

The Magical Number Seven, Plus or Minus Two

- Limit depends on the type information:
  - 5-9 items with 1-D information judgment task [Miller, 1956*]
  - 4-5 items with characters [Sperling, 1960]
  - 3-4 items with basic visual features & interference task [Luck & Vogel, 1997]

European Parliament Party Breakdown

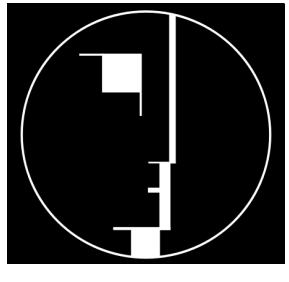


OUTLINE

- Patterns
- Gestalt
- Semiology

GESTALT THEORY OF PERCEPTION

- Psychology theory from early twentieth century
- An organized whole that is perceived as more than the sum of its parts
- Gestalt means *shape* in German and can be interpreted as *pattern* or *configuration*
- Used in several visual design fields, such as user interface design and cartography



Bahaus art school logo. Staatliches Bauhaus, Berlin 1919-1933.

GESTALT PRINCIPLES

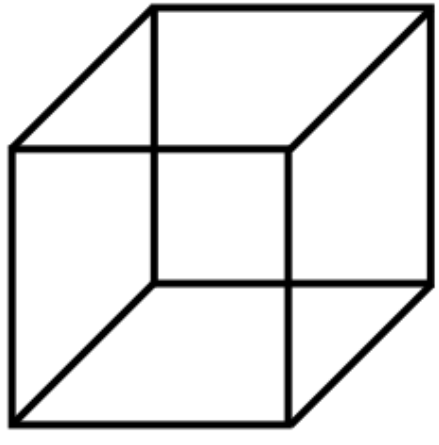
Emergence

We perceive images as a whole

Reification

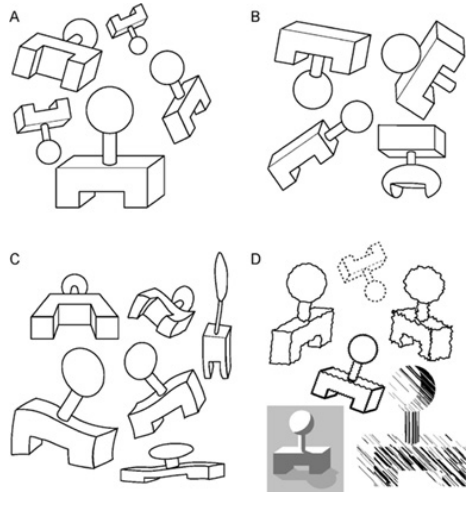
We perceive more than the stimulus contains

Multi-stability



Some stimuli are perceived as changing between two or more interpretations

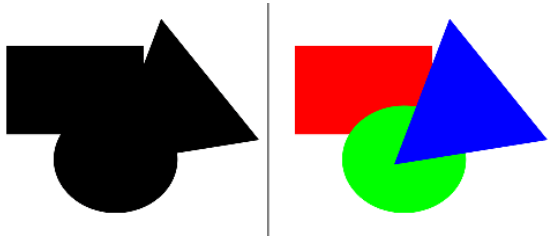
Invariance



Simple objects are recognized independent of pose, deformations, lighting, and features

GESTALT LAWS (1-3)

Pithiness (Prägnanz)

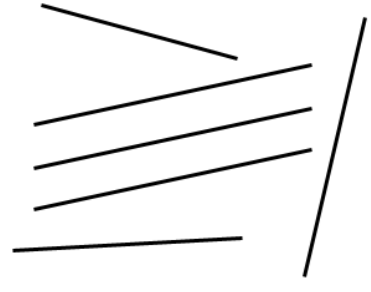


We order our experience in a manner that is regular, orderly, symmetric, and simple

Figure and ground

We tend to separate an object from its background

Parallelism



Parallel elements are seen as more related than elements not parallel

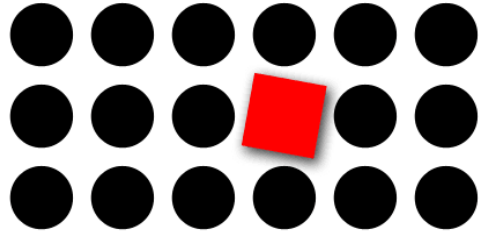
GESTALT LAWS (4-6)

Symmetry

[ ] { }

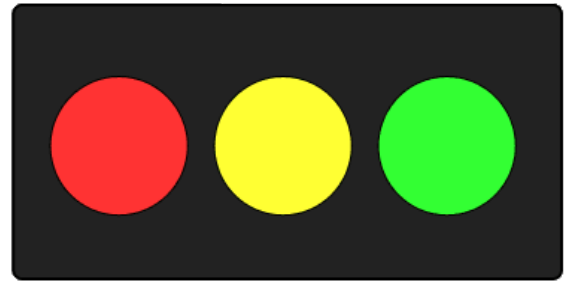
We perceive objects as being symmetrical and forming around a center point

Focal points



Elements with a point of interest, emphasis or difference will capture and hold attention

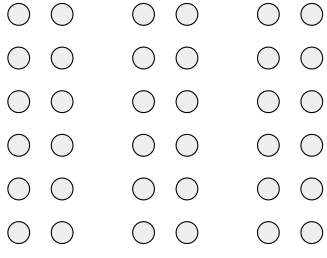
Past experience



Elements are perceived according to past experience

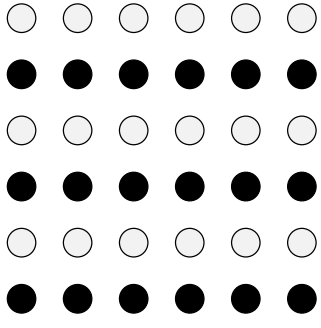
GESTALT LAWS OF GROUPING (1-4)

Proximity



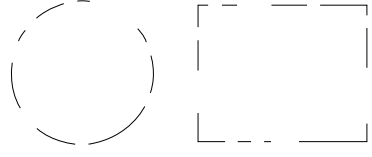
Elements close together are perceived as grouped

Similarity



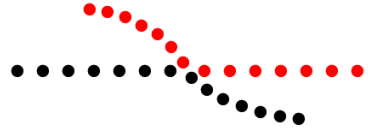
Objects with similar appearance are perceived as grouped

Closure



Parts of an object tend to be grouped together and we perceive the whole figure

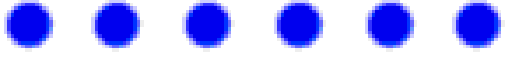
Continuity



We perceive the pieces to form a continuation as parts of a whole object

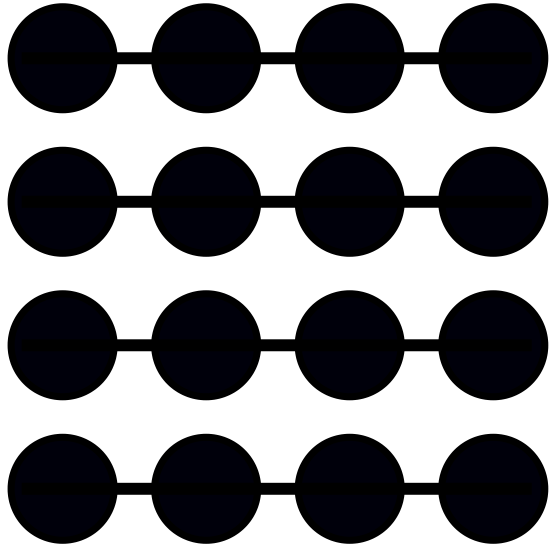
GESTALT LAWS OF GROUPING (5-7)

Common fate



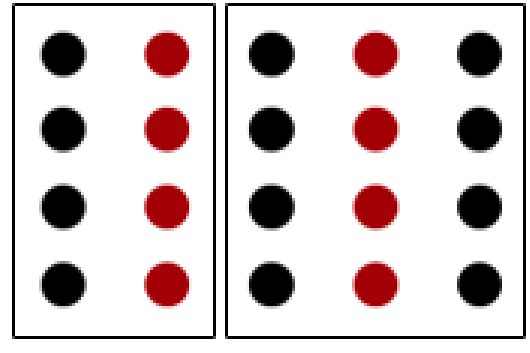
Objects moving in the same direction are perceived as grouped

Connection



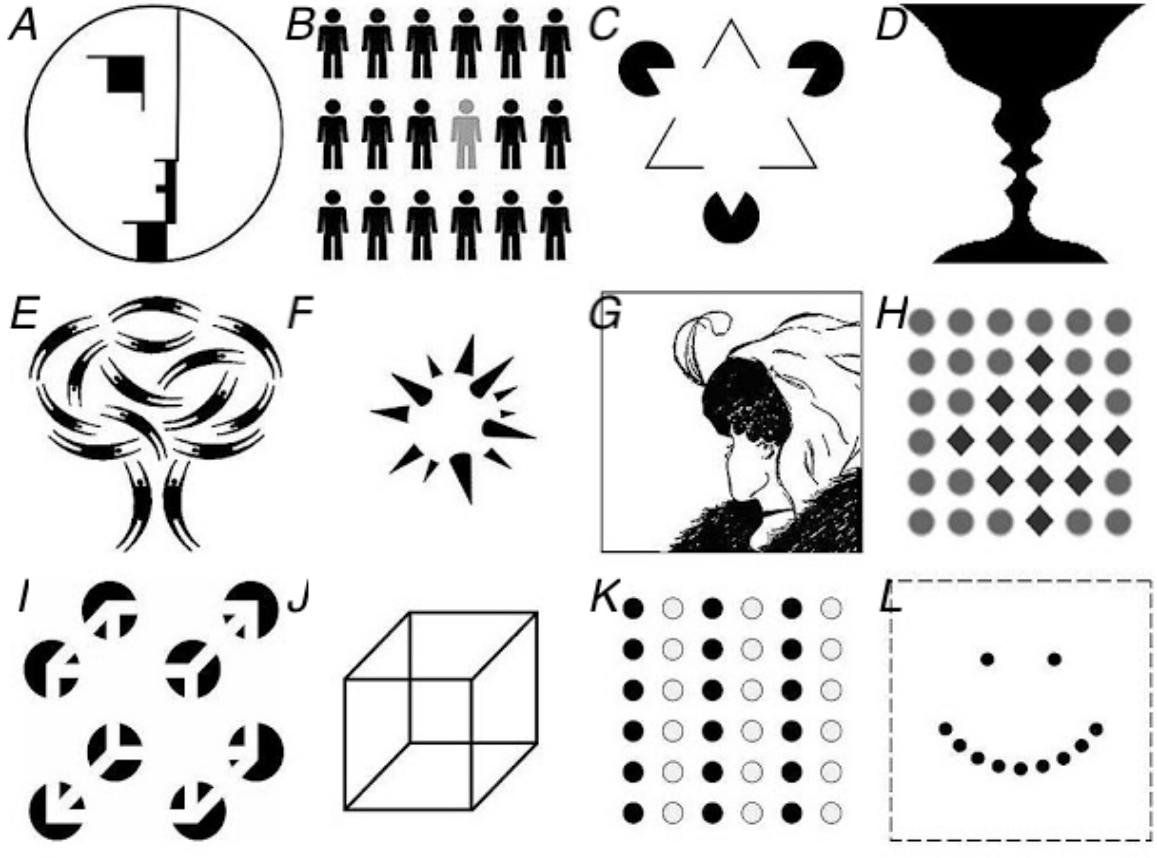
Objects that are connected are perceived as a group

Common region



Objects enclosed by a boundary are perceived as a group

A. Common region
B. Focal point, similarity, proximity
C. Reification, closure
D. Multi-stability, figure and ground
E. Invariance, proximity, similarity
F. Reification, closure
G. Multi-stability, figure and ground,
H. Similarity, proximity
I. Reification, closure
J. Multi-stability
K. Similarity, proximity
L. Common region, proximity, continuity



OUTLINE

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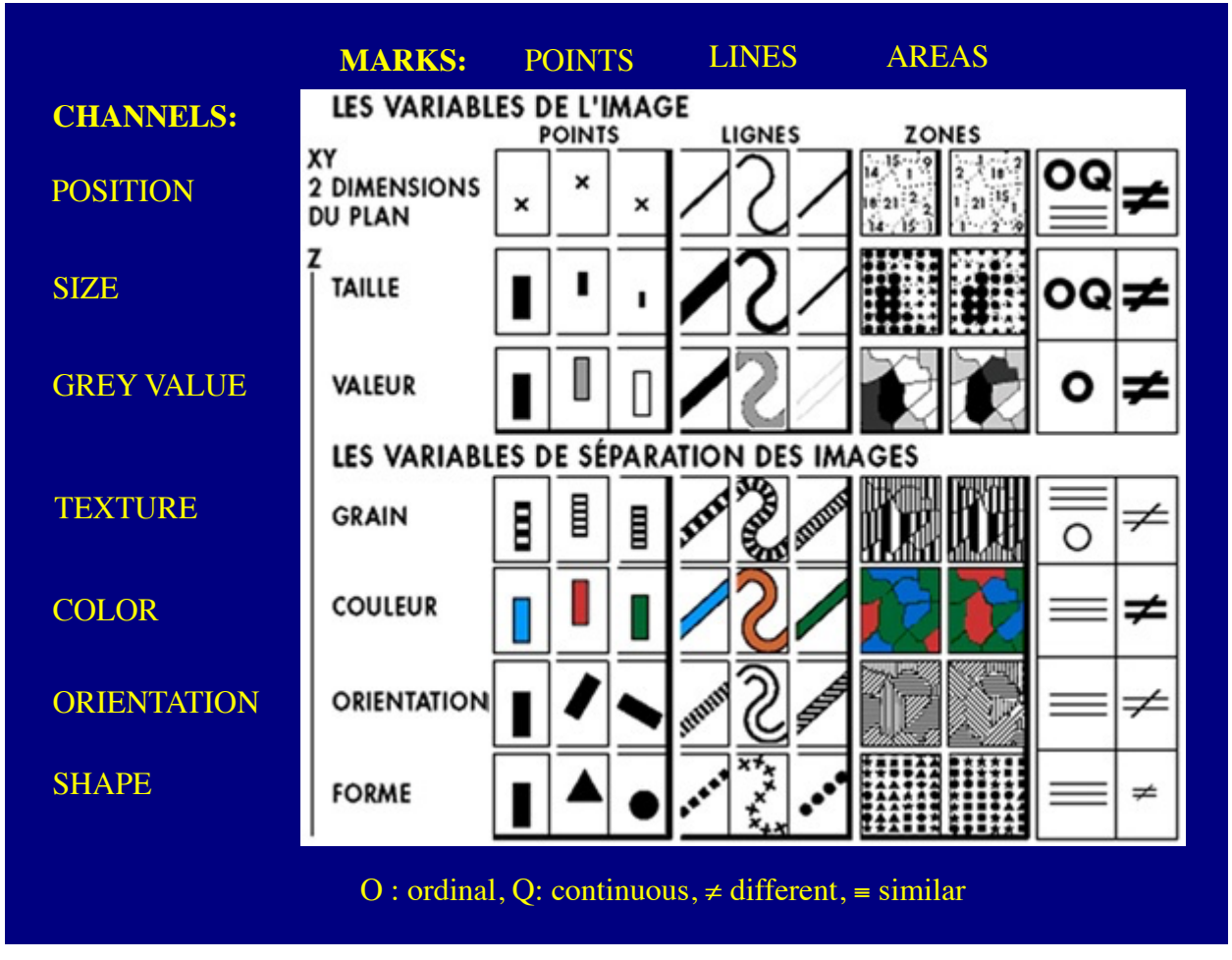
SEMIOLOGY OF GRAPHICS [BERTIN 1967]

Jaques Bertin, French cartographer and theorist

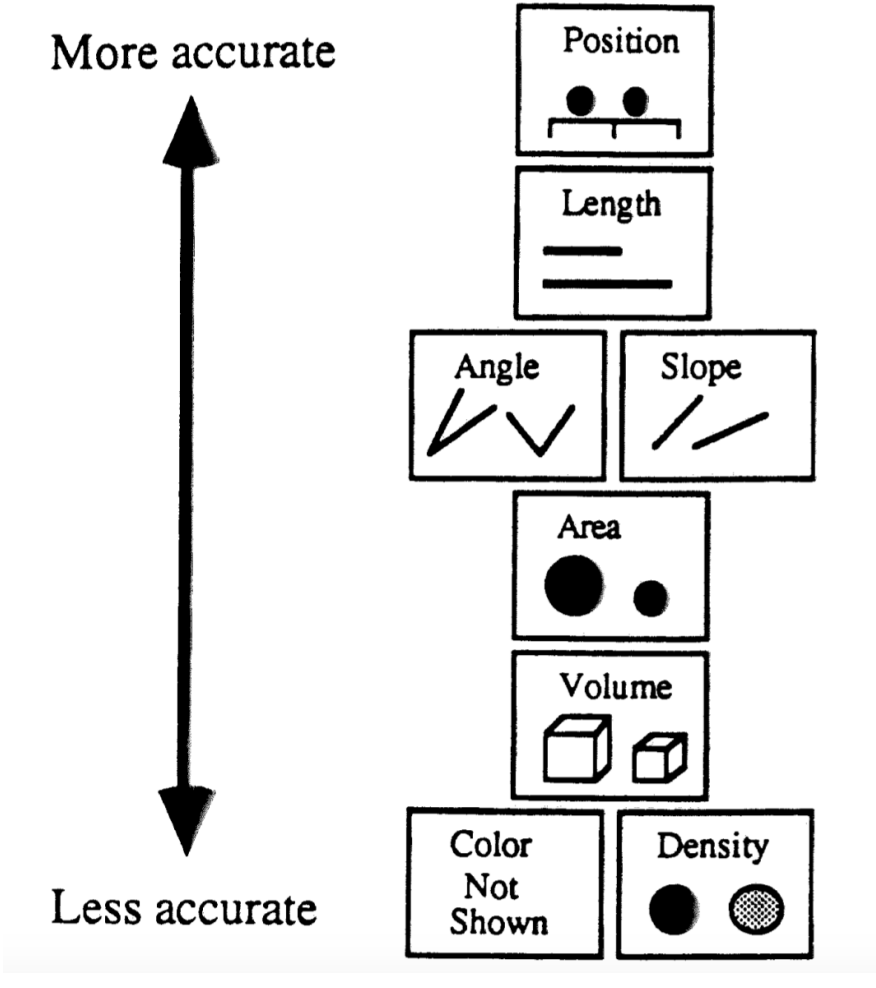
- Visual language is a sign language
- Sender encodes information in signs, receiver decodes information from signs
- Semiotics (semiology) is the study of signs and symbols and their use or interpretation

MARKS AND CHANNELS



Semiology of Graphics, J. Bertin, 1967

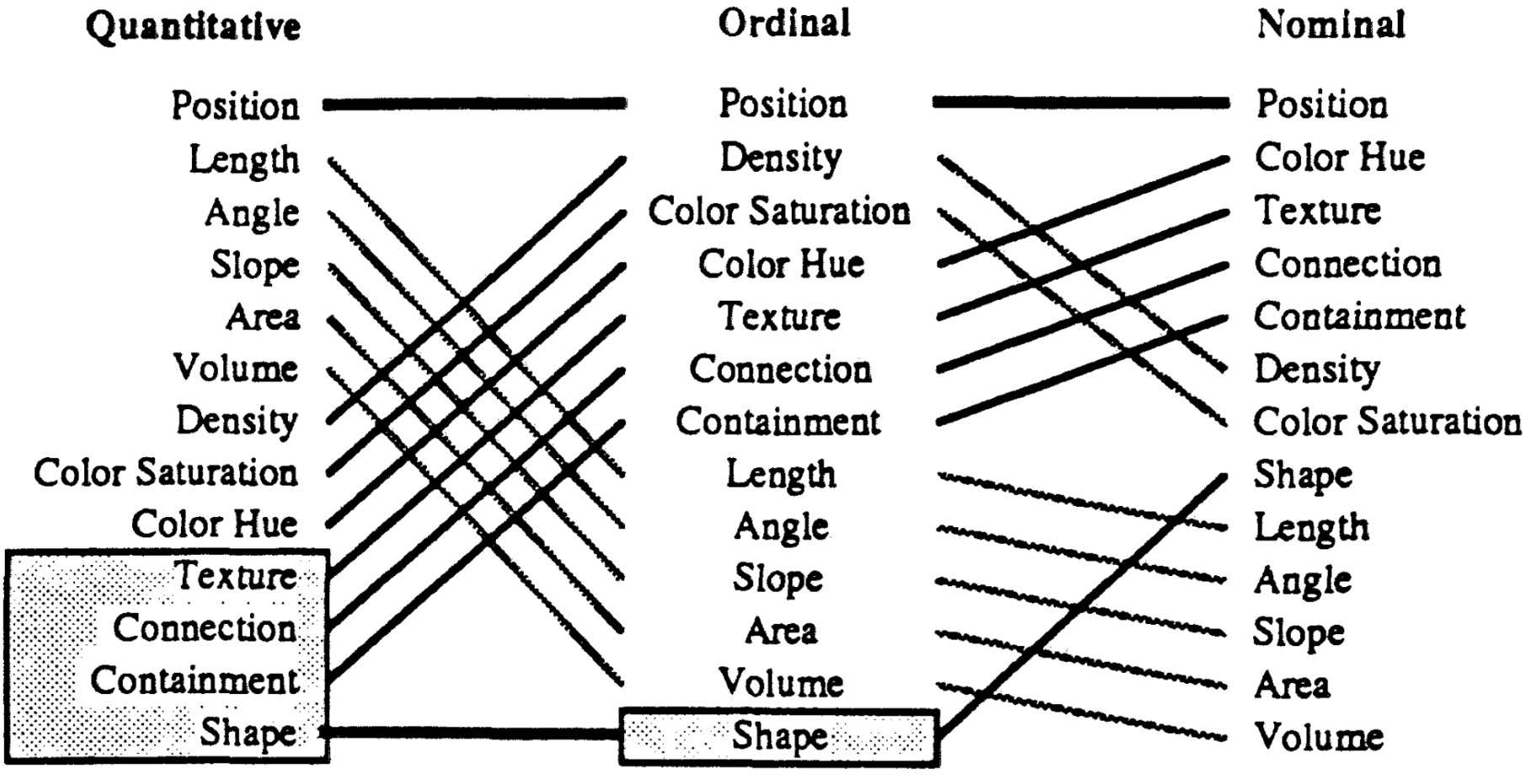
ACCURACY OF PERCEPTUAL TASKS [MCKINLEY 1986]



Higher tasks are accomplished more accurately than lower tasks.

Mackinlay, J., Automating the design of graphical presentations of relational information. ACM Transactions On Graphics, 1986.

ACCURACY OF PERCEPTUAL TASKS BY DATA TYPE [MCKINLEY 1986]



Ranking of perceptual tasks. Tasks in gray boxes are not relevant to these types of data.
Mackinlay, J., Automating the design of graphical presentations of relational information. ACM Transactions On Graphics, 1986.