King Saud University

College of Engineering

IE – 341: "Human Factors"

Spring – 2025 (2nd Sem. 1446H)

Chapter 3. Information Input and Processing

Part – 5: Perception – Memory – Attention

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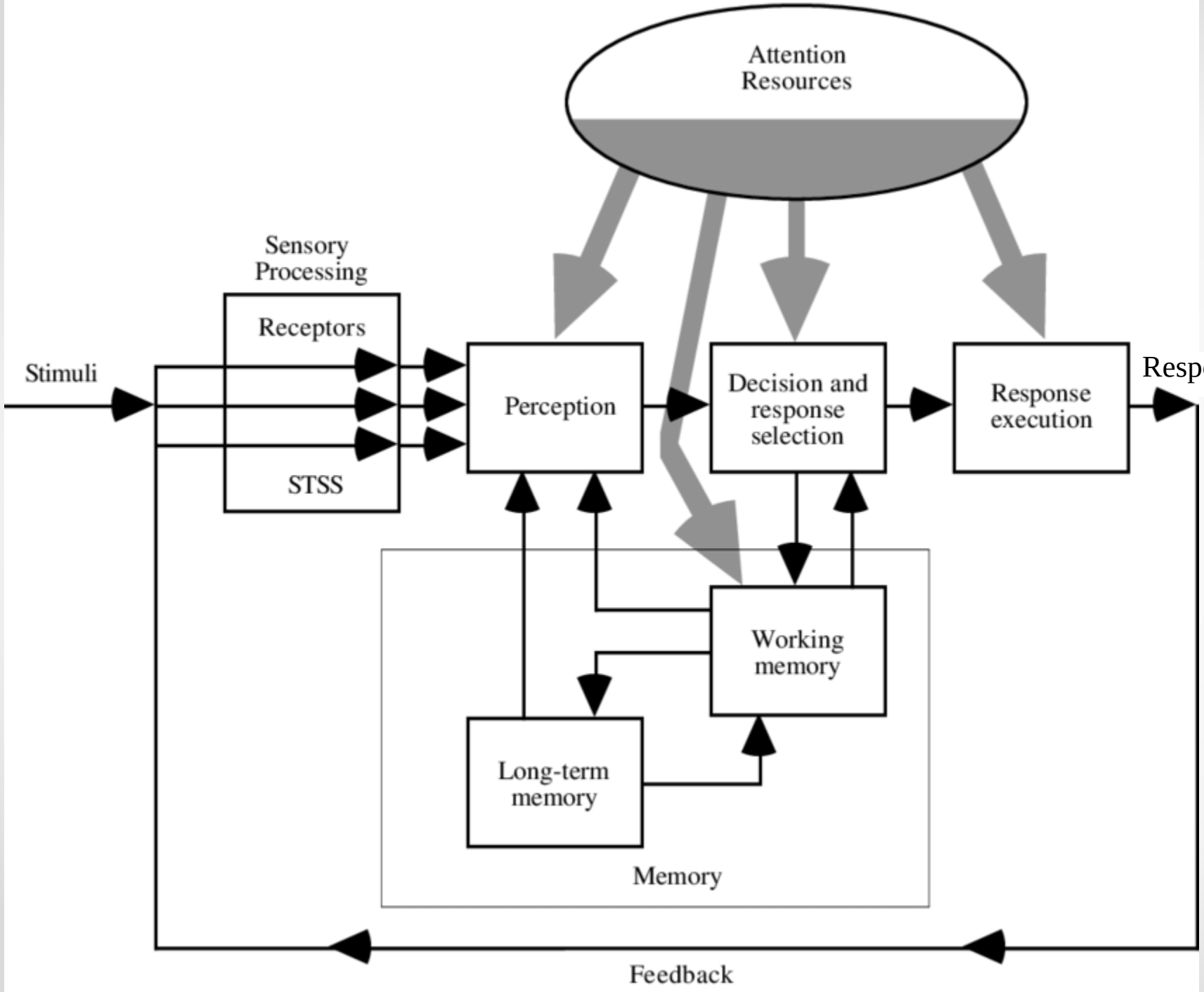
Chapter Overview

Information Processing and Compatibility

1. Information Display – Coding (Ch. 3)
2. Fitts' Law (Ch. 3, Ch. 9)
3. Hick Hyman Law (Ch. 3, Ch. 9)
4. Signal Detection Theory (Ch. 3)
5. Memory - Attention (Ch. 3)
6. Compatibility - Part 1 - Spatial Compatibility (Ch. 10)
7. Compatibility - Part 2 - Movement - Modality Compatibility (Ch. 10, Ch.3)

Contents

- A Model of Information Processing
- Perception
- Memory
- Decision Making
- Attention


Attention
Resources
Sensory
Processing
Receptors
Stimuli
STSS
Perception
Decision and
response
selection
Response
execution
Responses
Working
memory
Long-term
memory
Memory
Feedback

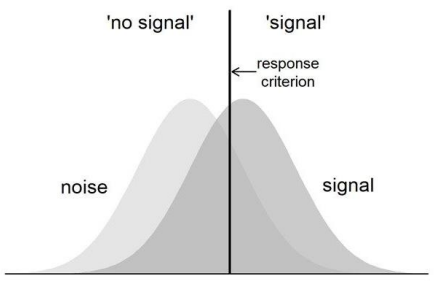
A Model of Information Processing

A Model of Information Processing

- What are models? What are they used for?
  - Models are "abstract representations of a system or process"
  - Best way to evaluate models is to see what they are used for
  - "Good" model = one that can represent behavior of actual system well

- Types of models:
  - Mathematical, physical, structural, verbal
  - Information theory: mathematical model of info. transfer in communication systems
  - Signal Detection Theory: also mathematical model

$$H_{av} = \sum_{i=1}^{N} p_i \left(\log_2 \frac{1}{p_i} \right)$$



- Stages of Human Information Processing:
  - Model of human information processing (*next slide*) shows
    - Major stages of human info. processing
    - Relationships between them

Cont. A Model of Information Processing

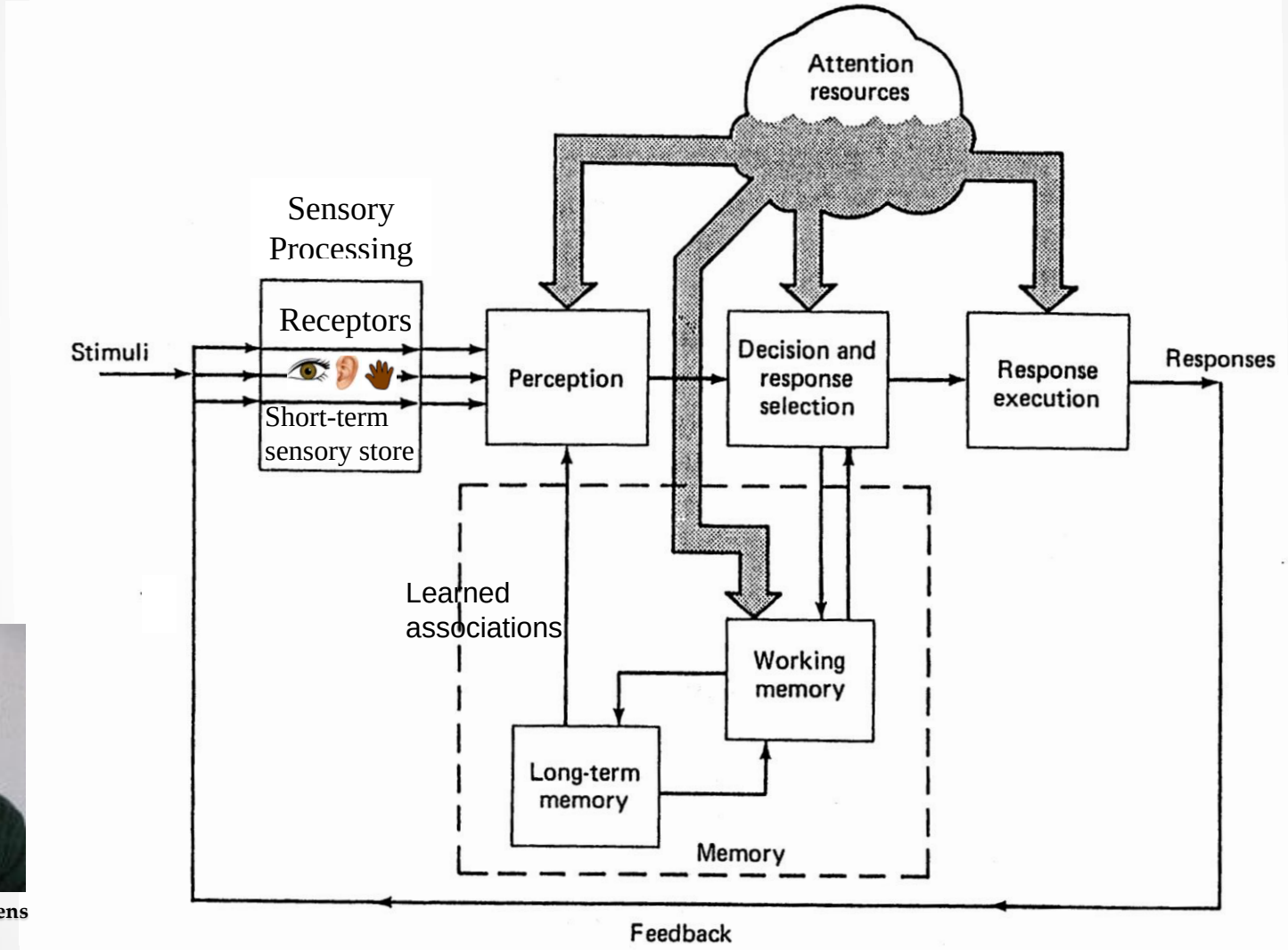


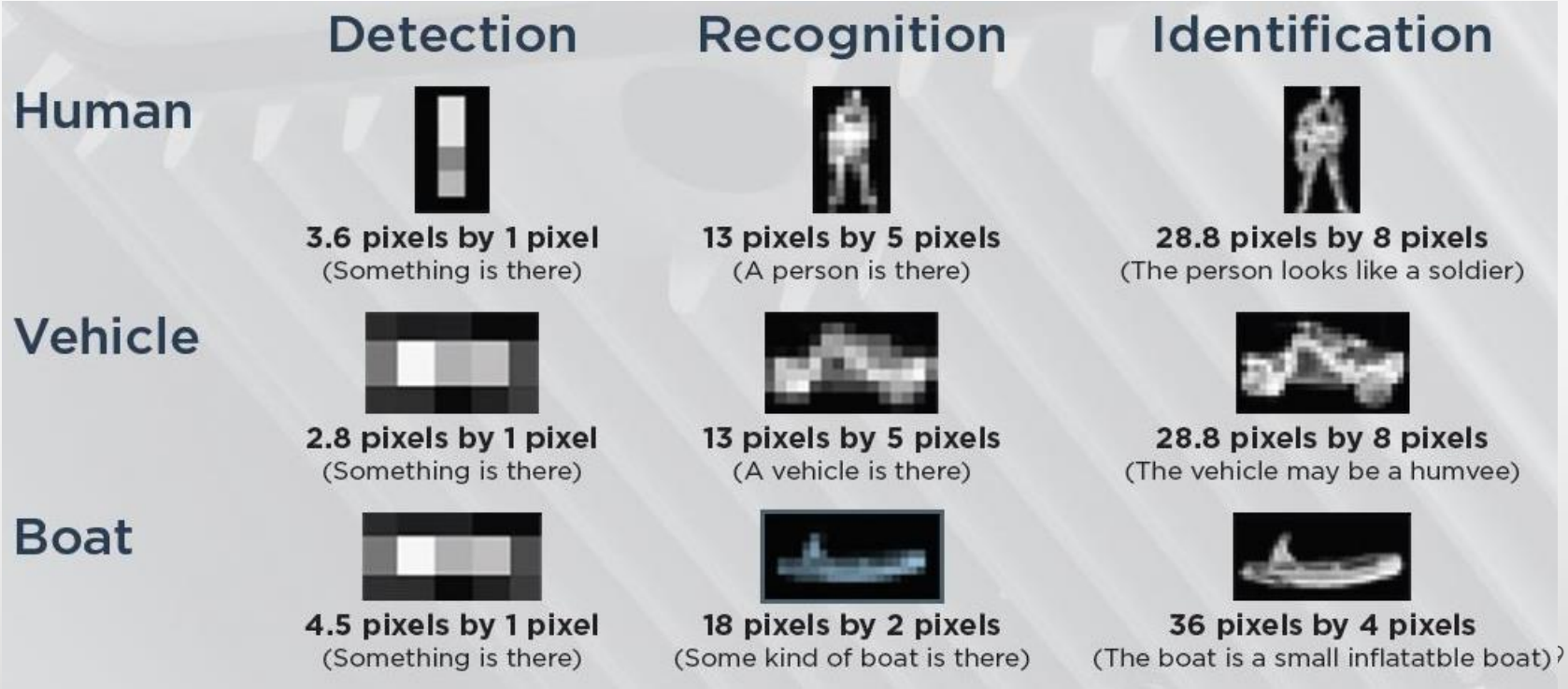
FIGURE 3-2
A model of human information processing showing the major processes, or stages, and the interrelationships. (*Source: Wickens, 1984, Fig. 1.1. Reprinted by permission of the publisher.*)

Christopher Wickens

Perception

Perception

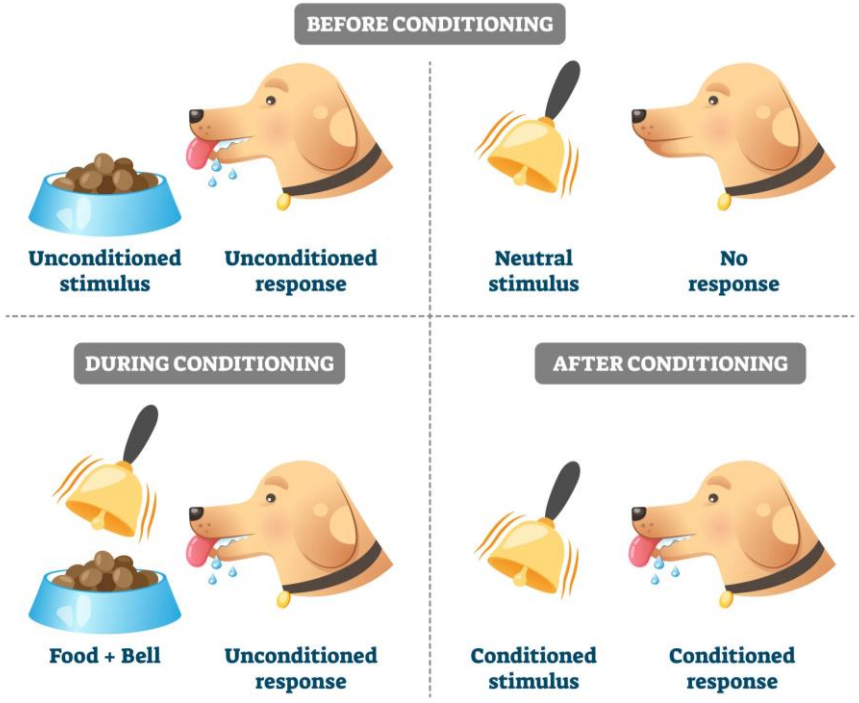
- Levels of Perception
  - "recognition and interpretation of sensory information"
  - Level of perception depends on: stimulus & task that person faces
  - Forms of perception:
    - Detection (most basic form): determine if signal is present/not
    - Recognition/Identification: indicating in which class target belongs
    - Multilevel classification: making abs. judgment along stimulus dimension

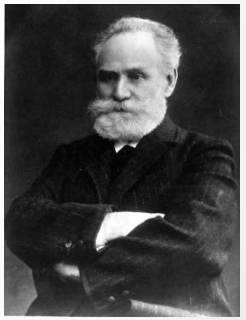


Perception

- Activities Involved with Perception
  - Simple detection involves complex:
    - Information processing
    - Decision making
  - This is included within signal detection theory
  - Perception involves our prior:
    - Experiences
    - Learned associations (line connecting long-term memory – perception)

Learning by Association: Classical Conditioning – Pavlov Dog Experiment (1897)





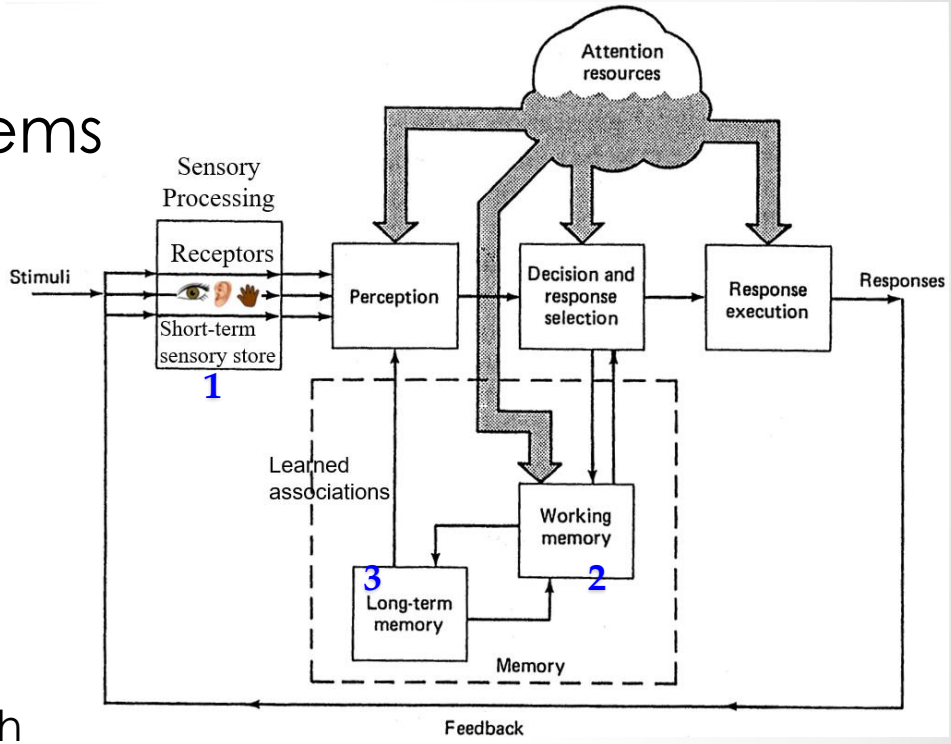
Ivan Pavlov
(Russian Physiologist)

Memory

Memory

- Memory: storage of information

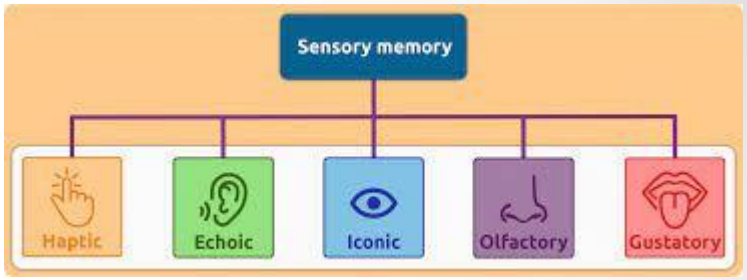
- Human Memory Subsystems
  1. Sensory storage
  2. Working memory
  3. Long-term memory



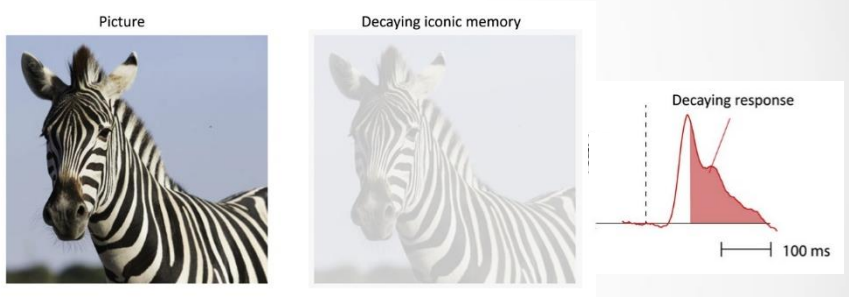
- Discuss here
  - Each of 3 subsystems
  - How information is coded in each
  - Practical applications in each subsystem

Cont. Memory

1. Sensory Storage



- Mechanism
  - Part of each sensory channel
  - Keeps record of stimulus for short period after stimulus is finished then fades
  - Allows further processing of stimulus
  - Associated with visual system:
    - "iconic storage"
    - Lasts < 1 second



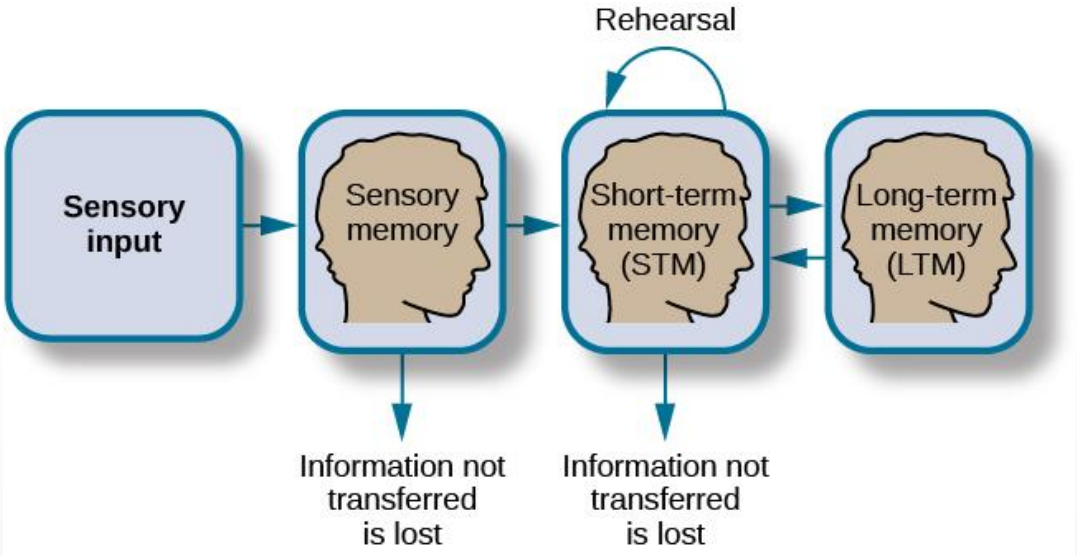
  - Associated with auditory system:
    - "echoic storage"
    - Lasts: few (2 – 4) seconds

Echoic memory example in conversation. When someone is preoccupied while being spoken to and asks, "What did you say?" Echoic memory allows the person to actually recall and recognize the words that were spoken even when they were not consciously listening.

Cont. Memory

1. Cont. Sensory Storage

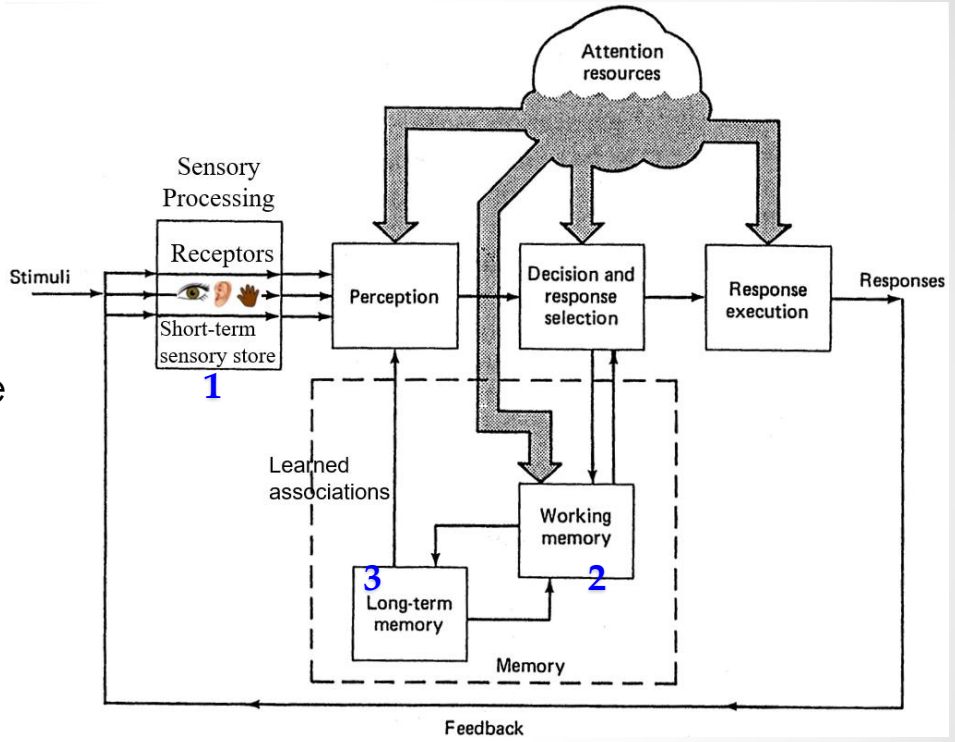
- Information Representation:
  - Information is not coded
  - Info. is kept in original representation
  - Sensory representation cannot be prolonged
  - To keep for longer time ⇒ transfer to working memory



Cont. Memory

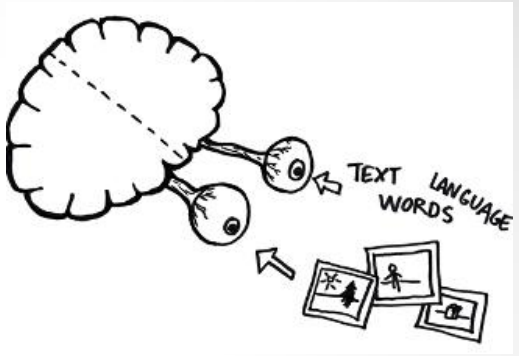
2. Working Memory (aka Short-term memory)

- Information coded as
  - Visual code
  - Phonetic code
  - Semantic code
  - Note, all 3 can exist at same time

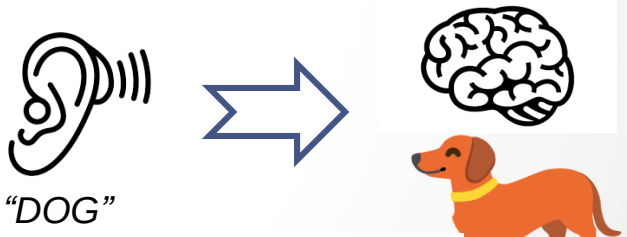


Cont. Memory

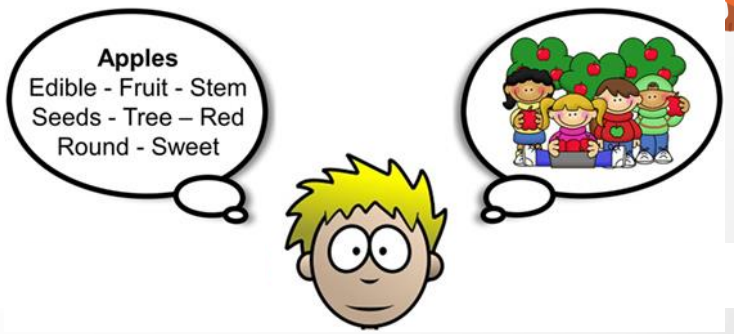
2. Cont. Working Memory



- Visual and phonetic codes
  - Visual or auditory representations of stimuli
  - Generated:
    - Internally from long-term memory (without hearing or seeing), or
    - Using stimulus of the opposite type
      - e.g. when seeing word "*DOG*" ⇒ coded as sound (the word)
      - e.g. when hearing the word "*DOG*" ⇒ visual code/picture of dog



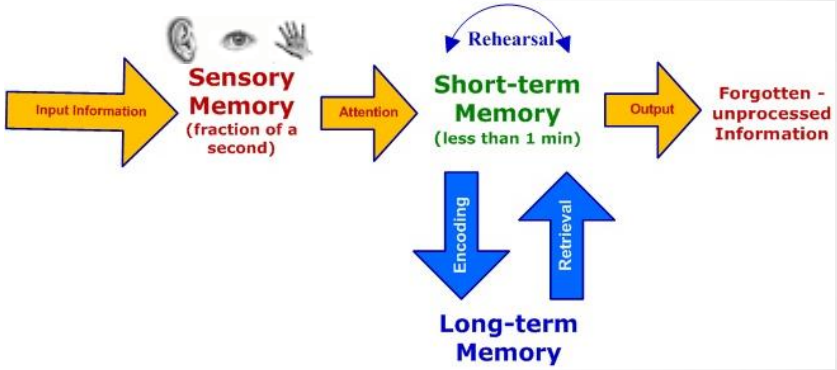
- Semantic code
  - Abstract representations of meaning of stimulus (i.e. based on meaning)
  - Important in long-term memory

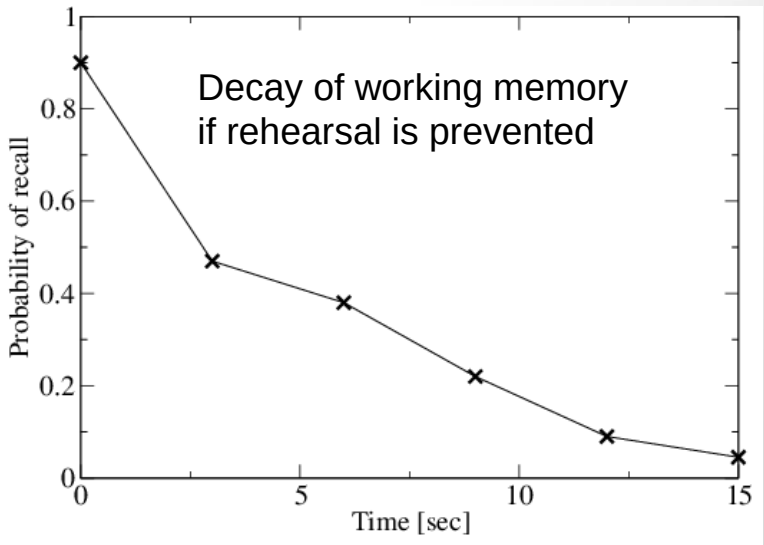


Cont. Memory

2. Cont. Working Memory

- Capacity of Working Memory
  - Information is only maintained by rehearsal (i.e. paying attention to process)
  - Example:
    - Think of four letters (e.g. *J*, *T*, *N*, *L*)
    - Count backwards by $3s$ from 187
    - What happens? You forget letters after ~$15\ s$, why? No rehearsal
    - Test your working memory here for: Numbers and Words
  - When list of items in memory increases
    - this "decay" occurs faster
    - greater number of items
      $\Rightarrow$ delay in rehearsing each item



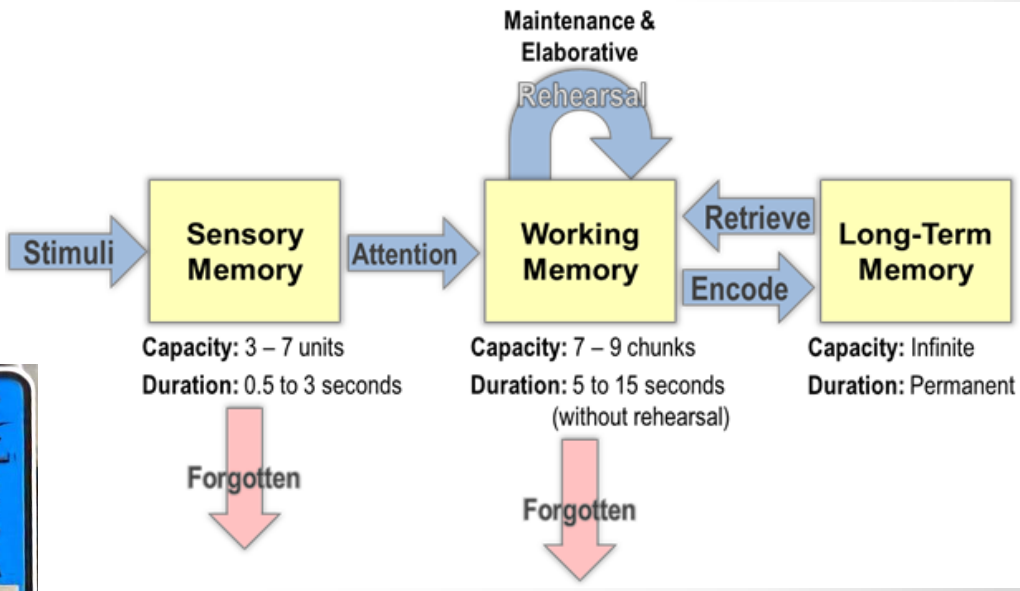


Cont. Memory

2. Cont. Working Memory

George Armitage Miller

- Cont. Capacity of Working Memory
  - Imp. Q: what is max. # of items that can be held in working memory?
    - Miller, 1956: "magical number": 7 ± 2 (i.e. $5 - 9$) items/units
    - Made of "chunks" of familiar units (e.g. words), i.e. 7 ± 2 chunks
    - This increases capacity of working memory
    - Example:
      - *C.A.T.D.O.G.R.A.T.*: string of 9 items (i.e. @ the 7 ± 2 limit)
      - But *CAT.DOG.RAT*: only 3 chunks



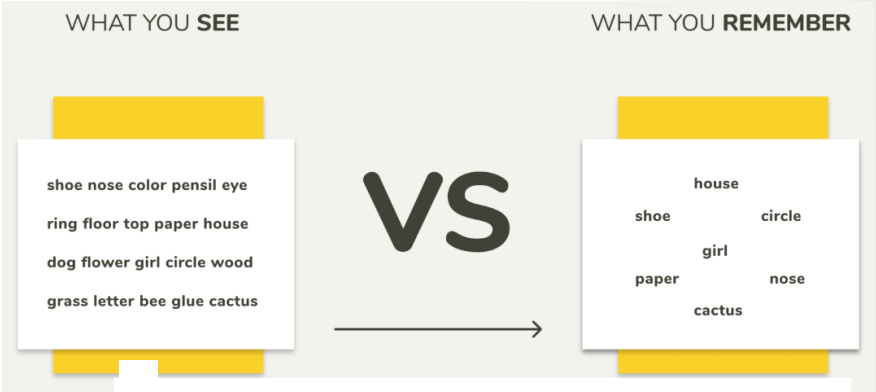
1 6 3 4 2 9 5 7 5 0

055 649 5378

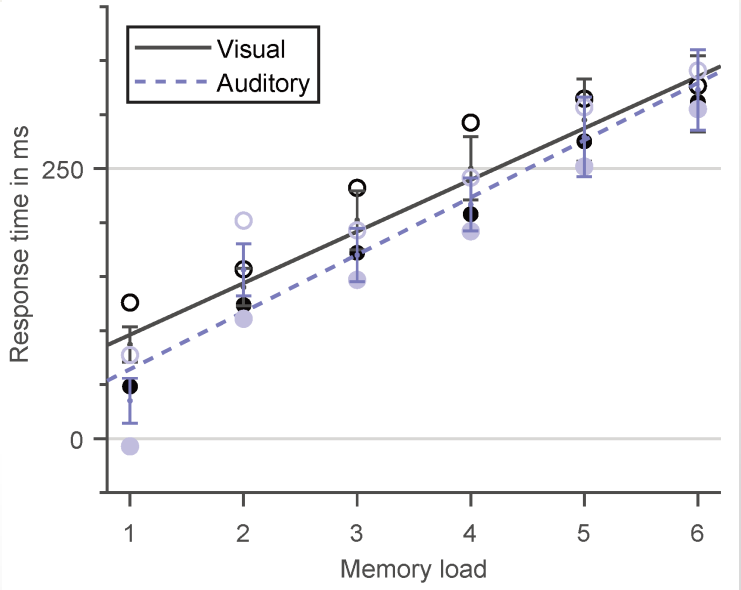
Cont. Memory

2. Cont. Working Memory

- Cont. Capacity of Working Memory
  - Summary:
    - Don't present more than 5 – 9 chunks of information to remember
    - Make chunks meaningful
    - Provide training on recalling chunked information

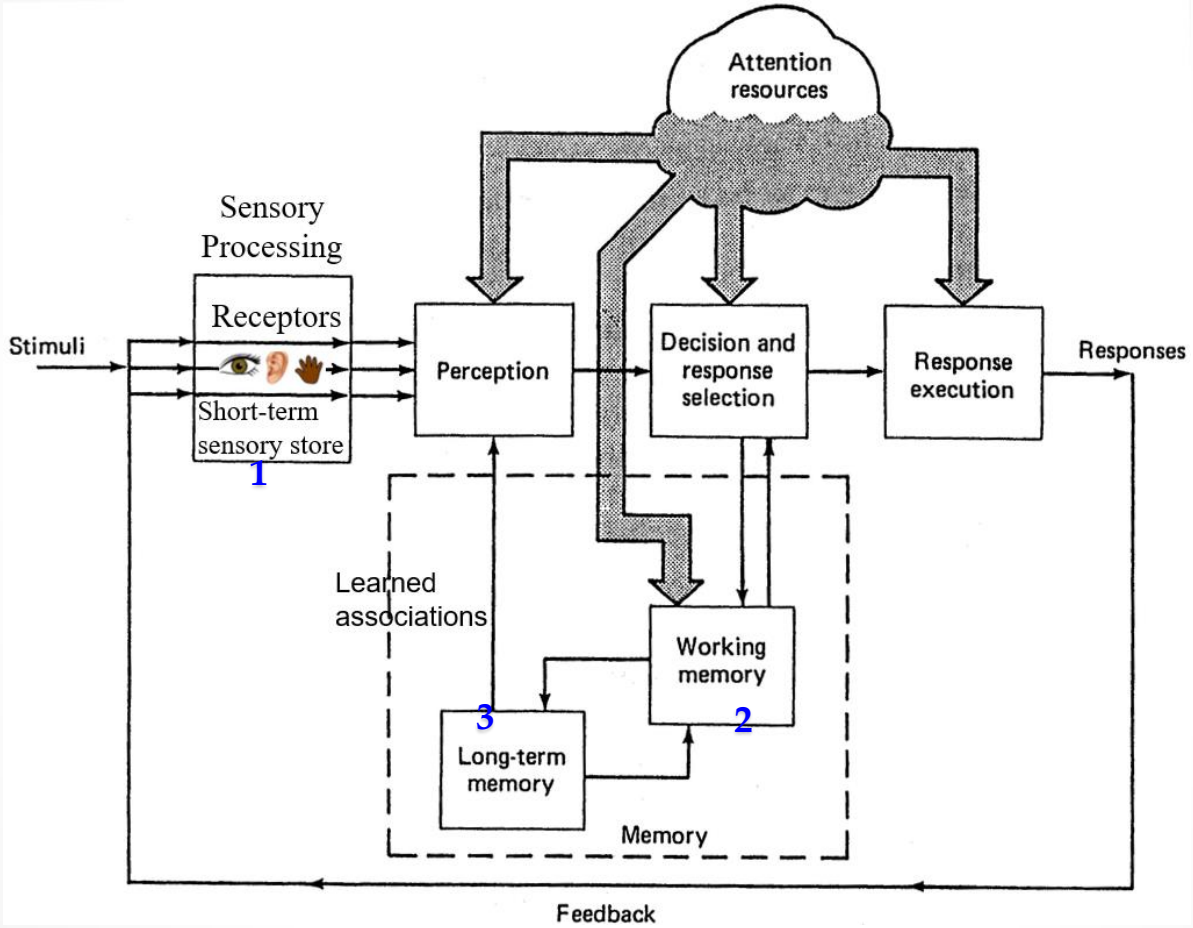


- Searching Working Memory
  - Time to search for item in WM list (e.g. names) ↑ as # list items ↑ linearly
  - Time to search for item in WM per item of memory = $\sim 38\ ms$
  - All items are searched for equally



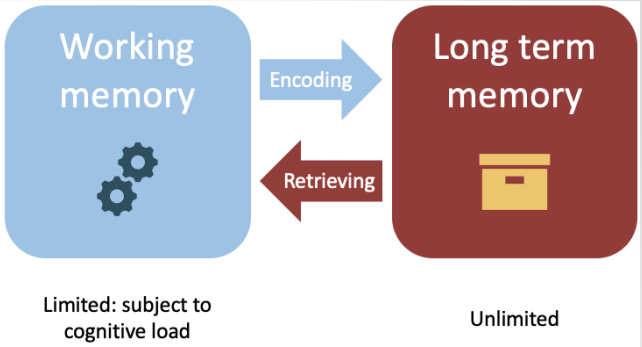
Cont. Memory

3. Long-term memory



Cont. Memory

3. Cont. Long-term memory



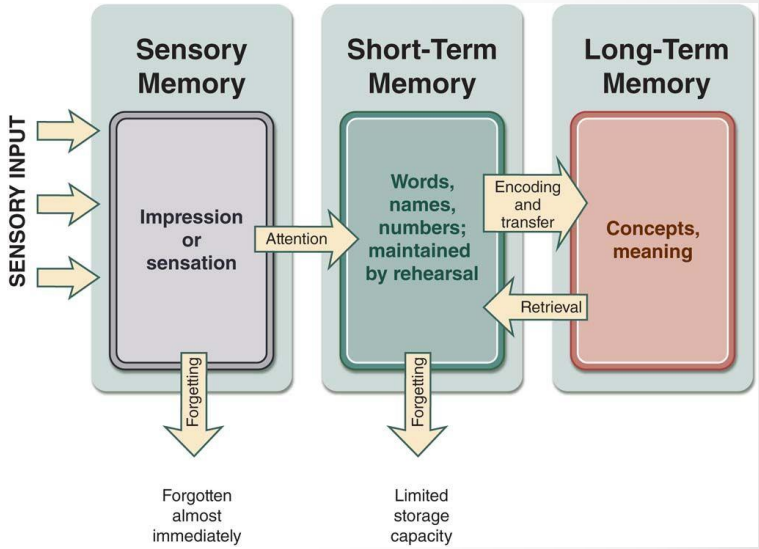
- Transferring information from WM to LTM
  - Transferred by semantic coding
  - i.e. by adding meaning to information + linking to items already in LTM
  - e.g.: studying for exams:
    - If by repeating material ⇒ hard to recall info.
    - Effective method: semantically encode info.

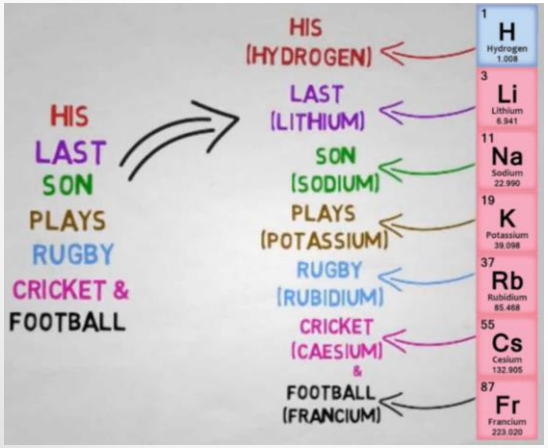
semantically relating information:
red circles = “payment methods”
blue circles indicate = “military equipment”
green circles = “audio devices”

Cont. Memory

3. Cont. Long-term memory

- Ways to recall information from LTM
  - Analyze, compare, relate to past knowledge
  - Organizing info. at start
    ⇒ easier to transfer to LTM
    ⇒ more organized info. in LTM
    ⇒ easier to recall/retrieve info. from LTM
  - Using "mnemonics" to organize info.:
    - i.e. use first letter of item in a list and attach word/image to it
    - Makes info. retrieval faster

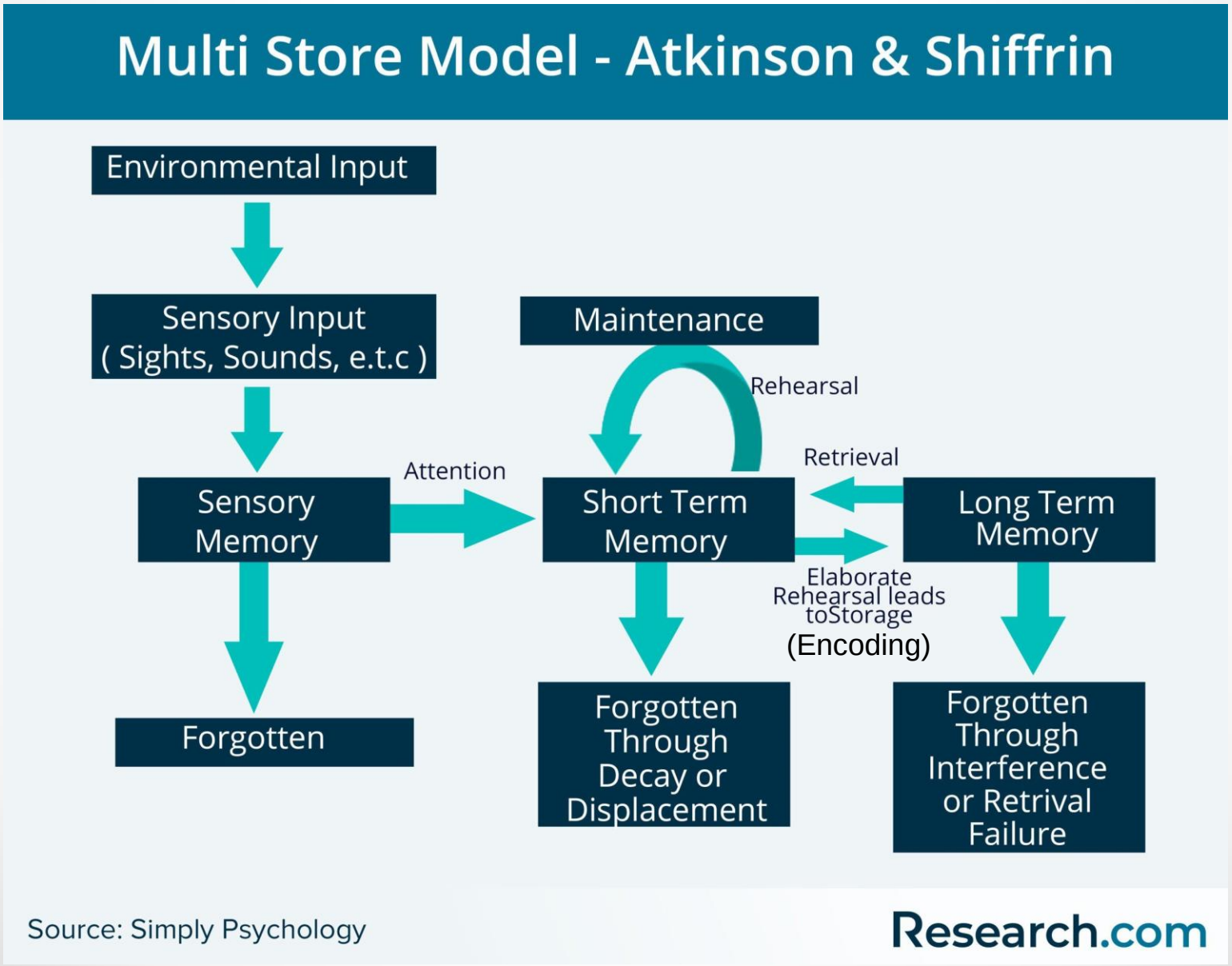




Please Excuse My Dear Aunt Sally

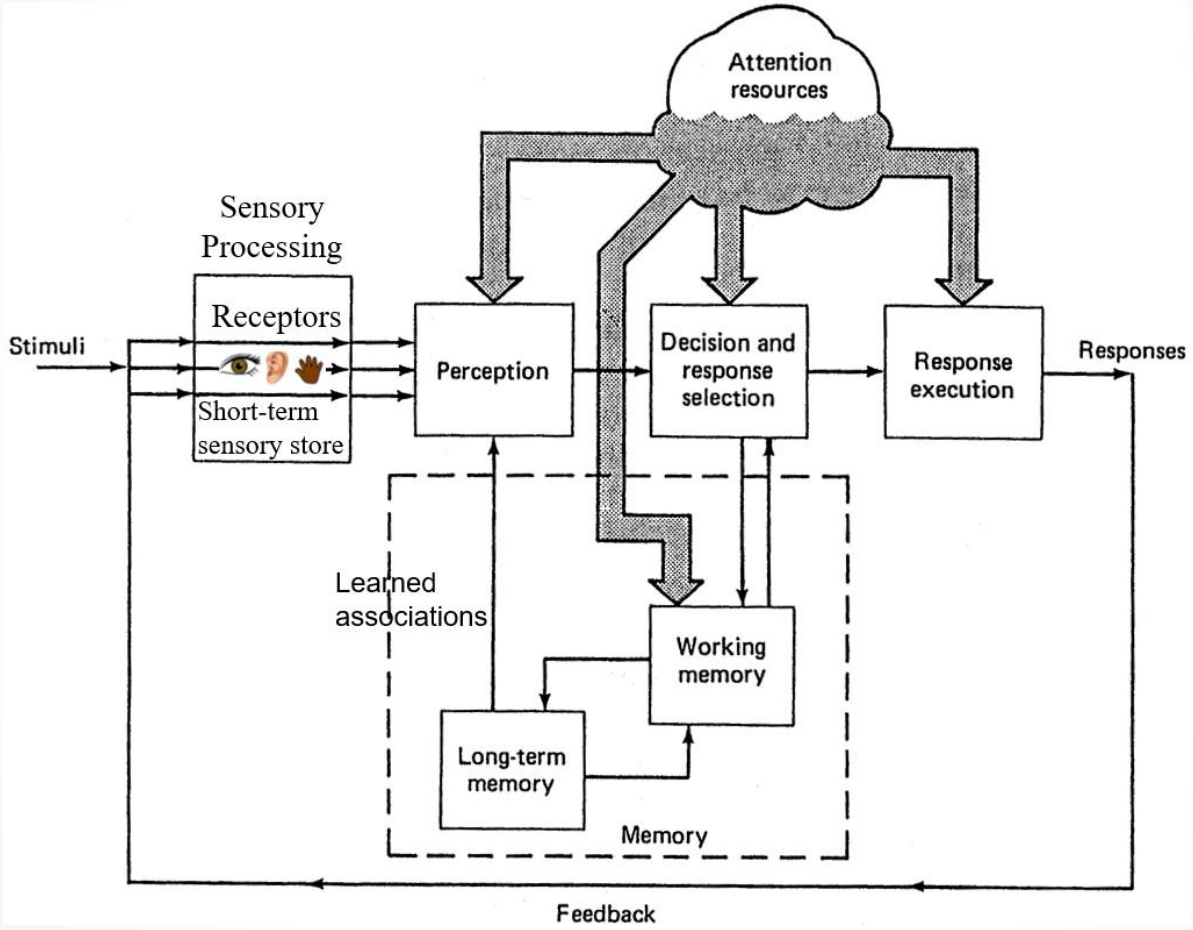
P	-	Parenthesis
E	-	Exponent
M	-	Multiplication
D	-	Division
A	-	Addition
S	-	Subtraction

Cont. Memory


Multi Store Model - Atkinson & Shiffrin
Environmental Input
Sensory Input
(Sights, Sounds, e.t.c)
Sensory
Memory
Attention
Forgotten
Maintenance
Rehearsal
Short Term
Memory
Retrieval
Long Term
Memory
Elaborate
Rehearsal leads
toStorage
(Encoding)
Forgotten
Through
Decay or
Displacement
Forgotten
Through
Interference
or Retrival
Failure
Source: Simply Psychology
Research.com

Decision Making

Decision Making



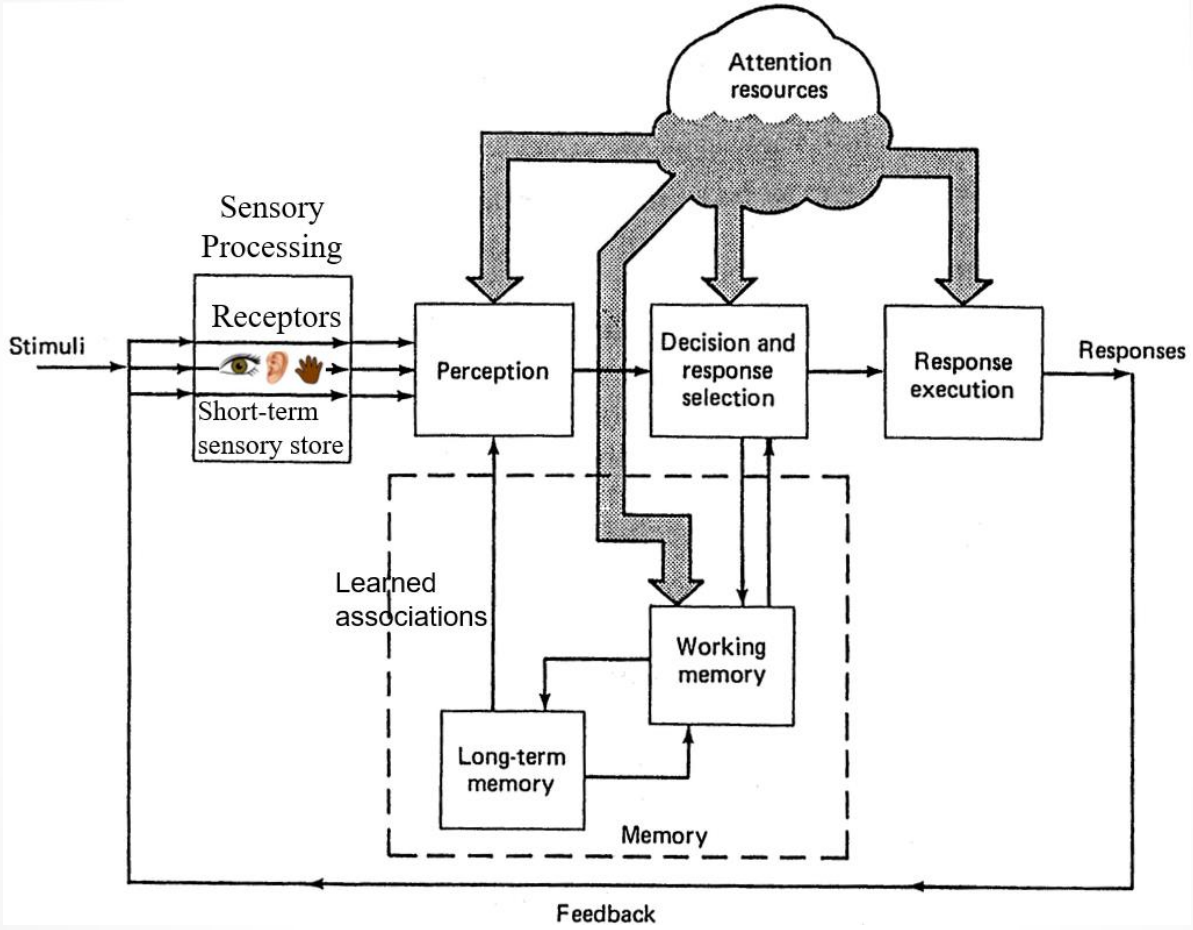
Cont. Decision Making

- What is Decision Making
  - It is a complex process by which people:
    - evaluate alternatives and
    - select a course of action

- Steps involved:
  - seeking information relevant to the current situation
  - evaluating probabilities of various outcomes, and
  - attaching values to the expected outcomes

Attention

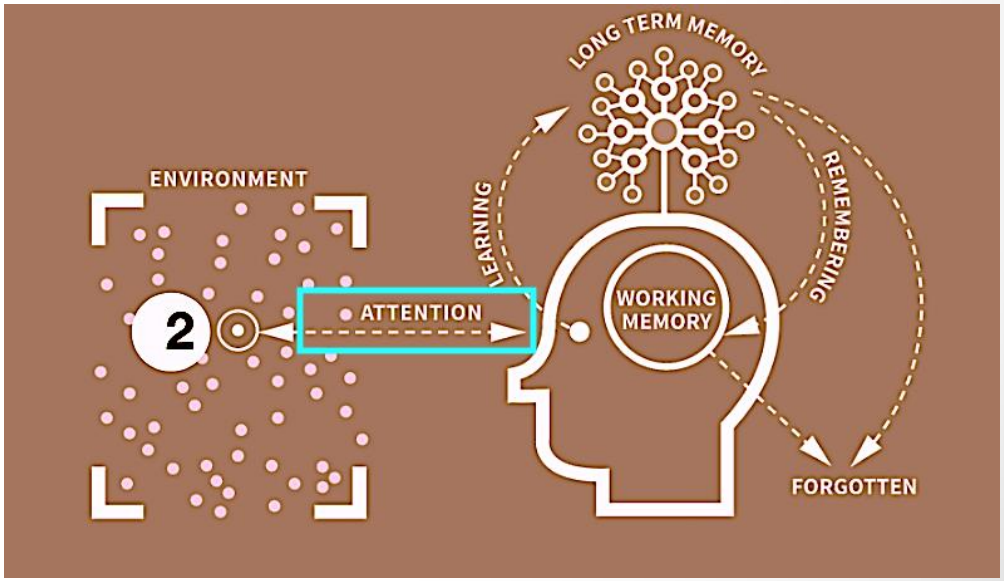
Attention


Attention resources
Sensory Processing
Receptors
Stimuli
Short-term sensory store
Perception
Decision and response selection
Response execution
Responses
Learned associations
Working memory
Long-term memory
Memory
Feedback

Cont. Attention

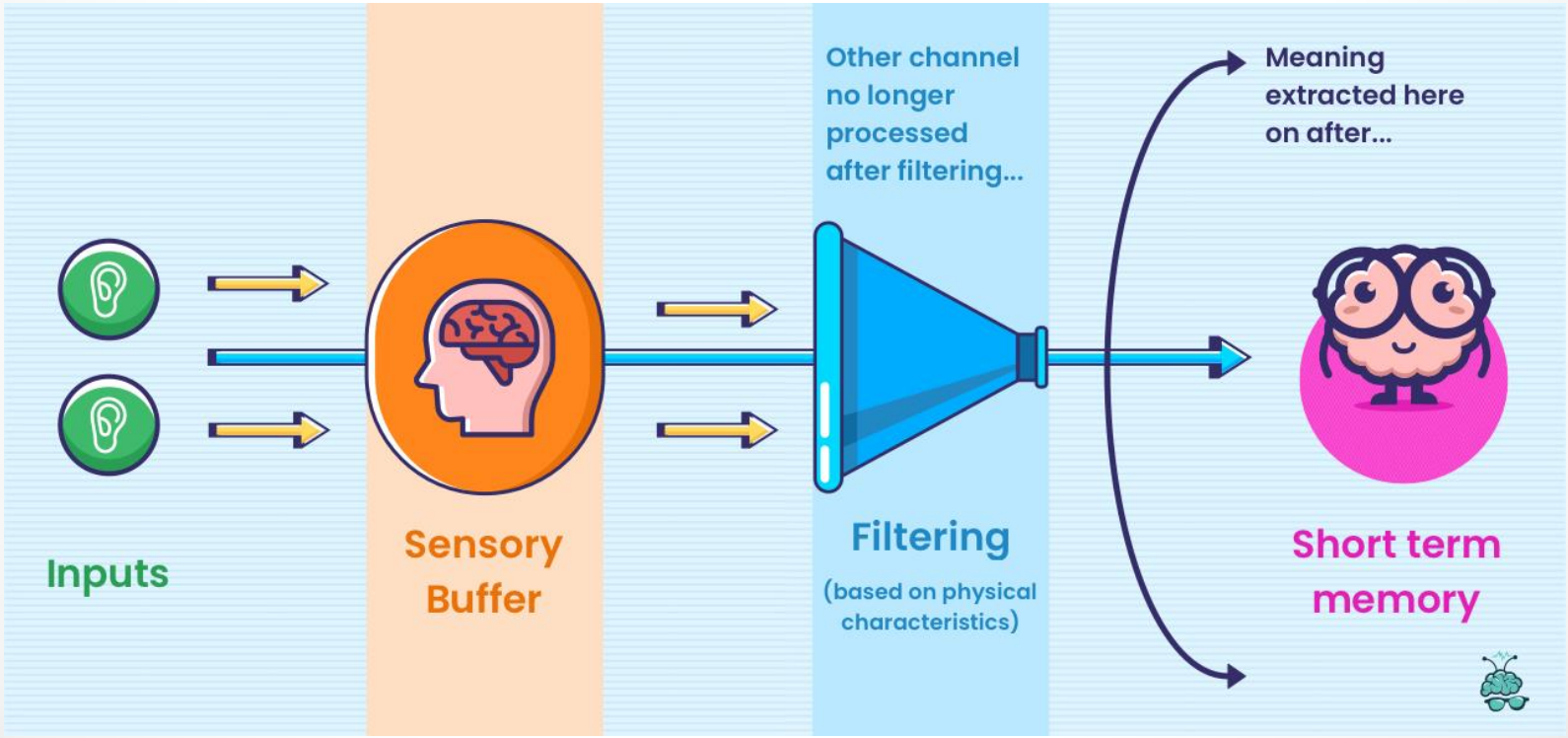
- Four types of attention tasks / situations

1. Selective attention
2. Focused attention
3. Divided attention
4. Sustained attention



Cont. Attention

1. Selective attention
   - Monitoring several sources of info. (aka channels) to perform a single task
   - e.g.: A pilot scanning the instruments
   - e.g.: player looking for opening in soccer field



Broadbent's Filter Model regarding selective attention

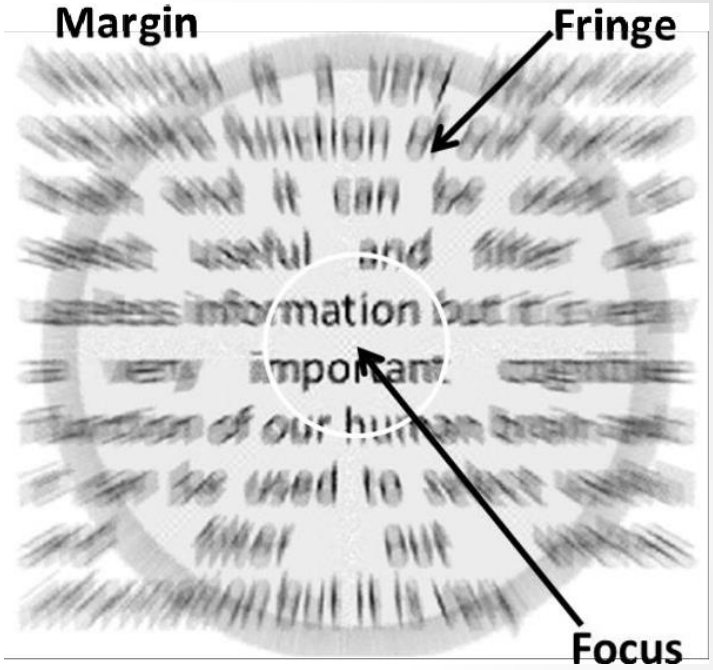
Cont. Attention

1. Cont. Selective attention

- Improving selective attention
  - Use as few channels to be scanned for signals as possible
  - Tell user which channel is more important ⇒ more effective attention
  - Reduce level of stress on person ⇒ scan more channels
  - Show person where signal is more likely to show up
  - Train person on how to scan effectively
  - Visual channels: keep close together (to scan easier)
  - Auditory channels: make sure they don't mask each other

Cont. Attention

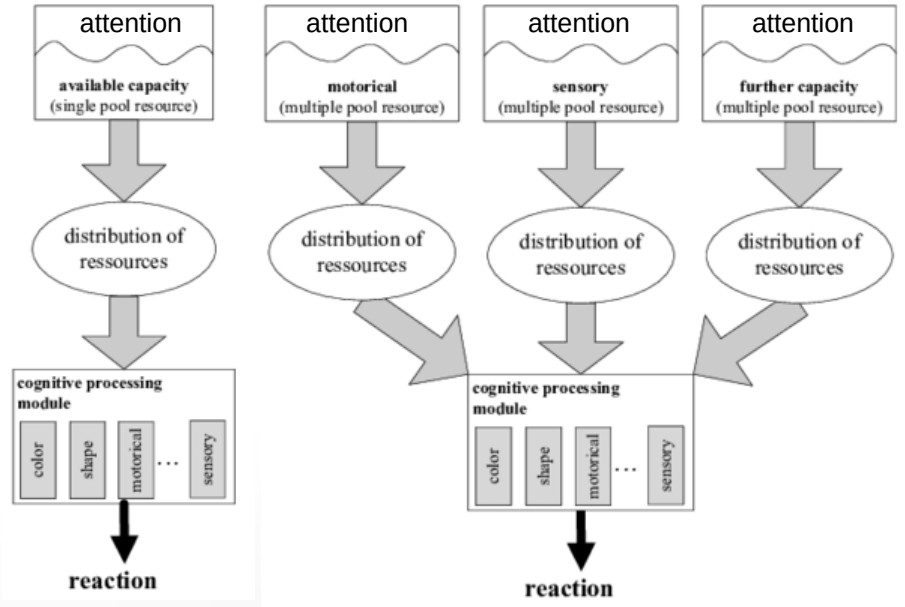
2. Focused attention
   - Attending one source of information and excluding other sources
   - e.g.: trying to read while someone is talking on the phone
   - e.g.: listening to a person talk in a crowded, noisy gathering



- Improving focused attention
  - Make competing channels as distinct as possible from channel of interest
  - Separate (in physical space) competing channels from channel of interest
  - Reduce number of competing channels
  - Make channel of interest (vs. competing channels) more distinct:
    - Larger
    - Brighter
    - Louder, etc.

Cont. Attention

3. Divided attention
   - Paying attention to
     - Two (or more) sources of information,
     - Perform two (or more) tasks simultaneously (aka time-sharing)
   - e.g.: driving a car while talking to a passenger
     - Driving: visual input and manual response
     - Talking: auditory input and vocal responses
   - e.g.: eating dinner while watching evening news
   - Theories existing to explain performance in divided attention:
     - Single-resource theories: 1 source of resources, shared by all mental processes
     - Multiple-resource theories: multiple, independent resource pools



Cont. Attention

3. Cont. Divided attention

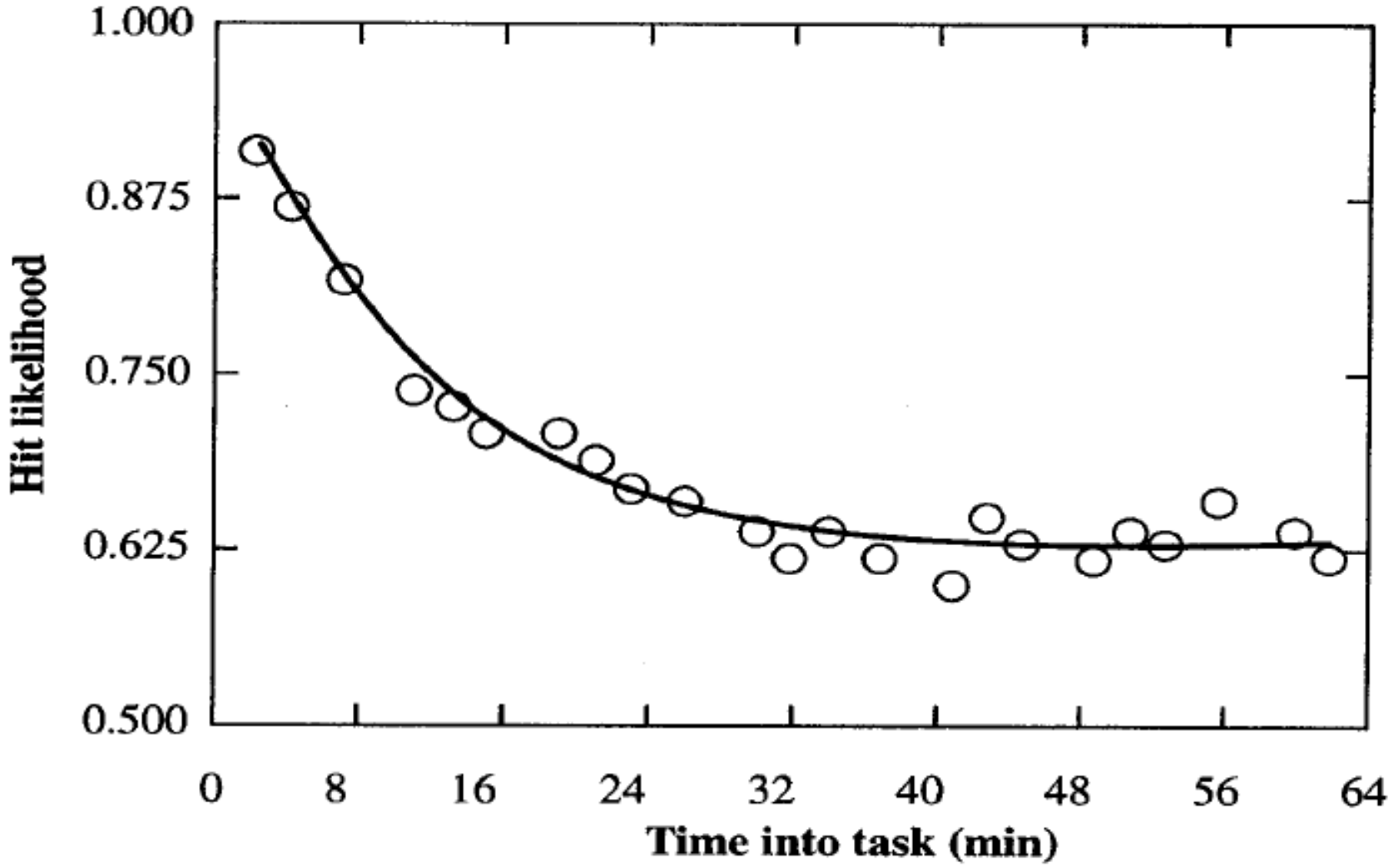
- Improving divided attention
  - Minimize as much as possible sources of information
  - Decrease as much as possible difficulty of tasks
  - Make tasks as different as possible in terms of input/output modes
  - Good way to divide attention: prioritize tasks relatively

Cont. Attention

4. Sustained attention (aka monitoring, vigilance)
   - Attention over long period of time to detect infrequently occurring signals
   - E.g.: security guards viewing TV monitors for the infrequent intruder
   - E.g.: air defense radar operator waiting to see missile
   - E.g.: inspector on assembly line looking for defect in endless line of products moving by
   - Vigilance decrement:
     - Decline in speed of signal detection with time for task
     - Decline in accuracy of detection with time for task
     - Occurs for first $20 - 35$ min of "vigil" (*see next slide*)

Cont. Attention

Sustained attention (vigilance)



Cont. Attention

4. Cont. Sustained attention

- Improving vigilance:
  - Scheduled rest breaks, task variation
  - Increase conspicuity of signal (e.g. make it larger, brighter, etc.)
  - Insert false signals to see how operator will respond
  - Motivation (i.e. show importance of task)
  - Stimulants (e.g. coffee)
  - Keep noise, temp., illumination, other environmental factors: optimum

Videos

- Watch videos on Information Processing Theory:
  - ***Basic Summary*** *(2 min.)*: https://youtu.be/ENzV7nVLuhk?si=yjBWF0M4PQMH0uvQ
  - ***Intermediate Summary*** *(6 min.)*: https://youtu.be/aURqy9BEJO4?si=wxHsQZuEntYfY1LI
  - ***Advanced Summary*** *(7 min.)*: https://youtu.be/pMMRE4Q2FGk?si=TCj8-iffHJCTfJ4A

References

- ***Human Factors in Engineering and Design***. Mark S. Sanders, Ernest J. McCormick. 7th Ed. McGraw: New York, 1993. ISBN: 0-07-112826-3.

- For more **memory tasks**:
  - Number memory test: https://www.humanbenchmark.com/tests/number-memory
  - Verbal memory tests:
    - https://www.humanbenchmark.com/tests/verbal-memory
    - http://www.dailymail.co.uk/femail/article-4136174/Can-complete-12-word-verbal-memory-test.html