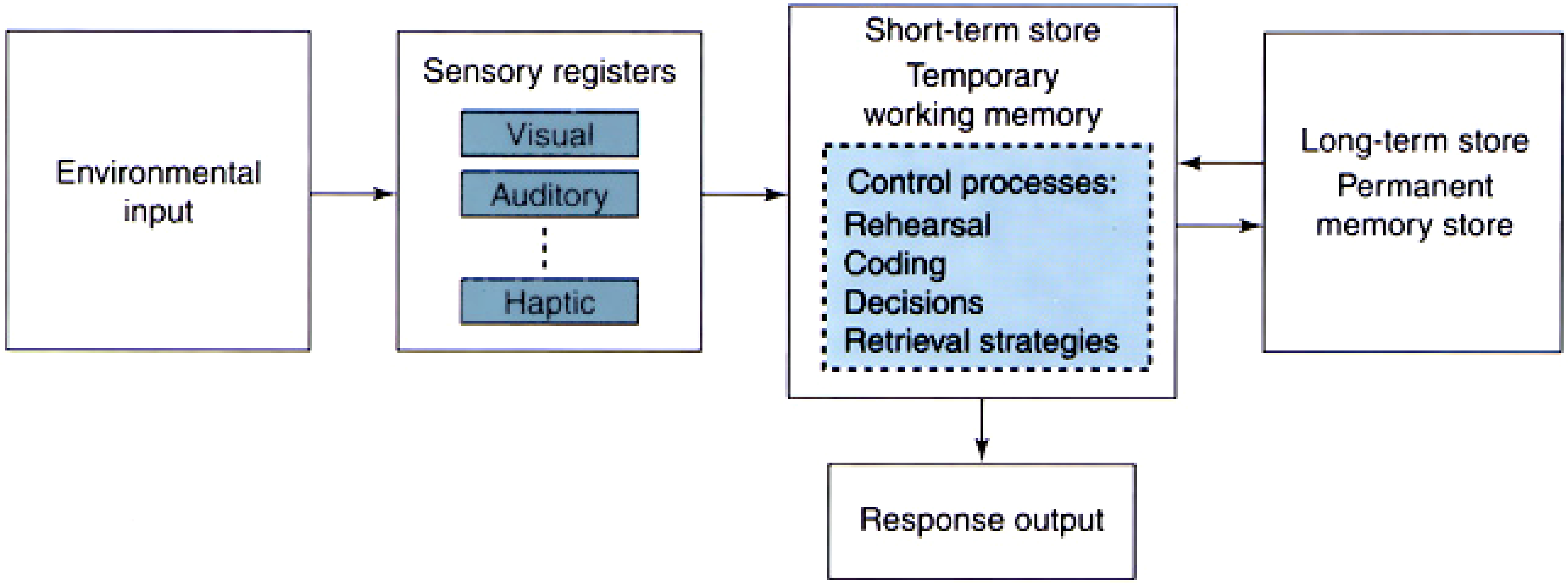
Human-Computer Interaction

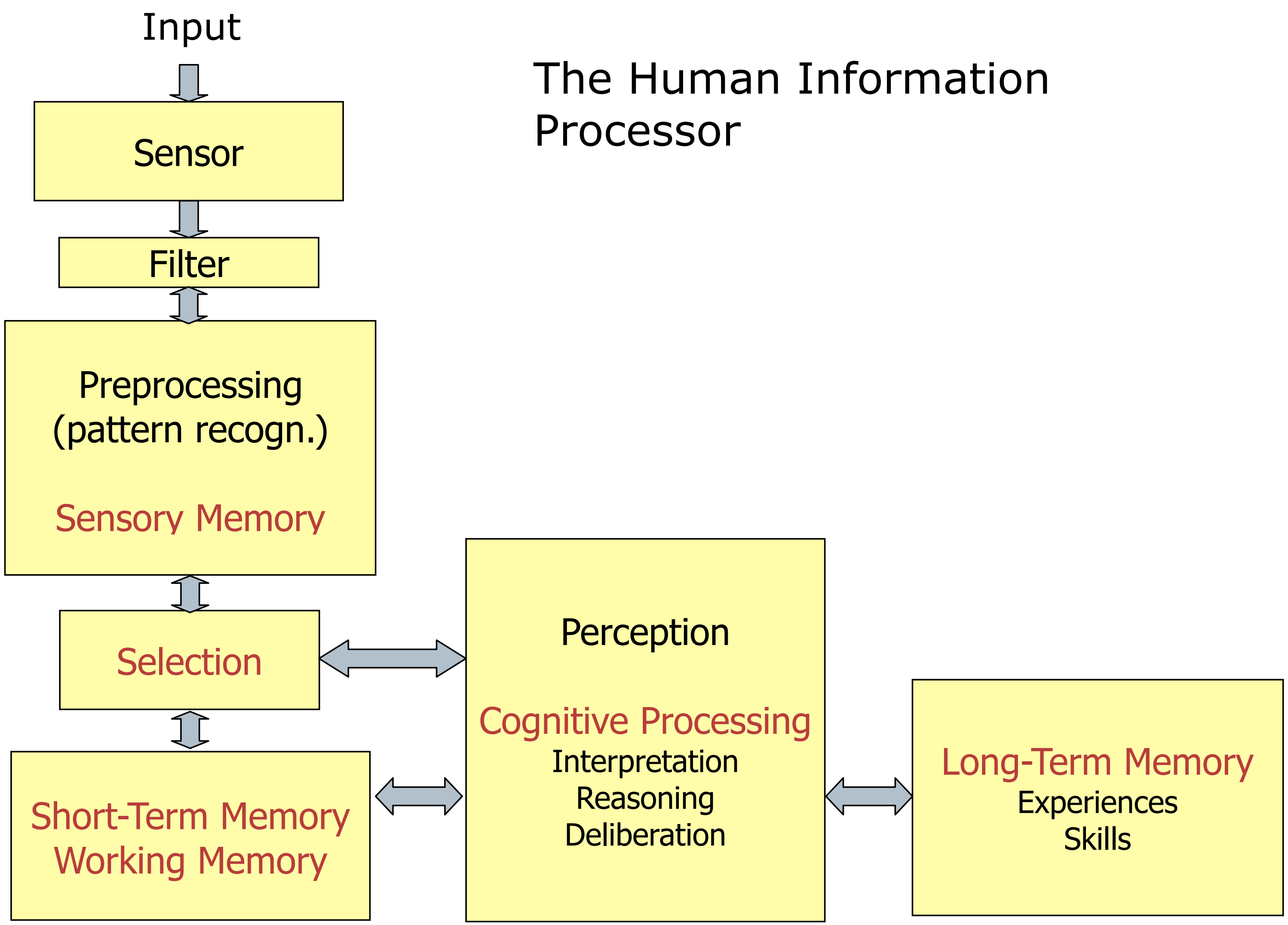
Termin 3:
Memory
Attention

Atkinson & Shiffrin (1968): Multi-store model



Standard theory of memory & information processing, also “Modal model”

The Human Information Processor



Sensory memory

- modality specific buffers for stimuli received through senses (Neisser, 1967)
- large capacities, but information lasts only short durations
  - *iconic memory*: visual stimuli, *~250-400 msec*
  - *echoic memory*: aural stimuli*, only little longer*
  - *haptic memory*: tactile stimuli
- FIFO, memories are "washed out" or "masked” (decay) by new incoming information
  - iconic memory: By the time ~4 items have been extracted, the remaining contents have been decayed
  - decay rate depends on intensity, contrast, duration of stimulus, following of another stimulus (masking)
- Example: Reading your watch quickly

Sensory memory

Sperling (1960):

- Presented an array of letters for 50 milliseconds

X	**M**	**R**	**J**
C	**K**	**P**	**R**
V	**F**	**L**	**B**

- *Whole-report method*: recall as much as possible
  - 4.5 letters on average
  - letters "fade away" before they can report them all
- *Part-report method*: only certain elements from array
  - tone (high, medium, low) *after* presentation to cue subjects to report a particular row
  - Recall a higher percentage of letters, depending on delay of tone: 50ms: 9 (i.e. 3 per row) → 300ms: 6 → 1s: 4.5
  - Attended to and scanned the row in sensory memory, until it faded away after 1 sec.

Short-term memory (STM)

- a more durable “scratch-pad” for temporary recall
  - ~ 20-30s, if not maintained (see below) or externalized
- rapid and reliable access: ~ 70ms

- limited capacity
  - Miller (1956): **7 ± 2 chunks**
  - Cowan (2002): **4 ± 2 chunk**

- overcome capacity limits by *chunking*
  - grouping info into larger meaningful units
  - found by looking for familiar pattern abstractions
    - individual differences, e.g., chess masters vs. novices
  - *closure* = successful formation of chunks, also seen in everyday tasks held in STM

Examples

212348278493202

0121 414 2626

FB-ITW-AC-IAIB-M

FBI-TWA-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 - maintenance rehearsal

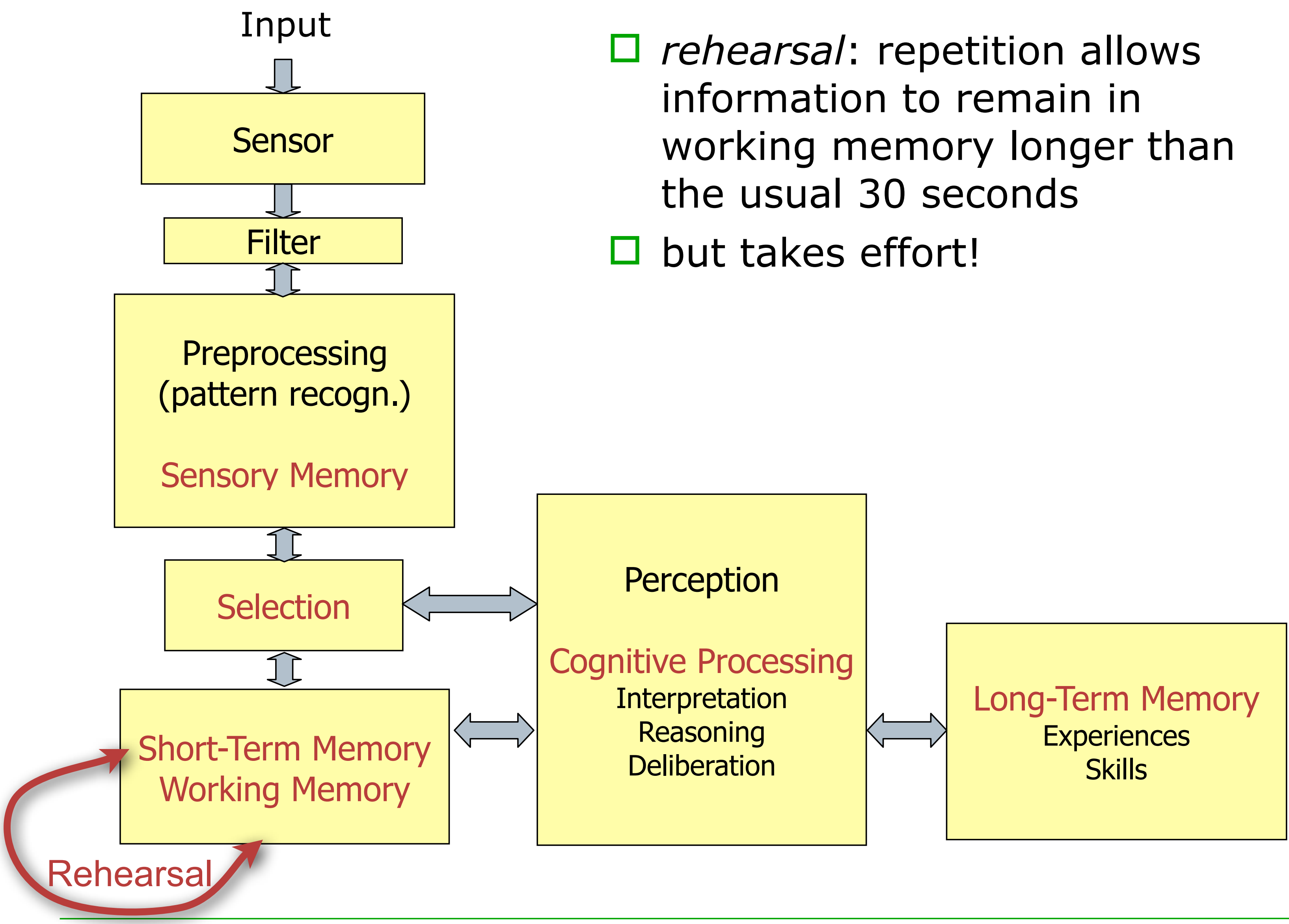
- what happens if you can’t use maintenance rehearsal?
- to demonstrate, again memorize a phone number,
  BUT count backwards from 1,000 by sevens (i.e., 1014,
  1007, 1000 … etc.)

STM – maintenance rehearsal

- what is the number?

628-5094

Without rehearsal, memory fades.



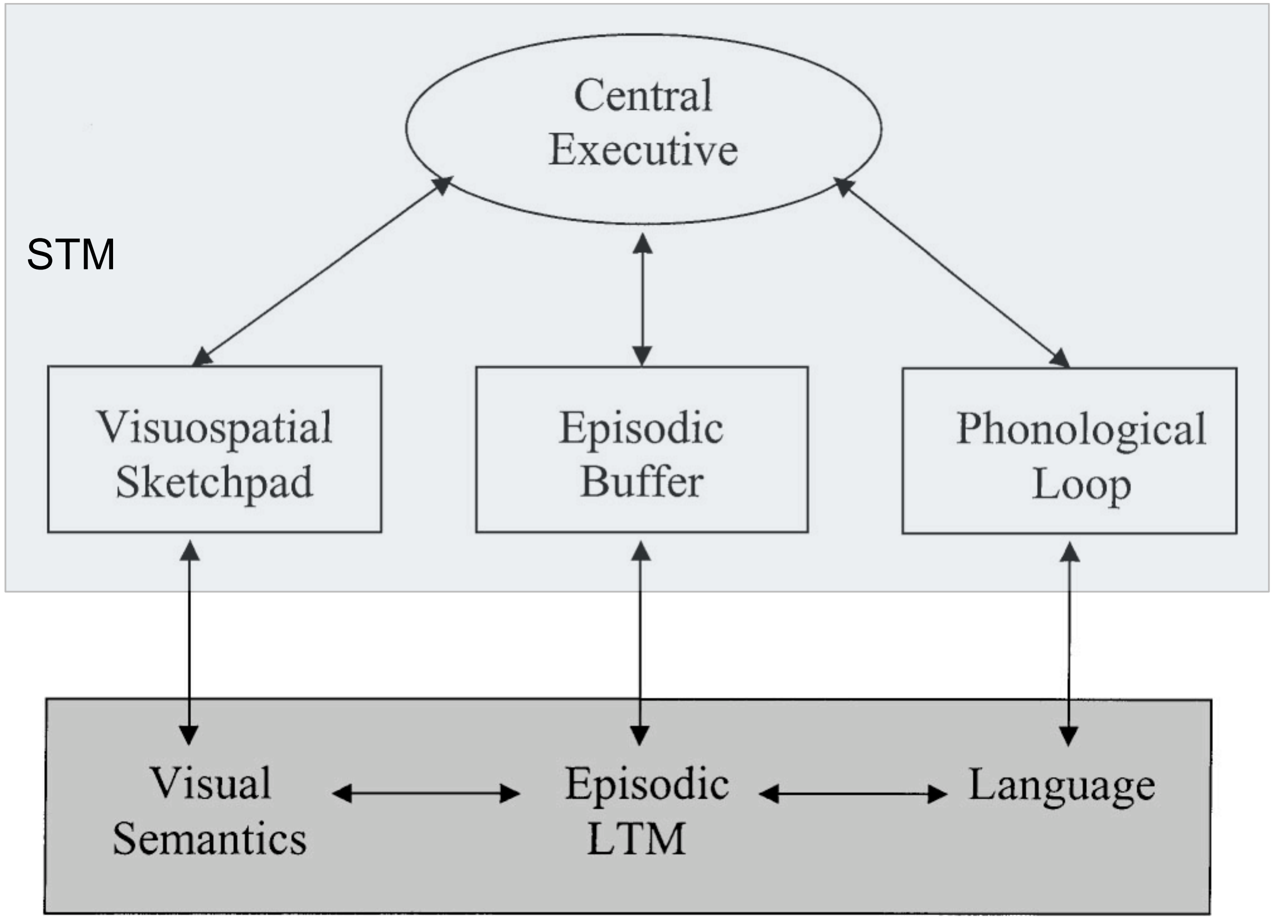
- *rehearsal*: repetition allows information to remain in working memory longer than the usual 30 seconds
- but takes effort!

STM & working memory

- Working memory = place where basic cognitive operations are carried out
  - comprehension, decision making, problem solving
  - modality-dependent (e.g. rehearsal of language and sounds vs. inspection or rotation of mental images)
  - WM = STM + „central executive“

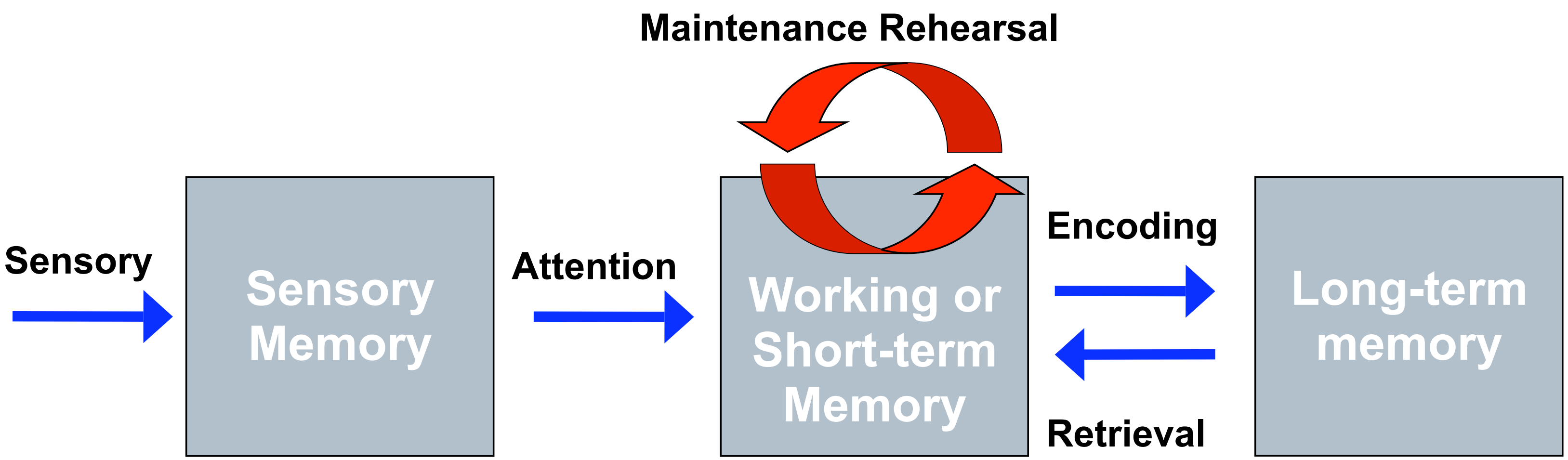
- Content of STM defines *context* in which cognitive processing is carried out
  - Can faciliate or hinder efficient processing
  - HCI: Beware of the context that is actively created by your system‘s feedback and functions, in which the user operates.

Baddeley (2000)



Long-Term Memory

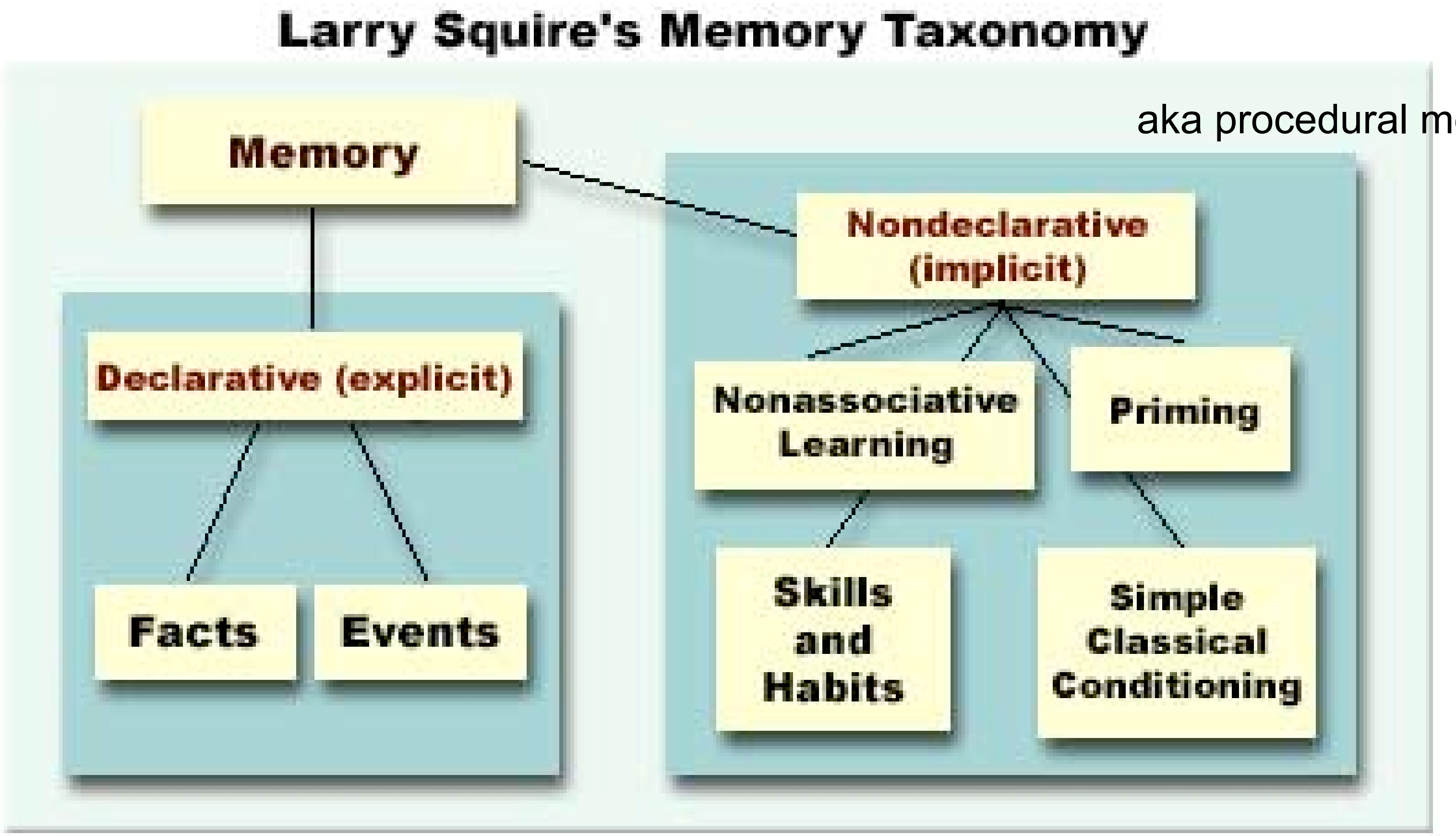
- Once information passed from sensory to working memory, it can be encoded into long-term memory



Long-term memory (LTM)

- Repository for all our knowledge and experiences
  - slow access ~ 1/10 second
  - slow decay, if any
  - huge capacity
- Storage for ...
  - Facts, data, concepts
  - Images, sounds, sents, ...
  - Situation, processes, ...
  - Connections, conclusions, insights, ...
- HCI:
  - The combined knowledge of these kinds about a system and the interaction forms a **mental model** of the user
  - Distinguishes a novice from an expert user

Kinds of memory

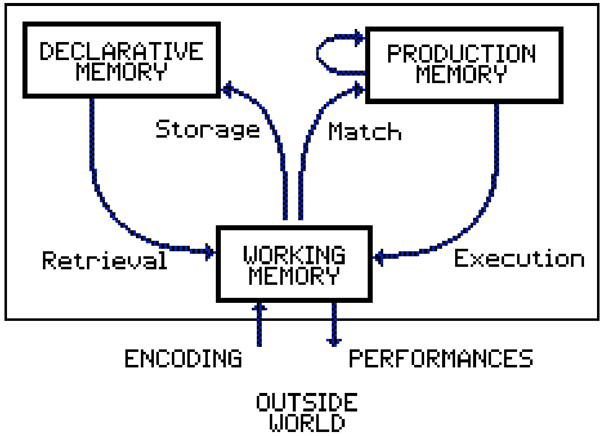


aka procedural memory

Larry R. Squire (UCSD)

Declarative vs. procedural memory

ACT* (Anderson, 1993)



Learning ↓ ↑ Retrieval

Learning ↓ ↑ Executing

Declarative memory
Facts, dates, concepts, models,...

Procedural memory
Skills, habits, ...

Long-term memory

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

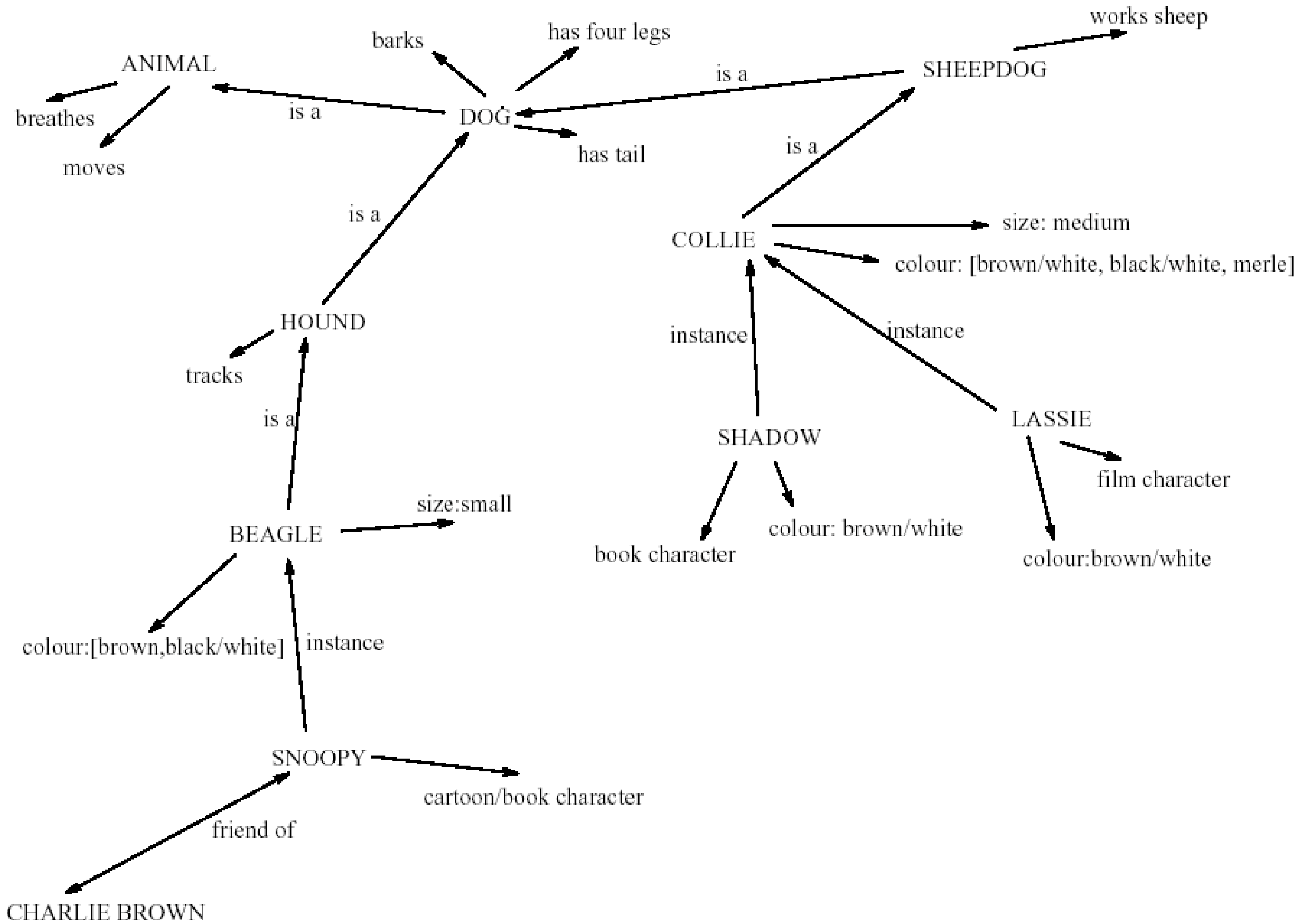
Semantic vs. episodic memory
(Tulving, 1983)

- Semantic Memory
  - structured memory of facts, concepts, meaning of words and things
  - abstracted and generalized (not tied to specific 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.

Associative memory

- Semantic memory structure
  - provides “associative” access to information
  - 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
  - by looking for associations with known facts or concepts
  - the more associations are found, the better something is learned

Associative or semantic network



How is information memorized ??

- Rehearsal
  - information moves from STM to LTM
  - *total time* hypothesis: amount of information retained is proportional to rehearsal time
- *Distribution of practice* effect
  - optimized by spreading the learning over time
- Importance of structure, meaning and familiarity
  - information about objects 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 more easily incorporated into memory (cf. associations)

When is information forgotten ?

decay

- information is lost gradually but very slowly

interference

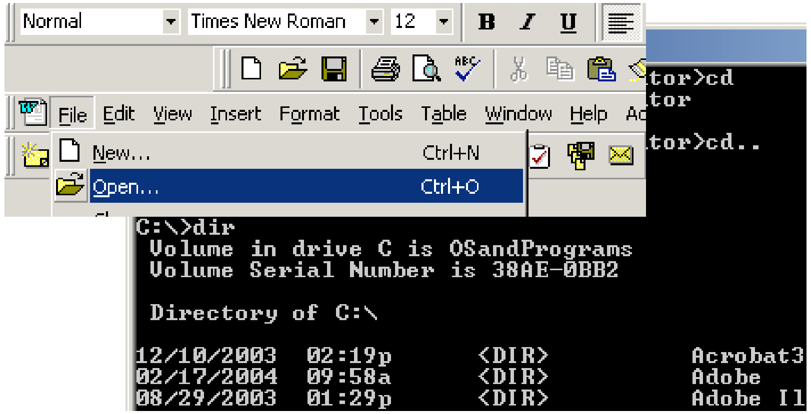
- new information replaces old: *retroactive interference*
  - new tel. number masks old one
- old may interfere with new: *proactive inhibition*
  - find yourself driving to your old house

memory is selective …

… affected by emotion – can subconsciously `choose' to forget

How is information retrieved?

Two basic mechanisms:

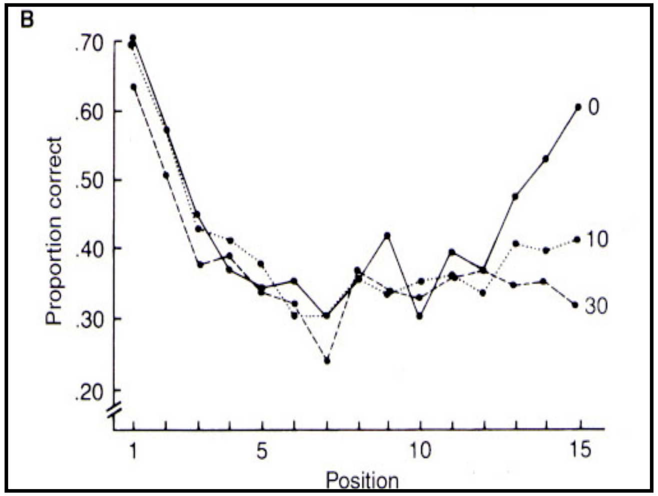


- recall
  - information must be retrieved from memory, without any hint
  - can be assisted by cues, e.g. categories, imagery
- recognition
  - present information „evokes" that it has been seen before plus further knowledge
  - less complex than recall - information itself acts as a cue

Recall

- Free recall list learning (Glanzer & Cunitz, 1966):
  - Subjects presented with a list of words (usually 15 to 20) auditorily
  - Results: Subjects were more likely to remember the words at the beginning (*Primacy*) and end of the list (*Recency*).

- Study provides evidence for the distinction between LTM and STM
  - Recency effects reflect limited STM capacity
  - Primacy effects reflect transfer to LTM via rehearsal
  - Primacy effect more robust than recency: less affected by interference or delay



Expert vs. novice users

- Beginners: Simple facts and rules, must build up a *mental model* of the system from the scratch
- Experts: Employ declarative and procedural (implicit) knowledge, which they can usually not explicate (e.g. verbalize)
- How to support learning ?
  - enable connections to existant knowledge
  - use metaphors to connect to known realms
  - build up knowledge step-by-step
  - account for different types of learners (learning by reading, visualizing, verbalizing, doing)

Acting

- Attention
- Reasoning
- Errors
- Reaction Times and Movement
- Affordances and Mappings

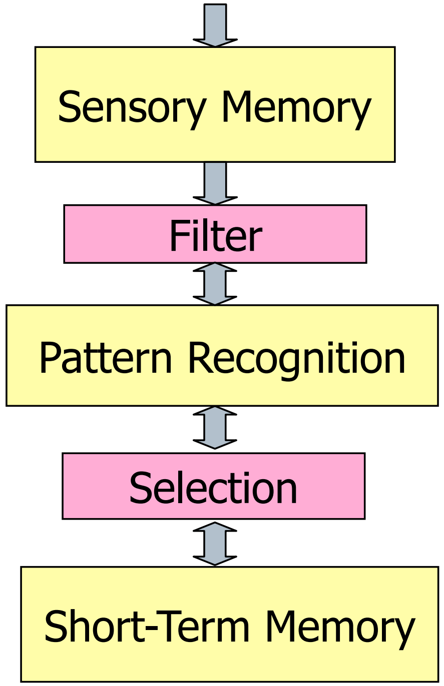
Attention

- Limited capacity of working memory restricts the amount of information we can take in and process at a time
- The brain actively *focuses* on and then *concentrates* on a certain kind of information
- With practice, some kinds of information require little to no effort (automatic) in becoming the focus of attention

- HCI:
  - Attention should be focused on *task* not on interaction
  - Minimize mental effort of using a system
  - Example: driving a car

Attention

- bottleneck theories
  - *Filter theory*: attention determines what info reaches pattern recognition stage through filter
  - *Late-selection model*: attention selects information for memory
- capacity theories
  - Selection occurs everywhere
  - depends on mental effort
- Automatic skills are those that require little mental effort (*habituation*)



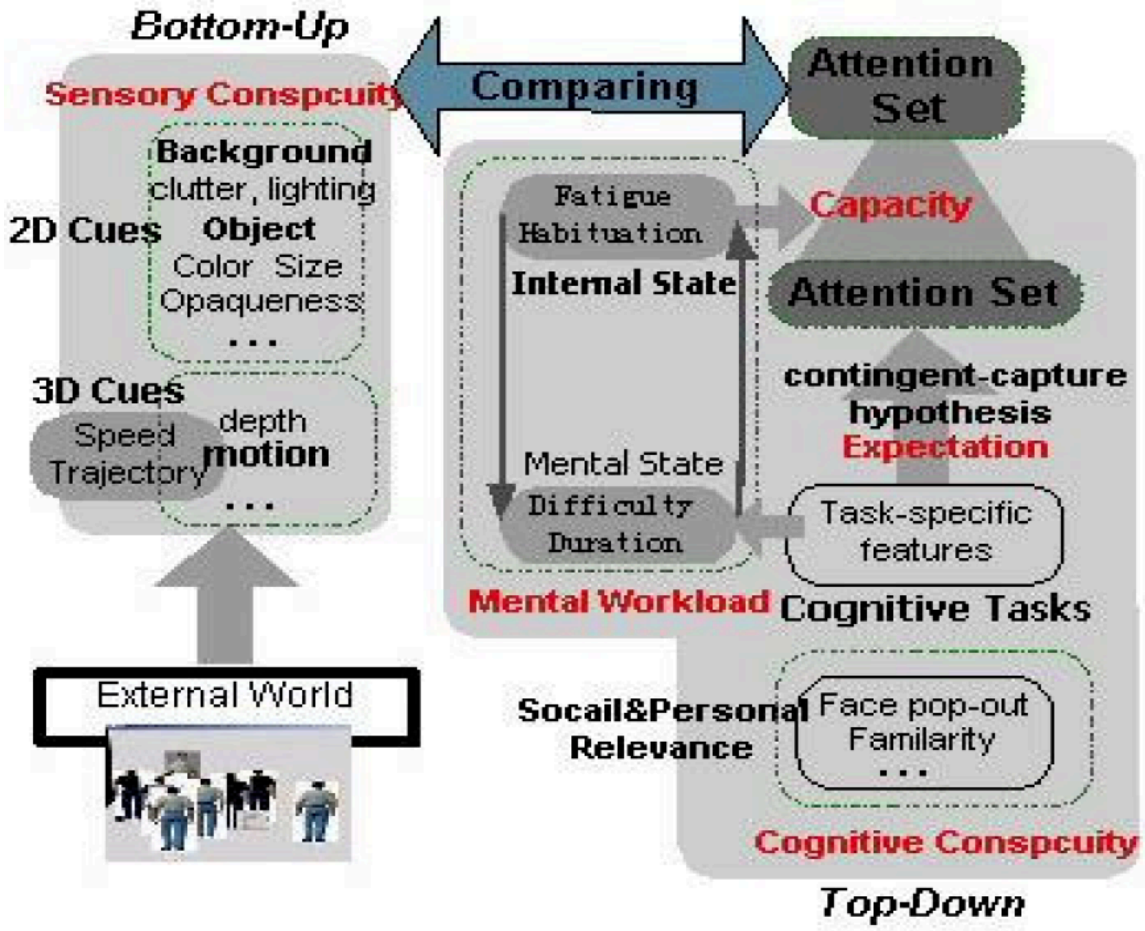
(cf. Reed. 2000)

What do we attend to ?

Attentional filter affected by (Green, 2004)

1. Conspicuity: Object‘s inherent ability to grab attention
   - Sensory conspicuity (physical properties)
   - Cognitive conspicuity (relevance, e.g. face pop-up)
2. Mental workload
3. Expectation
   - Causes specific stimuli to gain more weigth than other
   - *Contingent-Capture* Hypothesis (Ward):
     expected items are part of *attentional set*, informing the person what is relevant and important in a scene
   - Main cause of „inattentional blindness“
4. Capacity
   - number of items you can attend to at a time

A Computational framework of attention allocation



(Gu, Stocker & Badler, 2005)

Change blindness

Change blindness

Gender effects ?

This is a task women against men!

Watch the yellow team playing basketball. Count how often the **yellow** team **dribbles** the ball AND how often it **passes** the ball.