

# Introduction to Cognitive Psychology – Part I

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# Outline

- Theories, Models, and Perspectives
- Conceptual & Operational definition
- Research Methods

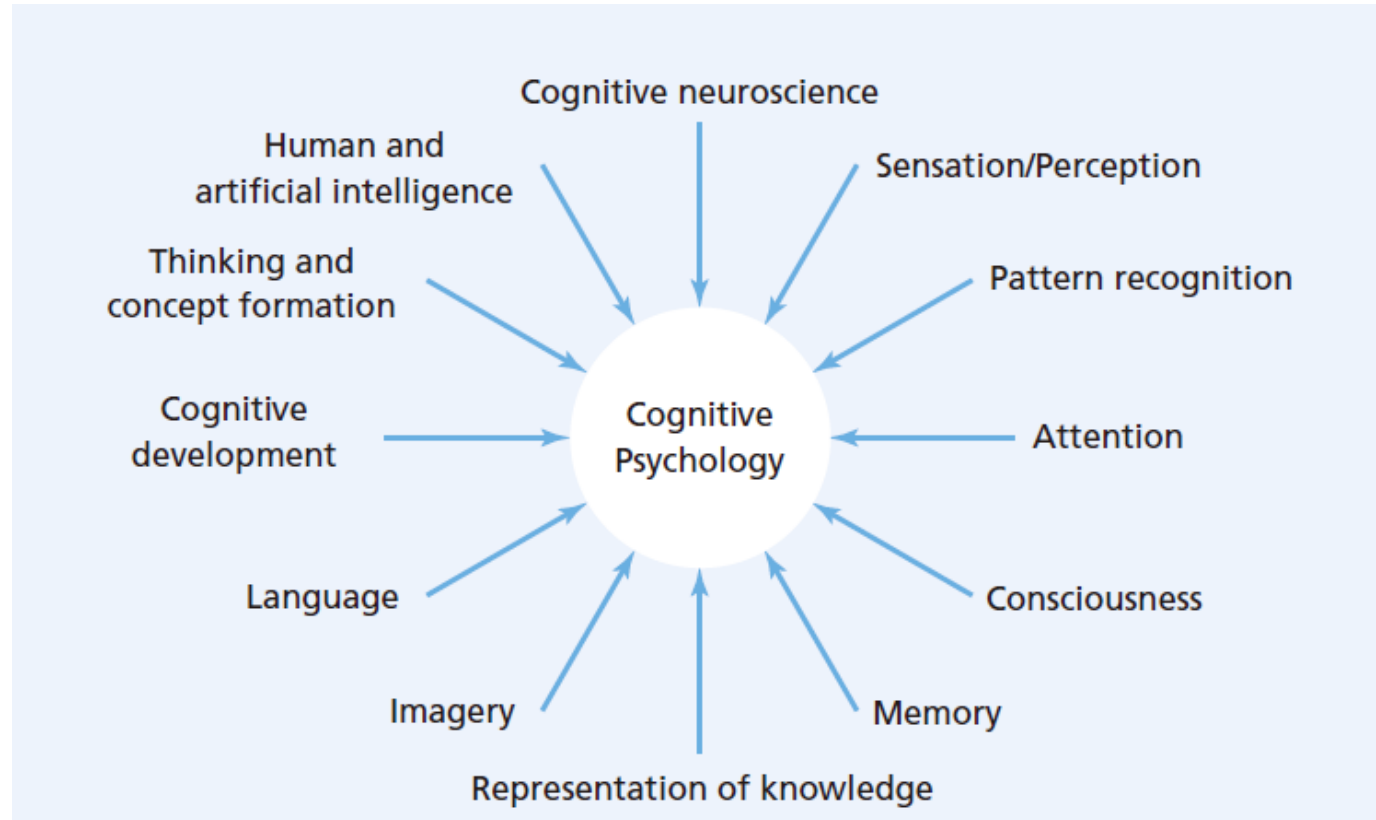
# Cognitive psychology is about **processing information**

- Cognitive psychology is **the study of processes underlying mental events.**
  - When you read and think about the question what is cognitive psychology, you are engaging in cognition.



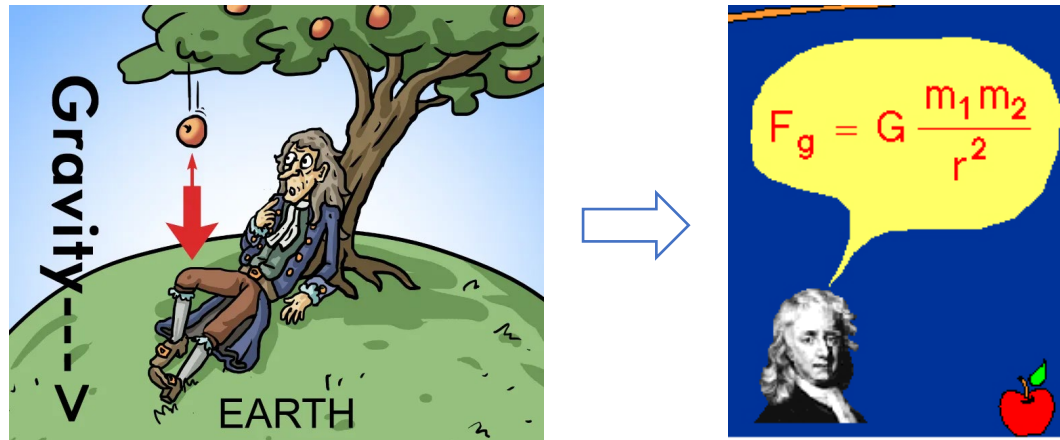
Perception  
Attention  
Memory  
Language  
Action  
Decision making  
Social interaction  
Multi-sensory integration  
...

Cognitive psychology is about **processing information**



# Theories, Models, and Perspectives

- How do we speculate about the nature of something we cannot observe, while remaining scientific?
- *Theories*: unobservable theoretical entities (e.g., force fields, cognitive operations)
- *Models*: the relationships between the theoretical construct and the behavior



# Theories, Models, and Perspectives

- **Theories**

- an organized body of general explanatory principles regarding a phenomenon, devised to link possible causes to their effects, usually based on observations.
- Theories generate *hypotheses*, tentative proposals regarding expected empirical consequences of the theory.

- Memory theories

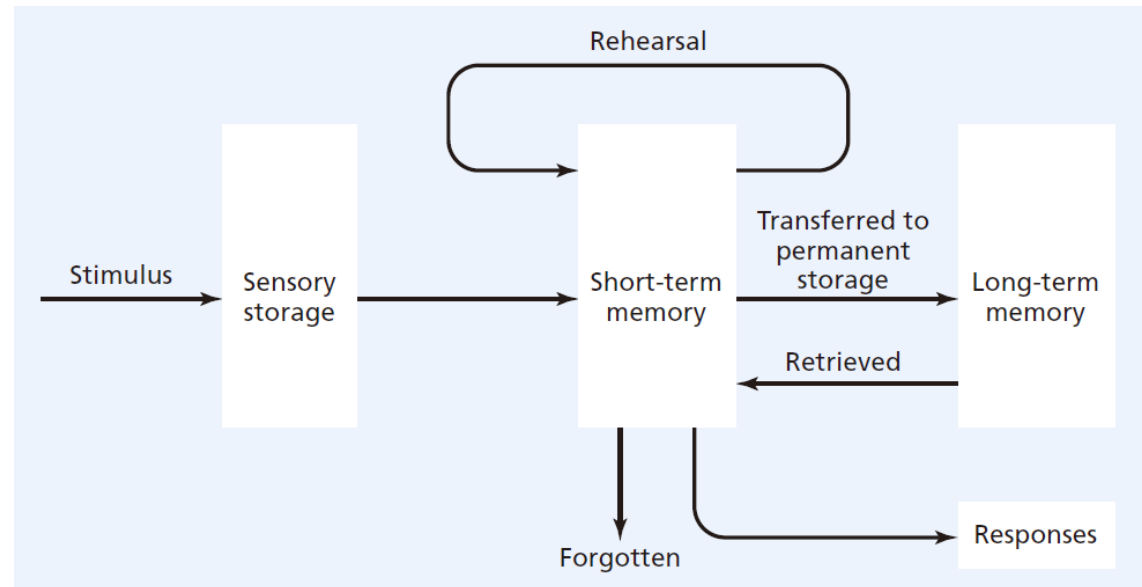
- ***Multicomponent theory*** – short-term memory (STM) and long-term memory (LTM) rely on two different storage systems
- Evidence:
  - A huge effect of phonological similarity and a small effect for semantic similarity in STM recall; this pattern reversed when LTM was required (Baddeley, 1966).
  - Amnesic patients who had preserved STM and impaired LTM, while other patients showed the reverse pattern (Shallice & Warrington 1970).
  - The recency effect in free recall (Glanzer 1972); the last few words of a list are well recalled on immediate test but not after a brief filled delay, unlike earlier items.
  - etc.

# Theories, Models, and Perspectives

- **Models**

- an organizational framework used to describe processes
- descriptive and analytical

- can be used to make predictions



**Modified Waugh and Norman (1965) memory model.**

# Theories, Models, and Perspectives

- **Theories**

- plausible explanatory propositions devised to link possible causes to their effects
- attempt to explain particular aspects of phenomena and are often used to test hypotheses.

- **Models**

- an organizational framework used to describe processes
- descriptive and analytical



**Perspectives**



# Models, Theories, and Perspectives

- **Perspectives**

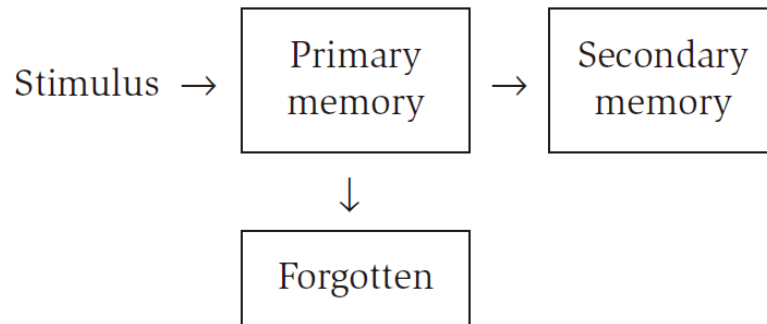
- Information processing
- Computer science
- Neuroscience
- Evolutionary

# Models, Theories, and Perspectives

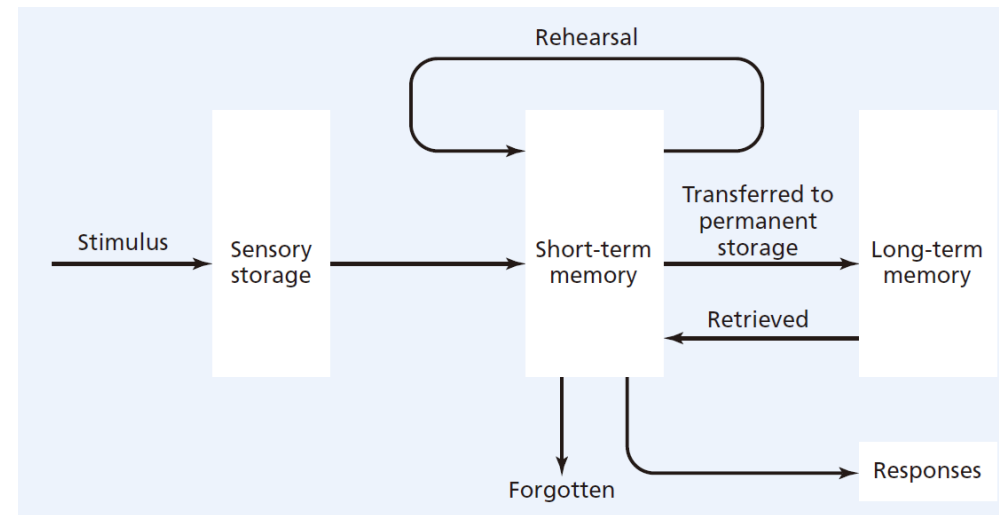
- **Perspectives**

- Information processing

- Cognition can be understood by analyzing it into **a series of sequential stages**.
    - Each stage receives information from preceding stages and then performs its unique function.



James' memory model



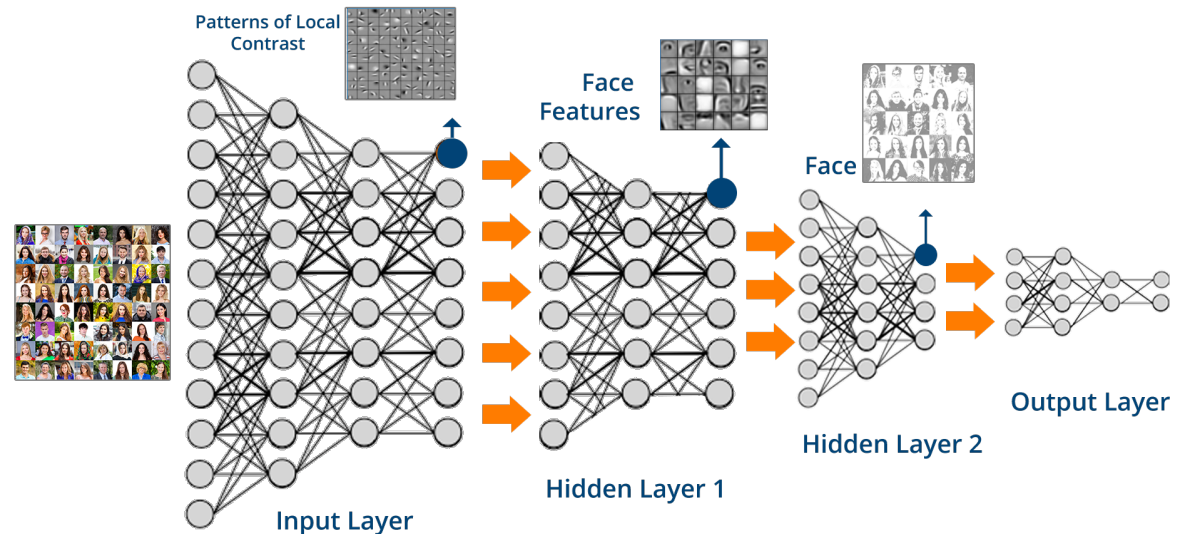
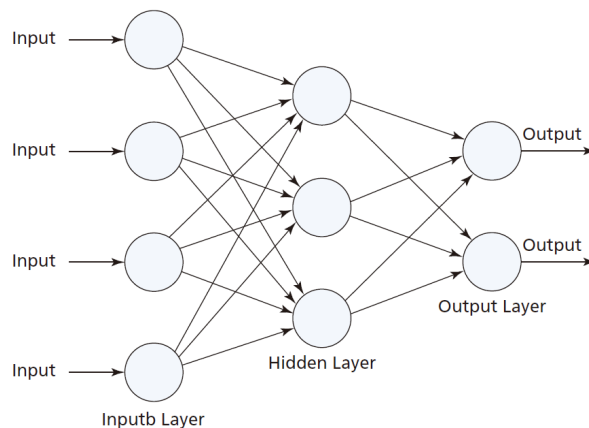
Waugh and Norman memory model

# Models, Theories, and Perspectives

- **Perspectives**

- Computer Science

- The parallel distributed processing (PDP) models assume that information processing takes place through **the interactions of a large number of simple processing elements** called units, each sending excitatory and inhibitory signals to other units



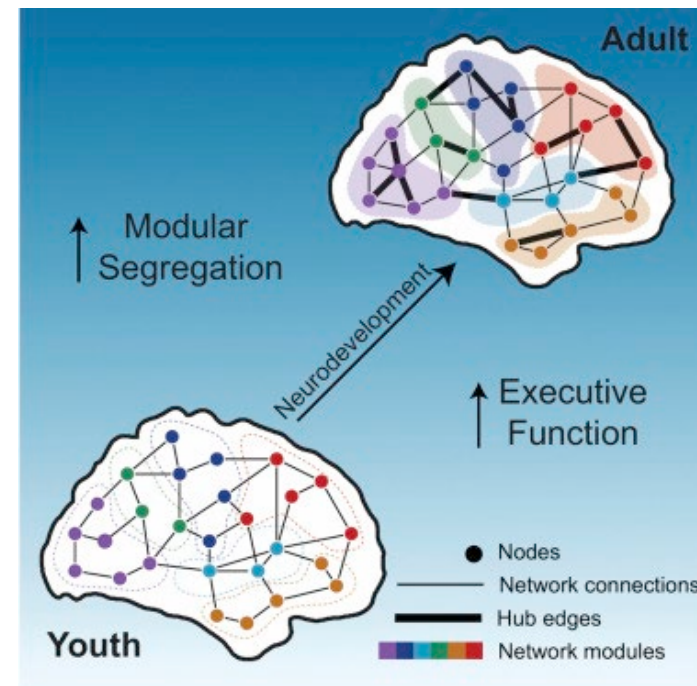
# Models, Theories, and Perspectives

- **Perspectives**

- Neuroscience

- Brain areas are responsible for particular psychological functions

e.g., whether the brain was a holistic organ, with cognitive functions distributed throughout its infrastructure, or whether functions were localized and tied to specific regions.



Baum et al., Current Biology, 2017

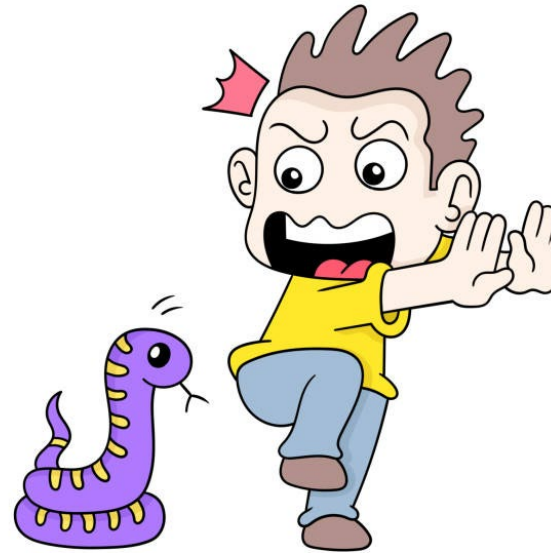
# Models, Theories, and Perspectives

- **Perspectives**

- Evolutionary Psychology

- This perspective is based on the idea that cognition is best understood from a **functionalist** approach.

It puts a constraint on theories and models that people would develop by forcing them to consider the utility and overall benefit of a particular process or trait.



# Theories, Models, and Perspectives

- **Theories**

- plausible explanatory propositions devised to link possible causes to their effects
- attempt to explain particular aspects of phenomena and are often used to test hypotheses.

- **Models**

- an organizational framework used to describe processes
- descriptive and analytical



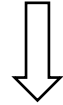
**Perspectives**

# Hypothesis testing through **experimentation**

- Cognitive psychology is different from previous psychological approaches in two key ways:
  - It accepts the use of the scientific method, and generally rejects introspection as a valid method of investigation, unlike phenomenological methods such as Freudian psychology.
  - It explicitly acknowledges the existence of internal mental states (such as belief, desire and motivation) unlike behaviorist psychology.

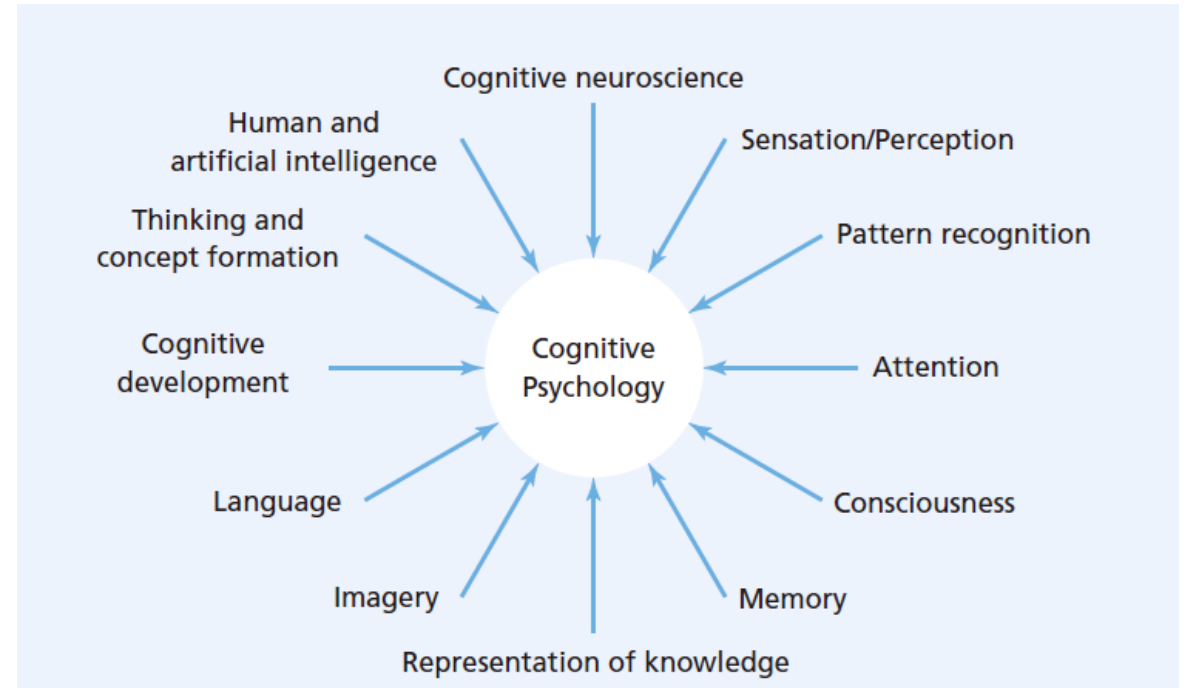
# Hypothesis testing through experimentation

- Conceptual definition



- **Operationalized definition**

- Specify the concept precisely and explicitly;
- The researcher determine what the operational definition is;
- Must be measurable and manageable.





# Hypothesis testing through experimentation

- Unit of analysis
  - What is actually being measured
    - Single cells
    - Individuals
    - A team
    - A conversation
    - etc.

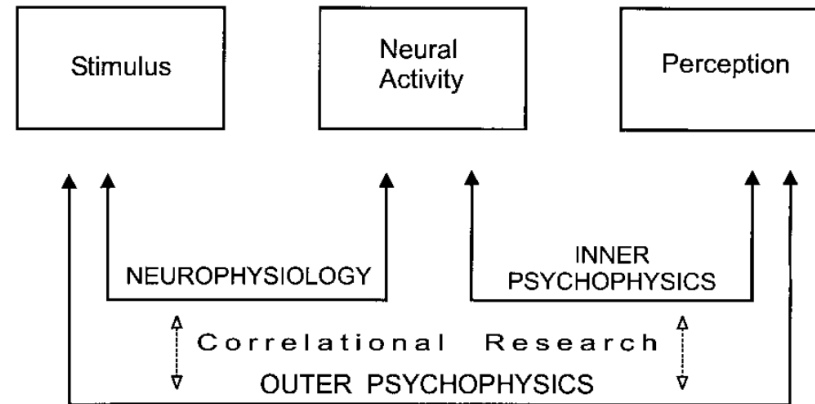
# Research Methods

- Measuring psychological correlates to the physical world
  - Psychophysics
  - Reaction-Time studies
  - Priming studies
  - Eye-Tracking studies
  - Single-Cell studies
- Documenting unique cases
  - Self-reports
  - Case studies
  - Naturalistic observation
  - Imaging studies

# Psychological correlates to the physical world

- **Psychophysics**

- The study of the relationship between physical stimuli and the sensations and perceptions evoked by these stimuli (Gescheider, 1976).
- *Central idea:* measurements of behavioral parameters (accuracy, reaction time, sensory thresholds) can be used to infer mental state (percept) of subjects



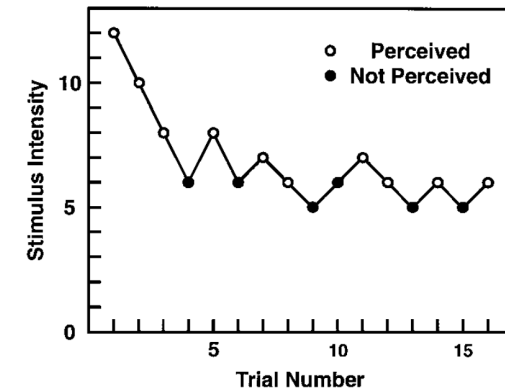
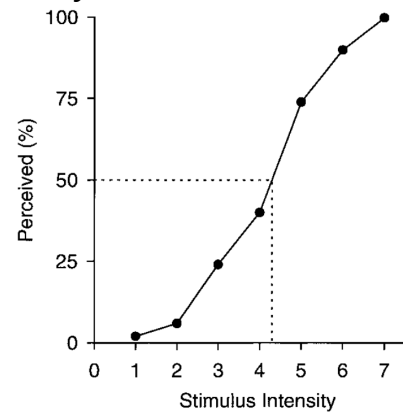
# Psychophysical methods

- Method of adjustment
  - The simplest and quickest way
- Method of limits
  - Ascending and descending series alternated
- Method of constant stimuli
  - A fixed set of stimuli with predefined intensities
- Adaptive methods
  - Staircases
  - Best Pest
  - QUEST

Stimulus Intensity	Alternating Ascending and Descending Series					
0	N		N		N	
1	N		N		N	
2	N		N	N	N	
3	N	N	N	Y	N	N
4	N	Y	N	Y	N	Y
5	N	Y	Y	Y	Y	Y
6	Y	Y		Y		Y
7		Y		Y		Y
Transition Points	5.5	3.5	4.5	2.5	4.5	3.5

Threshold = Average Transition Points =  $(5.5 + 3.5 + 4.5 + 2.5 + 4.5 + 3.5) / 6 = 24 / 6 = 4$

Psychometric function



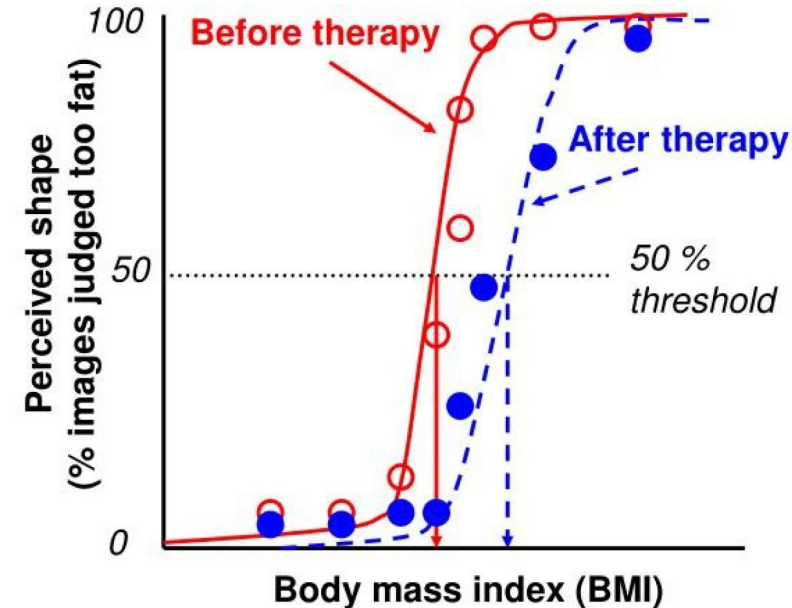
The choice among the methods is determined by the accuracy that is needed and the amount of time available.

# Psychological correlates to the physical world

- What can psychophysics be used for?
  - Sensory system neurophysiology/neuropsychology
    - Sensory limits of vision, hearing, touch...
    - Interspecies comparison (e.g., monkeys vs. humans)
    - Inferring neuronal mechanisms (e.g., illusions, aftereffects)
  - Quantitative measurement of perceptual states
    - Diagnostic tool (e.g., vision tests)
    - Assessment tool (e.g., therapeutic effectiveness)
  - Experimental psychology
    - Visuomotor interactions
    - Perception of speed, motion
    - Attention

## *Example: treatment of anorexia (厌食症)*

- Distorted self-image in anorexia: subjects perceive themselves as disproportionately overweight
- Suppose you want to test the effectiveness of therapy to improve self-image (reduce distortion). How can its effectiveness be quantified?
  - a) Show photos of subjects manipulated (Photoshop) to show different body size (BMI)
  - b) Ask subjects to rate photos as “too thin” or “too fat”; measure % judged “too fat”
  - c) Fit psychometric function to data
    - Note shape (logistic)
  - d) Perceptual boundary (threshold): BMI where 50% of photos judged “too fat”



# The power of psychophysics

- Quantitative – objective scale of measurement
- Does not suffer from subjectivity of introspection
- Can be used to study “pure” mental phenomena – e.g., attention
- Valid inter-subject, inter-species, and inter-method comparisons
  - e.g., sensitivity of neurons vs. sensitivity of brains
- Can be used to study subliminal percepts
- Can identify (possibly subconscious) response bias

# Psychological correlates to the physical world

- **Reaction-Time studies**
  - Suprathreshold Methods

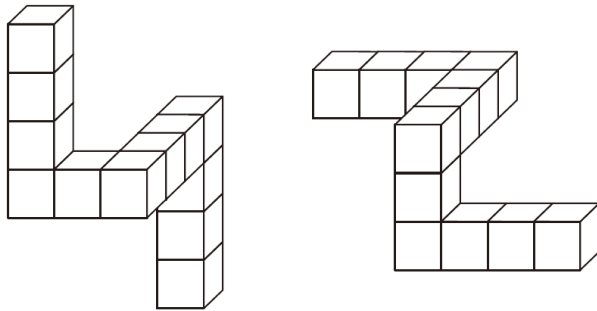
Type	Definition	Usage	Examples
Simple reaction time	There is just one stimulus. When it appears, you need to respond with the one response there is.	Measure sensory performance	Every time you see a light go on, you need to press the space bar of your computer keyboards.
Choice reaction time	There are multiple stimuli. Each stimulus requires a different response.	Study more complex sensorimotor or cognitive behavior (as it involves stages)	You see one of 10 letters presented. Each time you see the letter, you need to press the corresponding letter key of your keyboard.



# Psychological correlates to the physical world

- **Reaction-Time studies**

- Rely on the assumption that cognitive activity takes time and that one stage is completed before the other starts



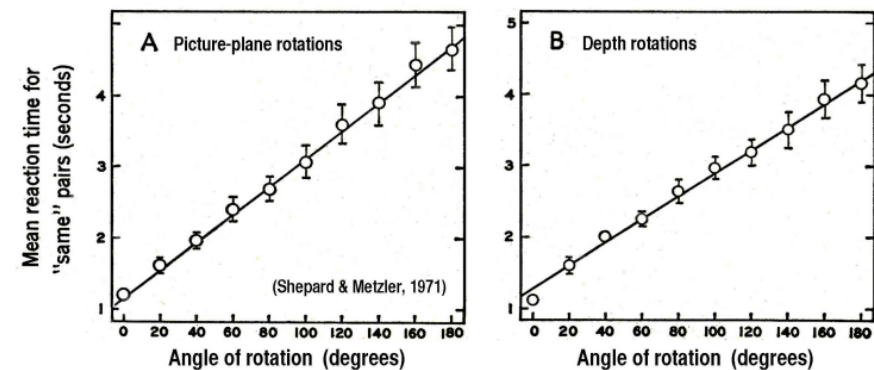
Based on Shepard & Metzler's "Mental Rotation Task"



Mental Rotation task based on Canonical Orientations

It took longer for participants to mentally rotate an object 45 degrees compared to 15 degrees.

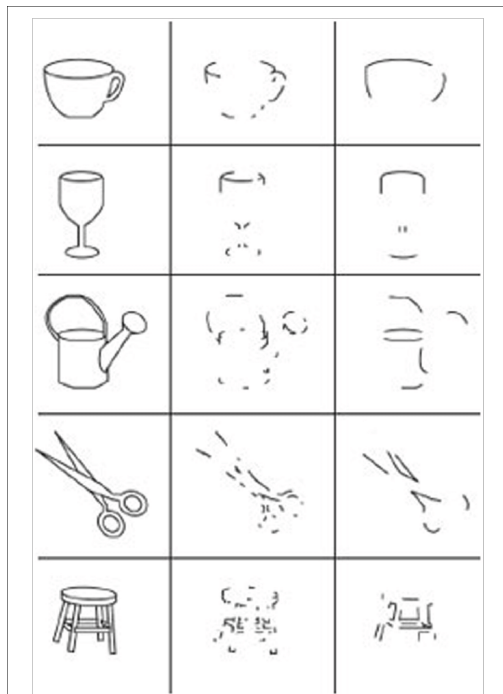
→ Mental events correspond to physical properties of the real world.



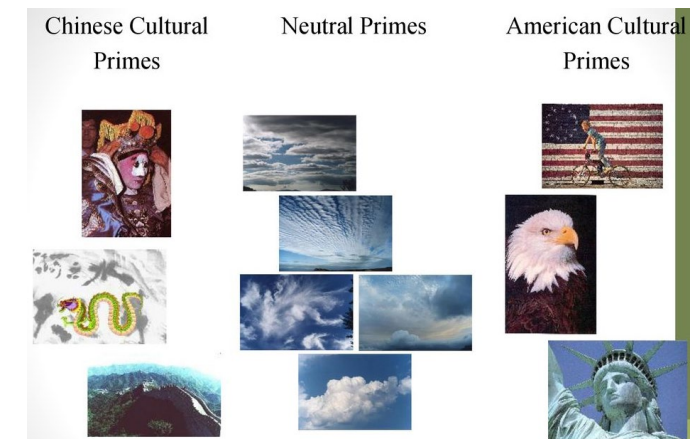
# Psychological correlates to the physical world

- **Priming studies**

- By activating one item that may be related to another item, the acceptability of the second item is enhanced.



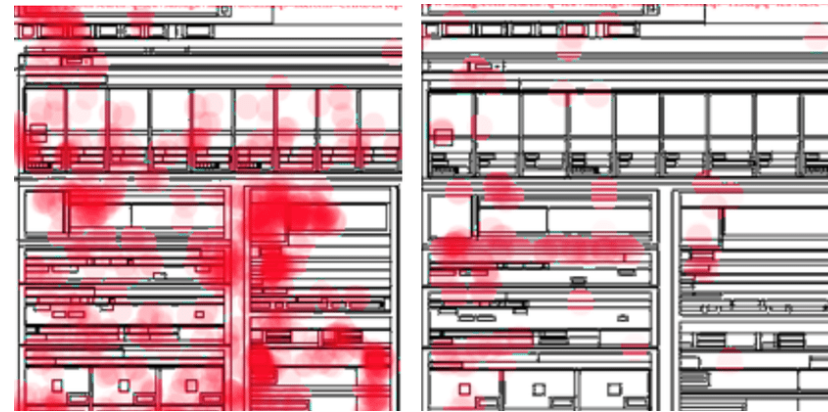
Biederman's RBC images



# Psychological correlates to the physical world

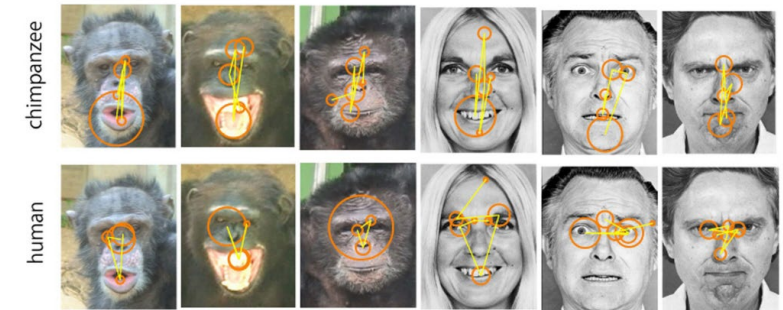
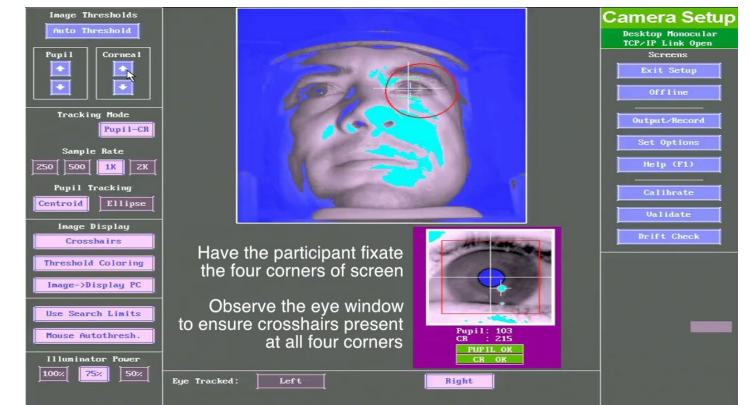
- **Eye-tracking studies**

- where a person's eye fixation is at any given moment.



Dyslexia

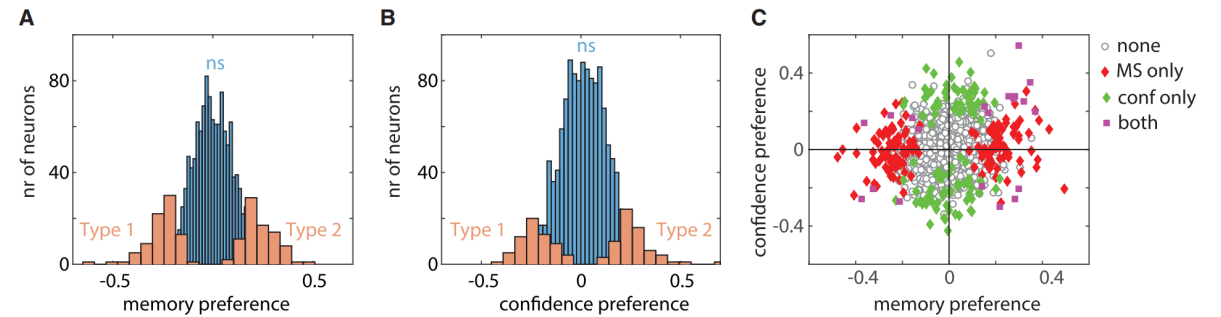
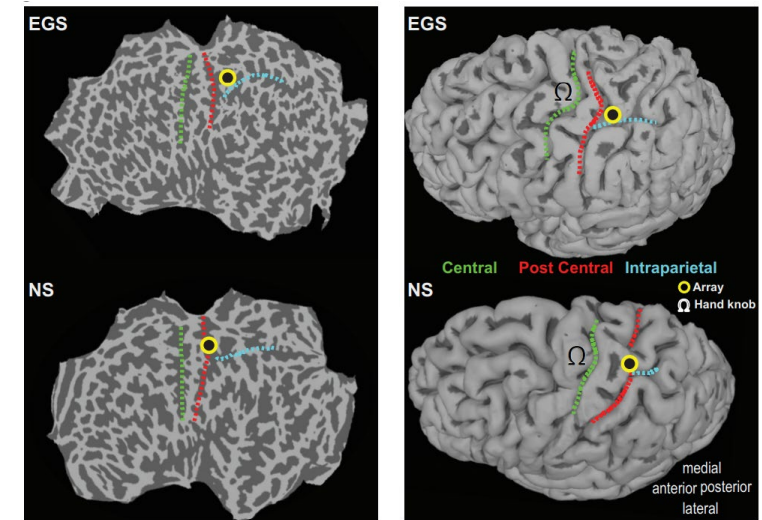
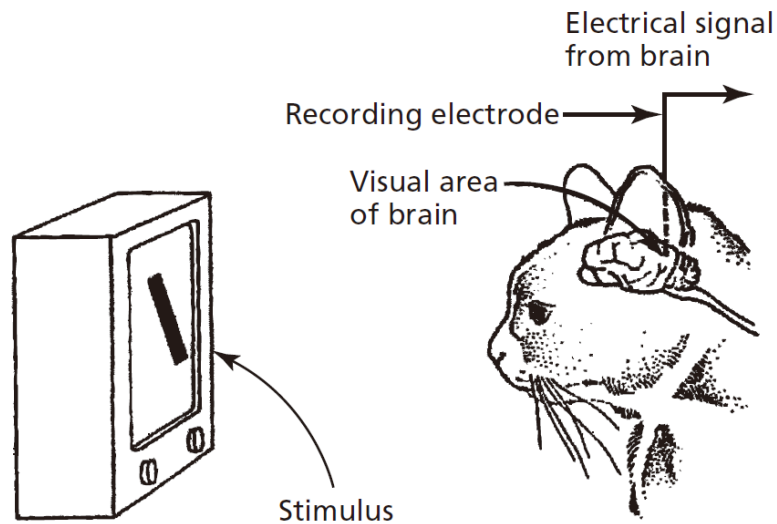
Control



# Psychological correlates to the physical world

- **Single-cell studies**

Single cell study on a cat.



Rutishauser et al., 2018

# Research Methods

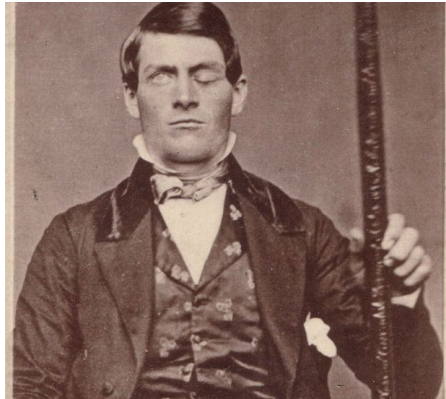
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  - Self-reports
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# Documenting unique cases

- **Self-reports**
  - An individual's own account of cognitive processes
- **Case studies**
  - In-depth studies of individuals
- **Naturalistic observation**
  - Detailed studies of cognitive performance in everyday situations and nonlaboratory contexts



Genie



Phineas Gage



Henry Molaison (H.M.)

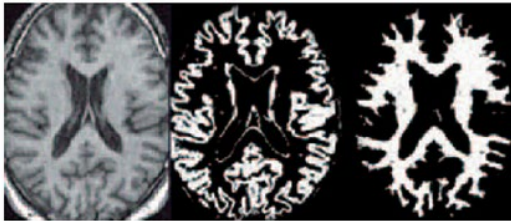
- **Strengths**
  - Very rare cases
  - Rich, qualitative data provides in-depth understanding
  - Can track and describe change over time
  - High ecology
- **Weaknesses**
  - Heavy reliance on retrospective & self-report data
  - Non-standardized methods may be difficult to replicate
  - Lack of generalisability



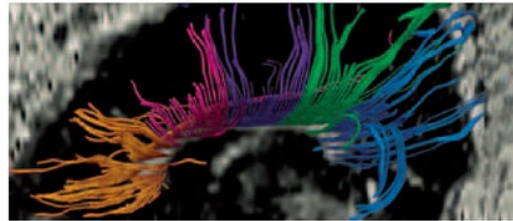
# Documenting unique cases

- Imaging studies

**a** Structural MRI (atrophy)



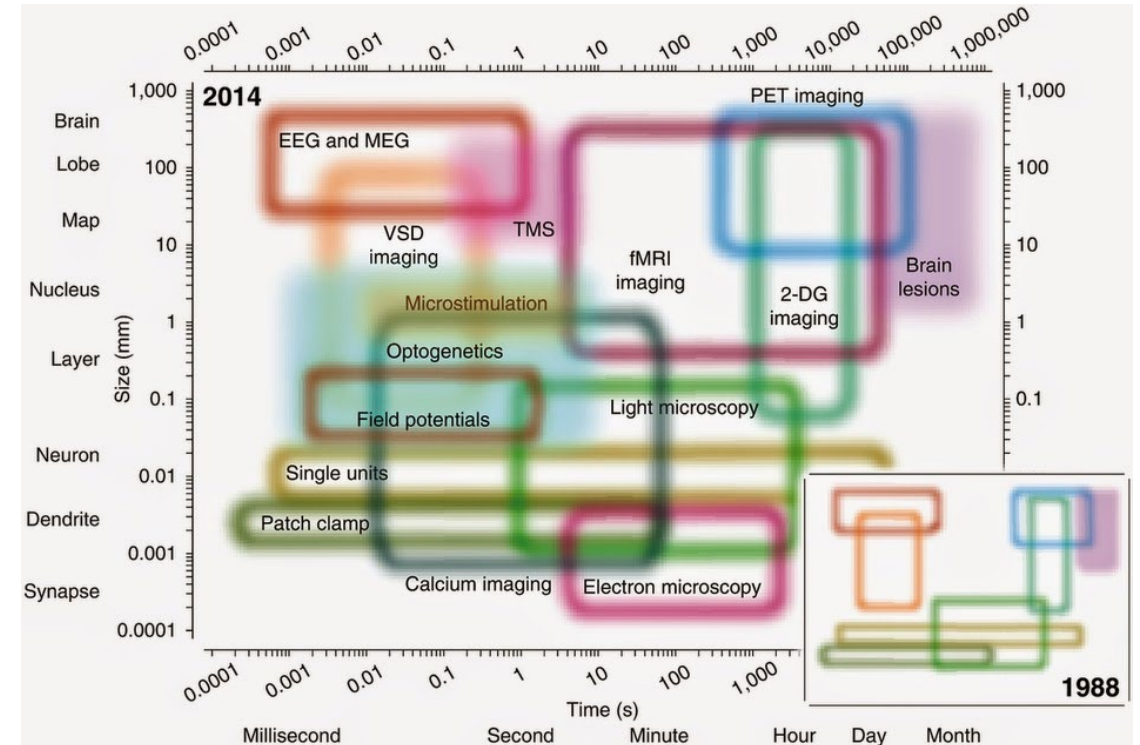
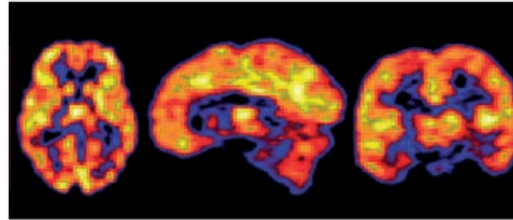
**b** DTI (white matter connectivity)



**c** Functional MRI (brain activity)



**d** PET (brain metabolism)



Sejnowski et al., 2014

# Research Methods

- Ethics
  - To weigh the benefits with the costs to both the quality of life of the animal and the quality of life gained by humans.
  - Approved by the ethic committee.
  - Obtain the consent from the participants.



# Summary

- Theories, Models, and Perspectives
- Conceptual vs. Operational definition
- Research methods
  - Measuring psychological correlates to the physical world
  - Documenting unique cases