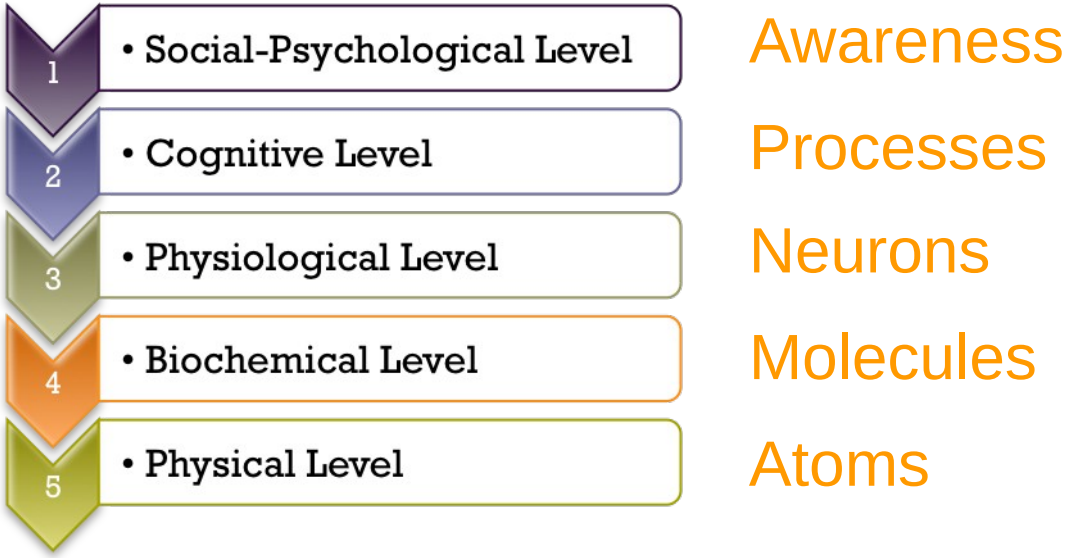
Human memory

Psychological Theories

- Theories are comparable to maps, helping to:
  - Summarize knowledge in a simple and structured manner
  - Pose new, testable questions that advance further discovery
- Theories, like maps, can be specialized to address questions on a variety of *related levels* of explanation, which can sometimes inform other levels, through a process called ***reductionism***:

The practice of explaining complex phenomena in terms of lower-level processes



A Brief History of Learning and Memory

Concurrent

19th Century, Germany

- Ebbinghaus first to study memory experimentally
- His tradition later blossomed into the **Verbal Learning Approach** advanced in the United States

1930s-1960s, United States

- **Verbal Learning Approach**
  - Reliance on observable stimulus-response associations
    - E.g., memorizing & recalling lists of words/non-words
- Research primarily sought to document, rather than explain, phenomena

1930s, Germany/North America

- **Gestalt Psychology**
  - Shifted emphasis away from behavior and towards internal memory representations

1930s, Britain

- Bartlet highlights the complex social aspects of memory, including:
  - **Schemas**: internal, cultural representations about the world that can lead to errors in memory

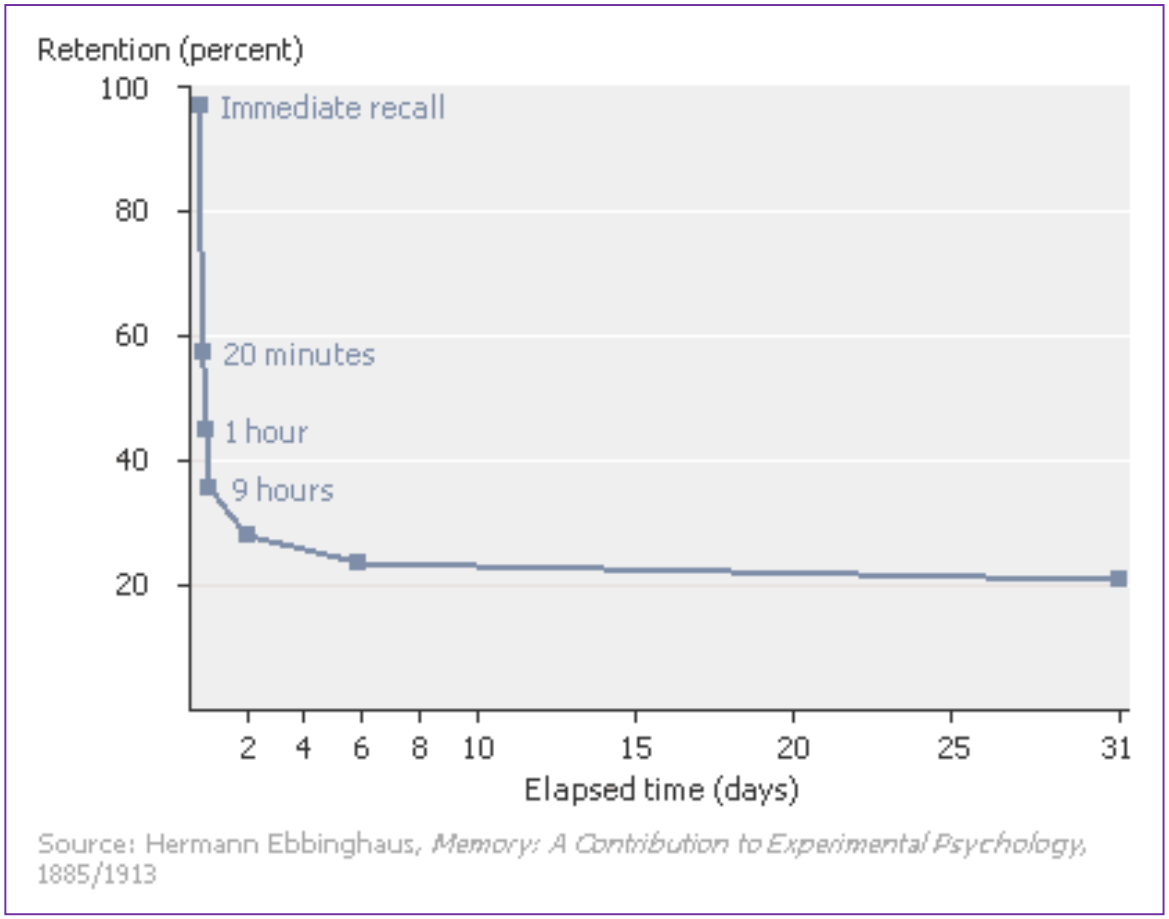
1950s-1960s, Britain

- **Information Processing Approach**
  - Mathematical models developed using computer metaphors
  - Inspired the development of **Cognitive Psychology** as a field

19th Century Germany

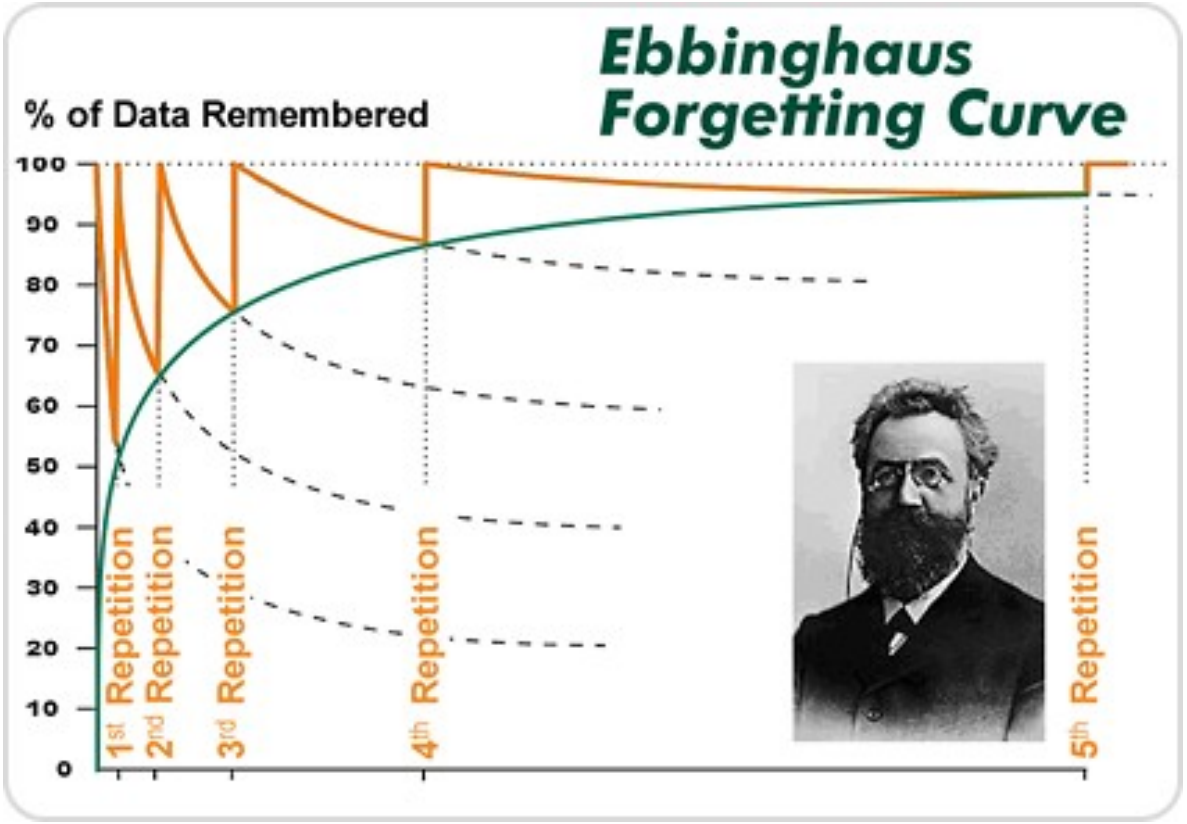
- Ebbinghaus (1850-1909)
  - Nonsense syllables
    - PIM DAG ZOL CEK
  - Learning curve – massed vs spaced practice
  - Forgetting curve – forgetting occurs rapidly
  - Overlearning – studying after something is learned
  - Savings – decreased effort needed to relearn
- Bartlett (1886-1969) – a critic
  - How does prior knowledge influence memory
  - Reconstruction is guided by schemas (concepts)

Ebbinghaus Forgetting Curve



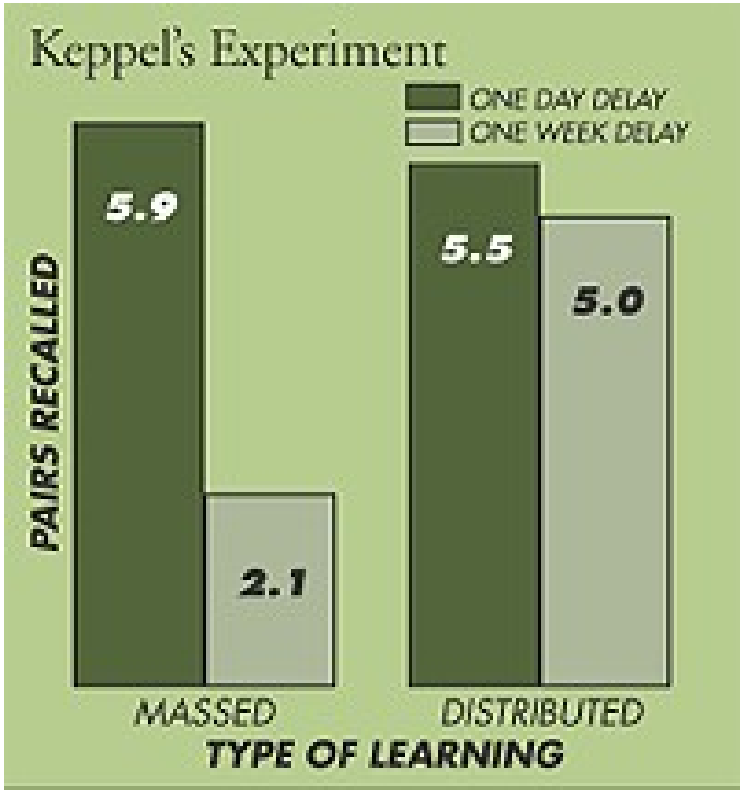
Source: Hermann Ebbinghaus, *Memory: A Contribution to Experimental Psychology*, 1885/1913

Importance of Practice



The more repetition (practice), the more likely information is to be remembered later.

Massed vs Spaced Study



Ebbinghaus, H. Memory: A contribution to experimental psychology. New York: Dover, 1964 (Originally published, 1885).

Keppel, Geoffrey. A Reconsideration of the Extinction-Recovery Theory. Journal of Verbal Learning & Verbal Behavior. 6(4) 1967, 476-486

Bartlett's "War of the Ghosts"

- Bartlett (1932) used multiple repetition of recalled material to study distortions over time.
- Participants were given a 328 word Native American folk tale "The War of the Ghosts" to read twice and then reproduce 15 minutes later and also hours to months later.
  - Total recall declined.
  - What was recalled was shaped by the need to form a coherent understandable story in the context of their own cultural knowledge (**schemata** – concepts).
  - He considered memory an active process of construction.

W.O.G content and errors

One night two young men from Edulac went down the river to hunt seals, and while they were there it became foggy and calm. Then they heard war-cries, and they thought: “Maybe this is a war-party.” They escaped to the shore, and hid behind a log. Now canoes came up, and they heard the noise of paddles, and saw one canoe coming up to them. There were five men in the canoe, and they said: “What do you think? We wish to take you along. We are going up the river to make war on the people.” … one of the young men went but the other returned home …

[it turns out that the five men in the boat were ghosts and after accompanying them in a fight, the young man returned to his village to tell his tale] …

and said: “Behold I accompanied the ghosts, and we went to fight. Many of our fellows were killed, and many of those who attacked us were killed. They said I was hit, and I did not feel sick.” He told it all and then he became quiet. When the sun rose he fell down. Something black came out of his mouth. His face became contorted … He was dead. (p.65)

One participant’s ecall of the story (two weeks later): There were two ghosts. They were on a river. There was a canoe on the river with five men in it. There occurred a war of ghosts … They started the war and several were wounded and some killed. One ghost was wounded but did not feel sick. He went back to the village in the canoe. The next morning he was sick and something black came out of his mouth, and they cried: “He is dead.” (p.76)

Contributions of Gestalt Psychology

- Gestalt movement (Kohler, Koffka, Wertheimer)
- The whole is different that the sum of its parts.
  - Anti-reductionistic
  - But they did acknowledge the importance of understanding the components of thought.
- Memory is influenced by the configuration of elements and context.
- Isomorphism of mental representation – material is represented mentally in the same configuration as it exists in the world.

Gestalt: Impact of context

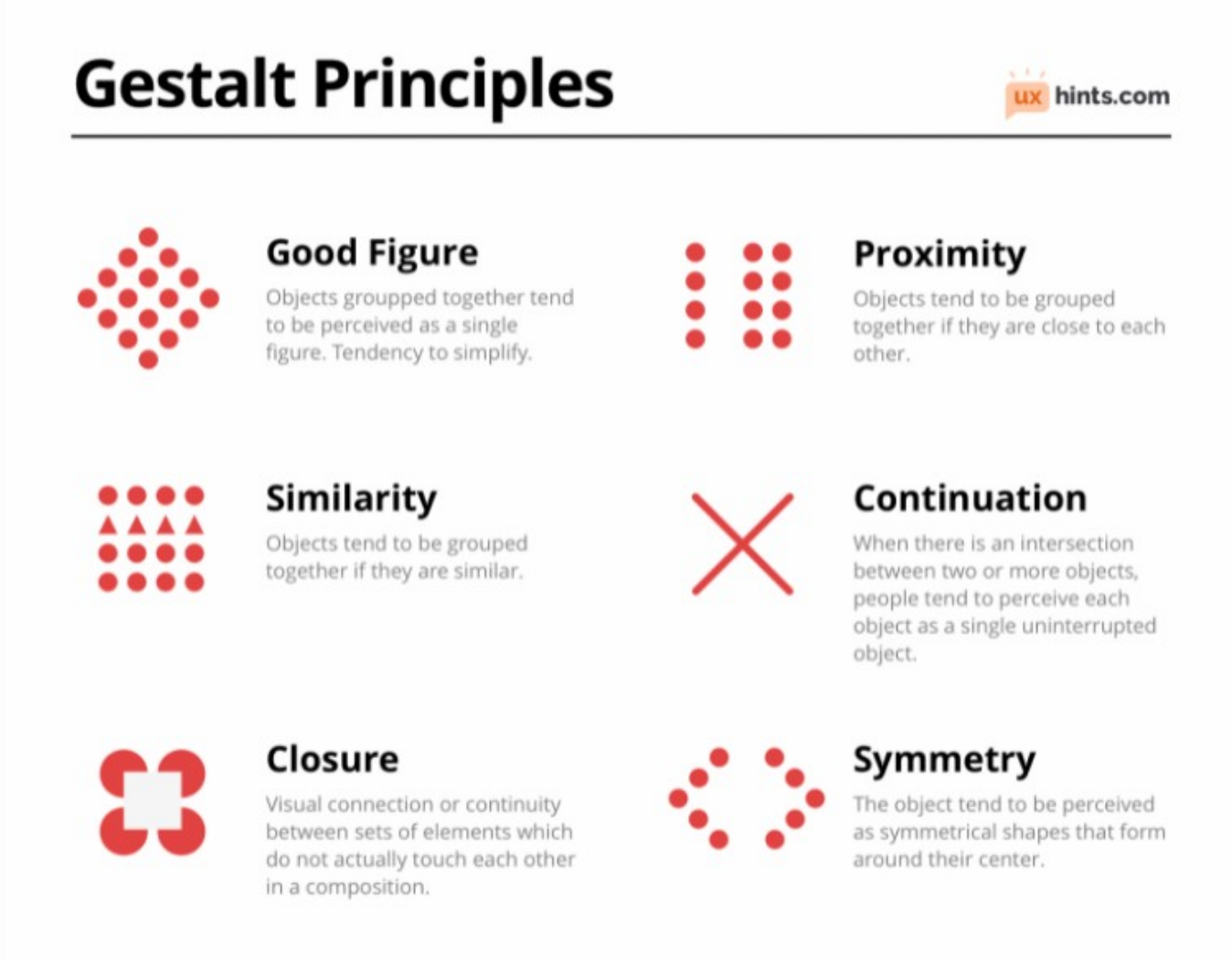


Image taken from:
https://uxhints.com/visual-ui-design/gestalt-principles/

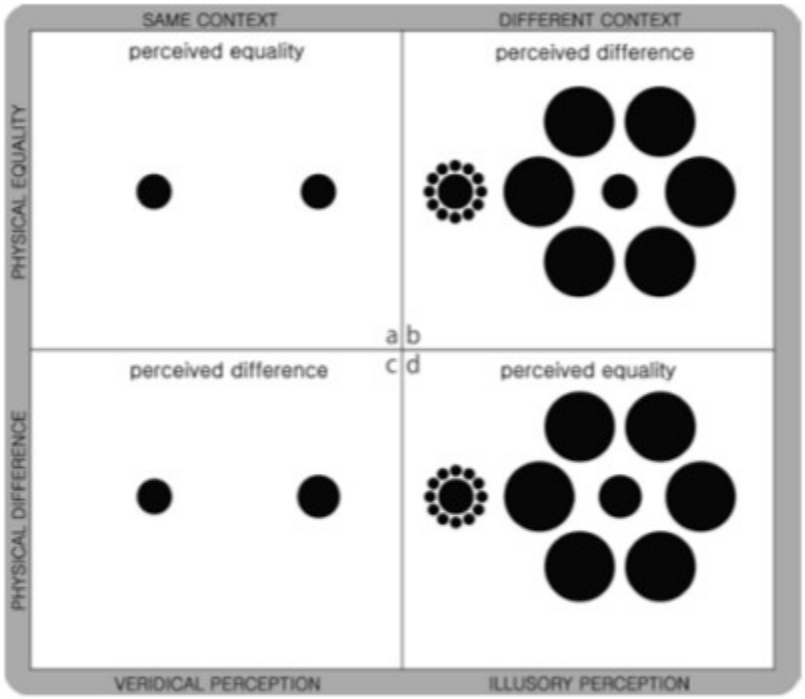


Figure 1. The effect of context in the perception of size. (a) Veridical perception: Disks with physically equal size, set in same context, are perceived as equal. (b) Illusory perception: Disks with physically equal size, set in different contexts, are perceived as different. (c) Veridical perception: Disks with physically different sizes, set in same context, are perceived as different. (d) Illusory perception: disks with physically different sizes, set in different contexts, are perceived as nearly the same.

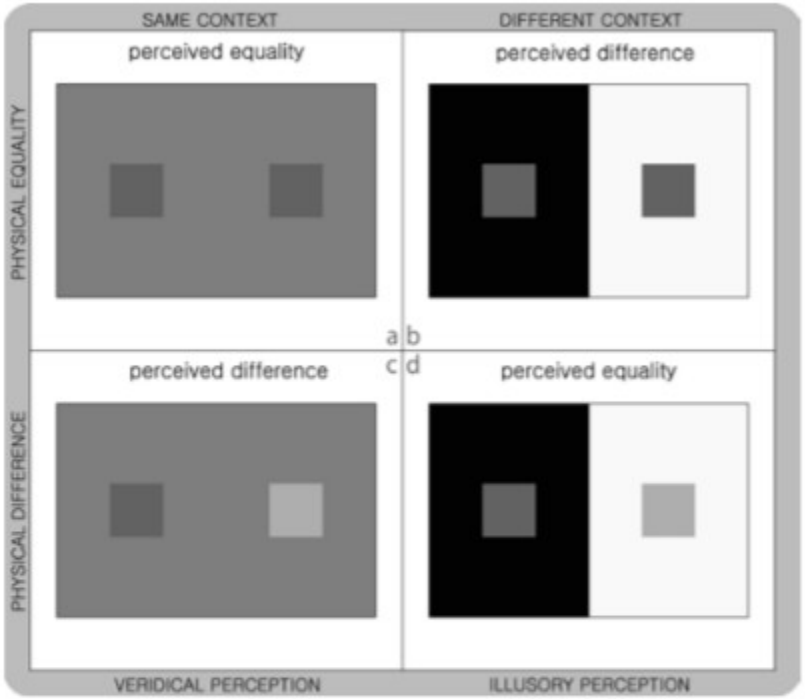


Figure 4. The effect of context in the perception of lightness. (a) Veridical perception: patches of equal luminance, set in same context, are perceived as equally light. (b) Illusory perception: patches of equal luminance, set in different contexts, are perceived as differently light. (c) Veridical perception: patches of different luminance, set in same context, are perceived as differently light. (d) Illusory perception: patches of different luminance, set in different contexts, are perceived as nearly equally light.

Behaviorism

- Behaviorism (Pavlov, Thorndike)
  - Psychology should be the study of observable behavior not structure of mind.
  - Behaviorism is associated with the term “learning”.
  - Later behaviorists (like Tolman) used mental explanations and representations (e.g., cognitive maps).
- Important types of learning -- Classical and operant conditioning both depend upon memory – associations are remembered.

Verbal Learning

- A behaviorist approach to the learning of verbal materials (words, sentences, stories).
  - Developed from Ebbinghaus's work.
- Memorization is the "attachment of responses to stimuli."
- Forgetting is the "loss of response availability."

Early Neuroscience -- Lashley

- Lashley (1890-1958) searched for the brain engram (the physical memory trace).
- First, rats learned a maze.
- Next, Lashley progressively removed larger and larger portions of rats brains from different locations and tested them in the maze to see how memory changed.
- Memory was affected more by the amount of brain tissue removed, not the location.

Hebb's Theory

- Hebb (1949) proposed that cortical organization occurs through "cell assemblies" and "phase sequences."
  - Cell assembly -- a set of associated neurons that work together because they are activated together.
  - Phase sequences incorporate several cell assemblies. They form systems involving multiple interconnected areas of the brain.
  - Repeated stimulation produces structural changes at the synaptic level – Hebb's rule: "What fires together wires together"

The Cognitive Revolution

- Thought is a valid subject for study
- This is the field of psychology associated with the term “memory”
- Cognitive psychologists adopted the methodological rigor of the behaviorists.
- The computer metaphor
  - hardware (brain) vs. software (thought processes)

Three Definitions of Memory

1. The location where memory is stored.
2. The physical entity that holds the memory:
    a) Trace
    b) Engram (biological storage of a trace)
3. The processes used to acquire (learn), store (encode) or remember (retrieve) information.

The Information Processing Metaphor

- Like a computer, human memory consists of three *interacting* components: