

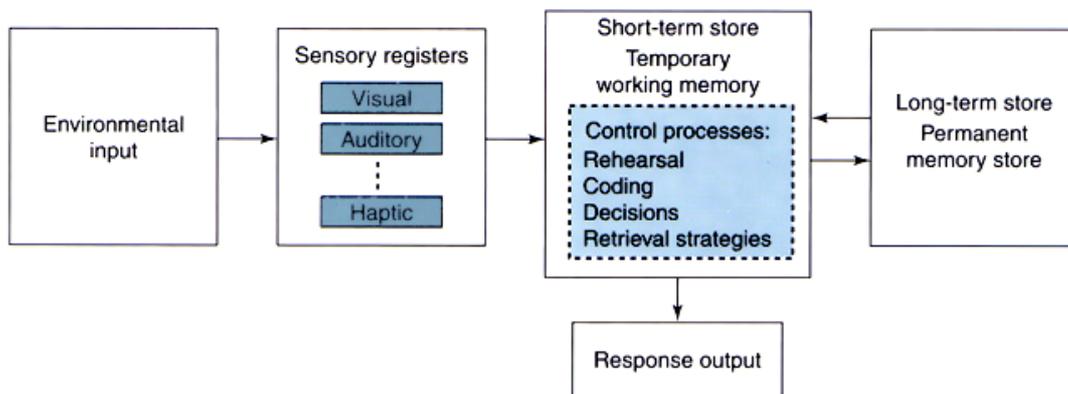
Human-Computer Interaction

Termin 3:
Memory
Attention

MMI/SS07

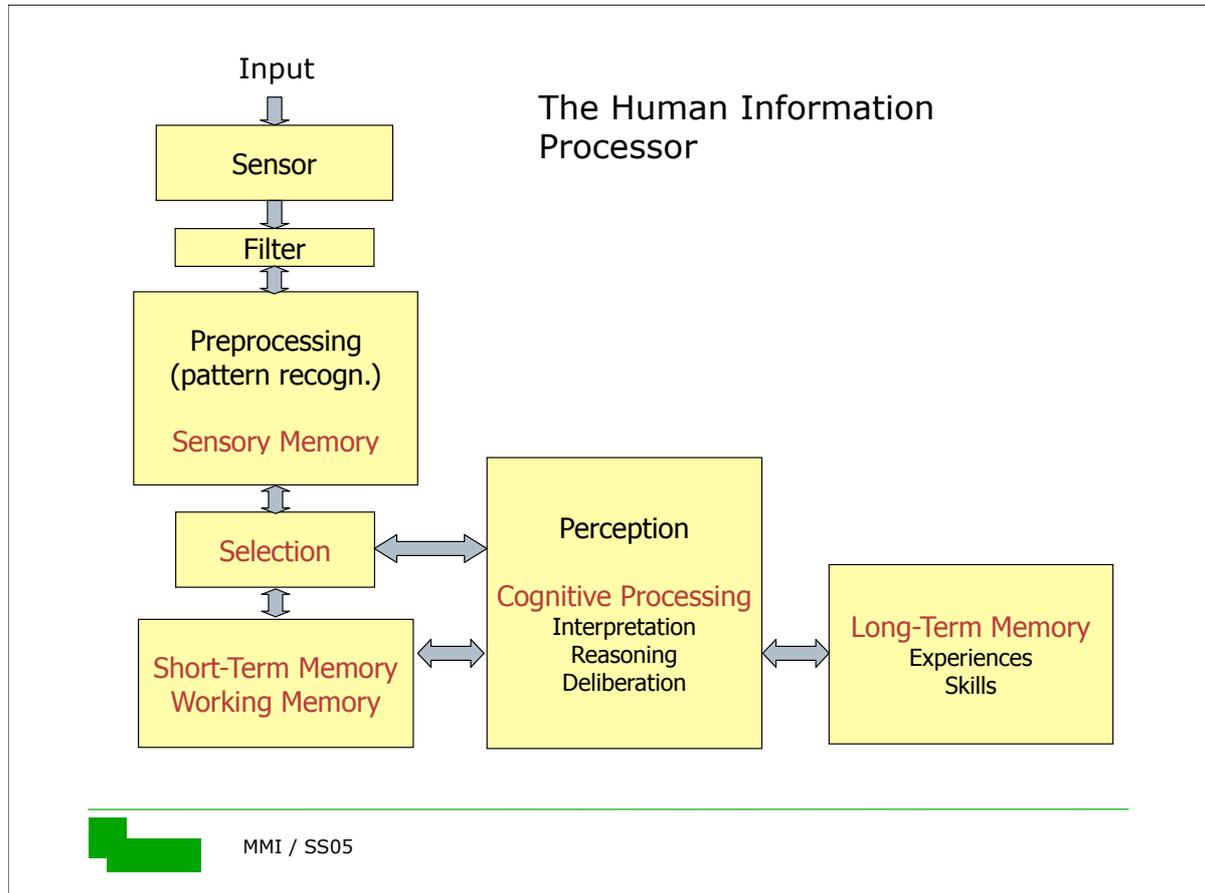
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Atkinson & Shiffrin (1968): Multi-store model



Standard theory of memory & information processing,
also "Modal model"





Sensory memory

- modality specific buffers for stimuli received through senses (Neisser, 1967)
- large capacities, but information lasts only short durations
 - *iconic memory*: visual stimuli, $\sim 250-400$ 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.



Examples 1

21234827849



Examples 2

0521 106 2902



Examples 3

FB-ITW-AC-IAIB-M



Examples 4

FBI-TWA-CIA-IBM



Examples result

21234827849

0521 106 2902

FB-ITW-AC-IAIB-M

FBI-TWA-CIA-IBM



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



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., 993, 986, 979 ... etc.) or similar

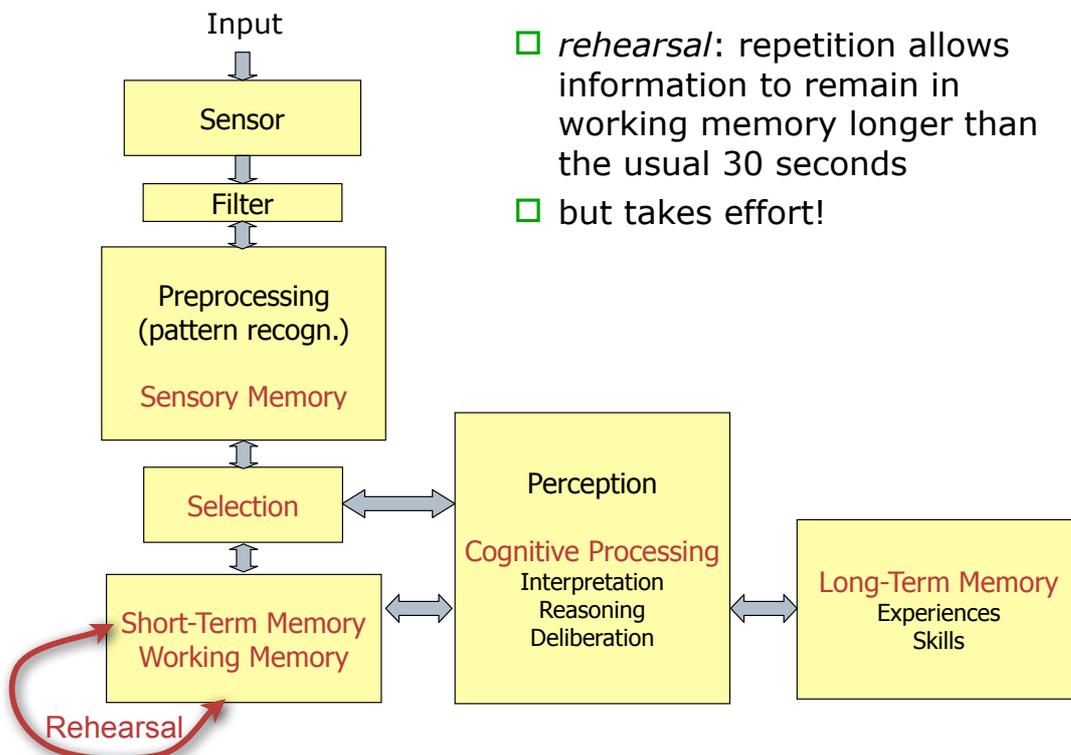


STM – maintenance rehearsal

- what is the number?

628-5094

Without rehearsal, memory fades.

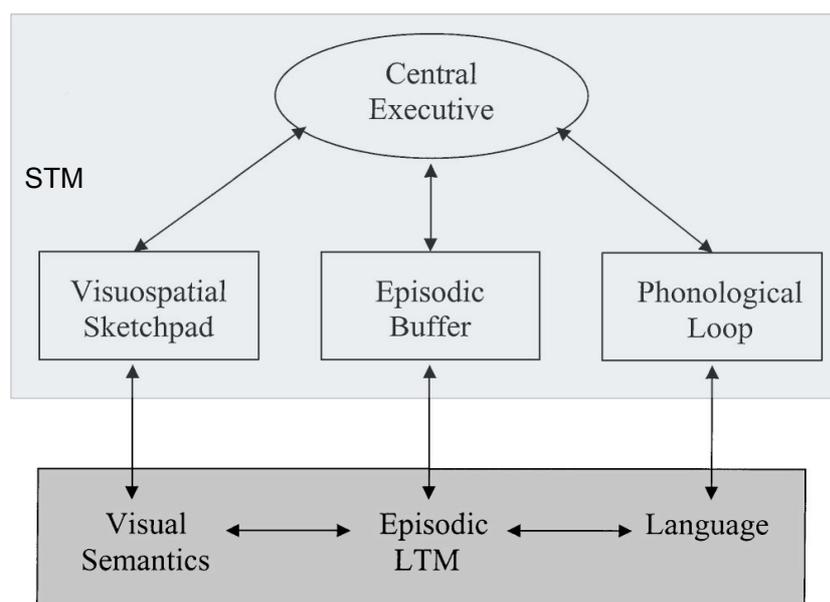


STM & working memory

- 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 facilitate 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.

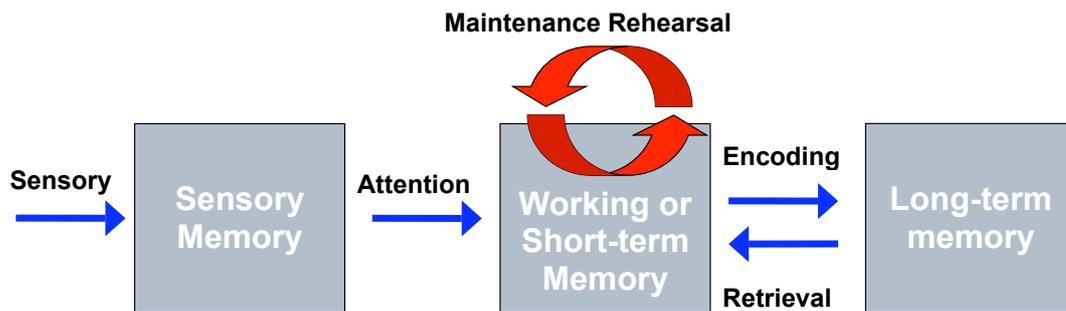


Baddeley (2000)



Long-Term Memory

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



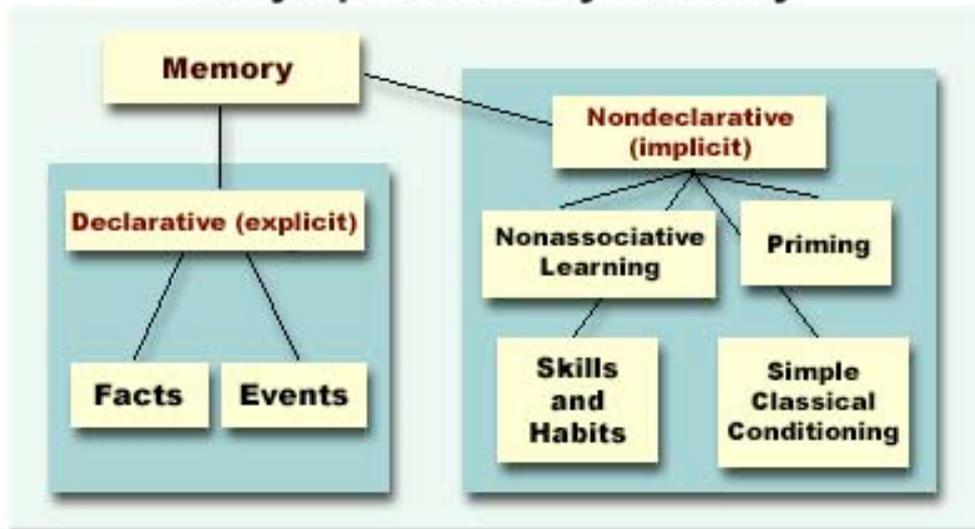
Long-term memory (LTM)

- 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, scents, ...
 - 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

Larry Squire's Memory Taxonomy

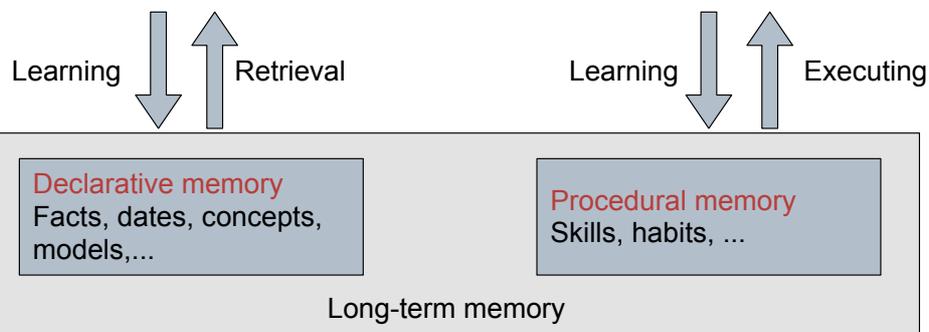
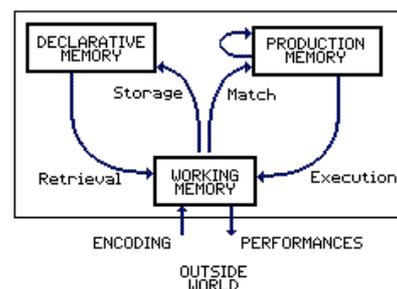


Larry R. Squire (UCSD)



Declarative vs. procedural memory

ACT* (Anderson, 1993)



Automatic sequences of keystrokes, menu 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.

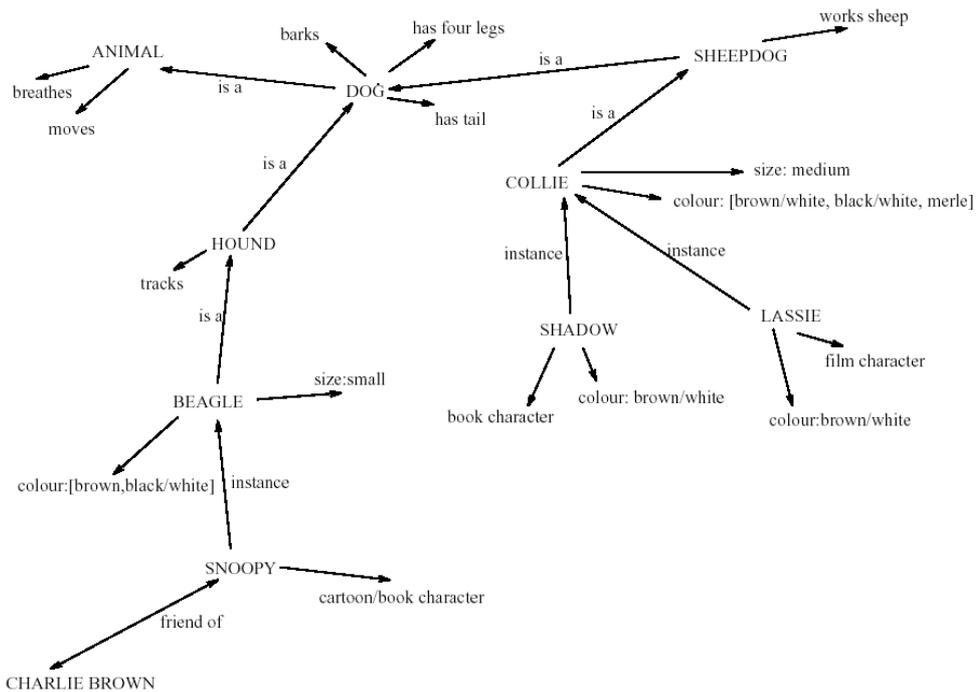


Associative memory

- 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?

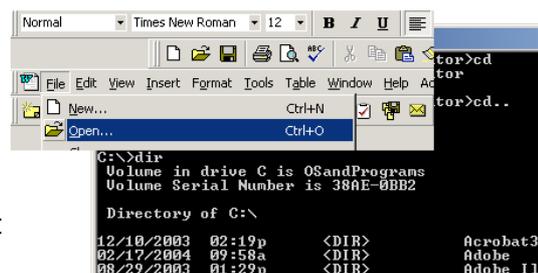
Two basic mechanisms:

□ recall

- information must be retrieved from memory, without any hint
- can be assisted by cues, e.g. categories, imagery

□ recognition

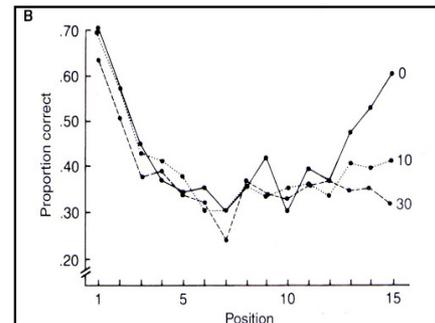
- present information „evokes“ that it has been seen before plus further knowledge
- less complex than recall - information itself acts as a cue



Recall

- Free recall list learning (Glanzer & Cunitz, 1966):
 - Subjects auditory presented with a list of words (usually 15 to 20)
 - 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 existent 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

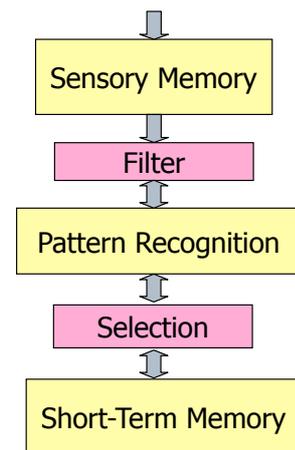
- Limited capacity of working memory restricts the amount of information we can take in and process at a time
- The brain actively *focuses* on and then *concentrates* on a certain kind of information
- With practice, some kinds of information require little to no effort (automatic) in becoming the focus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



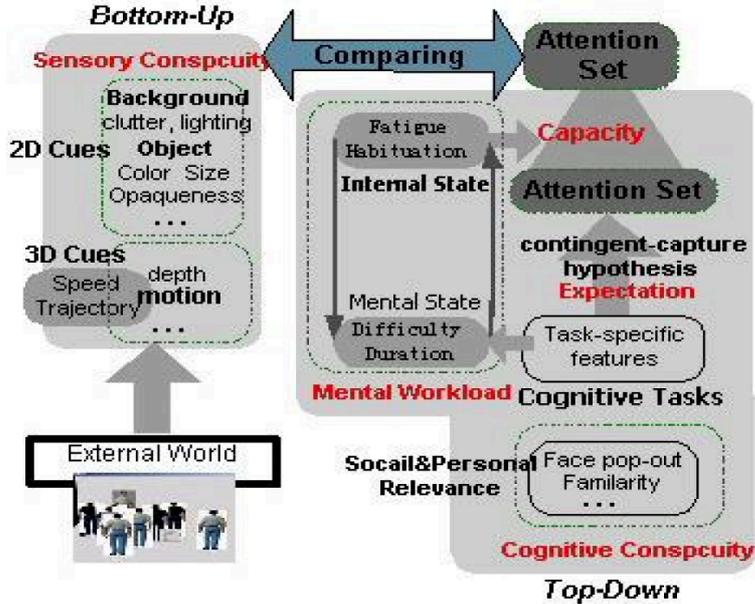
What do we attend to ?

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 weight 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 „in-attentional blindness“
4. Capacity
 - number of items you can attend to at a time



A Computational framework of attention allocation



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.

