REVIEW

NEXT

COLOUR TEST

What colour is it?

PURPLE

What colour is it?

BLUE

What colour is it?

YELLOW

What colour is it?

BLACK

Warna apakah ini?

MERAH

Warna apakah ini?

ABU

What colour is it?

PINK

Warna apakah ini?

HIJAU

What colour is it?

Gestalt Principles

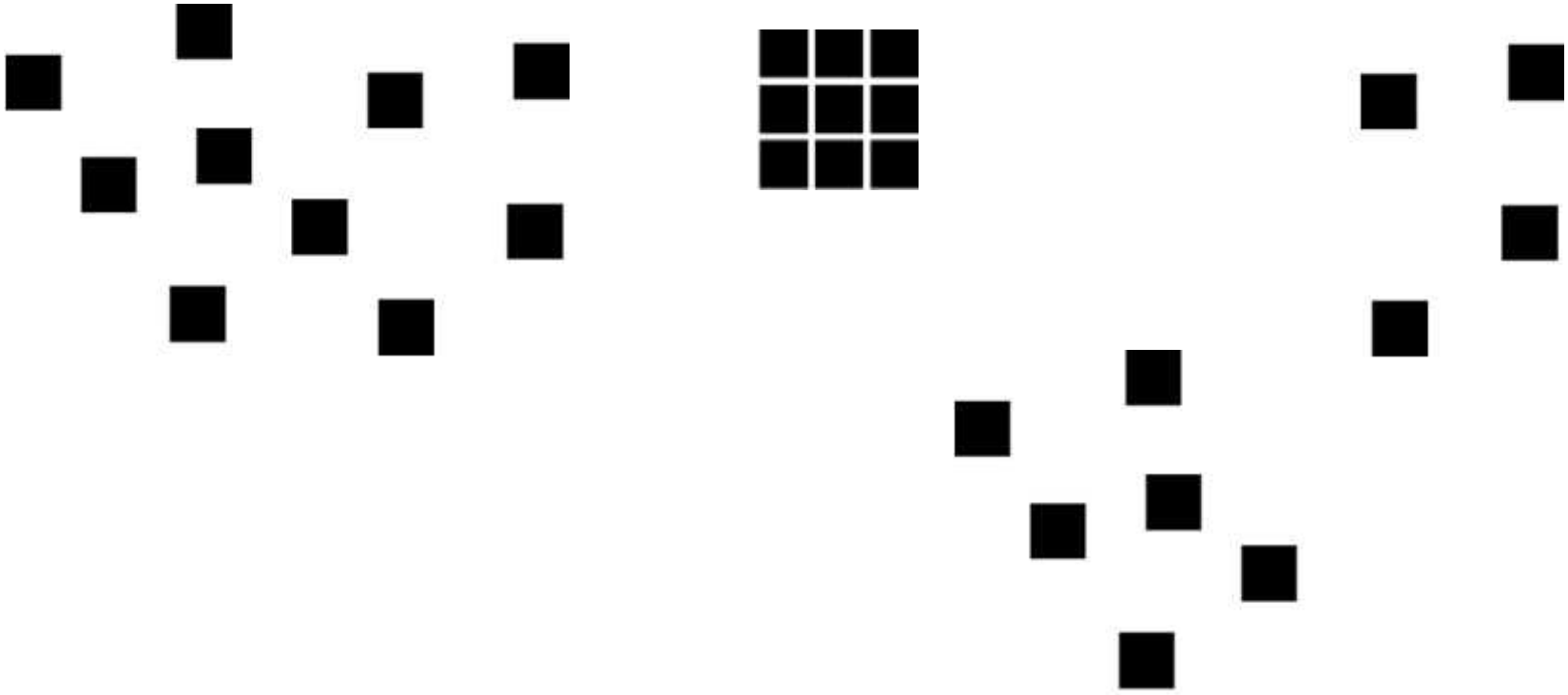
Gestalt Principles (1912)

(*Gestalt = Pattern*)

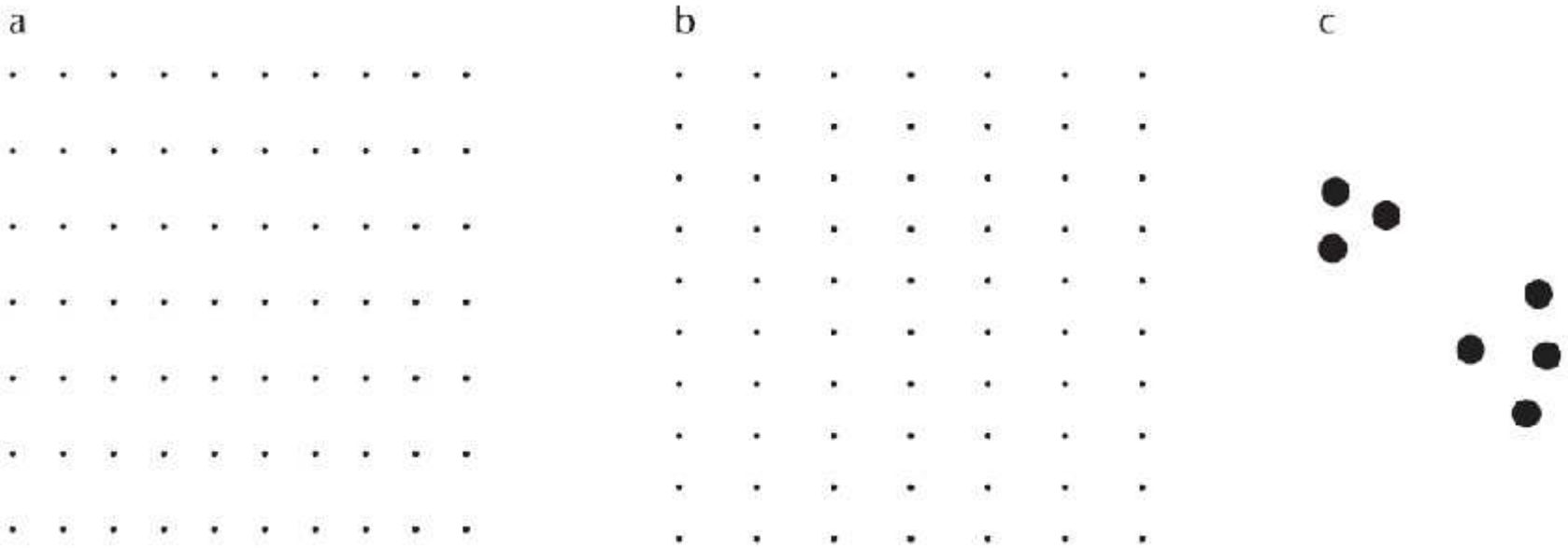
- Provided a clear description of many basic perceptual phenomena and pattern perception.
- Eight Gestalt laws:
  1. Proximity
  2. Similarity
  3. Connectedness
  4. Continuity
  5. Closure
  6. Symmetry
  7. Relative size
  8. figure-and-ground

Gestalt Laws: Proximity

- occurs when elements are placed close together, they tend to be perceived as a group.

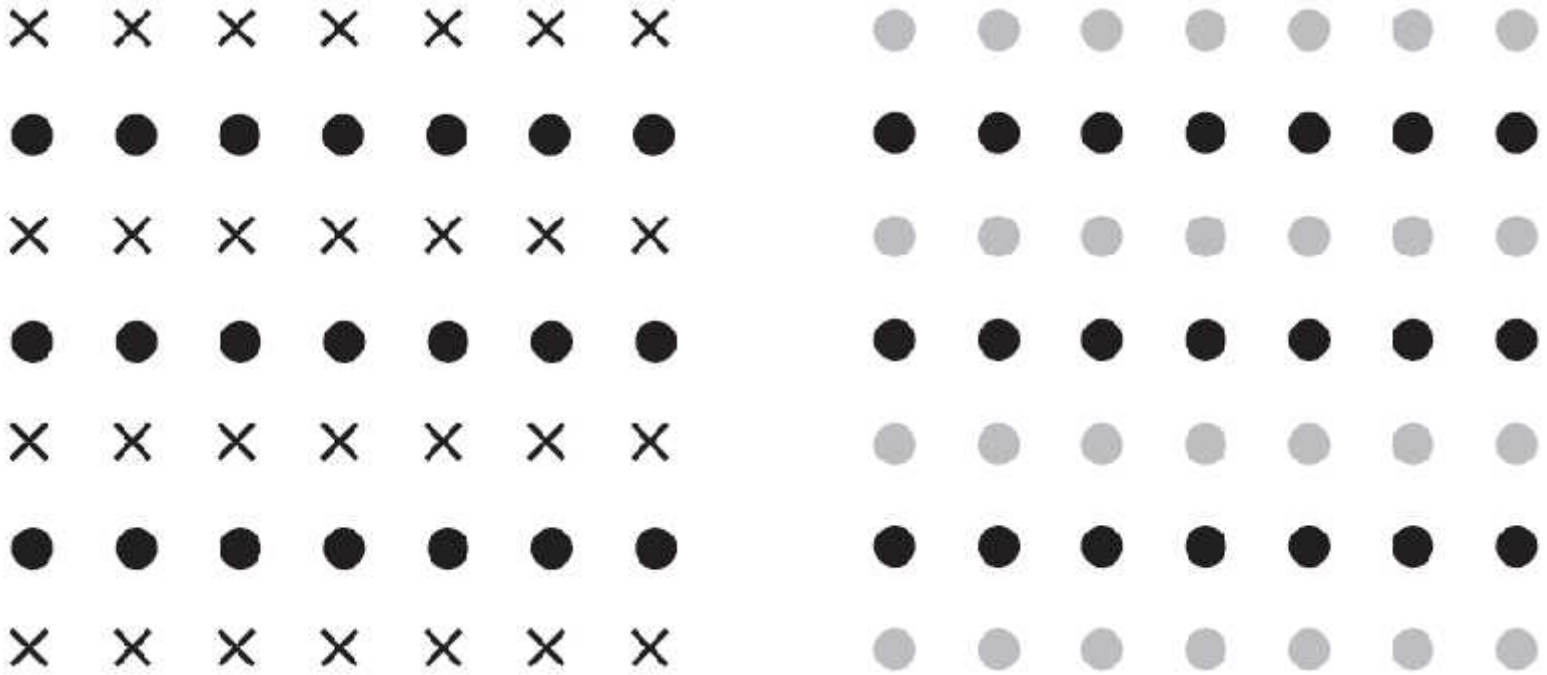


Gestalt Laws: Proximity (Cont.)

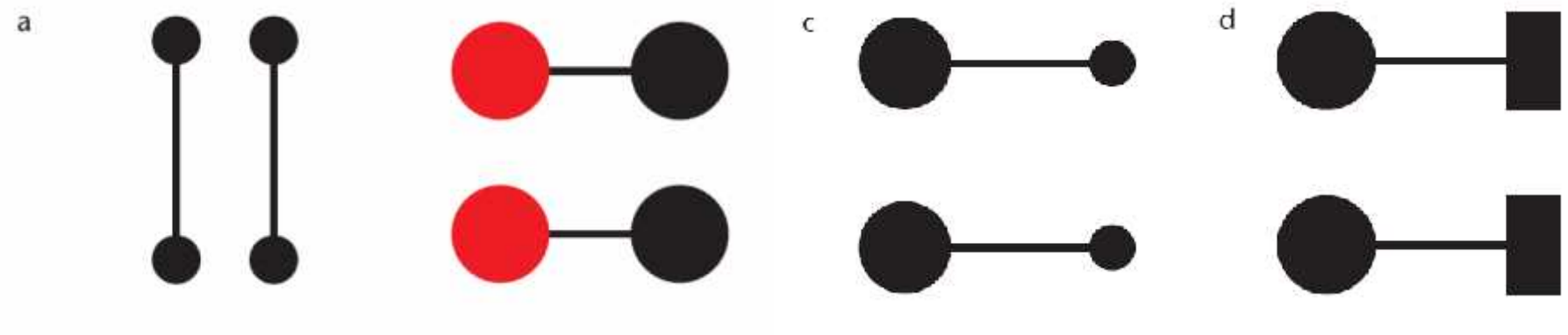


Gestalt Laws: Similarity

- Occurs when **objects look similar** to one another, people often perceive them as a group or pattern.

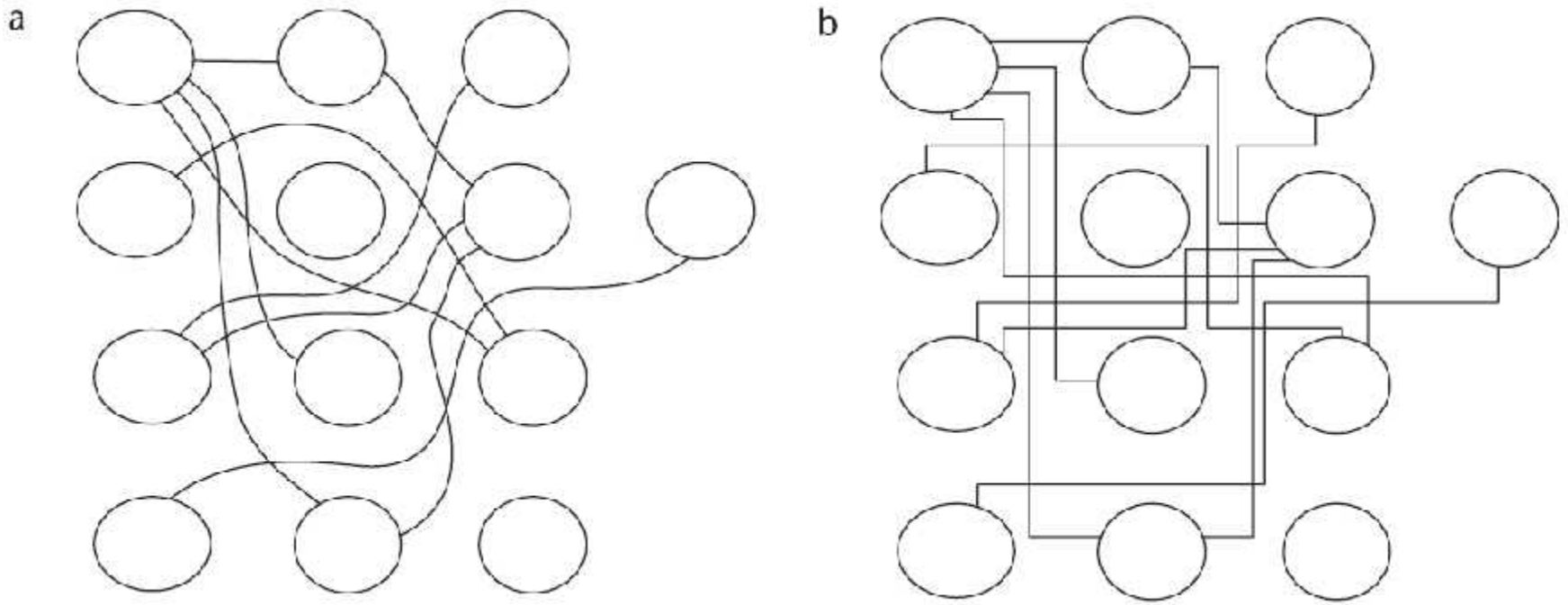


Gestalt Laws: Connectedness



Connectedness is a powerful grouping principle that is stronger than proximity, color, size, or shape

Connectedness (Cont.)

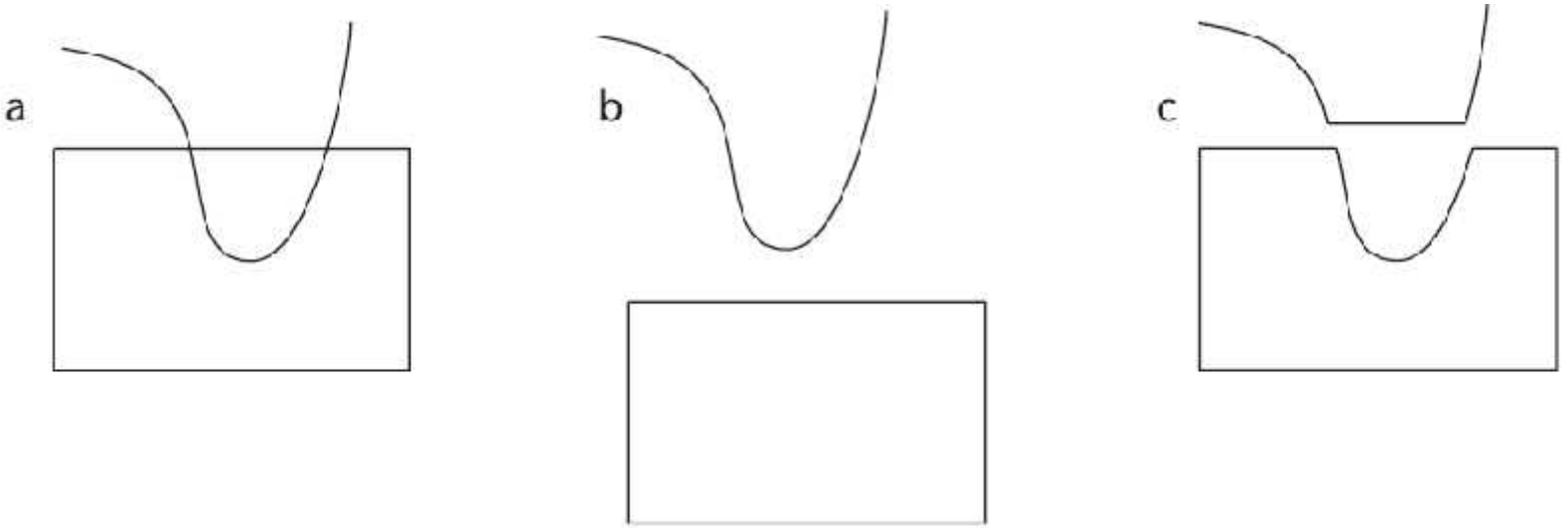


In (a), smooth continuous contours are used to connect the elements, whereas in (b), lines with abrupt changes in direction are used. It is much easier to perceive connections when contours connect smoothly.

Gestalt Laws: Continuity

- Continuation occurs when the eye is compelled to **move through** one object and **continue** to another object.

Gestalt Laws: Continuity (Cont.)

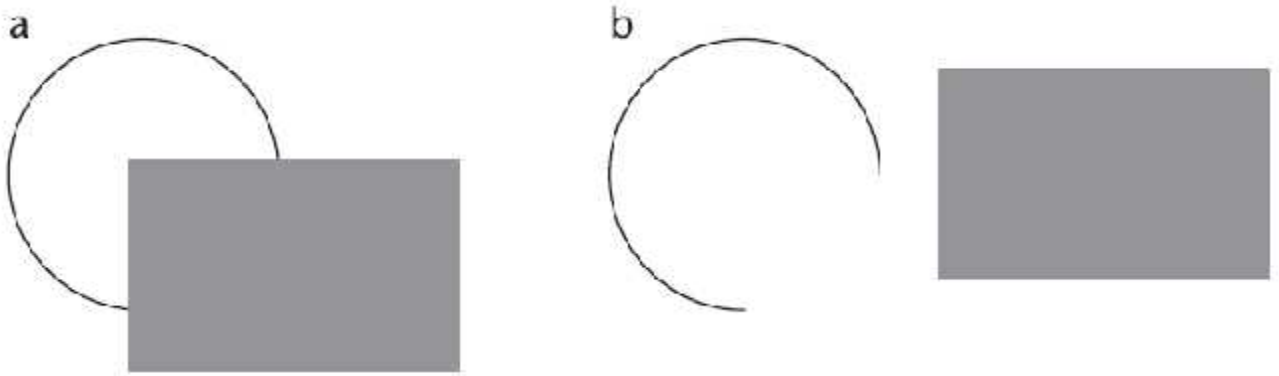


The pattern on the left (a) is perceived as a curved line overlapping a rectangle (b) rather than as the more angular components shown in (c).

Gestalt Laws: Closure

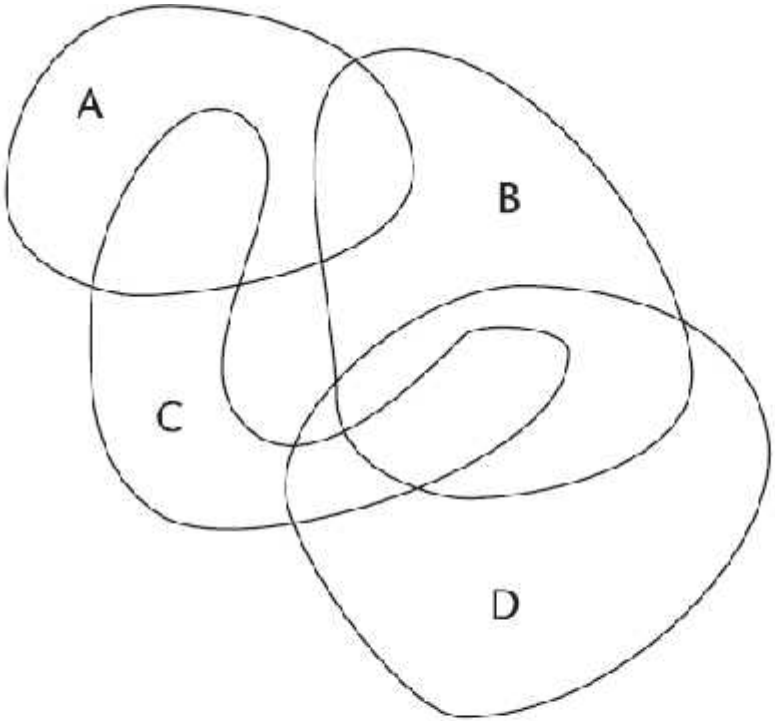
- Occurs when an object is *incomplete* or a space is not *completely enclosed*.
- If enough of the shape is indicated, people perceive the whole by filling in the missing information

Gestalt Laws: Closure (Cont.)



The Gestalt principle of closure holds that neural mechanisms operate to find perceptual solutions involving closed contours. Hence in (a), we see a circle behind a rectangle, not a broken ring as in (b).

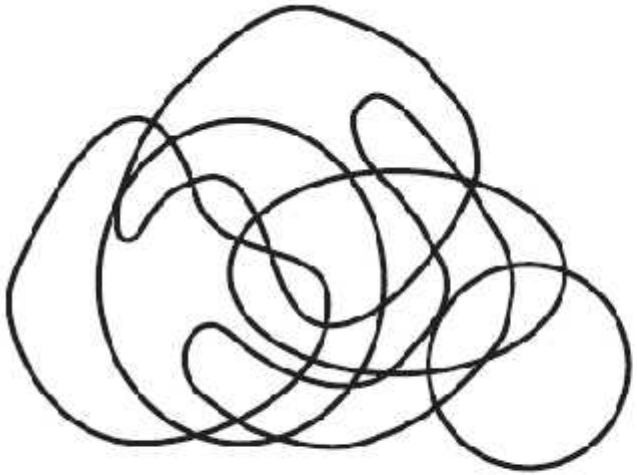
Gestalt Laws: Closure (Cont.)



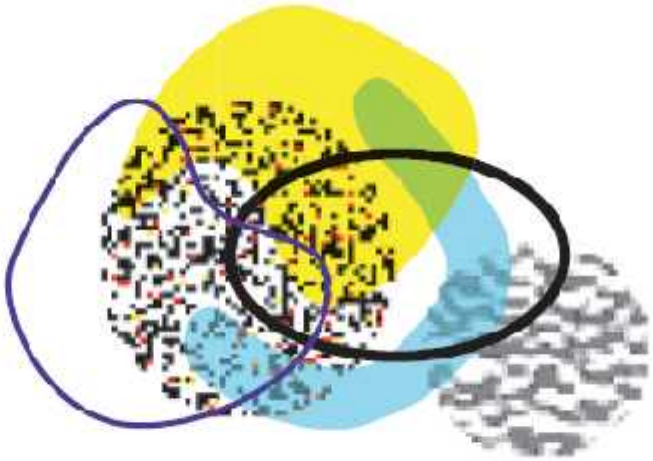
An Euler diagram. This diagram tells us (among other things) that entities can simultaneously be members of sets A and C but not of A, B, and C. Also, anything that is a member of both B and C is also a member of D. These rather difficult concepts are clearly expressed and understood by means of closed contours.

Gestalt Laws: Closure (Cont.)

a

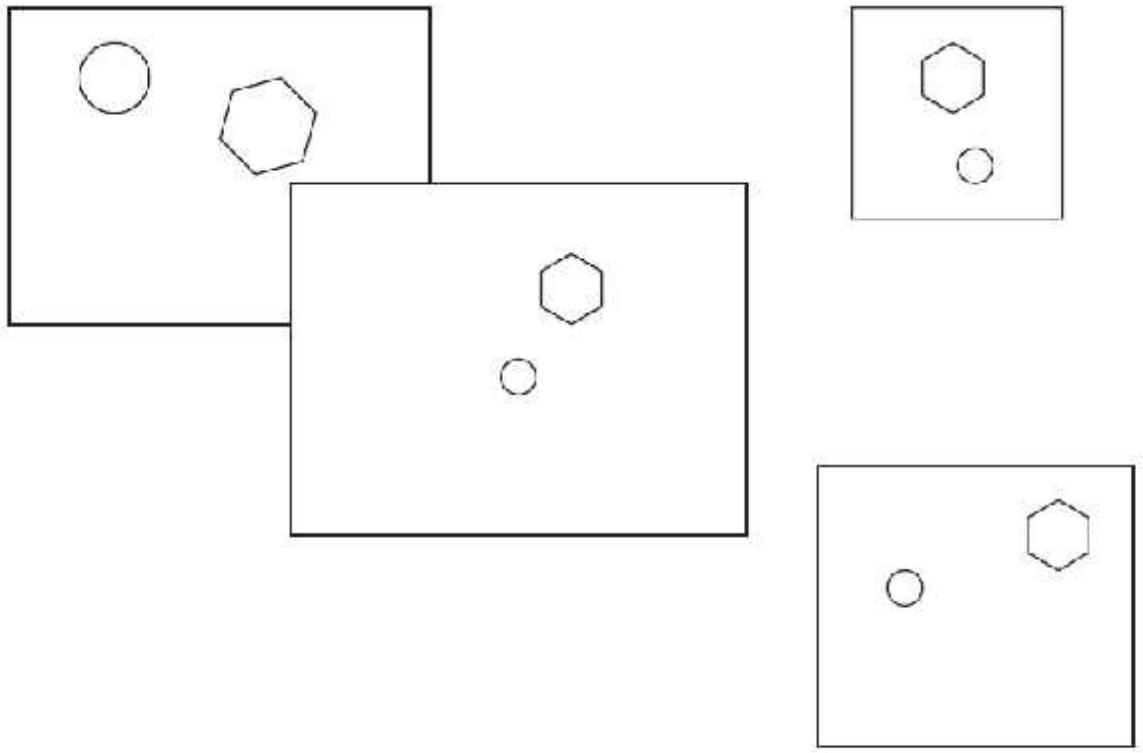


b



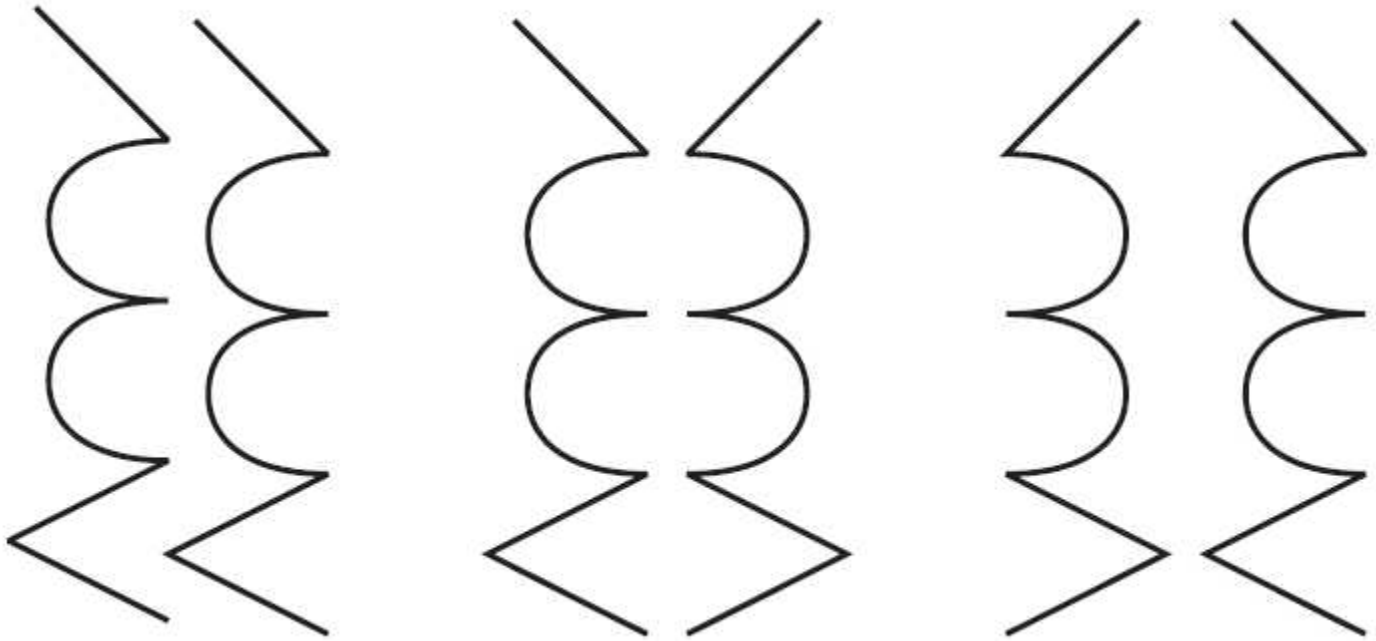
An Euler diagram enhanced using texture and color can convey a more complex set of relations than a conventional Euler diagram using only closed contour.

Gestalt Laws: Closure (Cont.)

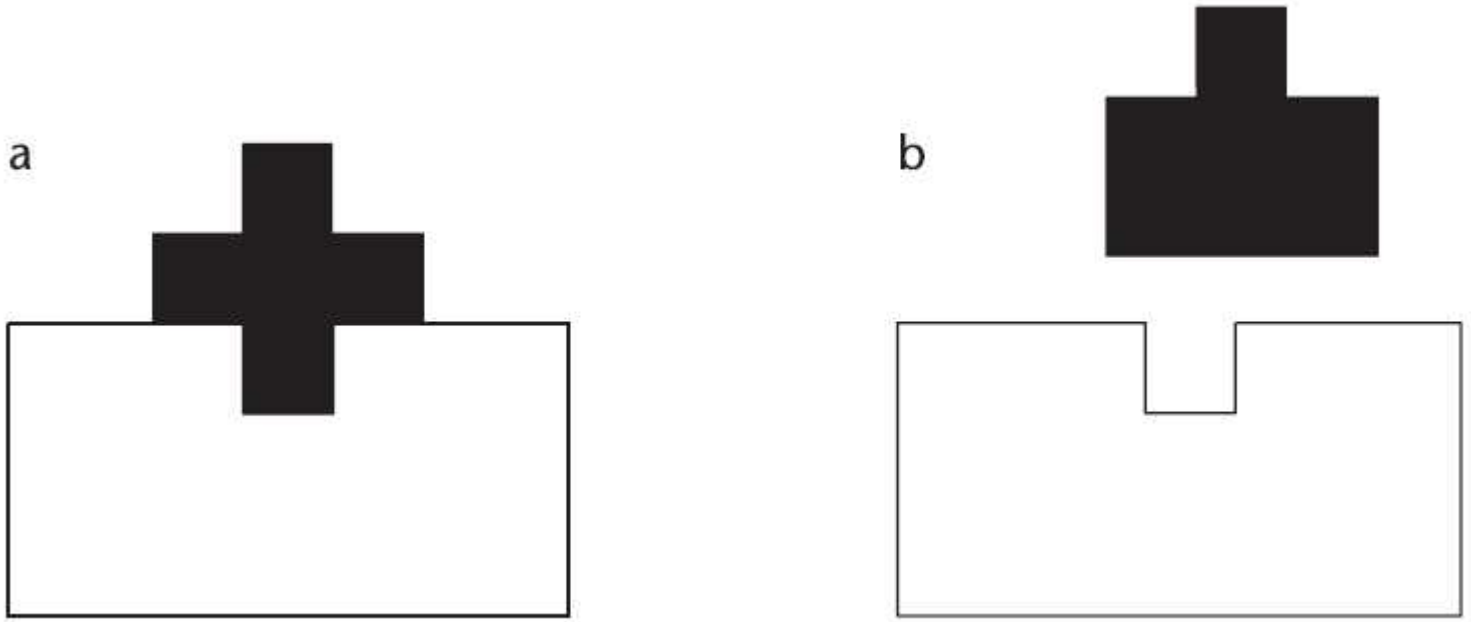


Closed rectangular contours strongly segment the visual field. They also provide reference frames. Both the positions and the sizes of enclosed objects are, to some extent, interpreted with respect to the surrounding frame.

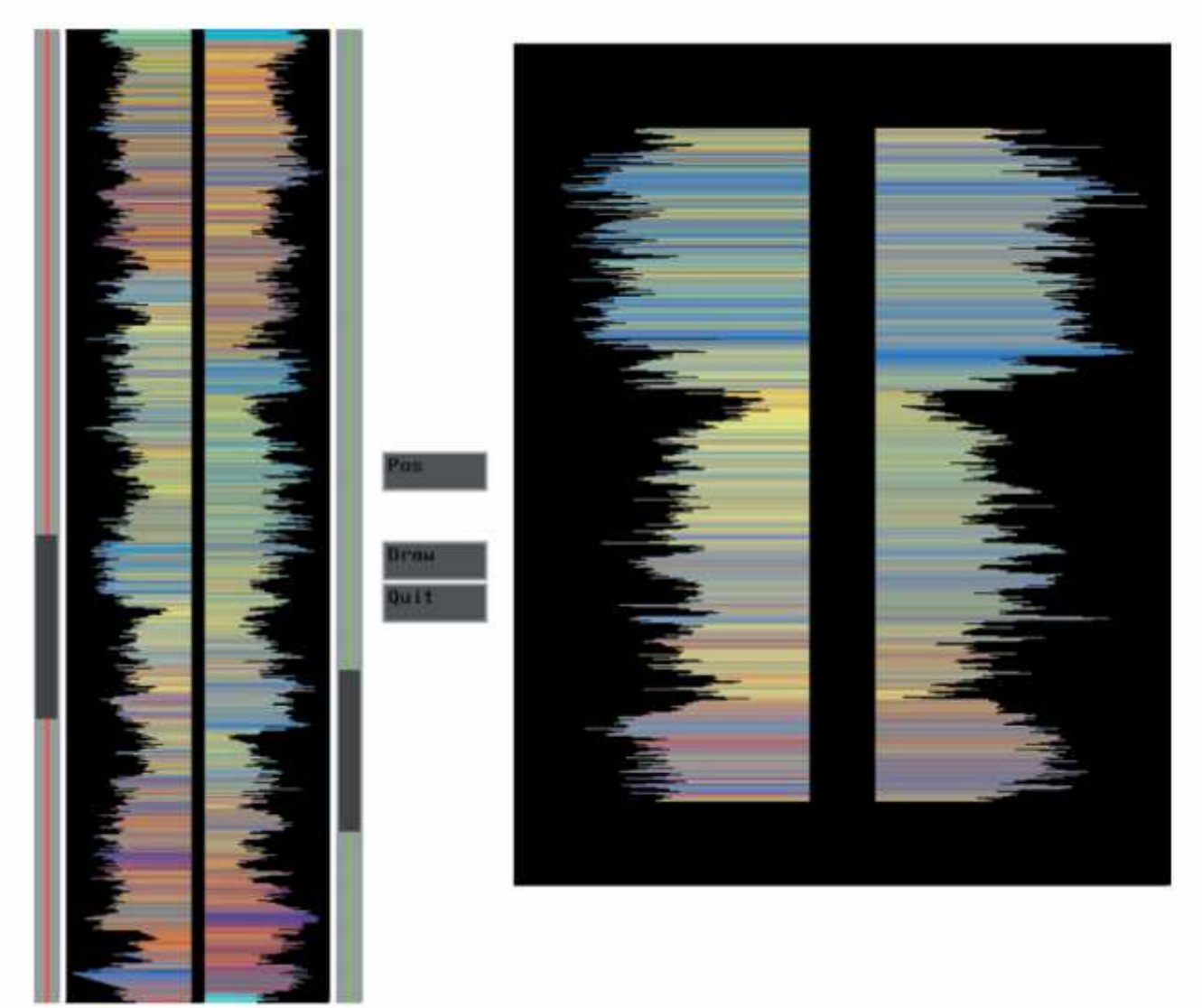
Gestalt Laws: Symmetry



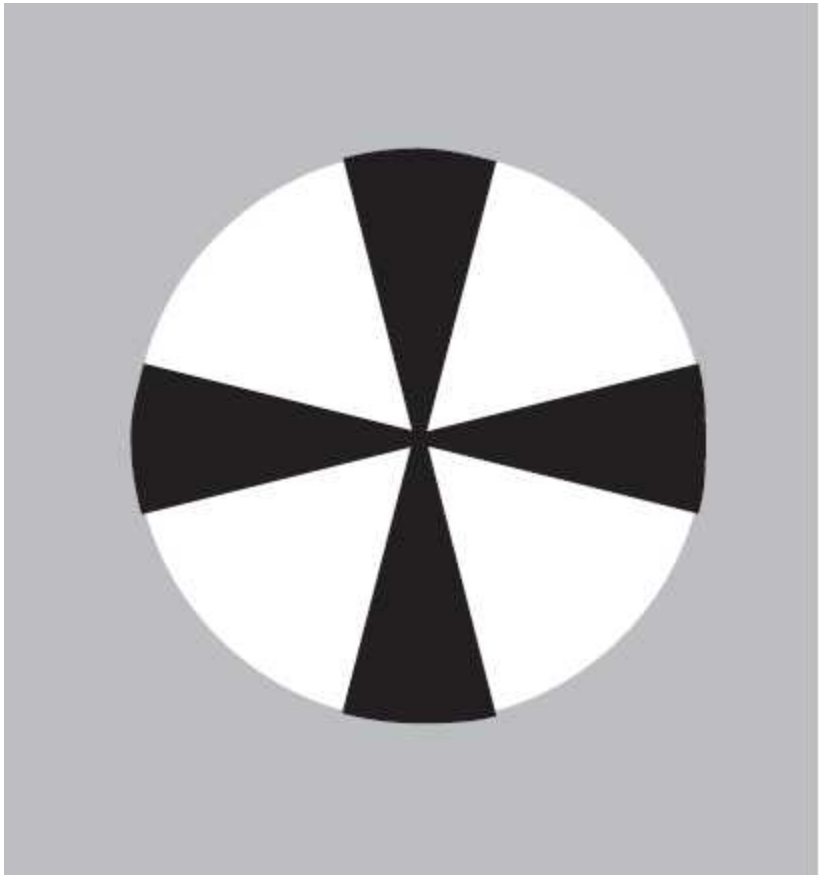
Gestalt Laws: Symmetry (Cont.)



Gestalt Laws: Symmetry (Cont.)



Gestalt Laws: Relative Size

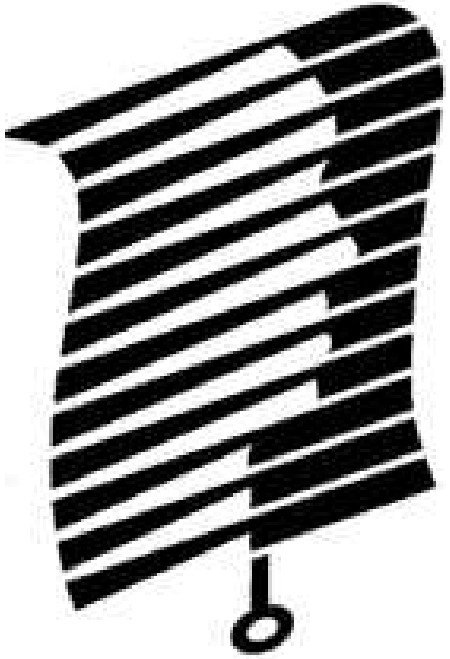


The black areas are smaller, and therefore more likely to be perceived as an object. It is also easier to perceive patterns that are oriented horizontally and vertically as objects.

Gestalt Laws: Figure-and-Ground

- The eye differentiates an object form its surrounding area.
- A form, silhouette, or shape is naturally perceived as **figure** (object), while the surrounding area is perceived as **ground** (background).
- Balancing figure and ground can make the perceived image more clear. Using unusual figure/ground relationships can add interest and subtlety to an image.

Gestalt Laws: Figure-and-Ground



Gibson's Affordance Theory

Gibson's Affordance Theory

- Pendekatan Top-down
  - Manusia tidak mempersepsi setiap titik cahaya, tetapi mempersepsi aksi yang mungkin kita lakukan
  - Contoh:
    - Permukaan untuk berjalan
    - Pegangan untuk menarik (pintu)
    - Kakas untuk memanipulasi

Translating the affordance concept into the interface domain

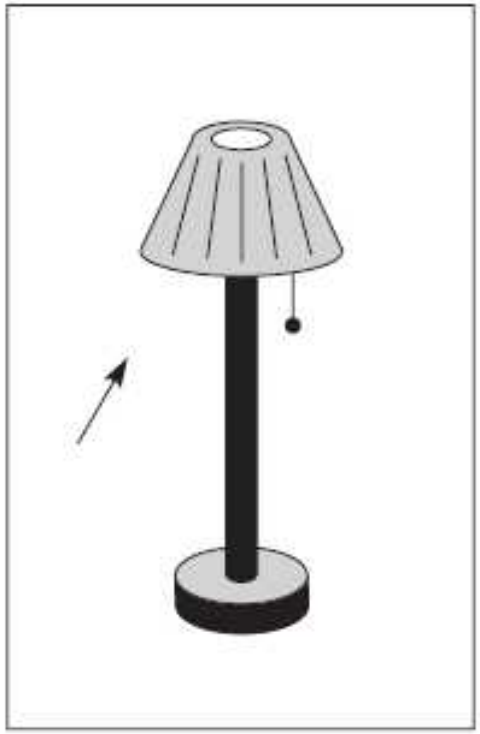
- Principle:

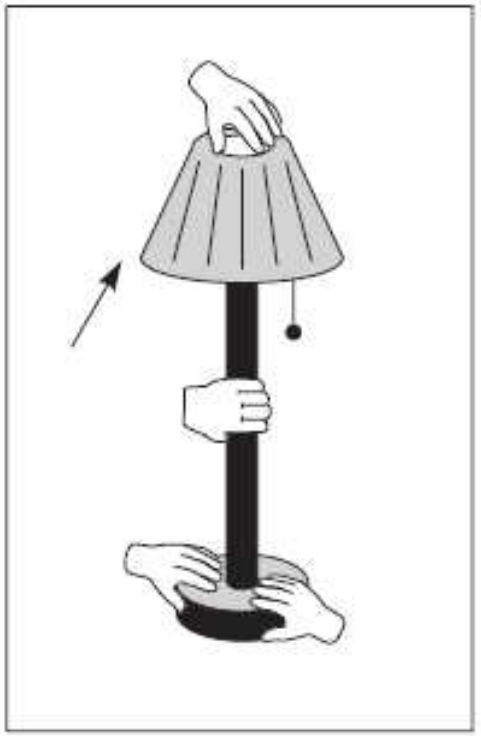
  Create good interface with the appropriate affordances to make the user's task easy.

- Example:

  If we have a task of moving an object in 3D space, use clear handles for rotating and lifting the object such as illustrations of gripping

Example (Houde, 1992)





Problems of Gibson's direct perception

1. Even if perception of the environment is direct, visualization of data through computer graphics is very indirect.
2. There are no clear physical affordances in any graphical user interface.
3. Gibson's rejection of visual mechanisms is a problem (top-down vs bottom-up approach).

Related works: Norman, *The Psychology of Everyday Things* (1988).

Perceptual Evaluation Techniques

Research Goals

- Uncover fundamental truths and test theories.
- Discover the nature of the world.
- Ascertain if an existing theory generalizes to practice.
- Make an objective comparison between two or more display methods.
- Make an objective comparison between two or more display systems.
- Measure task performance.
- Ascertain user preferences for different display methods.

Perceptual Evaluation Techniques

Applying empirical research methods, such as:

- Psychophysics and Information Psychophysics
- Cognitive Psychology
- Structural Analysis
- Statistical Exploration
- Cross-cultural Studies
- Child Studies

Psychophysics and Information Psychophysics

1. Psychophysics

- A set of techniques based on applying the methods of physics to measurements of human sensation
- Examples:
  - defining the basic set of limits of the visual system
    - How rapidly must a light flicker before it is perceived as steady?
    - What is the smallest brightness change that can be detected?

Problems with Psychophysics

- Often carried out using only one or two observer → generalized to the entire human race
  - But, some experiments require hundreds of hours of careful observation → large subject population is out of question
- It is usually assumed that instructional biases are not significant in the experiment

Information Psychophysics

- A new variant of psychophysics
- To apply classical psychophysics to common information structures, e.g:
  - elementary flow pattern
  - surface shape
  - paths in graphs

Psychophysics Method (1)

- **Detection Method**
  - The goal of the experiment:
    - Determining the error rate → how many errors people make when performing a certain task
      - E.g.: aircraft inspection process → expected error rate of an inspector is critical
    - Error rate is commonly used to determine **threshold**

Psychophysics Method (2)

- **Method of Adjustment**
  - Give application domain experts control over some variable and ask them to adjust it so that it is optimal in some way for them

Psychophysics and Information Psychophysics

Thresholds and the Dawn of Psychophysics

- Ernst Weber (1795-1878) was an experimental philosopher whose work eventually fostered the establishment of what would become known as scientific psychology.

SENSATION & PERCEPTION 4e, Figure 1.4

Psychophysics and Information Psychophysics

Thresholds and the Dawn of Psychophysics

- Ernst Weber discovered that the smallest change in a stimulus that can be detected is a constant proportion of the stimulus level.
- i.e. human sensory sensitivity is **relative** rather than **absolute** in nature

- This relationship has been formalized as **Weber's Law** (see next slide)

Psychophysics and Information Psychophysics

Thresholds and the Dawn of Psychophysics

- Scientific psychology's first law (Weber's Law)

$$\Delta I = \kappa I$$

algebraically rephrased as

$$\frac{\Delta I}{I} = \kappa$$

where

I = stimulus intensity

ΔI = just noticeable difference

k = numerical constant

Psychophysics and Information Psychophysics

Thresholds and the Dawn of Psychophysics

- If we know the value of "k" and "I",
  we can use Weber's Law to determine how much a stimulus needs to change in order for the average person to detect that change.
- For example:
- If the Weber fraction (k) for judging weight = 0.02
  then the JND (delta I) for a 10 ounce weight
  would be (10 ounce x k) = (10 x 0.02) = 0.2 ounces
- Hence,
  an 10.1 ounce weight would be indistinguishable from a 10 ounce weight…but a 10.2 ounce weight would appear heavier than the same 10 ounce weight (i.e., >= JND).

Psychophysics and Information Psychophysics

Thresholds and the Dawn of Psychophysics

- How many ounces would you need to add to a 100 ounce weight before you could tell the difference?
- What about a 1 ounce weight?
- How about a 0.01 ounce weight?
  (This one is a “trick question”)

- **Some common Weber Fractions (k)**

Electric shock	0.01
Lifted weight	0.02
Sound intensity	0.04
Light intensity	0.08
Taste (salty)	0.08

Source: From Teghtsoonian (1971).

Cognitive Psychology

2. Cognitive Psychology

- The area of psychology that focuses on internal mental processes. Such processes include thinking, decision-making, problem-solving, language, attention, and memory.
- How people acquire, process, and store information.

Cognitive Psychology

2. Cognitive Psychology

- Goal of experiments: testing a hypothesis about a **cognitive** **model**
- Methods:
  - Measuring reaction time or measuring error
    - E.g. Determining whether or not a particular object is in a display
  - Measuring interference between visual patterns
    - Increase in the resulting errors is used as evidence that different channels of information processing converge at some point

Structural Analysis

3. Structural Analysis

- In structural analysis, theories of cognitive processing are constructed using direct observation as evidence
  - Studies are conducted via interviews rather than formal experiments
  - Often especially appropriate for studies of computer interfaces → fast moving and can take variety of factors into account
- Research tools:
  A. Test-bench applications
  B. Semi-structured interviews
  C. Rating scales

Structural Analysis

A. Test-bench Applications

- A flexible tool capable of producing a range of visual mappings of the data and a range of interaction possibilities
- E.g. Problem: find the best way to represent the shape of a surface, then the test-bench app should be able to:
  - Load different surface shapes, change lighting, change surface texture properties, turn stereoscopic viewing on/off, provide motion parallax cues, etc.

Structural Analysis

B. Structured Interviews

- Construct an interview with a structured set of questions of elicit information about specific task requirements
- Advantage: to gain information about a wide range of issues with relatively little effort
- In visualization:
  - To evaluate what aspects of visualization actually are important for potential users
  - To evaluate a number of different solutions for strengths and weaknesses

Structural Analysis

C. Rating Scales

- A method for turning opinions into numbers, e.g.:

(GOOD) 1 2 3 4 5 (BAD)

We have six visual representations of a flow pattern, we might ask subjects to rate how well they are on a scale of 1 to 5

- Subjects tend to bias the rating scale toward either the lower or upper end
- No absolute meaning should be given to rating scale data
- Rating scale → an excellent tool for measuring relative preferences

Statistical Exploration

4. Statistical Exploration

- Statistical discovery techniques can be useful to learn about some class of visualization methods
  - Using statistics to discover how many dimensions that can be conveyed by a visualization
- Major techniques:
  - Principal Component Analysis
  - Multidimensional Scaling
  - Clustering
  - Multiple Regression

Statistical Exploration

Principal Component Analysis

- The goal:
  - to take a set of variables and find a new set of variables (the principal components) that are uncorrelated with each other

    → might be used to reduce a high-dimensional dataset to lower dimensions

Statistical Exploration

Multidimensional Scaling

- A method explicitly designed to reduce the dimensionality of a set of data points to two or three
  - so that these dimensions can be displayed visually

Statistical Exploration

Clustering

- A statistical technique designed to find clusters of points in a data space of any dimensionality
- Two basic kinds: hierarchical and k-means

Statistical Exploration

Multiple Regression

- A statistical technique that can be used to discover whether it is possible to predict some response variable from display properties

Cross-cultural Studies

5. Cross-Cultural Studies

- Cross-cultural studies can be used to test whether sensory codes are interpreted easily by all humans
  - E.g. Color naming are compared across more than 100 languages (Berlin & Kay, 1969)
  - It is becoming impossible with the globalization of world culture

6. Child Studies

- Using behaviorism techniques:
  - To discover things about a child's sensory processing even before the child is capable of speech → revealing basic processing mechanism

Practical Problems in Conducting User Studies (1)

- **Experimenter bias**
  - There are many opportunities for experimenter bias in both the gathering and the interpretation of results
- **How many subjects are used?**
  - Statistically, the number of subjects and the number of observations required depend on the variability of responses with a single subject and the variability from one subject to another

Practical Problems in Conducting User Studies (2)

- **Combinatorial Explosion**:
  - In visualization design problems, there are often many possible independent variables → leads to combinatorial explosion → cannot be experimented using brute force approach
- **Task Identification**:
  - In order to provide a useful measure of performance, it is also important that the task can be set up to have a clear and simple user response

Practical Problems in Conducting User Studies (3)

- **Controls**:
  - A control is a condition that is used to provide some basis for comparison
  - In evaluating a new visualization method, the most reasonable control is the current best practice display method
- **Getting help**:
  - Studies in information visualization are fundamentally multidisciplinary