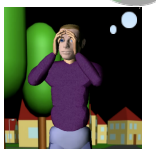
Universität Bielefeld

SFB 673
Alignment in Communication

Wir suchen eine
Studentische Hilfskraft



Zeitlicher Umfang: 9 Stunden/Woche

Wir bieten: Einblicke in aktuelle und interdisziplinäre Forschung, Arbeiten mit virtuellen Agenten

Aufgaben: Programmieraufgaben (System zur Generierung von Sprache und Gestik, virtuelle Charaktere)

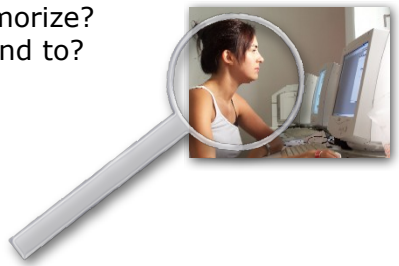
Voraussetzungen: Programmierkenntnisse und möglichst –erfahrung (C++, Java), Interesse an kognitionswissenschaftlichen und linguistischen Fragestellungen

Kontakt: Kirsten Bergmann (kbergman@TechFak.Uni-Bielefeld.DE)

Human-Computer Interaction

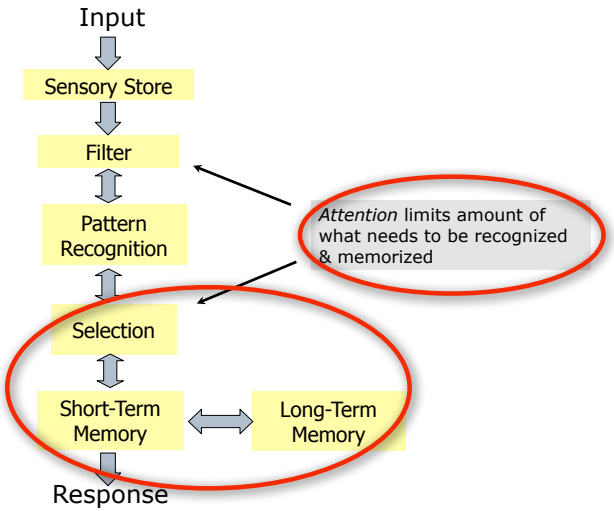
Session 3:
Psychological basis -- memory & attention
(cognitive resources)

Human users
what can they memorize?
what can they attend to?

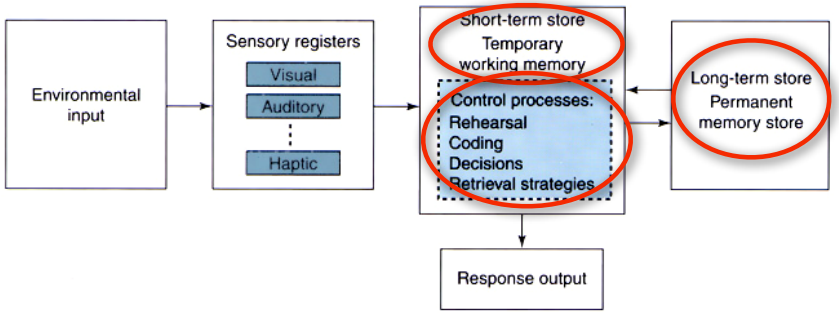


Recommended readings:
- Dix et al.: "Human-Computer Interaction"
- Reed: „Cognition" (5th ed.), Wadsworth, 2000
- Benyon et al.: „Designing Interactive Systems", 2005

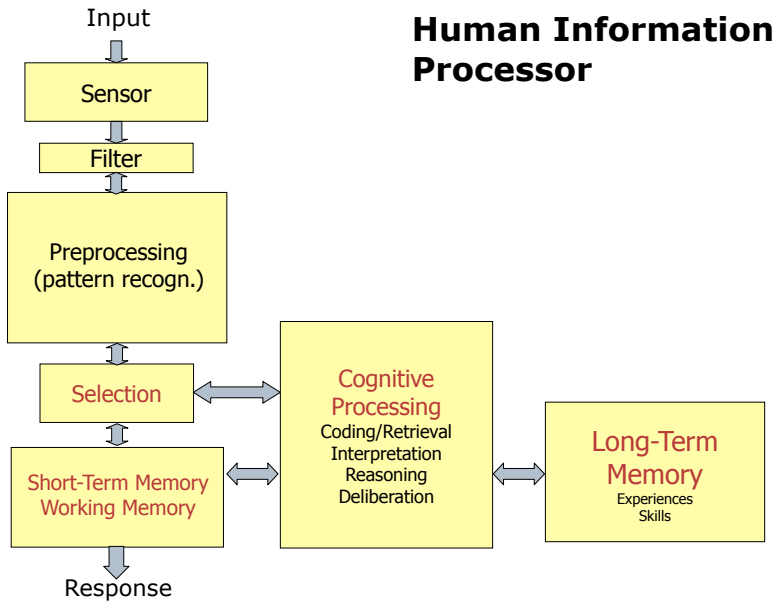
Human Information Processor



Multi-store model (Atkinson & Shiffrin, 1968)

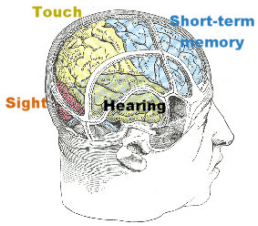


Standard theory of memory & information processing, aka. modal model



Human Information Processor

Short-term memory (STM)



- a "scratch-pad" for temporary recall
  - limited duration: ~20-30s
  - rapid, reliable access: ~ 70ms
  - limited capacity
    - Miller (1956): **7 ± 2 chunks**
    - Cowan (2002): **4 ± 2 chunk**
- capacity limits can be overcome by chunking
  - grouping of information into larger meaningful units
  - found by looking for familiar pattern abstractions
  - individual differences, e.g., chess masters vs. novices
  - *closure* = successful formation and completion of chunks, also seen in everyday tasks that must be held in STM

Examples

2123482784 9

0121 414 2626

FB-IUS-AC-IAIB-M

FBI-USA-CIA-IBM

STM - maintenance

- what happens if you need to keep information in memory longer than 30 seconds?
- to demonstrate, memorize the following phone number (presented one digit at a time):

STM - maintenance

- what is the number?

857-9163

The number lasted in your short-term memory longer than 30 seconds. How were you able to remember the number?

STM - rehearsal

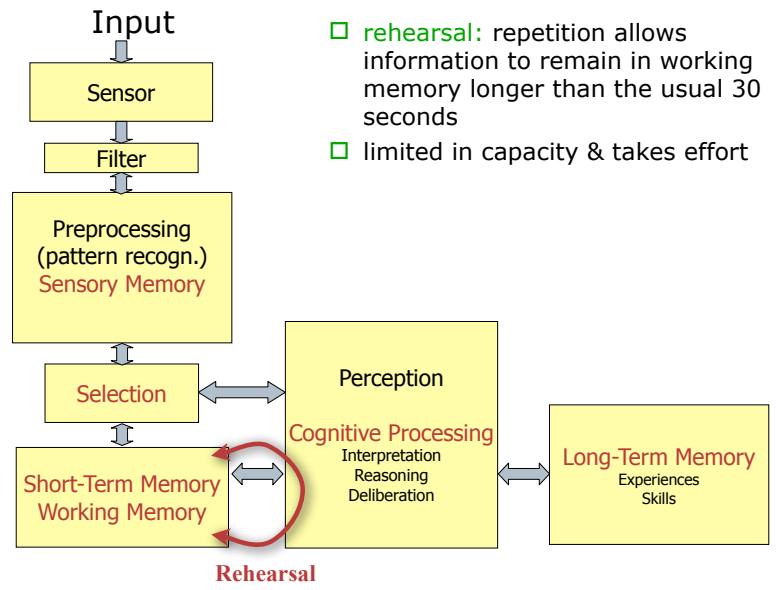
- what happens if you can't use maintenance rehearsal?
- to demonstrate, again memorize a phone number, BUT count backwards from 1,000 by sevens (i.e., 1014, 1007, 1000 … etc.)

STM – rehearsal

- what is the number?

628-5094

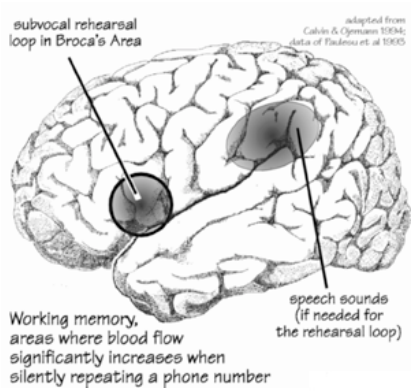
Without rehearsal, memory fades.



- rehearsal: repetition allows information to remain in working memory longer than the usual 30 seconds
- limited in capacity & takes effort

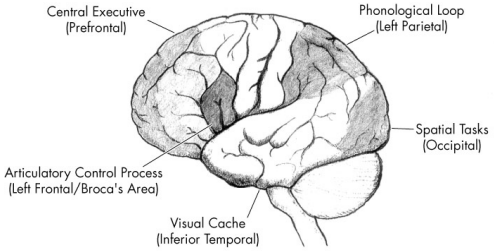
Working memory

- working memory = place where basic cognitive operations are being carried out
  - WM = STM + „central executive"
  - comprehension, decision-making, problem-solving
  - modality-dependent (e.g., rehearsal of language and sounds vs. inspection or rotation of mental images)
- content of working memory defines the cognitive context in which cognitive processing is carried out
  - faciliates or hinders efficient processing, controls attention!
  - HCI: beware of the context in which the user operates, created by your system's feedback and functions

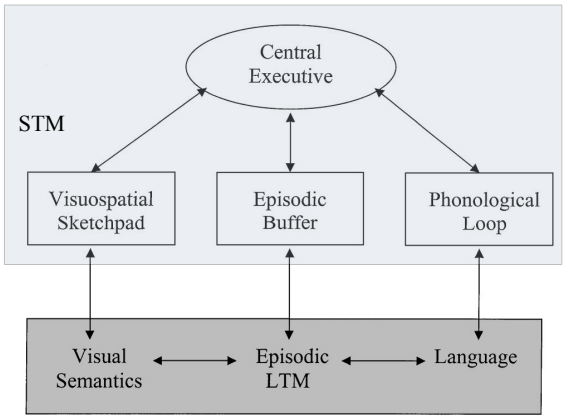


working memory

- memory is (at least partly) modal
- brain areas involved in working memory



Theory of Working (Baddeley 2000)

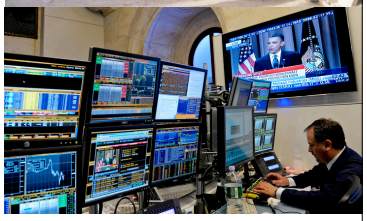


Working memory consisting of multiple independent, processes maintaining modality-specific information

Effective size of WM is expanded when using multiple modalities

Cognitive effort

- Cognitive load = total amount of mental activity imposed on working memory at a point in time during learning
  - intrinsic vc. extraneous complexity
  - major factor: number of elements that need to be attended to
- increasingly applied in HCI design to ease the learnability of systems



Cognitive effort in human-computer interaction

- Example: Study by Oviatt et al. (ICMI'04)
  - task: deliver instructions to the map system to coordinate emergency resources
  - different levels of difficulty

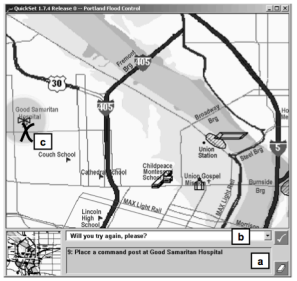
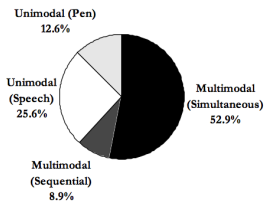
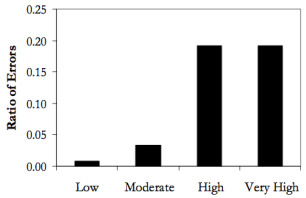


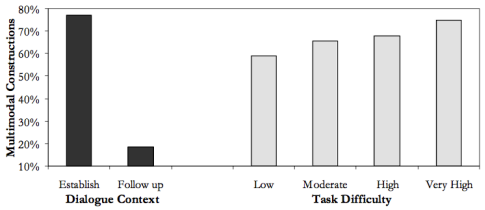
Figure 1. User interface

Difficulty	Message from Headquarters
Low	Situate a volunteer area near ***Marquam Bridge***
Moderate	Send a barge from ***Morrison Bridge barge area*** to ***Burnside Bridge dock***
High	Draw a sandbag wall along ***east riverfront*** from ***OMSI*** to ***Morrison Bridge***
Very High	Place a maintenance shop near the ***intersection of I-405*** and ***Hwy 30*** just ***east*** of ***Good Samaritan***

Cognitive effort in human-computer interaction







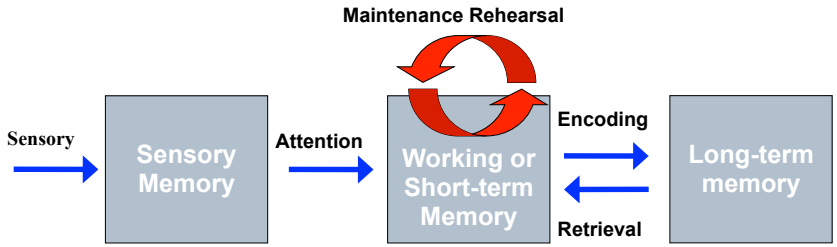
In cognitively difficult tasks:

- more errors and longer reaction times
- people switch to multimodal (speech+pen) input

Long-Term Memory

Long-Term Memory

- Once information passed from sensory to working memory, it can be learned = encoded and stored in long-term memory



Long-term memory (LTM)

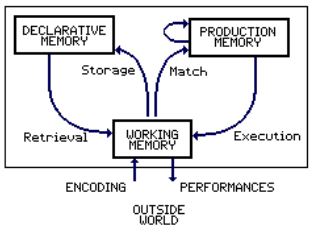
- Repository for all our knowledge and experiences
  - slow access ~ 1/10 second
  - slow decay, if any
  - huge but not infinite capacity
- Storage for ...
  - Facts, data, concepts, ...
  - Images, sounds, sents, ...
  - Situation, episodes, processes, ...
  - Connections, conclusions, insights, ...
  - Procedures, recipes, movements, ...

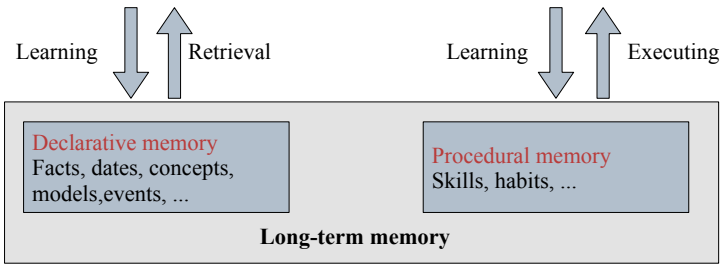
Semantic vs. episodic memory
(Tulving, 1983)

- Semantic Memory
  - memory of facts, concepts, meaning of words & things
  - abstracted and generalized (not tied to place, time or event)
- Episodic Memory
  - serial, biographical memory of events
  - memory tied to explicit autobiographical events
  - subjective sense of "being there"
- distinction supported by neuropsychological evidence
  - Frontal lobe patients and some amnesics have relatively intact semantic memories, but are significantly impaired in their memories of events

Declarative vs. procedural memory

ACT* (Anderson, 1993)





Automatic sequences of keystrokes, menue selections, condition-action rules, etc.

LTM - memories

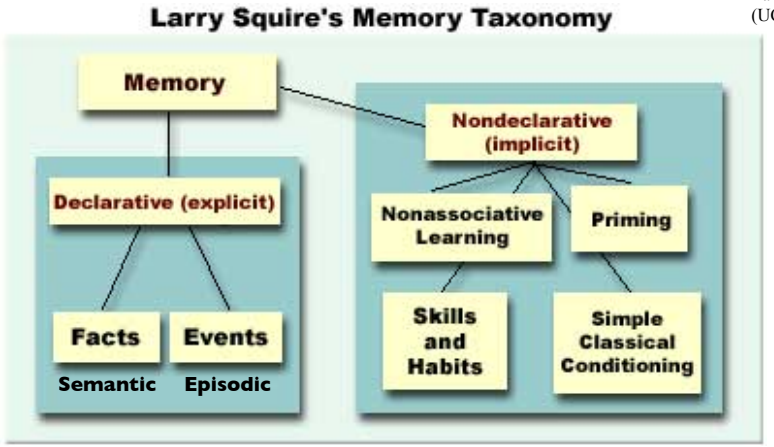
Stanford Encycl. of Phil.

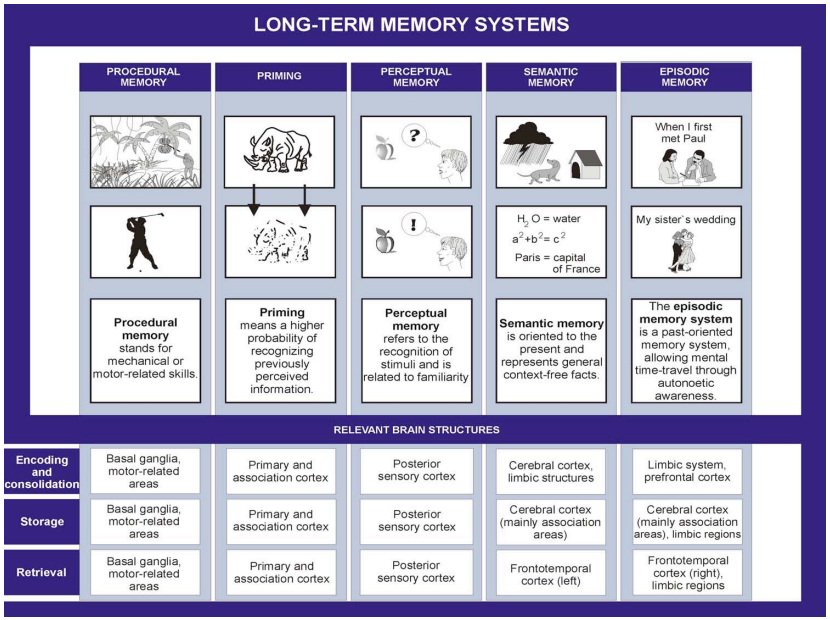
- procedural memory
  - embodied skills such as typing, playing golf, using a knife and fork
- semantic memory
  - network of conceptual information underlying our world knowledge
- episodic memory (psych.), 'personal memory', 'direct memory' (phil.)
  - experienced events and episodes, generic or specific, of more or less extended temporal periods

- semantic + episodic memories = 'declarative memory'
  - more controversial: 'explicit' vs. 'implicit' memory
    - explicit memories: accessed verbally or otherwise by subject
    - implicit memory: without awareness, better seen as label for a set of memory tasks rather than a distinct system of memory

LTM - memories

Larry R. Squire (UCSD)





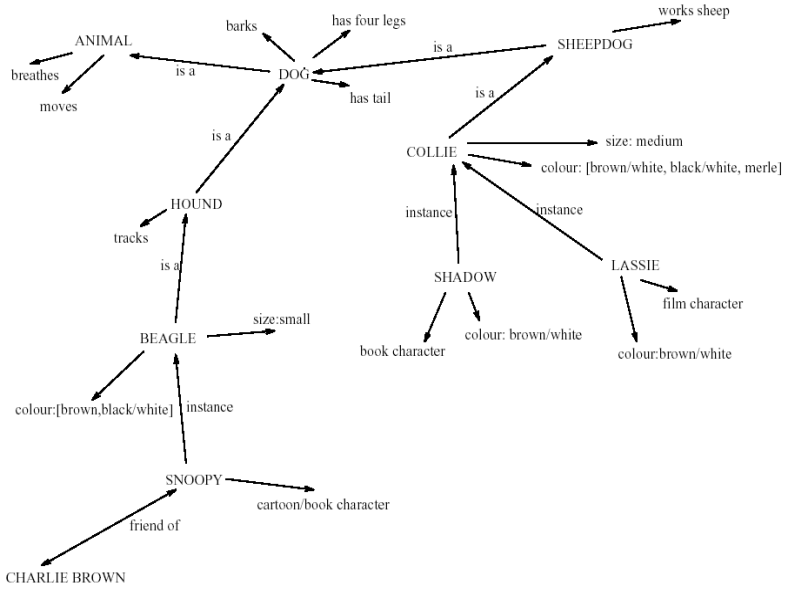
H. Markowitsch, 2006

LTM - associative memory

- semantic memory provides associative access
  - represents relationships between bits of information
  - supports inference

- Model: semantic network (e.g., ACT-R)
  - „closeness" of concepts represented by closeness in graph (number of edges between nodes)
  - inheritance – child nodes inherit properties of parent nodes
  - relationships between bits of information explicit
  - supports inference through inheritance

- learning of information through embedding
  - find associations with known facts or concepts
  - the more associations found the better something is learned, anchored in our conceptual knowledge



Mental models

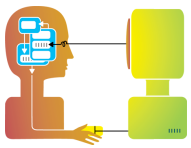
- *"In interacting with the environment, with others, and with the artifacts of technology, people form internal, mental models of themselves and of the things with which they are interacting. These models provide predictive and explanatory power for understanding the interaction."*

  -Norman (in Gentner & Stevens, 1983)

- first used by Craik (1943), rennaisance in 80's in Cognitive Science and then in HCI (Johnson-Laird, Gentner & Stevens)
  - structural models: set of beliefs about how a system works
  - functional models (a.k.a. task-action mapping models): procedural knowledge about how to use the system

Mental models

- characteristics:
  - minimal, incomplete, not accurate
  - unstable, constantly evolving, built on-the-fly
  - simplified representation of complex phenomena
  - `runnable´, allow to make predictions and evaluate consequences of a change of state
- can be constructed from perception, imagination, interpretation of discourse, can represent abstract notions (as metaphors)
- for HCI practitioners: a mental model is a set of beliefs about how a system works
  - crucial for interface design from a user-centered perspective (see next lectures)!!



Expert vs. novice users

- Beginners: memorize and operate upon simple facts and rules (declarative), build up their mental model of the system from the scratch, looking for analogies
- Experts: have a proper mental model already, utilize declarative and procedural (implicit) knowledge
- How to support learning in HCI?
  - enable connections to existant knowledge
  - use metaphors to connect to known realms
  - build up knowledge step-by-step, support rehearsal
  - account for different types of learners (learning by reading, visualizing, verbalizing, doing)

How is information memorized ??

- Rehearsal
  - information moves from STM to LTM through repetition
  - *„total time"* hypothesis: amount of information retained is proportional to rehearsal time
  - *„Distribution of practice"* effect: optimized by spreading learning over time
- importance of structure, meaning, and familiarity (embeddedness)
  - information about objects is easier to remember:
    - Faith Age Cold Tenet Quiet Logic idea Value Past Large
    - Boat Tree Cat Child Rug Plate Church Gun Flame Head
  - information related to existing structures is more easily incorporated into memory

When is information forgotten ?

- Decay
  - information is lost gradually, but very slowly
- Interference
  - new information replaces old: *retroactive interference*
    - new tel. number masks old one
  - old may interfere with new: *proactive inhibition*
    - find yourself driving to your old house
- memory is selective …
  - affected by emotion – can subconsciously `choose' to forget

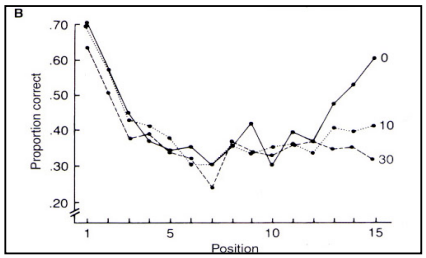
Retrieval is of unequal difficulty

- **Free recall ("Who are these persons?")**
- **Cued recall ("Last name starts with an M.")**
- **Recognition ("Whose last name is Fischer?")**

H. Markowitsch, 2006

How is information retrieved?

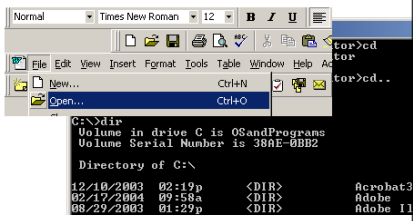
- free recall list learning (Glanzer & Cunitz, 1966):
  - subjects presented with a list of words (usually 15 to 20)
  - more likely to remember the words at the beginning (Primacy effect) and end of the list (Recency effect)



- Evidence for LTM-STM
  - recency effects reflect limited STM capacity, ceases with time
  - primacy effects reflect transfer to LTM via rehearsal
  - primacy effect more robust than recency: less affected by interference or delay

How is information retrieved?

HCI: two main mechanisms



- recall
  - information must be retrieved from memory without any hint
  - hard, error-prone
  - can be assisted by cues, e.g. categories, imagery
- recognition
  - present information „evokes" that it has been seen before, plus further useful knowledge
  - less complex than recall - *information itself acts as a cue*
  - frequent design goal