Summary Cognitive Psychology: Connecting Mind Research and Everyday Experience - ch: 1-12 except 8

Introduction to Cognitive Psychology (University of Toronto)

Chapter 1 — Introduction to Cognitive Psychology

- Cognitive psychology — branch of psychology concerned with the scientific study of the mind

Cognitive Psychology: Studying the Mind

- What is the mind?
  - *Mind creates and controls mental functions such as perception, attention, memory, emotions, language, deciding, thinking, and reasoning.*
    - Memory, problem-solver, make decision & consider probabilities
    - Cognition — mental processes, such as perception, attention, and memory, that are what the mind does
  - Mind is a system that creates representations of the world so that we can act within it to achieve our goals.
    - Associated with normal functioning
    - How mind operates (creates representations) and its functions (enables us to act & achieve goals)
- Studying the Mind: Early work in Cognitive Psychology:
  - Franciscus Donders — Cognitive Psychology Experiment: How long it takes for a person to make a decision?
    - Measuring reaction time — how long it takes to respond to presentation of a stimulus
      - Simple reaction time — asking subjects to push a button as rapidly as possible when they saw a light goes on
      - Choice reaction time — using two lights and ask subjects to push the left button when they saw the left light go on and right button when they saw right light go on
    - Presenting stimulus (light) → Mental response (perceiving light) → Behavioural response (push button)
    - Reaction time = time between presenting stimulus and behavioural response
    - Difference between simple and choice reaction time indicate how long it took to make the decision for correct button — Donders concluded tat the decision-making process took one-tenth of a second
    - Important experiment: 1) First cognitive psychology experiment; 2) Mental responses must be *inferred* from behaviour (cannot be measured directly)

- Wilhelm Wundt's Psychology Laboratory: Structuralism and Analytic introspection
  - Structuralism — our overall experience is determined by combining basic elements of experience the structuralists called sensations. — "Periodic table of the mind"
  - Analytic introspection — trained subjects described their experiences and thought processes in response to stimuli (describe in terms of elementary mental elements)
  - e.g Experience hearing a five-note chord played on piano (Whether subjects were able to hear each of the individual notes that mad up the chord)
- Ebbinghaus's memory experiment: What is the time course of forgetting?
  - How rapidly information that is learned is lost over time?
  - Quantitative method for measuring memory:
    - Repeated lists of 13 nonsense syllables: DAX, QEH, LUH, ZIF one at a time at constant rate
    - Determine how long it took to learn a list for the first time, then wait for a period of time (*delay*), then determine how long it took to relearn the list
  - Savings — determine how much was forgotten after a particular delay:
    - Savings = (Original time to learn the list) - (Time to relearn the list after the delay)
    - Longer delays → smaller savings
    - Smaller savings → more forgetting
  - Savings curve (forgetting curve) — memory drops rapidly for the first 2 days after initial learning → levels off
  - Memory could be quantified & able to describe property of mind (e.g ability to retain information)
- William James's Principles of Psychology
  - Observed that paying attention to one thing involves withdrawing from other things

Person	Procedure	Results & Conclusions	Contribution
Donders (1868)	Simple reaction time Vs. Choice reaction time	Choice reaction time takes 1/10 sec longer; therefore it takes 1/10 sec to make a decision	First cognitive psychology experiment; mental responses can be inferred from behaviour
Wundt (1879)	Analytic introspection	No reliable results	Established the first laboratory of scientific psychology
Ebbinghaus (1885)	Savings method to measure forgetting	Forgetting occurs rapidly in the first 1 ~ 2 days after original learning	Quantitative measurement of mental processes
James (1890)	No experiments; reported observations	Descriptions of a wide range of experiences	First psychology textbook

Abandoning the Study of the Mind

- John Watson Founds Behaviorism
  - Problems with analytic introspection:
    - 1) produced variable results from person to person
    - 2) Results were difficult to verify (interpreted in terms of invisible inner mental processes)
  - New approach — Behaviourism — Purely objective, experimental branch of natural science. Theoretical goal is the prediction and control of behaviour
    - 1) Rejects introspection as method
    - 2) Observable behavior, not consciousness
  - "Little Albert" experiment
    - Pair loud noise with a rat
    - Classical conditioning — how pairing one stimulus (e.g loud noise presented) with another, previously neutral stimulus (e.g rat) causes changes in the response to the neutral stimulus
    - Similar to Pavlov's experiment: Pairing bell with food, measure dog's salivation
  - Cared about how behaviour was controlled by stimuli
- Skinner's operant conditioning
  - Operant conditioning — how behaviour is strengthened by the presentation of positive reinforcers (e.g food/social approval) or withdrawal of negative reinforces (e.g shock/social rejection)
  - e.g Reinforcing a rat with food for pressing a bar ↑ rat's rate of bar pressing
- Setting the Stage for reemergence of the mind in psychology
  - Edward Chance Tolman: Used behaviour to infer mental processes
    - 1) Place rat in maze. Rat explores maze
    - 2) Place rat at A. Place food at B. Rat turns *right* to obtain food
    - 3) Place rat at C. Rat turns *left* for food.
    - Cognitive map — conception within the rat's mind of maze's layout
  - Noam Chomsky: language development not by imitation or reinforcement, but by an inborn biological program that holds across culture

Rebirth of the Study of Mind

- Cognitive revolution (1950s) — Shift in psychology from the behaviourist's stimulus
- Introduction of the Digital Computer
  - Flow diagrams for computers:
    - Information is received by input processor → store in a memory unit → processed by an arithmetic unit → output
    - Information-processing approach — traces sequences of mental operations involved in cognition
    - Experiment: how well people are able to focus their attention on information when other information is being presented at the same time
  - Flow diagrams for the mind:
    - Colin Cherry (experiment):
      - Present subject with 2 audio messages (1 left ear, 1 right ear)
      - Focus on one message (attended message) and ignore the other (unattended message)
      - Result: Hear sounds of unattended message but unaware of the content
    - Donald Broadbent: Flow diagrams of the mind:
      - Input (sound of both attended & unattended messages) → filter lets through attended message and filters out unattended message → detector records information through filter
      - Provided a way to analyse the operation of mind in terms of sequence of processing stages
      - One of the standard ways of depicting the operation of the mind
- Conferences on Artificial Intelligence and Information Theory
  - John McCarthy: program computers to mimic operation of human mind — Organized *Conference*
    - Artificial Intelligence — making a machine behave in ways that would be called intelligent if a human were so behaving
  - Herb Simon & Alan Newell: Create a computer program to create proofs for problems in logic
    - Logic theorists: able to create proofs of mathematical theorems that involve principles of logic, use humanlike reasoning process
  - George Miller: "The Magical Number Seven Plus or Minus Two" — there are limits to the human's ability to process information — information processing of human mind is limited to about 7 items
    - Similar to Broadbent's filter model

- Cognitive "Revolution" took a while
  - Cherry's experiment, Broadbent's filter model, two conferences in 1956
    - Shifts from behaviorism → Study of mind
      - *Cognitive revolution*
- Looking ahead
  - Goal: measure how to use behaviour to revel how mind operates; understanding the mind

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Modern Research in Cognitive Psychology

- 2 Aspects: 1) How research progresses from one question to another; 2) Role of models
- Following a trial: How research progresses from one question to another
  - Problem → Question → Design experiments → Obtain & interpret results
  - Sian Beilock: Problem of "Choking under pressure" — *choking*: performing more poorly than expected given a person's skill level when person feels pressure
    - Beginning of research trial: "a phenomenon (choking) that needed an explanation"
  - Beilock & Carr: *Working memory*
    - Experiment: Present subjects with math problems and ask whether result had a remainder
      - Low pressure condition: "here's a problem" Vs. High pressure condition "you will be videotaped & do well to receive cash payment"
      - Results: Performance ↓ (*choking*) for more difficult problems so depend more on working memory
      - Pressure caused subjects to worry; worry used up some of their working memory capacity
  - Meredyth Danaman & Patricia Carpenter: Test to measure working memory capacity
    - Low working memory (LWM) Vs. High working memory (HWM)
      - Perform math problems under low & high pressure
      - Results: LWM more likely to choke
  - Michael Kane & Richard Engle: Presented verbal task to LWM & HWM subjects under low load (verbal task presented alone) & high load (subjects did another task while they were doing verbal task)
    - Results: Low pressure: HWM did better; High pressure: same performance
      - ∴ Advantage of HWM subjects vanished under pressure
      - = Subjects with best working memory reserves — more likely to choke

- Beilock & Marci DeCaro: Determine the strategy a person use to solve problem
  - Ask subjects how they solve problems
  - Results: HWM arrive answer by doing calculation (accurate but place a heavy load), LWM — use "short-cut" if numbers are even, the answer is no (low load but not always correct)
    - HWM calculations affected by pressure

- Role of Models in Cognitive Psychology
  - 2 kinds of models:
    - 1) *Structural models* — structures in brain that are involved in specific functions
    - 2) *Process models* — illustrate how a process operates
  - Structural models:
    - Structural models — representation of a physical structure
    - Can mimic appearance of an object
    - Purpose: simplify — easier to study & understand the system
    - E.g model of visual system ~ each box represents a complex structure — help us to visualise the layout of a system and how different components are connected + interact
    - Designed to represent structures involved in specific functions
      - E.g *Pain matrix* — involved in our perception of pain
  - Process models:
    - Process models — represent the processes that are involved in cognitive mechanisms, with boxes usually representing specific processes & arrows indicating connections between processes
    - e.g Broadbent's filter model of attention
    - E.g Operation of memory:
      - Input → Sensory memory (holds information for a fraction of second) → Short-term memory (holds information for seconds) ↶ Rehearsal (repeat something) ⇄ Long-term memory
    - E.g 3 components of Long-term memory:
      - Episodic memory — events in your life; Semantic memory — facts; Procedural memory — physical actions
      - Can add detail to model

Chapter 2 — Cognitive Neuroscience

- E.g Waking up
- Cognitive neuroscience — Study of physiological basis of cognition

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Why study Cognitive Neuroscience?

- Levels of analysis — a topic can be studied in a number of different ways
- E.g Car
  - Test drive: acceleration, brake, gas mileage
  - Another level: mechanisms (motor and steering systems)
  - Deeper level: how car's engine works (the cylinder)
- E.g Conversation between Gil & Mary
  - After a few days, he remembers: simple behavioural description of having an experience & later having a memory of that experience
  - Physiological level: chemical processes in eyes & ears → electrical signals in neurons → activated brain structures → perception
    - Electrical signals → trigger chemical & electrical processes → Brain storage → memory
  - When he walk past the park → trigger sequence of physiological events → retrieve memory
- Neurons — cells that are building blocks and transmission lines of nervous system

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Neurons: Communication and Representation

- Neurons — small units that create and transmit information about what we experience and know
- Microstructure of the Brain: Neurons
  - Observe brain structure: apply special stains to brain tissue → contrast between different types of tissues
  - Nerve net — a continuous pathway for conducting signals uninterrupted through the network
  - Camillo Golgi: developed a staining technique ~ thin slice of brain tissue immersed in a solution of silver nitrate
  - Ramon y Cajal: used 2 techniques to investigate the nature of nerve net — nerve net not continuous

- 1) Used Golgi stain to stain only some cells in a slice of brain tissue
- 2) Study tissue from brains of newborn animals (small density compared to adult brain)
- Results: Not continuous nerve net — made up of individual units connected together
  - Neuron doctrine — idea that individual cells transmit signals in the nervous system, and these cells are not continuous with other cells
- 1) Individual neuron
  - Cell body — metabolic center of neuron, contains mechanisms to keep cell alive
  - Dendrites — branch out from cell body to receive signals from other neurons
  - Axons (nerve fibers) — long processes that transmit signals to other neurons
- 2) Synapse — small gap between end of neuron's axon and dendrites/cell body of another neuron
- 3) Neural circuits — groups of interconnected neurons (form connections to specific neurons)
- Receptors — Specialized neurons to pick up information from environment

- Signals that travel in Neurons
  - Edgar Adrian: record electrical signals from single sensory neurons
    - Method
      - Microelectrodes — small shafts of hallow glass filled with conductive salt solution — pick up electrical signals at the electrode tip
      - Recording electrode — recording tip inside the neuron
      - Reference electrode — located some distance away so it is not affected by electrical signal
    - Measure difference between recording & reference electrode
      - At rest: difference in potential between two electrodes — -70 millivolts (mV) — resting potential
        - neuron has a charge that is 70mV more -ve than outside
      - Nerve impulse: +40 mV compared to outside
      - Action potential: mechanism by which information is transmitted throughout the nervous system (from resting potential → nerve impulse → resting potential)
    - Each action potential travels all the way down the axon without changing height/shape — once action potential is started at one end, signal will still be the same size when it reaches the other end
    - Experiments: relate nerve signals to stimuli in the environment and to people's experience
      - Experiment: Relation between nerve firing and sensory experience

- Measuring firing of neuron from receptor in skin while applied more pressure to skin
- Result: shape & height of action potential remained the same; rate of firing (number of action potentials that traveled down the axon per second) ↑
    - Nerve impulses are crowded closely together: sensation is intense; separated by long intervals: sensation is correspondingly feeble
    - Electrical signals are representing the **intensity** of the stimulus
    - Rate of neural firing ~ intensity of stimulation ~ magnitude of experience
- Neurotransmitter — chemical released that makes it possible for signal to be transmitted across the synapse

- Principle of Neural representation
    - Principle of neural presentation — everything a person experiences is based not on direct contact with stimuli, but on representations in the person's nervous system
    - E.g Gil's conversation with Mary:
        - Gil sees Mary → light reflected from Mary enters Gil's eyes → image is focused on retina (layer of neurons that lines the back of the eye) = a representation of Mary
            - Receptors in retina transform image into electrical signals → travel through retina → leave back of eye in optic nerve → visual cortex (area at the back of brain that receives signal from the eye)

Representation by Neurons

- Magnitude of experience: e.g perception of a 100-watt light brighter than a 40-watt bulb — related tgo rate of nerve firing
- Quality of experience
    - Across the senses — different experience associated with each of the senses (perceiving light for vision, sound for hearing, smells for olfaction)
    - Within a sense — shape, color / movement for vision, recognizing different kinds of objects based on their shapes or different people based on their faces
- Representation by Single Neurons
    - Featured Detectors:
        - David Hubel & Thorsten Wiesel: experiment determine which stimuli caused specific neurons to fire
            - Present visual stimuli to cats

- Result: found that each neuron in visual area of cortex responded to a specific type of stimulation presented to a small area of the retina
- Some stimuli caused neurons in and near visual cortex to fire: a) oriented bar, b) oriented moving bar, c) short moving bar
  - Feature detectors — respond to specific stimulus features (e.g orientation, movement & length)

- Neurons that respond to complex stimuli:
  - Charles Gross: recorded from single neurons in monkeys temporal lobe
    - Presented monkeys with lines, squares, and circles (some were light, some were dark)
    - Result: found a neuron that refused to respond to any of the standard stimuli ⇒ respond to handlike shape with finger pointing up
  - Neurons from visual cortex — simple stimuli (e.g oriented bars)
    - send axons to higher levels of visual system → signals from many neurons combine & interact
  - Neurons in temporal lobe — complex geometrical stimuli
  - Neurons in another area of temporal lobe — faces
  - Hierarchical processing — progression from lower to higher areas of brain

- Sensory coding
  - Sensory code — how neurons represent various characteristics of the environment
  - Problem of sensory coding — problem of neural representation for senses
  - Specificity coding — an object could be represented by the firing of a specialised neuron that responds only to that object
    - Unlikely to be correct ~ neurons usually respond to a number of different faces ⇒ a number of neurons are involved in representing an object
  - Population coding — representation of a particular object by the pattern of firing of a large number of neurons
    - Advantage: large number of stimuli can be represented
  - Sparse coding — a particular object is represented by a pattern of firing of only a small group of neurons
    - Particular neuron can respond to more than one stimulus
    - E.g Neurons responded to pictures of actor Steve Carell

Organization: Neuropsychology and Recording from Neurons

- Localization of function — specific functions are served by specific areas of the brain
- Cerebral cortex — layer of tissue (3mm thick) that covers the brain (carry out most cognitive function)
- Neuropsychology — study of behavior of people with brain damage
- Localization demonstrated by Neuropsychology
    - Brain damaged caused by stroke — disruption of blood supply to brain (usually caused by blood clot)
        - Paul Broca: Left frontal lobe — Broca's area — specialized for speech
            - Patient Tan: can only say the word "Tan"
            - Producing language
        - Carl Wernicke: temporal lobe — Wernicke's area — speech was fluent and grammatically correct but tended to be incoherent
            - Comprehending language
    - Effect of brain injuries:
        - E.g Japanese soldiers during Russo-Japanese war (1904-1905) & Allied soldiers in WWI
            - Damaged to occipital lobe — visual cortex is located — resulted in <u>blindness</u>
    - *Upper* temporal lobe — auditory cortex (receives signals from the ears) — hearing
    - Parietal lobe — somatosensory cortex (signals from skin) — perceptions of touch, pressure & pain
    - Frontal lobe — signals from all senses — coordination of senses & (thinking + problem solving)
    - Prosopagnosia — inability to recognize face (面部認知障外) — damage to temporal lobe on *lower right side* — cannot recognize whose face it is
- Double dissociation
    - Double dissociation — occurs if damage to one area of brain causes function A to be absent while function B is present, damage to another area causes function B to be absent while function A is present
    - E.g Face recognition & object recognition
        - Find a patient who can't recognize face (Function A) but can recognize objects (Function B) + patient who can recognize face but can't recognize objects
    - Shows that functions A & B are served by different mechanisms (operates independently of each other)
- Localization demonstrated by recording from neurons
    - Doris: 97% of neurons in lower part of monkey's temporal lobe only responded to pictures of faces

- In human: “face area” located near area associated with prosopagnosia

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Organization: Brain imaging

- Magnetic resonance imaging (MRI) — create images of structures within the brain
  - Detecting tumours & other brain abnormalities
  - Excellent for revealing brain structures, but doesn’t indicate neural activity
- Functional magnetic resonance imaging (fMRI) — determine how various types of cognition activate different areas of the brain
- METHOD: Brain Imaging
  - Blood flows increases in areas of brain activated by cognitive task
    - Measure: hemoglobin (carries oxygen) contains a ferrous (iron) molecule ~ has magnetic properties
    - fMRI indicates presence of brain activity because hemoglobins molecules in areas of high brain activity lose some oxygen they are transporting → more magnetic → molecules respond to magnetic field
      - Detects changes in magnetic response of hemoglobin
        - Red & yellow → increases in brain activity; Blue & Green → decreases in brain activity
  - Activity is recorded in voxels — small cube-shaped areas of brain about 2 or 3 mm on a side — small units of analysis created by fMRI scanner (like pixels)
- Brain Imaging evidence for Localisation of Function
  - Looking at pictures:
    - Fusiform face area (FFA) — specific area of brain activated by face (in the fusiform gyrus on the underside of temporal lobe)
    - Parahippocampal place area (PPA) — specific area of brain activated by pictures representing indoor and outdoor scenes (spatial layout)
    - Extrastriate body area (EBA) — specific area of brain activated by pictures of bodies & parts of bodies
  - Looking at movies:
    - Alex Huth: fMRT experiment having subjects view film clips for 2 hours — to analyse how voxels in brains responded to different objects & actions in films
- Distributed representation across the brain:
  - Distributed representation — specific cognitive functions activate many areas of brain

- E.g Face recognition: activate FFA but also other areas of brain
- E.g Perceiving a rolling ball: neutral stimulus causes a wide distribution of activity in brain (each ball's qualities, color/movement/shape/location, processed in different areas of brain)

All Together Now: Neural Networks

- Neural networks — groups of neurons or structures that are connected together
  - e.g Pain matrix: all structures in this network, determine the nature of overall experience of pain
- Trace pathways of nerve fibres that create communication between different structures
  - Diffusion tensor imaging (DTI) — detection of how water diffuses along length of nerve fibres
- *Levels of analysis* (studying topic at different levels) // *Neural representation* (experience determined by representations in nervous system)

Chapter 3 — Perception

Nature of Perception

- Perception — experiences resulting from stimulation of the senses
- Some basic characteristics of Perception:
  - Perception - "reasoning" process — e.g Crystal seeing driftwood → umbrella
  - Perception occurs in conjunction with action
- Perceiving a scene:
  - Pattern of light and dark — creates a scene on the retina (structure that lines the back of eye and contains receptors for seeing)
  - E.g Robotic vehicles: can detect moving objects but cannot recognize large number of different objets hat humans identify with little effort
  - E.g Computer face: determine whether 2 straight-on views (front & side) are the same person

Why is it so difficult to design a Perceiving Machine

- Stimulus on the Receptors is ambiguous:
  - Inverse projection problem — task of determining the object responsible for a particular image on the retina (by extending rays (solid lines) out from the eyes)
    - rays can be created by infinite number of objects — image on retina is ambiguous
  - Problems of <u>hidden objects</u>: people understand covered objects continue to exist
  - Problem of objects <u>not sharp in focus</u>: people can often identify most of them (e.g blurred faces)
- Objects look different from different viewpoints:
  - Viewpoint invariance — ability to recognize an object seen from different viewpoints

Information for Human Perception

- Perception is built on foundation of information from environment
- Bottom-up processing — sequence of events from eye to brain (light entering the eye and electrical signals in brain), environmental energy stimulate receptors
- Perception involves factors (e.g person's knowledge of environment)
  - Top-down processing — originates in the brain (expectations people bring to perceptual situation)

- E.g Perceiving objects:
  - Top-down processing: "multiple personalities of a blob" — different contexts influences our interpretation of the identity of "blob" (unknown blurred object)
  - E.g Perceiving rocks at first → change to faces
- E.g Hearing words in a sentence:
  - E.g Spanish-language TV channel:
    - People who doesn't speak Spanish: dialogue sounds like unbroken string of sound
    - Speaks Spanish: knows where one word ends and next one begins — Speech segmentation
  - Sound signal enters ears & triggers signals to speech areas of brain — **bottom-up processing**
  - Understands language: knowledge (**top-down processing**) creates perception of individual words
- E.g Experiencing pain:
  - 1950s-1960s: Direct pathway model — pain occur when receptors in skin (*nociceptors*) are stimulated and send signals in a direct pathway from skin to brain
    - Bottom-up: Depends on stimulation of receptors
  - 1960s: Pain was affected by other factors
    - Beecher: Soldiers from WW2 "denied pain from wounds / did not want medication" — provided escape from battlefield to safety hospital
    - Pain influenced by:
      - What person **expects**
        - Surgical patients were told what to expect and instructed to relax to alleviate pain → requested fewer painkillers after surgery + sent home 2.7 days earlier than patients not provided with info
        - Patients with pathological pain get relief from taking placebo (pill they believe contains painkillers but actually contains no active ingredients)
          - Placebo effect — ↓ in pain from a substance that has no pharmacological effect
            - Patient believes substance is an effect therapy → expect a reduction in pain
      - How person directs **attention**
        - Attention is focused: pain↑; Pain ignored: pain↓
      - Type of distracting stimuli
        - Ian's pain occurred not when he was injured, but when he *realized* he was injured

- Distract a person's attention from source of pain → decrease pain
- Virtual reality techniques:
  - James Pokorny: 3rd-degree burns over 42% of body when fuel tank exploded
  - Black helmet contained 3D graphics — kitchen contained virtual spider, he has to chase spider into sink and grind it up with garbage disposal
  - Reduce pain by shifting attention from bandages → virtual reality world — pain reduction

- Perception is created by a combination of bottom-up & top-down processing

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Conceptions of Object Perception

- Helmholtz's Theory of Unconscious Inference:
  - Hermann von Helmholtz: realization that image on retina is ambiguous (particular pattern of stimulation on retina can be caused by large number of objects in environment)
  - Likelihood principle — we perceive object that is *most likely* to have caused the pattern of stimuli we received
  - Unconscious inference — perceptions are the result of unconscious assumptions/inferences that we make about the environment — infer based on experience
    - Perceptual system applies the observer's knowledge of environment to infer what object might be
    - Happens rapidly & unconsciously
- Gestalt principles of organization:
  - Gestalt psychologists — perception is based on more than just the pattern of light & dark on retina, determined by specific organizing principles
  - Wundt: overall experience be understood by combining basic elements of experience called *sensations*
  - Max Wertheimer: stroboscope (device that created an illusion of movement by rapidly alternating two slightly different pictures) ~ wondered how the structuralist idea that experience is created from sensations could explain the illusion of movement he observed
    - Apparent movement — illusion of movement created by stroboscope — although movement is perceived, nothing is actually moving
      - 3 components:
        - 1) One light flashes on & off
        - 2) a period of darkness (fraction of a second) — we don't see the darkness because our perceptual system adds something during the period of darkness

- 3) Second light flashes on & Off

- Conclusions: apparent movement cannot be explained by sensations; the whole is different than sum of its parts

  - Principles of perceptual organization — elements are grouped together to create larger objects

- Good continuation:

  - Principle of good continuation — points that, when connected, result in straight or smoothly curving lines are seen as belonging together, and lines tend to be seen in such a way as to follow the smoothest path. Also, objects that are overlapped by other objects are perceived as continuing behind the overlapping object

  - E.g Crystal perceiving rope, didn't perceive rope as consisting of separate pieces but as continuous

- Pragnanz:

  - Law of pragnanz / Principle of good figure / Principle of simplicity — every stimulus pattern is seen is such a way that the resulting structure is as simple as possible

  - E.g Olympic symbol — 5 circles instead of 9 separate shapes

- Similarity:

  - Principle of similarity — similar things appear to be grouped together (size, shape, color, orientation)

- Max Wertheimer: organising principles as "intrinsic laws" — they are built into the system

  - experience can *influence* perception (minor compared to perceptual principles)

- Taking regularities of the Environment into account:

  - Regularities in the environment — characteristics of environment that occur frequently (e.g blue ~ sky, landscape ~ green & smooth)

  - Physical regularities:

    - Physical regularities — regularly occurring physical properties of environment

      - E.g More vertical & horizontal orientations in environment than oblique (angled) orientations

      - Oblique effect — can perceive horizontals and verticals more easily than other orientations

    - Light-from-above assumption — assume light is coming from above (light in environment including light & sun usually comes from above)

      - Picture of two textured protrusions jutting out from wall, when picture is turned upside down, protrusions appear reversed (textured surface → indented) — pop out ⇄ indented (when flip)

  - Semantic regularities:

- Semantic — meaning of scene
- Semantic regularities — characteristics associated with the functions carried out in different types of scene
- Scene schema — knowledge of what a given scene typically contains
    - Our visualizations contain information based on our knowledge of different kinds of scenes
        - e.g Office: desk, chair, books etc
        - e.g Microscope: lab bench
        - e.g Lion: forest/Savannah/zoo
- Stephen Palmer: Use scene schema for kitchens to help them perceive bread
    - Present picture of kitchen, then ask observer to identify objects of bread, mailbox & drum
    - 80% identified bread, 40% identified mailbox & drum

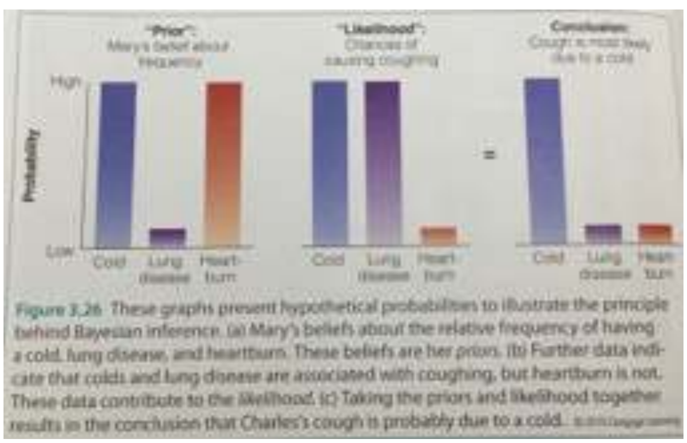
- Bayesian Inference:
    - Bayesian inference — our estimate of probability of an outcome is determined by 2 factors:
        - 1) Prior probability — Initial belief about the probability of an outcome
        - 2) Likelihood — Extent to which the available evidence is consistent with the outcome
    - E.g: 

Figure 3.26 These graphs present hypothetical probabilities to illustrate the principle behind Bayesian inference. (a) Mary's beliefs about the relative frequency of having a cold, lung disease, and heartburn. These beliefs are her priors. (b) Further data indicate that colds and lung disease are associated with coughing, but heartburn is not. These data contribute to the likelihood. (c) Taking the priors and likelihood together results in the conclusion that Charles's cough is probably due to a cold.

    - E.g Observing a book:
        - Prior: Books are rectangular
        - Likelihood: Additional evidence i.e book's retinal image combined with perception of book's distance and angle viewing book
        - Process is automatic and rapid
    - Bayesian — restate Helmholtz's idea — we perceive what is most likely to have created the stimulation we received — in terms of probabilities

- Comparing Four approaches:
    - 1) Helmholtz's Unconscious Inference
    - 2) Gestalt Laws of Organization
    - 3) Regularities in environment
    - 4) Bayesian Inference
    - 1 & 3 & 4 — use data about environment (Top-down processing)
    - Gestalt: Bottom-up processing - central role
        - However: Principle of Good Continuation possibly determined by experience

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Neurons and Knowledge about Environment

- More neurons in visual cortex that respond to horizontal & vertical orientations than oblique orientations
- Neurons that respond to Horizontals & Verticals:
    - Theory of natural selection — characteristics that enhance animal's ability to survive, and therefore reproduce, will be passed on to future generations
    - Evolution: Organisms whose visual system contains neurons that fire important things (i.e verticals & horizontals) - more likely to survive & reproduce
- Experience-Dependent Plasticity:
    - Experience-Dependent plasticity — structure of brain is changed by experience
    - Neurons in animal's brain change → respond more strongly to specific aspects of environment
    - Colin Blakemore & Graham Cooper: Kittens in vertical black & white stripes
        - Result: contained neurons that responded mainly to vertical cortex, no neurons for horizontals
        - Similar for kittens in horizontal environment
        - Kitten's brain reshaped to respond best to environment it had been exposed
    - Isabel Gauthiner: Determine human neurons' response to face by measuring FFA activity responding to faces + Greebles (all have same basic configuration but different in shapes of parts like faces)
        - After training (recognize Greeble): more FFA activity
            - Neurons in FFA respond strongly to faces (lifetime experience perceiving faces)
    - Brain's function can be "tuned" to operate best within a specific environment

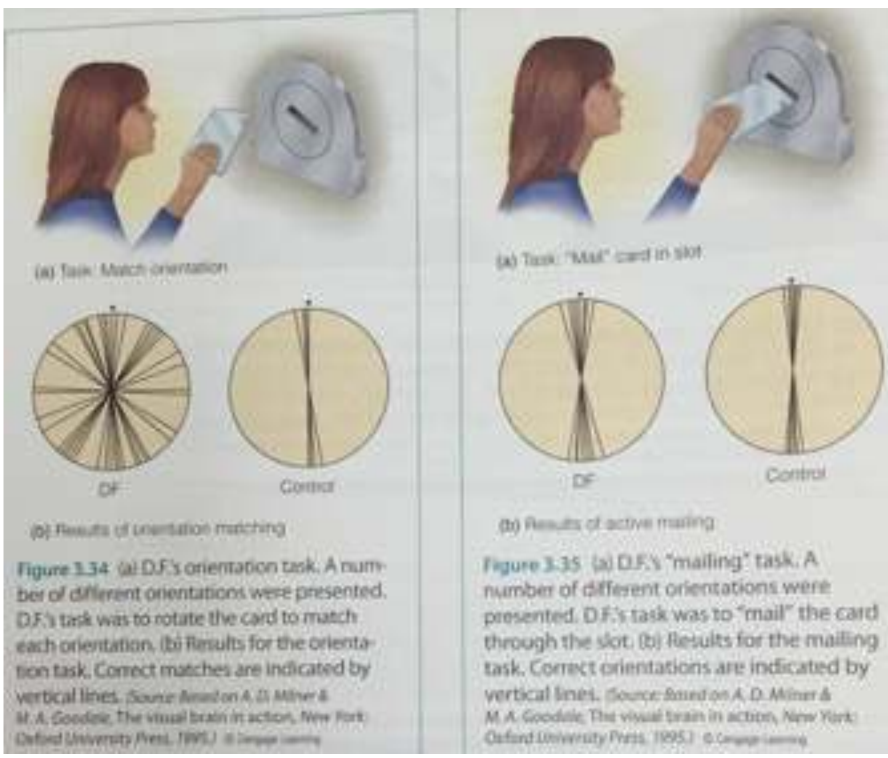
- Continued exposure to things that occur regularly in environment → neurons adapted to respond best to these regularities
- Neurons can reflect knowledge about properties of environment
- Action nearly always accompanies perception (may affect it too)

Interaction between Perceiving and Taking Action

- Movement facilitates Perception:
  - Movement helps us perceive objects in environment more accurately (not from single viewpoint)
  - E.g Distorted horse
- Interaction of Perception and Action:
  - Movement: helps us perceive objects by revealing additional information about them
  - Pick up coffee cup: 1) Perceiving and recognizing cup; 2) Reaching for it; 3) Grasping & picking it up
    - All automatic & interacted
- Physiology of Perception & Action:
  - 2 methods for physiological research:
    - 1) Brain ablation — study of effect of removing parts of brain in animals
    - 2) Neuropsychology — study of behavior of people with brain damage
  - <u>What and where streams:</u>
    - Leslie Ungerleider & Mortimer Mishkin: studied how removing part of monkey's brain affected ability to identify object & determine object's location (Brain ablation — removing part of brain)
      - Method: (Brain ablation // lesioning)
        - Determine function of a particular area of brain
        - Determine animal's capacity by testing it behaviorally (measure its perception) → Particular area of brain removed/destroy (by injecting chemical in area to be removed) → monkey tested to determine which perceptual capacities remain & which have been affected
      - Mishkin:
        - 2 tasks: 1) Object discrimination problem; 2) Landmark discrimination problem
        - Object discrimination problem: Shown rectangle → present with rectangle + another stimulus (i.e triangle) → monkey need to choose rectangle
        - Landmark discrimination problem: Tall cylinder that contains food → monkey remove cover

- **Temporal lobe** removed: object discrimination problem became difficult ~ temporal lobes responsible for determining object’s identity
    - *What* pathway — pathway leading from striate cortex to temporal lobe
- **Parietal lobe** removed: difficulty solving landmark discrimination problem ~ parietal lobe responsible for determining object’s location
    - *Where* pathway — pathway leading from striate cortex to parietal lobe
- Grabbing coffee: what ~ initial perception of cup; where ~ detrmining its location

- Perception & Action streams:
    - David Milner & Melvin Goodale: used neuropsychological approach to reveal 2 streams (1. temporal lobe, 2. parietal lobe)
        - D.F.: 34-year-old women (damage to temporal lobe from carbon monoxide poisoning)



- Couldn't match the orientation at first ~ Once she started moving the card toward the slot, she was able to rotate it to match the orientation
- Performed poorly at first, but did well once action was involved

- One mechanism for judging orientation and another for coordinating vision & action
- Perception pathway (what pathway) — Pathway from visual cortex → temporal lobe (damaged in DF’s brain)

- Action pathway (where pathway) — Pathway from visual cortex → parietal lobe (intact in DF's brain)

- Picking up a coffee cup and other behaviours:
  - Picking up a coffee cup:
    - 1) Identify coffee cup (perception of what & where pathway) → 2) Reach for coffee cup (action / where pathway) → 3) Position fingers to grasp the cup (action pathway) & Perception of cup's handle (perception pathway) → 4) Lift cup with force (action pathway) & Estimate how heavy based on perception of fullness of cup (perception pathway)
  - Hearing someone call your name & turning around to see:
    - 2 pathways:
      - 1) Hear and identify sound (auditory what pathway)
      - 2) Locate where the sound is coming from (auditory where pathway)
- Perception is "dynamic" ~ involves inference and taking knowledge into account & how closely perception is linked to action

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Something to Consider

- Where perception meets memory:
  - Perception provides a window on the world by creating sensory experiences
  - Memory creates window to the past (retrieving experiences) — have strong sensory components
  - Hagar Gelbard-Sagix: there is neurons in hippocampus — area involved in storing memories — that respond to seeing pictures & remembering them later
    - View 5~10 seconds video clips a few times - recording from neurons in their hippocampus
      - Some neutrons respond better
    - Think back of clips - record from neutrons
    - Remember Simpson — larger response
    - Neurons in hippocampus are involved in storing representations of memories
  - Method: (Recording from single neurons in humans)

Chapter 4 — Attention

- Attention — The ability to focus on specific stimuli or locations
- Selective attention — Attending to one thing while ignoring others
- Distraction — one stimulus interfering with the processing of another stimulus
- Divided attention — Paying attention to more than one thing at a time
- Attentional capture — Rapid shifting of attention usually caused by a stimulus (e.g loud noise, bright/sudden movement)
- Visual scanning — Movements of the eyes from one location or object to another

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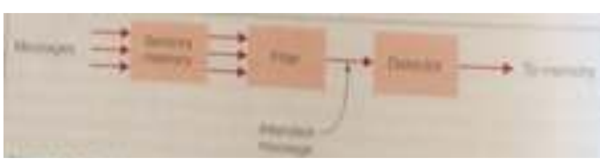
Attention as Information Processing

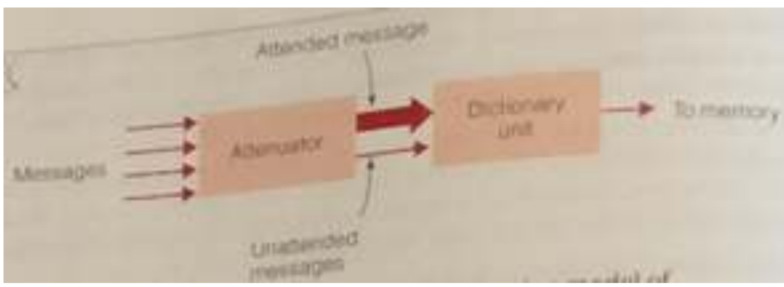
- Broadbent's Filter Model of Attention:
  - Filter model of attention
    - Dichotic listening — presenting different stimuli to left and right ears
    - Attended ear vs. Unattended ear
    - Shadowing —Focus word on one ear and repeating it
  - Colin Cherry: Can shadow spoken message + report unattended message (male/female) - cannot content
    - Not aware of info presented to unattended ear
  - Neville Moray: Subjects unaware of word repeated 35 times in unattended ear
  - Cocktail party effect — Ability to focus on one stimulus while filtering out other stimuli
  - Donald Broadbent: Model of Attention - how it is possible to focus on one message and why info isn't taken in from other message



    - 1. *Sensory memory* — Holds all incoming information (fraction of second) → Filter
    - 2. *Filter* — Identifies message being attended to based on physical characteristics (e.g tone of voice, pitch, speed of talking, accent etc)
    - 3. *Detector* — Processes info from attended message → Determine higher-level characteristics of message (i.e meaning) - only important, attended info let through filter
    - 4. *Short-term memory* — Holds info for 10~15 seconds → Transfer info into long-term memory

- Bottleneck model — Filter restricts info flow much as the neck of a bottle restricts flow of liquid
  - Filters info based on specific physical characteristics
- Early selection model — Filter eliminates unattended into right at the beginning of the flow of into
  - Bottom-up processing

- Modifying Broadbent's Model: More early selection models:
  - Neville Moray: Dichotic listening experiment - subjects shadow message presented to one ear and ignore the other ear
    - When Moray present listener's name to other ear - 1/3 of subjects detected it
  - J.A. Gray & A.I Wedderburn: "Dear Aunt Jane" experiment
    - One ear - "Dear 7 Jane" ; Another ear - "9 Aunt 6"
    - Result: Report "Dear Aunt Jane"
    - Switching channel — taking meaning of words into account
  - Anne Treisman — Attenuation model of attention (Leaky filter model) — language and meaning can also be used to separate messages



    - Attenuator (process) — Analyzes incoming message in terms of:
      - i) Physical characteristics (High/low-pitched, fast/slow)
      - ii) Language (how message groups into syllables/words)
      - iii) Meaning (sequences of words create meaningful phrases)
    - Attended message - full strength; Unattended message - still presented but weaker
    - Dictionary unit — contains words, stored in memory, has threshold for being activated
      - Words that are common / especially important - low thresholds

- Late Selection Model:
  - Donald MacKay:
    - 1. One ear - ambiguous sentence - "They were throwing stones at bank" ; Another ear - biasing words - "river" / "money"

- 2. Pairs of sentences - “They threw stones toward side of river” & “They threw stones at savings and loan association” → Indicate closest meaning to sentence they heard perviously
- Results: Biased words affect subjects’ choice
- Late selection models of attention — most of incoming info is processed to level of meaning before message to be further processed is selected

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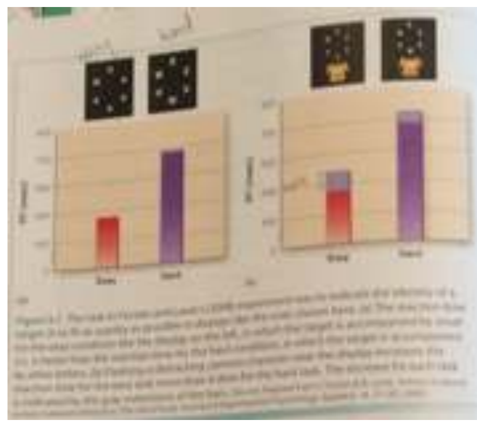
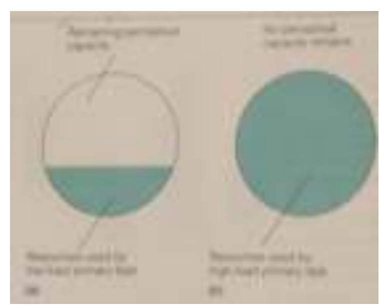
Processing Capacity & Perceptual Load

- Processing capacity — Amount of information people can handle and sets limit on their ability to process incoming information
- Perceptual load — Difficulty of a task
  - Low-load tasks - easy, use up small amount of person’s processing capacity
  - High-load tasks - difficult, use more processing capacity
- Sophie Froster & Lavie:



  - Distractions (e.g letters) + target letter (i.e N or X)
  - Results:
    - Easier - target surround by one type of letter
    - Harder - different letters
    - Difference - shown by reaction time
    - Task-irrelevant stimulus: unrelated cartoon



      - Respond slows for easy more than hard task
      - Load theory of attention — low-load task, still processing capacity left - resources available to process task-irrelevant stimulus - slows down responding
        - For high-load task: No resources remain to process other stimuli - irrelevant stimuli can’t be processed
- Stroop effect — situation in which task-irrelevant stimuli are difficult to ignore
  - Identify color of shapes vs. color of printed color words
  - Names of words cause competing response → slows responding
  - Powerful distraction - reading words automatic

Attention as Selection: Overt and Covert Attention

- Overt attention — Shifting attention from one place to another by moving eyes

- Covert attention — Shifting attention from one place to another while keeping eyes stationary
- Overt attention: Scanning a scene with eye movements:
  - Central vision — area you are looking at
    - Objects in fovea (has better detail vision)
  - Peripheral vision — everything off to the side
  - Fixation — Briefly paused on one target
  - Saccadic eye movement — rapid, jerky movement from one fixation to the next
  - How people shift attention by moving eyes:
    - *Bottom-up* — Based on physical characteristics of stimulus
    - *Top-down* — Cognitive factors (e.g knowledge about scenes & past experiences with specific stimuli)
  - Scanning based on <u>stimulus salience</u>:
    - Stimulus salience — physical properties of stimulus (e.g color, contrast, movement)
    - <u>Bottom-up processing</u> - depends solely on pattern of light & dark, color & contrast - without meaning
    - Attention capture - attention due to stimulus salience causes involuntary shift of attention - serves as a warning of something dangerous
    - Analyzing characteristics (e.g color, orientation, intensity) at each location → Combine these values to create Saliency map
    - Derrick Parkhurst: Calculate saliency map → measure fixations
      - First few fixations - light areas on saliency map - fixations more likely on high-saliency areas
      - After first few fixations - scanning influenced by top-down / cognitive processes (depend on things such as observers' goals and expectations determined by past experiences in observing environment)
  - Scanning based on <u>cognitive factors</u>:
    - *Meaning* attracts attention
    - <u>Top-down processing</u> - Scene schemas — observer's knowledge about what is contained in typical scenes
    - Melissa Võ & John Henderson: Picture of kitchen
      - Look longer at printer than pot - printer not usually found in kitchen
      - Look at things out of place - attention affected by knowledge of what is usually found in the scene
    - Hiroyuki Shinoda: Measure fixations → test ability to detect traffic signs in driving stimulation
      - Drivers more likely to detect stop signs in intersection (45%) than middle of block
      - Regularities of environment

- Scanning based on <u>task demands</u>:
  - Where people look - determined by sequence of actions involved in task
  - Eye movement preceded a motor action by fraction of second
    - "Just in time" strategy — eye movements occur just before we need the information they will provide
      - Eye movement faster than real movement
- Covert attention: Directing attention without eye movements:
  - Attention to location:
    - Michael Posner: whether paying attention to location improves ability to respond to stimuli presented there
      - Precueing procedure: whether test stimulus will enhance processing of target stimulus
        - Arrow pointing to left/right → Square appears on left/right
        - Valid trial: target square appears on side indicated (80%)
        - Invalid trial: arrow directed subject's attention away from target square (20%)
      - Results: reaction time significantly longer for invalid trial
  - Attention to objects:
    - Egly:

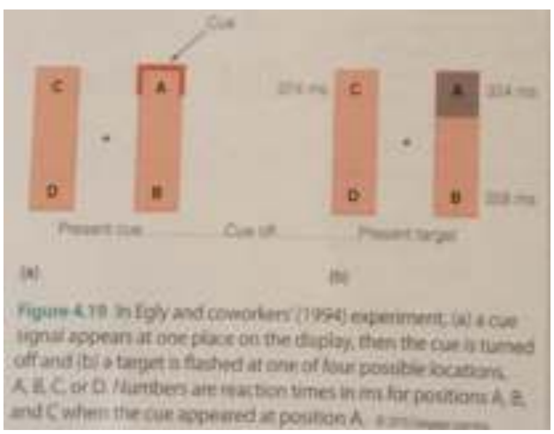


Figure 4.10 In Egly and coworkers' (1994) experiment, (a) a cue signal appears at one place on the display, then the cue is turned off and (b) a target is flashed at one of four possible locations, A, B, C or D. Numbers are reaction times in ms for positions A, B, and C when the cue appeared at position A.

    - B's advantage - located within object receiving subject's attention
    - Same-object advantage — Faster responding that occurs when enhancement spreads within an object

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Divided Attention: Can we attend to more than one thing at a time?

- Divided attention — distribution of attention among two or more tasks
- Divided attention can be achieved with practice: Automatic processing:
  - Walter Schneider & Robert Shiffrin:

- 2 tasks: 1) Hold information about target stimuli in memory; 2) Pay attention to series of "distractor"stimuli determine whether one of target stimuli is present among these distractor stimuli
- Memory set: target stimuli → test frames containing distractors → whether target stimuli is in distractors
- Results: beginning: 55% → after 900 trials: 90%
  - After 600 trials - task become automatic
- Practice made it possible to divide attention
- Automatic processing — type of processing that occurs (1) without intention and (2) cost only some of person's cognitive resources (e.g Locking door)

- Divided attention becomes more difficult when tasks are harder:
  - Using letters for both targets + distractors // changing targets and distracts on each trial so target on one trial can be distractor on another ⇒ automatic processing not possible even with practice
- Distractions while driving:
  - Study: 100-Car Naturalistic Driving: vid records driver + view out front & rear windows
    - 82% crashes (80%) & 771 near crashes (67%) - driver was inattentive 3 seconds beforehand
    - Study: Toronto Cell phone use & traffic accidents - risk of collision 4 times higher
    - Hands-free cell phone units offered no safety advantage
  - David Strayer & William Johnson: apply brakes as quickly as possible when presented red light
    - While talking on cell phone - miss twice as many; ↑ time to apply brake
    - Fraction of red lights missed + Reaction time ↑
    - Talking on phone use cognitive resources ⇒ fewer cognitive resources available to focus attention on driving
  - Toronto study - same ↓ in performance regardless of using hands-free cell phone / handheld model
  - Talking on cell phone vs. talking to passenger in car - passenger aware of traffic situation
  - Study: 2008 survey by Nationwide Mutual Insurance: 45% report been hit / nearly been hit
    - Identify talking on phones as risky - but think others are dangerous not themselves
  - Study: Virginia Tech Transportation Institute: truck drives send text while driving - 43% more likely to crash
  - Anything that distracts attention → degrade driving performance
  - *Measuring Cognitive Distraction in the Automobile*: voice-activated activities more distracting

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What happens when we don't attend?

- Inattentional blindness:

- Inattentional blindness — not attending to something that is clearly visible
- Arien Mack & Irvin Rock: subjects can be unaware of clearly visible stimuli if they aren't directing their attention to them
  - Ula Cartwright-Finch & Nilli Lavie: Cross stimulus - which arm is shorter in length
    - On 6th trial: square was aded to display
    - Only 10% reported they seen the square
- Look at display on window - fail to notice reflections on surface of window
- Daniel Simons & Christopher Chabris: Attention can affect perception within a dynamic scene
  - Created 75-sec film: basketball between white & black shirt - count number of passes on team white
    - After 45 seconds - woman carrying an umbrella / person in gorilla suit walked through (5 seconds)
    - 45% of observers failed to report they saw woman/gorilla
  - Observers attending to one sequence of events, can fail to notice other events when when right in front o them

- Change detection:
  - Lack of attention - using change detection
  - Ronald Rensink: found that pictures had to alternate back and forth before differences was detected
  - Change blindness — Difficulty in detecting changes in scenes
    - Added a cue - indicate which part of scene had been changed → subjects detect changes more quickly
  - Also when changes in different shots of a film - only 1/10 notice any changes
    - Continuity errors — some aspect of scene that should remain the same changes from one shot to the next

- What about everyday experience:
  - Our perceptual system focus on only small portion of environment - most adaptive features - making optimal use of our limited processing resources
  - Fei Fei Li:
    - Look at fixation point → *Central stimulus* (array of 5 letters) → *Peripheral stimulus* (either disc that was half green half red / picture of scene) for 27 ms at random position on edge of screen
    - *Central task* - indicate all letters in central stimulus were same
    - *Peripheral task* - indicate wether scene contained animal (90%) / whether disc red-green or green-red (50%)
    - Possible to take in information about some objects but not others in scenes even when attention is focused elsewhere
  - Lila Reddy: peripheral task - picture of face showed male / female - same result

Attention and Experiencing a Coherent World

- Binding — Process by which features such as color, form, motion, and location are combined to create our perception of a coherent object
- Why is binding necessary?
    - Due to localization of function - experiences integrated perception of movement
    - Binding problem — how object's individual features become bound together - Anne Treisman's *True integration theory*
- Feature integration theory?
    - Feature integration theory — how we perceive individual features as part of same object (2 stages)
    - Preattentive stage:
        - Preattentive stage — objects are analyzed into separate features
        - Features exist independently of one another
        - Occurs early in perceptual process - before we become conscious of the object
        - Anne Treisman & Hilary Schmidt: 4 objects + 2 black numbers (1/5 of second)
            - Subjects - report numbers first → report 4 objects
            - 18% - combination of features from 2 different stimuli ⇒ Illusory conjunctions
                - E.g Red small triangle → Red small circle, Interchanging colors of objects
            - Independent features - "free floating" → incorrectly combined if there is more than one object
    - Focused attention stage:
        - Focused attention stage — "Free-floating" features are combined
        - Attention is important - Treisman experiment - ask subjects to ignore black numbers this time, focus all attention to 4 objects
            - Eliminated illusory conjunctions → all shapes paired with correct colors
        - Patient R.M (damaged parietal lobe) - Balint's syndrome — inability to focus attention on individual objects
            - Difficult to combine features correctly - reported illusory conjunctions 23% of trials
            - Cannot perform conjunction search
        - Mostly bottom-up processing (knowledge usually not involved)
        - Visual search — something we do when we look for an object among a number of other objects (e.g Where's Waldo)
        - Conjunction search — search for a combination of two or more features in the same stimulus: 1. Feature search — searching for a particular feature in stimulus → then add more features

Something to Consider

- Taking possession by Brain:
  - William James: Attention - *taking possession by the mind*
  - Paying attention enhances brain activity
  - Topographic map (spatial map of visual stimuli on visual cortex) — each point on visual stimulus causes activity at specific location on visual cortex, points next to each other on stimulus cause activity at points next to each other on visual cortex
  - Roberto Datta & Edgar DeYoe: How shifts of attention affect activity of brain
    - Observer covertly shift attention to different locations on display (measure brain activity on fMRI)
    - Shift attention → change brain activity - yellow "hot spot"
    - Attention maps - show how directing attention to specific area of space activates specific area of brain
      - Can predict where observer is paying attention to with 100% accuracy
  - Kathleen O'Craven: Attention on one of two superimposed stimuli (face & house)
    - One still, another one moving back & forth
    - When subject focus on one stimulus - measure activity in fusiform face area and parahippocampal place area
      - Attend to moving / stationary face - activity ↑ in FFA
      - Attend to moving / stationary house - activity ↑ in PPA
- Both perception + attention support our ability to know about our environment and act within it

Chapter 5 — Short-Term and Working Memory

- 2 definitions of memory:
  - Memory — Process involved in retaining, retrieving, and using information about stimuli, images, events, ideas, and skills after the original information is no longer present
  - Memory is active any time some past experience has an effect on the way you think / behave now or in the future
- 5 types of memory:
  - Sensory memory: brief persistence of image
  - Short term memory / working memory: Information that stays in memory for brief periods (10~15 seconds) if we don't repeat it
  - Long-term episodic memory: Long-term memories of experiences from the past
  - Long-term procedural memory: Ability to do things that involve muscle coordination (e.g ride bike)
  - Long-term semantic memory: Memories of facts (e.g address / birthday / name of objects)

Modal Model of Memory

- Donald Broadbent's filter model of attention
  - Use flow chart guide information processing approach to cognition
- Richard Atkinson & Richard Shiffrin: Modal model of memory (3 types of memory):
  - 1) Sensory memory: Initial state that holds all incoming information for seconds or fractions of second
  - 2) Short-term memory: Holds 5 ~ 7 items for about 15 ~ 20 seconds
  - 3) Long-term memory: Hold large amount of information for years or even decades
  - Structural features — Boxes that indicated the types of memory listed above
  - Control processes — Dynamic processes associated with the structural features that can be controlled by the person and may differ from one task to another
    - E.g Rehearsal (short term memory) — repeating a stimulus over and over
    - E.g Other strategies to make a stimulus more memorable (e.g relating digits of phone number to date in history)
    - E.g Strategies of attention that focus on information that is important / interesting

- Encoding — Process of storing information in long-term memory
- Retrieval — Process of remembering information that is stored in long-term memory

- Components of memory do not act in isolation

Sensory Memory

- Sensory memory — Retention, for brief periods of time, of the effects of sensory stimulation
- Sparkler's Trial and Projector's Shutter:
  - Persistence of vision: — Continued perception of a visual stimulus even after it is not longer present
    - E.g Sparkler: Retention of perception of light in your mind
    - E.g Film: Transition of still images (24 times per second)
- Sperling's Experiment: Measuring the Capacity and Duration of Sensory Store:
  - George Sperling: How much information people can take in from briefly presented stimuli
    - Flashed letters for 50millisec → Report as many letters as possible
    - Whole report method — Subjects were asked to report as many letters as possible from the entire 12-letter display
      - Results: Report an average of 4.5 out of 12 letters
      - Subjects report they seen all 12 letters but perception faded rapidly as they report
    - Partial report tone method — Subjects were told to report letters in a single 4-letter row
    - Partial report tone immediate: Tones were presented immediately after the letters were turned off
      - Results: Report 3.3 of the 4 letters (82%)
    - Delayed partial report method — letters were flashed on & off and then cue tone was presented after a short delay
      - Delayed for 1 second: Report only slightly more than one letter in a row
    - Iconic memory / visual icon — sensory memory stage of Atkinson & Shiffrin's modal model
      - Retains information for only a second or fraction of a second
    - Echoic memory — persistence of sound (lasts for a few seconds after presentation of stimulus)

Short-Term Memory

- Short-term memory — System involved in storing small amounts of information for a brief period of time

- Window on the present
- Method: (Recall)
  - Recall — Subjects are presented with stimuli and, after a delay, asked to report back as many of stimuli as possible
  - Memory performance: Measured as percentage of stimuli that are remembered
  - Subject's responses can be analyzed: whether there is pattern to items are recalled
- What is the duration of Short-term memory:
  - John Brown & Lloyd Peterson & Margaret Peterson: Used method of recall to determine duration of STM
  - Give 3 letters + 3 numbers → Number minus 3 → Recall the 3 letters
    - Results: 3 seconds count - remember 80% of three-letter groups; 18 seconds - 12%
    - Memory traced vanished because of decay that occurred during the passage of time after hearing the letters
  - Geffory Keppel & Benton Underwood: Subject's performance dropped after a few trials
    - Proactive interference — interference that occurs when information that was learnt previously interfere with learning new information
    - Retroactive interference — learning new information interfere with remembering old learning
  - STM - due to constant interference - only 15~20 seconds or less
- How many itms can be held in short-term memory?
  - Digit span:
    - Digit span — number of digit a person can remember
    - George Miller: "Magical number 7, plus or minus 2" - Average capacity of STM: 5~9 items
  - Change Detection:
    - Steven Luck & Edward Vogel: Change detection
    - Method: (Change detection)
      - 2 pictures of scene were flashed one after the other → Subject has to identify the difference
      - Conclusion: People after miss changes in a scene
      - Determine how much information people can retain from a briefly flashed stimulus

- E.g Show an image on left (100 ms) → Blank image (900 ms delay) → Another image on right (2,000 ms) → Same or different
- Easy if number of its is within capacity of STM
- Results: Perfect when there were 1 ~ 3 squares (items)
  - Performance ↓ when 4 or more squares

- Chunking:
  - Miller: Chunking — small units can be combined into larger meaningful units
  - Chunk — Collection of elements that are strongly associated with one another but are weakly associated with elements in other chunks
  - K. Anders Ericsson: Effect of chunking
    - Subject - S.F - Repeat strings of random digits
      - At first: 7 digits
      - After training: 79 digits (through chunking)

- How much information can be held in Short-term memory?
  - Instead of "number of items" → should measure in "amount of information"
  - George Alvarez & Patrick Cavanagh: Used **change detection** method
    - Using complex stimuli (e.g coloured squares, chinese characters, random polygons, shaded cubes)
    - Result: Memory capacity ~ Colored squares: 4.4; Shaded cubes: 1.6
    - Conclusion: Greater the amount of information, fewer items can be held in visual short-term memory
  - Considering items/information: upper limit for STM: about 4 items
  - STM → Working memory → LTM

Working Memory

- Working memory — Baddeley & Hitch — Limited-capacity system for temporary storage *and manipulation of information for complex tasks such as comprehension, learning and reasoning*
- STM: storing // limited time ; WM: manipulation of information
- Involves both *holding* information in memory + *processing* information
- WM: Dynamic & consist of components that function separately:
  - 1) Phenological loop (has 2 components)

- Phenological store — has a limited capacity & holds information for only a few seconds
  - Holds verbal & auditory information
- Articulatory rehearsal process — responsible for rehearsal that keep items in phenological store from decaying

- 2) Visuospatial sketch pad — holds visual & spatial information
  - E.g forming picture in mind / finding your way around campus / solving puzzle
- Phenological loop & Visuospatial sketch pad connected to central executive — major work of working memory occurs
- Pulls information from long-term memory and coordinates activity of phonological loop & visual spatial sketch pad (by focusing on specific parts of task & divides attention)
  - E.g driving: Phenological loop: taking in verbal directions; sketch pad: visualizing a map of streets
    - Coordinating & combining 2 kinds of information

- Phenological loop:
  - Phonological similarity effect:
    - Phonological similarity effect — confusion of letters or words that sound similar
    - R. Conrad: flashed series of letters on screen, subjects write down letter in order
      - Results: Errors: misidentify another letter that *sounded like* the target letter
        - E.g "F" misidentified as "S" or "X"
  - Word length effect:
    - Word length effect — memory for lists of words is better for short words than for long words
    - More difficult to remember when words are longer
    - Baddeley: tested word length effect
      - Results: 77% short words; 60% long words
      - Takes longer to rehearse the long words & produce them during recall
    - Baddeley: remember items in about 1.5 ~ 2 seconds
      - Number of words able to produce ~ close to digit span
  - Articulatory suppression:
    - Study phonological loop - determining what happens when its operation is disturbed
      - Prevented from rehearsing items (repeating an irrelevant sound)

- Articulatory suppression — Repetition of an irrelevant sound — reduces memory because speaking interferes with rehearsal

- Baddeley: repeating "the, the, the…" when remember list of words

  - Results: Reduce ability to remember list of words + eliminates word length effect (eliminates advantage for short words, both short & long words are lost from phonological store)

- Visuospatial sketch pad:

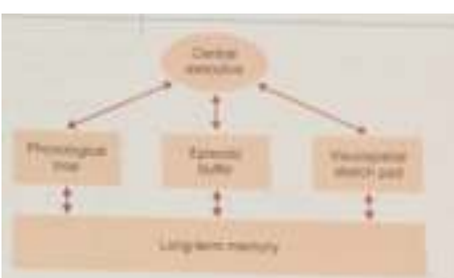
  - Handles visual & spatial information
  - Visual imagery — creation of visual images in mind in the the absence of a physical visual stimulus
  - Roger Shepard & Jacqueline Metzler: Comparing objects (view two images from different perspectives and decide whether they are same or different)
    - Results:
      - Rotate 40º - 2 seconds to decide they are the same
      - Rotate 140º - 4 seconds
      - Reaction time longer for greater differences in orientation
    - Mental rotation — Subjects were solving problem by rotating an image of one of the objects in mind
  - Sergio Della Sala: Recalling visual patterns
    - See patterns of shaded squares → Recreate pattern
    - Results: Complete patterns consisting of avg. 9 squares
    - Individual squares can be combined into subpattens (chunking → ↑ number of squares remembered)
  - Lee Brooks: Demonstrated interference can affect operation of visuospatial sketch pad
    - Outside // Inside corner of F
      - 1) Point Out / In in chart when go through outer or inner corner
      - 2) Say "Out" / "In" when go through outer or inner corner
      - Second task easier - holding image of letter & pointing are both visuospatial tasks (overloaded)
      - Saying "Out" / "In" - articulatory task handled by phonological loop

- Central executive:

  - Not store information, but coordinate how information is used by phonological loop & visuospatial sketch pad
  - *Attention controller* - how attention is divided, how it is switched between tasks

- Frontal lobe patient - problem controlling their attention - Perseveration — repeatedly performing the same action or thought even if it is not achieving the desired goal
  - E.g “Pick the red object” - can solve ; switch to “Pick the blue object” - person continues following old rule (perseveration represents a breakdown in central executive’s ability to control attention
- Edmund Vogel: separating groups based on performance on test of working memory
  - *High-capacity group*: hold number of items in working memory
  - *Low-capacity group*: hold fewer items in working memory
  - Tested under change detection: Red rectangles → Blank delay → Red reactants
    - Whether the red rectangles had the same / different orientations
    - Measure event-related potential (ERP) — how much space was used in working memory as they carried out the task
    - Method (Event-related potential):
      - Picks up signals from neutrons that fire together when making judgement
      - Larger ERP response - more space is used in working memory
      - 1) Only red bars - Similar results for low & high working memory group
      - 2) Add some blue bars - Low working memory group have higher ERP response; High working memory group have similar ERP response as only red bars
        - High capacity group very efficient at ignoring distractors (irrelevant blue stimuli did not take up much space in working memory)
        - Low capacity group - blue bars taking up space in WM
    - More efficient working memories are more likely to perform well on tests of readings & Reasoning abilities

- Episodic Buffer:
  - Episodic buffer — store information (providing extra capacity) and is connected to LTM (making interchange between working memory & LTM)



- Nelson Cowan: Working memory and attention are essentially the same mechanism

Working Memory and Brain

- Major methods to determine connection between cognitive functioning and brain:
    - 1) Analysis of behaviour after brain damage (human / animal)
        - Double dissociation (Chp 2); Brain Ablation (Chp 3)
        - How removal of prefrontal cortex affects ability to remember for short periods of time
    - 2) Recording from single neurons in animals (Chp 2)
        - How neurons in monkey prefrontal cortex hold information during a brief delay
    - 3) Measuring activity of human brain (Brain imaging Chp 2)
        - Areas of brain that are activated by working memory tasks
    - 4) Recoding electrical signals from human brain (Event-related potential)
- Effect of Damage to Prefrontal Cortex:
    - Damage to frontal lobe → Problems in controlling attention
    - Delayed-response task — required monkey to hold information in working memory during delay period
        - Monkey sees food in one or two food wells → Cover screen → Monkey remember which food well
        - If prefrontal cortex is removed → performance drops (correct food well half of the time)
    - Prefrontal cortex (PF) hold info for brief time
    - PF in infants not well developed (until 8 months of age)
- Prefrontal neurons that hold information:
    - How PF cortex are able to hold information after original stimulis is no longer present
    - Shintaro Funahashi: Recorded neurons in monkey's PF cortex while monkey carried a delayed response task
        - Monkey look at a fixed point → Square flashed at different position on screen → Small response in neuron → delay
            - During delay: neuron continued firing - monkey's working memory for position of square
            - Some neutrons respond to specific location
- Holding information in the Visual cortex:
    - Stephanie Harrison & Frank Tong: Test working memory:

- 2 samples of oriented objects → 11 seconds delay → test grating present → subject indicates whether grating rotate clockwise / anticlockwise (brain activity measured with fMRI)
- METHOD (neural mind reading):
  - Neural mind reading — using a neural response, usually brain activation measured by fMRI, to determine what a person is perceiving / thinking
  - fMRI - measures what voxels (small cubed-shape areas of brain) are activated while subject carries out task
  - Pattern of voxels - depends on task & nature of stimulus being perceived / remembered
- Yukiyasu Kamitani & Frank Tong: Used neural mind reading to predict what orientation a person is looking at 75 ~ 100%
- Harrison & Tong: Used neural mind reading to predict what orientation a person is holding in mind during the 11 seconds delay (83% accuracy)
- Distributed representation: E.g number of areas of brain involved in working memory

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Something to Consider

- Math performance & Working memory:
  - Mark Ashcraft & Elizabeth Kirk: how math performance would be affected by having to carry out another task that used some of a person's working memory
    - Carry group: Involves more complex math problem
    - *Duel-task condition* group: Perform math problem + hold 6 letters in memory
    - *Control condition* group: Only math problem
    - Results: Error increases for duel-task, especially for carry group (requires more working memory)
      - Letter memory drained some working memory resources required by math task
    - Related to "choking under pressure" - pressure causes subjects to worry about testing situation and use some of working memory capacity
  - Ramirez & Beilock: Eliminating worrying ↓ choking under pressure effect
    - *Control group*: Math preset + instruction for high pressure → Sat quietly for 10 minutes → Post-test
    - *Expressive writing group*: Math preset + instruction for high pressure → Write about their thoughts for 10 minutes → Post-test
    - Results: Error in post test ↑ for control group, but ↓ for expressive writing group
      - Expressive group - worry less - expressed their worries before post test (free working memory)

Chapter 6 — Long term memory: Structure

- *Division* — distinguishing between different types of memory
  - E.g Short-term, long-term, episodic memory; semantic memory; procedural memory
- *Interaction* — Different types of memory can interact and share mechanisms

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Comparing Short-Term and Long-Term Memory Processes

- Long-term memory (LTM) — system responsible for storing information for long periods of time
  - "Archive" of information about past events in our lives & knowledge we have learnt
- Distinguish LTM & STM:
  - Duration: LTM - long ; STM/WM - very short
  - Capacity: LTM - very large ; STM/WM - very limited
- Serial position curve: Percentage of subjects recalling each word versus its position in the list
- Serial position curve:
  - Memory is better for words at the beginning of list and end of list than words in the middle
  - Primacy effect — subjects are more likely to remember words presented at beginning of sequence
    - More time to rehearse words → LTM
    - Dewey Rundus: tested primacy effect (subjects have more time to rehearse):
      - 1) Presented list of 20 words (1 word every 5 seconds)
        - Write down the words — Serial position curve (Primacy effect)
      - 2) Repeat the words out loud
        - Rehearsal curve matches initial part of serial position curve
  - Recency effect — Better memory for the stimuli presented at the end of sequence
    - Most recently presented words are still in STM - easier for subjects to remember
      - Storage of recently presented items in STM
    - Murray Glanzer & Anita Cunitz: Subjets recall words backwards for 30 seconds (prevented rehearsal and allowed time for information to be lost from STM) — delay eliminated recency effect

Procedure	Illustrates
Subject begins recall immediately after hearing list of words	Primacy effect & Recency effect
List is presented and subject repeats words out loud in 5-seconds intervals between words	Words at beginning of list are repeated more, so they are more likely to get into LTM — Primacy effect
Subject begins recall after counting backwards for 30 seconds	Recency effect is eliminated because rehearsal is prevented

- Coding in Short-term and Long-term memory:
  - Coding — form in which stimuli are represented
    - Physiological approach to coding — determining how stimulus is represented by firing of neurons
    - Mental approach to coding — how stimulus / experience is represented in mind
  - Visual coding (coding in mind in form of visual image)
  - Auditory coding (coding in mind in form of sound)
  - Semantic coding (coding in mind in terms of meaning)
  - Visual coding in short-term and long-term memory:
    - Use visual coding when visualize a person / place from past
  - Auditory coding in Short-term & Long-term memory:
    - Conrad's demonstration of phonological similarity effect (misidentify target letters as another that sounds like target)
    - E.g Play songs - listened to playlist many times, can "hear" beginning of next song during silence
  - Semantic coding in Short-term memory: Wickens Experiment:
    - Delos Wickens: semantic coding in short-term memory
      - Presented with words related to either a) fruits / b) professions → Listen to 3 words → Count backward for 15 seconds → Recall 3 words → Total of 4 trials
      - Subjects recalled words so soon after hearing - using STM
      - Create proactive interference — decrease in memory that occurs when previously learnt information interferes with learning new information
        - High performance for trial 1 but ↓ trials 2 & 3, but ↑ trial 4
          - Release from proactive interference — increase in performance
          - Depends on words' categories - categories involves the meanings of words — semantic coding

- Semantic coding in Long-term memory: Sachs Experiment:
  - Jacqueline Sachs: Semantic coding in LTM
    - Subjects listen to tape recording of passage → Measure their *recognition memory* - determine whether they remembered exact wording of sentences or just general meaning
    - Method (Measuring Recognition Memory):
      - Recognition memory — identification of stimulus that was encountered earlier
      - Present stimulus during study period → Present same stimulus + others that were not presented → Subjects indicate whether word was presented previously or not (yes/no)
    - Demonstration: Subjects hear a passage → Offer few sentences to pick which one identical to a sentence in passage
      - Result: Specific wording is forgotten but general meaning can be remembered for a long time
      - Meaning as an example of semantic coding in LTM

- Comparing coding in Short-term & Long-term memory:
  - Depends largely on task
  - Auditory coding - predominant type of coding in short-term memory
  - Semantic coding - predominant type of coding in long-term memory

Code	Short-Term Memory	Long-Term Memory
Visual	Holding an image in mind to reproduce a visual pattern that was just seen	Visualizing what Lincoln Memorial in Washington D.C, looked like when you saw it last summer
Auditory (STM)	Representing the sounds of letters in mind just after hearing them	Song you have heard many times before, repeating over and over in mind
Semantic (LTM)	Placing words in STM task into categories based on meaning	Recalling general plot of novel you read last week

- Locating memory in Brain:
  - Some evidence that STM & LTM are separated in brain ; some evidence for overlap
  - Neuropsychology:
    - Henry Molaison (patient H.M): Eliminate his severe epileptic seizures - removal of hippocampus
      - Successfully decreasing seizures but eliminated his ability to form new LTM
      - STM remained intact (remember what just happened), but unable to transfer into into LTM
      - Brenda Milner: tested H.M for many times but he doesn't recognize her

- Hippocampus — forms new LTM

- Clive Wearing (musician & director): Viral encephalitis (腦炎) - destroyed parts of medial temporal lobe (including hippocampus, amygdala & other structures in temporal lobe)
    - Remembers the most recent 1 or 2 minutes of life and forget everything else
    - Demonstrates separation of STM & LTM
- Patient K.F: Damage to parietal lobe in motorbike accident
    - STM reduced digit span
    - Had functioning LTM and can for new memories of events in life
- K.F and (H.M & Clive Wearing) : establish a double dissociation between STM & LTM

Patient	**STM**	**LTM**
H.M & Clive Wearing	OK	Impaired
K.F	Impaired	OK

- STM & LTM are caused by different mechanisms - act independently

- Brain imaging:
    - Charan Ranganth & Mark D'Esposito: Whether hippocampus (for storing LTM) also helps store STM
        - Sequence of stimuli presented to subjects as they are having their brain scanned (1 second) → 7 seconds delay → Test face presented (whether it matches sample face)
        - 1) "novel face" condition - seeing each face for first time — Activity in hippocampus ↑
        - 2) "Similar face" condition - faces had seen prior to experiment — Activity slightly changes
        - Hippocampus is involved in maintaining novel information in memory during short delays
    - Hippocampus & other medial temporal loe structures involved in LTM but also play some role in STM

Episodic & Semantic Memory

- Distinctions between episodic & semantic memory:
    - Handle different *types of information* remembered; *type of experience* associated
    - Differences in experience:
        - Tulving: defining property of episodic memory involves - Mental time travel — experience of traveling back in time to reconnect with events that happened in the past

- Experience of mental time travel/episodic memory — *self-knowing // remembering*
- Semantic memory - accessing knowledge about world that does not have to be tied to remembering a personal experience (i.e facts, vocabulary, numbers & concepts) — *knowing*

- Neuropsychology:
  - Case of K.C: damaged hippocampus and surrounding structures
    - Lost episodic memory (no longer remember past events); semantic memory intact
    - Know certain things happened - brother died 2 years ago, eating utensils are located in kitchen, difference between strike and spare in bowling
  - Italian woman: suffered attack of encephalitis (腦炎)
    - Headache & fever → hallucination → difficulty recognizing familiar people → trouble shopping (couldn't remember meaning of words → no longer recognize famous people / recall facts
    - Lost semantic memory but still able to form new episodic memories
  - Double dissociation — Episodic & Semantic memory involve different mechanisms
- Brain imaging:
  - Brain Levine: brain imaging experiment - subjects keep diaries on audiotape describing everyday personal events + facts from semantic knowledge
    - Subjects listen to audiotaped descriptions in fMRI
      - Everyday events - elicited episodic autobiographical memories
      - Other recordings - reminded people of semantic facts
      - Yellow areas - brain regions associated with episodic memories
      - Blue areas - brain regions associated with semantic, factual knowledge
      - Can be overlap between activation caused by episodic & semantic memories, also major differences

- Interactions between Episodic & Semantic memory:
  - Knowledge (semantic) affects experience (episodic):
    - E.g Watching baseball game - know where to look, what is going to happen
    - Our knowledge (semantic memory) guides our experience, and this, influences the episodic memories that follow from that experience
  - Makeup of autobiographical memory (contains both semantic & episodic components):

- Autobiographical memory — memory for specific experiences from our life, which cnan include both episodic and semantic components
- E.g Meeting Gil and Mary at Le Buzz (coffee shop), hard to get in in the morning
  - Episodic components: meeting Gil & Mary
  - Semantic components: Le Buzz is coffee shop; table difficult to get in morning
- Personal semantic memories — Facts associated with personal experiences

Type	Definition
Episodic	Memory for specific personal experiences, involving mental time travel back in time to achieve a feeling of reliving the experience
Semantic	Memories for facts
Autobiographical	People's memories for experiences from their own lives. These memories have both episodic (relived specific events) + semantic (facts related to these events) components. These semantic components of autobiographical memory — personal semantic components

- Robyn Westmacott & Morris Moskovitch: people's knowledge about public figures - include both semantic + episodic components
  - E.g Know Oprah Winfrey had TV program - pure semantic
  - E.g Remember watching Oprah Winfrey's TV shows - memory include episodic components
  - Autobiographically significant semantic memories - Memories involving personal episodes
    - Test people's ability to remember public figures - better if have higher autobiographical significance - more likely to remember name of singer if attended concerts

- What happens to Episodic & Semantic memories as time passes:
  - Measure: present stimuli → after time passes → ask subject to real stimuli
  - Forgetting - not "all-or-nothing" process:
    - Familiarity - can't remember details about specific experiences involved (semantic memory)
    - Recollection - remember specific experiences related (episodic memory)
    - ⇒ Remember/know procedure
  - Method: (Remember/Know procedure) ~ remember - episodic; know - semantic
    - 1) Remember if stimulus is familiar and also remember circumstances under which they encountered
    - 2) Know if stimulus seems familiar but don't remember experiencing it
    - 3) Don't know if they don't remember stimulus at all

- Raluca Patrican: If people's memory for public events change over time
  - Present descriptions of events happened over 50 years to adults
  - Respond according to Remember/Know procedure (the 3 questions above)
  - Results: Most recent (10 years) - Know > Remember > Don't know ; 40-50 years ago - Know > Don't know > Remember
    - Memories for 40-50 years events had lost mouch of their episodic character
  - Semanticization of remote memories - loss of episodic detail for memories of long-ago events
    - How you acquired knowledge that makes up semantic memories
      - Knowledge in semantic memories initially through personal experiences (episodic memories), but memory for these experience often fades, only semantic memory remains

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Imagining the Future

- x predict future, create possible scenarios about future
- Patient K.C: lost episodic memory due to brain damage
  - Unable to use imagination to describe personal events that might happen in the future
- Patient D.B: difficulty recalling past events & imaging future events
  - Only restricted to things that might happen to him personally, can still imagine other future events
- Donna Rose Addis: Physiological link (using fMRI) - determine how brain is activated by remember the past and imagining future
  - All brain regions active during description of past also active during description of future
  - Similar neural mechanisms are involved in remembering past & predicting future
  - Schacter & Addis — *constructive episodic simulation hypothesis* — episodic memories are extracted and recombined to construct simulations of future events
    - Enable people simulate possible future scenarios to anticipate future needs + guide behaviours
  - Semantic dementia — poor semantic memory but intact episodic memory
    - Also have problems in describing episodic details of what might happen in future
    - Need functioning semantic + episodic memory systems to think about personal future

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Procedural Memory, Priming, and Conditioning

- Explicit memories — memories we are aware of

- Implicit memories — memories we aren't aware of
    - Procedural memory
    - Priming
    - Conditioning
- Procedural memory:
    - Procedural memory (skill memory) — memory for doing things that usually involved learned skills
    - E.g Tying shoes
    - Clive Wearing: lost ability to form new LTM but can still play piano
    - H.M: Amnesia caused by having hippocampus removed
        - Mirror drawing - copying picture seen in a mirror
        - Difficult at first, but easy after practice
        - H.M cannot form new memories → thought he was practicing mirror drawing for first time
        - After practicing → can trace star in mirror even though he could't remember doing it before
    - Patient K.C: can't form new LTM but can learn new skills - Learned how to sort + stack books in library
    - People with amnesia - retain skills from past → learn new ones
    - E.g motor skills that involve movement + muscle action
    - Cognitive skills - e.g ability to have a conversation using grammar
- Priming:
    - Priming— presentation of one stimulus (priming stimulus) changes the way person responds to another stimulus (test stimulus)
    - Repetition priming — test stimulus is same as / resembles priming stimulus
        - E.g Seeing word "bird" respond more quickly to the word / another presentation of "bird" than other words
        - Implicit memory - priming effect occur even subjects may not remember original presentation of priming stimuli
    - Peter Graf: test priming
        - 1) Amnesiac patients - Korsakoff's syndrome (associated with alcohol abuse and eliminates ability to form new LTM
        - 2) Patients without amnesia - under treatment for alcoholism

- 3) Patients without amnesia - no history of alcoholism
- Read 10-word list → rate how much they like each word (focus on word other than memorizing)
- 1) Test on explicit memory (recall words they had read)
- 2) Word completion test (test of implicit memory)
  - 3 letters from list, 3 letters not from list (e.g tab_ _) → subjects fill in words
- Results:
  - Recall experiment: Amnesiac patients recall fewer words than other 2 controls
    - Explicit memory associated with amnesia
  - Word completion test: Amnesiac patients performed just as well as 2 controls ⇒ Priming

- Method: (Avoiding explicit remember in priming experiment)
  - Present priming stimulus in a task that does not appear to be a memory task
  - E.g Presented with names of animals - indicate which animal stand more than 2 feet high
  - Focus on task of estimating height - x remember
  - Don't use testing procedures that refer to memory
  - Measure how accurately / quickly subject responds to stimulus
    - E.g Presented with a list → Press button when see 4 letters
      - Result: faster / more accurate responding to 4 letter words that corresponded to priming stimuli
- Repetition priming occur in everyday experience
  - E.g Advertisements
    - T. J. Perfect & C. Askew: Subjects scan articles in magazine (with advertisement) → Asked to rate advertisements on dimensions (i.e how appealing, eye-catching, memorable etc.)
      - Gave higher ratings to ones they had been exposed to
      - Implicit memory — don't remember seeing the ads. (recognized 2.8 out of 25 ads)
    - Propaganda effect — subjects are more likely to rate statements they have read or heard before as being true, simply because they have been exposed to them before
      - Implicit - can occur if people are not aware they have been exposed to before

- Classical conditioning:
  - Classical conditioning — when two stimuli are paired: 1) neutral stimulus that initially does not result in a response; 2) conditioning stimulus that does not result in a response

- E.g Presenting tone followed by a puff of air to eye → Blink → After few times → person blinks in response to tone
    - Implicit memory - person forgotten about original pairing of tone and air puff
- Often related to emotional reactions - not always implicit memory (aware of conditioned response)
- See person who seems familiar but you can't remember
    - Felt positively / negatively about person without knowing why ⇒ implicit memory

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Something to consider

- Memory loss in the movies:
    - P*sychogenic fugue* — (Symptoms: traveling away from where person lives, lack of memory for past, takes on new identity)
        - E.g Jason Bourne (*The Bourne Identity*): Lost episodic memories of past, semantic memory intact, lost none of his procedural memories from training as CIA agent
        - E.g (*Who Am I?)* Jackie Chan: loss memory in helicopter crash, a quest to recover his identity
        - E.g (Dead Again) Emma Thompson: can't remember anything about her life
        - E.g (*The Long Kiss Goodnight*) Geena Davis: remembering events from previous life as a secret agent after suffering a blow to head
    - Trouble forming new memories: E.g (*Memento*) Lenny: continually forgets what happened to him, unable to form new memories (similar to H.M & Clive Wearing) - can still function with some difficulty
        - Though no STM (but STM - recent 15 ~ 20 seconds) - Didn't lose STM but couldn't form new LTM
    - Fiction: E.g (*Total Recall*) Arnold Schwarzenegger: Lives in future word, can implant memories
    - Creating specific memories ⇄ Forgetting specific events: E.g (*Eternal Sunshine of Spotless Mind*): Procedure to selectively eliminate their memory for previous relationship
    - E.g (*50 First Dates*) Lucy: Memory resets every morning (retrograde amnesia)
        - Real world: Patient F.L: head injury from automobile accident, after she woke up → no memory of previous day
            - Learnt material on same day, but no memory for materials she knew previous day
            - But if material was mixed with new material → can remember old material
            - F.L not intentionally making believe she had amnesia, but influenced from knowledge of amnesia

Chapter 7 — Long term memory: Encoding, Retrieval, and Consolidation

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- Encoding — Process of acquiring information and transferring it into LTM
- Coding: Refer to form (how info is presented)
- Encoding: Process used to get into to LTM
- Retrieval — Process of transferring info from LTM to working memory

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Encoding: Getting information into LTM

- Some ways are more effective than others - different ways of rehearsing info
- Maintenance rehearsal — Research without any consideration of meaning or making connections with other information → Result in poor memory
- Elaborative rehearsal — Remembering by considering meaning / making connections to other information
- Levels of Processing Theory:
  - Memory retrieval is affected by how items are encoded
  - Fergus Craik & Robert Lockhart: Levels of Processing Theory:
    - Memory depends on Depth of Processing an item receives:
      - Shallow processing — Little attention to meaning / attention is focused on word's physical features
      - Deep processing — Close attention, focusing on item's meaning and relating better memory than shallow processing
  - Craik & Endel Tulving: testing levels of processing
    - Presented words → Ask 3 questions:
      - 1) Physical features of word (e.g whether it is printed in capital letters) ⇒ Shallow processing
      - 2) Rhyming (e.g ask if words rhyme) ⇒ Deeper processing
      - 3) Fill-in-the-blanks question (e.g whether the word fits into a sentence) ⇒ Deepest processing
    - Then given memory test to test how well they recalled words
      - Results: Deeper processing associated with better memory
    - Difficult to define what depth of processing is

- Forming visual images:
  - Gordon Bower & David Winzenz: Test whether visual imagery that connect words visually can enhance memory
    - Paired-associate learning — list of word pairs is presented → first word of each pair is presented and subject has to remember the word it is paired with
    - Present list of 15 pairs of nouns:
      - 1) Told to silently rehearse words
      - 2) Told to form a mental picture that 2 words are interacting
    - Results: Second group remembered more than twice as many words
- Linking words to yourself:
  - Self-reference effect — Memory is better if you are asked to relate a word to yourself
  - T. B. Rogers: Similar to Craik & Tulving's Depth-of-processing experiment:
    - 4 questions:
      - 1) "Printed in small case?" (happy)
      - 2) "Rhymes with happy?" (snappy)
      - 3) "Means the same as happy?" (upbeat)
      - 4) "Describes you?" (happy)
    - Results: Answer yes → More likely to remember words they rated as describing themselves
  - Words become linked to something subjects know well — themselves
- Generating information:
  - Norman Slameka & Peter Graf: Generation effect — generating material rather than passively receiving it → enhances learning & retention
    - Study list of words in 2 ways:
      - 1) Read group: Read pairs of related words
      - 2) Generate group: Fill in blank with word related to first word
    - Then subjects were presented with first word → need to indicate the word that went with it
      - Results: Generate group produce 28% more word pairs
- Organizing information:
  - Presented with list of words → remember → write out as many as you can

- Similar items are grouped together - Spontaneously organize items as they recall them
- Retrieval cue — word or other stimulus that helps a person remember information stored in memory
- Gordon Bower: words are presented in organized ways during encoding
  - Tree → Study for 1 minute → Recall
  - Presenting materials in organized tree - organized words according to categories - remember 73 words; another group - tree with randomized words - remember 21 words
  - Organizing material → remember better
- John Bransford & Marcia Johnson: preventing organization reduces ability to remember
  - Present a confusing paragraphs ~ difficult to picture & difficult to remember
  - 2 groups:
    - 1) Present the associated pic before reading paragraph - remember twice as much than 2nd group
    - 2) Present the associated pic after reading paragraph
  - Picture provides a mental framework - helps link sentence to next to create a meaningful story
    - Organization makes it easier to comprehend & remember

- Relating words to survival value:
  - James Nairne: Memory shaped to increase ability to survive
    - Words → Access them count number of vowels / rate item's survival value
    - Result: linking to survival value ~ created memory than vowels task + "elaborative" task

- Retrieval practice:
  - Study for tests: make up and answering practice test results in better memory than rereading information
  - Henry Roediger & Jeffrey Karpicke: Advantages of practice test

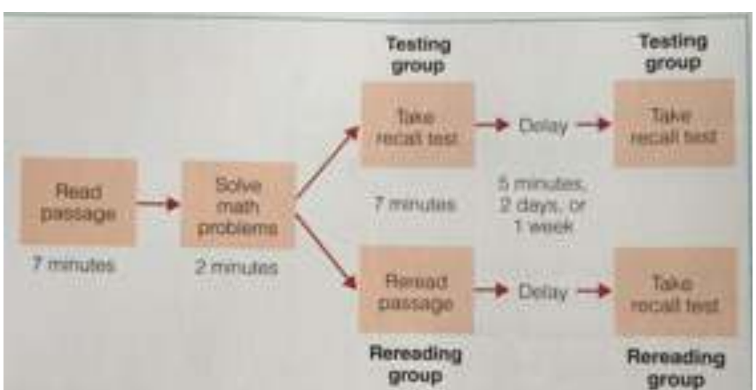

Figure 7.6 Design of the Roediger and Karpicke (2006) "testing effect" experiment.

- Result:

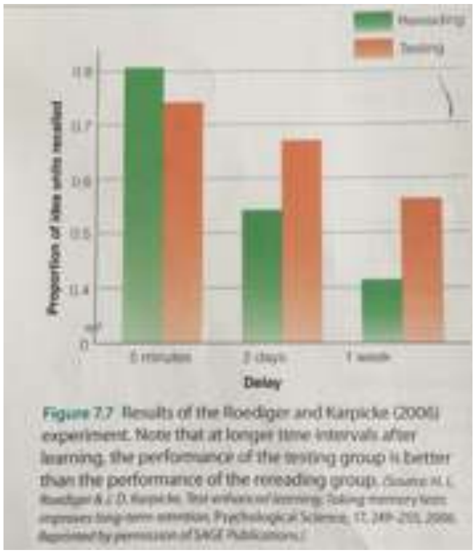

Figure 7.7 Results of the Roediger and Karpicke (2006) experiment. Note that at longer time intervals after learning, the performance of the testing group is better than the performance of the rereading group.

- Testing effect — Enhanced performance due to retrieval practice

- Practicing retrieval + Generating information - actively creating & recreating material
    - Connections between material to be remembered + material in memory
- Close relationship between encoding & retrieval

Condition	Experiment/Result
Forming visual images	Pairs of words are remembered beter if images are formed (compared to just reading word pairs)
Linking words to yourself	Words associated with yourself are remembered better (self-reference effect)
Generating information	Memory is better if second word of a word pair is generated by the person, compared to just being presented with the word (generation effect)
Organizing information	Studying information that is organized, as in a “tree” result in better memory. Presenting information so organization is difficult
Relating words to survival value	Memory is enhanced by relating words to survival value. Helps link words to something meaningful
Practicing retrieval	Testing following learning, results in better memory than rereading material after learning (testing effect)

Retrieval: Getting information out of memory

- Failure of memory is retrieval failure
- Retrieval cues:
    - Location served as a retrieval cues
    - Method: (Cued recall)

- 2 types:
  - Free recall — subject simply asked to recall stimuli
  - Cued recall — subject presented with retrieval cues to aid in recall (e.g words/phrases, provided with names of categories)
- Tulving & Pearlstone: retrieval cues aid memory
  - Free recall: recalled 40% of words; cued recall: recalled 75%
- Timo Mantyla: presented 504 nouns → subjects write 3 words associated → presented with those 3 words → recall nouns
  - Result: Self generated words - 95% of words; Other people's generated cues - 55%
  - Retrieval cues significantly more effective when created by the person whose memory is tested

- Matching conditions of encoding and retrieval:
  - Retrieval increased by matching conditions (e.g location) at retrieval to conditions that existed at encoding
    - 1) Encoding specificity — matching *context*; 2) State-dependent learning — matching *internal mood*; 3) Transfer-appropriate processing — matching *task* involved
  - Encoding specificity:
    - Encoding specificity — states that we encode information along with its context
    - D. R. Godden & Alan Baddeley: "diving experiment"
      - Study list of words → one group on land ; another group under water
        - These groups divided → half subjects on land, half subjects on water → land; half → water
        - Results: Best recall occurred when encoding & retrieval occurred in same location
    - Harry Grant: "studying experiment"
      - Study paragraphs → one under noise condition, one under quiet condition
        - Half of both groups tested under noise condition, half tested unde quiet condition
  - State-dependent learning:
    - State-dependent learning — learning that is associated with particular internal state (e.g mood/state of awareness)
    - Principle of state-dependent learning - memory will be better when a person's internal state (mood/awareness) during retrieval matches his/her internal state during encoding
    - Eric Eich & Janet Metcalfe: mood

    - Subjects think positive thoughts while listening to “merry” music / depressing thoughts while listening to “melancholic” music → study list of words → after 2 days → same mood procedure → recall words
        - Result: Better memory when their mood at retrieval matched their mood during encoding
- Matching Cognitive Task: Transfer-appropriate processing
    - Donald Morris: same cognitive tasks are involved during both encoding & retrieval
        - Procedure:
            - 1) Encoding: hear a sentence, but *blank* = word → 2 seconds → hear target word
                - Answer yes/no questions based on *meaning* or *rhyming* condition
                - E.g *Blank* had a silver engine ; target word: train ; answer: yes (focus on meaning)
                - E.g *Blank* rhymes with pain ; target word: train ; answer: yes (focus on sound)
            - 2) Retrieval: presented with series of words (some words rhyme with target words presented during encoding part) → answer yes/no
                - Subjects retrieval performance depended on retrieval task matched encoding task
                - Subjects focused on sound in part 1 → did better then test involved focusing on sound
            - Transfer-appropriate processing — Better performance when type of pressing matches in encoding & retrieval
            - Deeper processing at encoding does not always result in better retrieval

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Consolidation: Life History of Memories

- Every experience creates potential for new memory ~ but they are fragile - can be disrupted
- George Muller & Alfons Pilzecker:
    - Learn nonsense syllables → “immediate”: immediately learn another list // “delay”: 6 minutes delay then learn second list → recall first list
        - Result: Delay group: remember 48%, immediate: 28%
        - Consolidation — process that transforms new memories from a fragile state, in which they can be disrupted to a more permanent state, in which they are resistant to disruption
        - Mechanisms:
            - Synaptic consolidation — takes place over minutes or hours, involves structural changes at synapses

- Systems consolidation — takes place over months or years, involves the gradual reorganization of neural circuits within brain
- They occur together, at different speeds and at different levels of nervous system

- Synaptic consolidation: Experience causes changes at synapse:
  - Donald Hebb: learning and memory are represented in brain by physiological changes that take place at synapse
    - Repeated activity can strengthen synapse by causing structural changes → greater transmitter release → increased firing
    - Activity at synapse → causes sequence of chemical reactions → synthesis of new proteins → causes structural changes at synapse → strengthening of synaptic transmission ⇒ Long-term potentiation (LTP) — enhancing firing of neurons after repeated stimulation
- Systems consolidation: The Hippocampus and Cortex:
  - H.M: Importance of hippocampus
  - Standard model of Consolidation — Incoming information activate a number of areas in cortex
  - Activation in cortex (many sensory & cognitive) - across many cortex areas → communicates with hippocampus → hippocampus coordinates activity of different cortical areas
  - Reactivation — hippocampus replays neural activity associated with memory
    - Helps form direct connections between various cortical areas
    - Hippocampus that helps bind together representations of memory from different cortical areas
  - Retrograde amnesia — loss of memory for events that occurred before injury - can extend back minutes, hours, or even years, depending on nature of injury
  - Graded amnesia — amnesia tends to be most severe for events that happened just before injury and to become less severe for earlier events
    - Time passes - connections between cortical areas are formed & strengthened → connections between hippocampus & cortex weaken + vanished → hippocampus strongly active as memories are formed, less involved as memories are consolidated → cortical areas are sufficient to retrieve remote memories — memories for events that occurred long ago

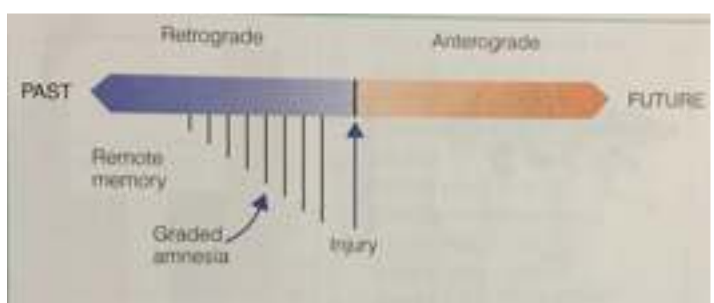

Figure 7.16 Anterograde amnesia is amnesia for events that occur after an injury (the inability to form new memories). Retrograde amnesia is amnesia for events that happened before the injury (the inability to remember information from the past). The vertical lines, which symbolize the amount of retrograde amnesia, indicate that amnesia is more severe for events or learning that was closer in time leading up to the injury. This is the graded nature of retrograde amnesia. © Cengage Learning

- Multiple trace model of consolidation — hippocampus involved in retrieval of episodic memories, even if they originated long ago
  - Asaf Gilboa: hippocampus was activated during retrieval of both recent & remote episodic memories
    - Show subjects photograph of themselves engaging in activities (recent ~ very past)
  - Indre Viskontas: response of hippocampus can change over time
    - View pairs of stimuli (alligator & candle) → Imagine both items interacting with each other
    - After 10 minutes // 1 week → Original stimulus + someone → Respond to each pair
      - 1) Remember (R) - "Remember seeing pair when it was originally presented"
      - 2) Know (K) - "Pair looks familiar, don't remember when I was originally seeing it"
      - 3) Don't - "Don't remember or know the stimuli"
    - R responses - episodic memory; K responses - semantic memory
    - Results: More remember (episodic) than know (semantic) - 10 minutes ; Only half remember left - 1 week
      - Memory looses episodic character over time
      - Hippocampus remained high for (RR - remember 10 mins, remember 1 week), but dropped to near zero for RK pairs
        - Hippocampus response change over time ~ for stimuli that lost their episodic character

- Consolidation & Sleep: Enhancing memory:
  - Reactivation process associated with consolidation begin as soon as memory is formed - particularly strong during sleep
  - Steffan Gais: sleep enhances consolidation:
    - High school students learn list of 24 pairs of English-German vocabulary words
    - Sleep group: Study list → sleep within 3 hours
    - Awake group: Study list → remain awake for 10 hours
    - Results: Sleep — forgot much less material
    - Going to sleep eliminates environmental stimuli that might interfere with consolidation
  - Ines Wilhelm: Memories are more likely to be consolidated than others
    - Subjects learn a task → told test on this task later (expected group) / test on another task later (unexpected group) → sleep → test on task (if what they expected had any effect on consolidation)

- Task: card memory task - list of paired cards on screen → remember cards position → flip cards → need to pair them up again
- Result: Expected group perform better
  - Memories that are more important are more likely to be strengthened by consolidation

- Consolidation and Retrieval: Reconsolidation:
  - Reconsolidation — when a memory is retrieved, it becomes fragile, as it was originally formed, and that when it is in this fragile state, needs to be consolidated again (update memory)
  - Modifying or forgetting memory
  - Karim Nader:

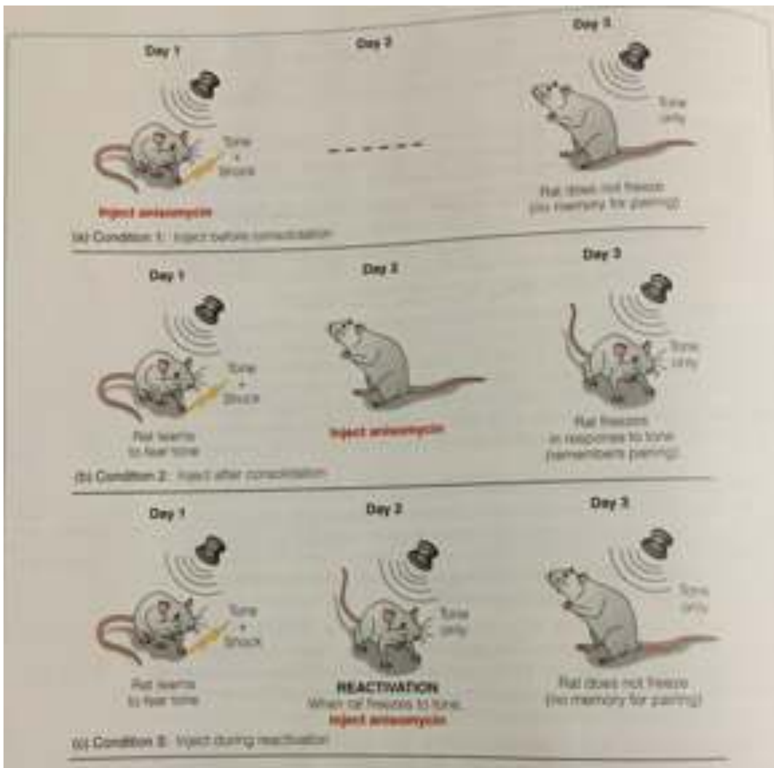

Figure 7.20 The Nader et al. (2000a) experiment on how injecting anisomycin affects fear conditioning. (a) Anisomycin is injected on Day 1, before consolidation, so memory for the tone–shock pairing is not formed. (b) Anisomycin is injected on Day 2, after consolidation, so memory for the tone–shock pairing remains. (c) Anisomycin is injected after reactivation on Day 2, so memory for the tone–shock pairing is eliminated.

-Classical conditioning on rat to create fear response of "freezing" (not moving) to presentation of tone

-Injected with *anisomycin* (antibiotic that inhibits protein synthesis, prevents changes at synapse responsible for forming new memories)

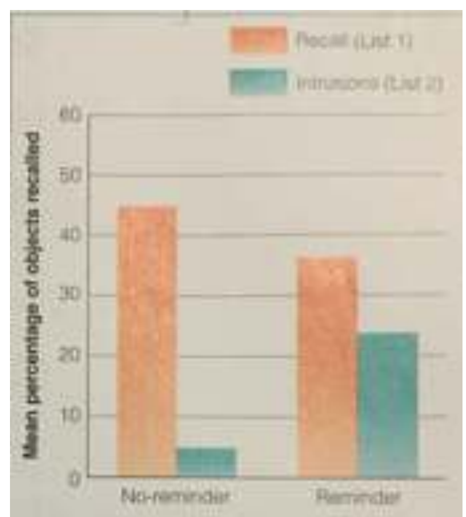

Figure 7.21 Results of Hupbach et al.'s (2007) experiment. The fact that the reminder group had more intrusions supports the idea that reactivation and reconsolidation can affect human memory. (Source: Based on A. Hupbach, R.

- Alan Hupbach: effect of reactivation
  - Day 1: List of words naming everyday objects → Day 2: reminded of their training on day 1 (reminder group) / learn new list directly (no-reminder group) → Day 3: Remember list 1 & 2
  - Reminder reactivated memory for list 1 and "opened the door" for changes to occur in memory

- Posttraumatic stress disorder (PTSD) — condition that occurs when following traumatic experience, person experiences "flashbacks" of experience, often accompanied by extreme anxiety and physical symptoms
  - Alain Brunet: reactivation + reconsolidation help alleviate symptoms
    - During reactivation → administer drug *propranolol* (blocks activation of stress hormone receptors in amygdala)
    - One group receive drug, another group receives placebo
    - Propranolol group - much smaller increases in heart rate and skin conductance

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Something to Consider

- Effective studying:
  - Elaborate: thinking about what you are reading and giving it meaning by relating it to other things that you know
  - Generate and test: generation effect & testing effect - active involvement with material
    - Self testing - indicates what you know and increases ability to remember what you know later
  - Organize: Create framework to relate information to other information to make material more meaningful and strengthen encoding
    - Helps reduce load on memory
  - Take breaks: Spacing effect — advantage for short study sessions; sleep follows learning
  - Avoid "illusions or learning": (ineffective method for studying)
    - Rereading material results in fluency — repetition causes reading to become easier and easier
    - Familiarity effect — material to be more familiar
    - Highlighting: Survey by Sarah Peterson - 82% of student highlight → not effective because it becomes automatic behaviour and no deep thinking about material
  - Most important - practice testing and distributed practice (breaks)

Chapter 9 — Knowledge

- Conceptual knowledge — knowledge that enables us to recognize objects and events and to make inferences about their properties
- Concepts — mental representation of class or individual ; meaning of objects, events, and abstract ideas
- Category — all possible examples of a particular concept
  - Concepts provided rules for sorting objects into categories
- Categorization — process by which things are placed in categories

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How are objects placed into categories?

- Why definitions don't work for categories:
  - Definition approach to categorization — decide whether something is a member of a category by determine whether a particular object meets the definition of the category
  - Works well - for geometric objects
  - Don't work - natural objects, man-made objects
  - Not all members of same category have same features
  - Ludwig Wittgenstein: Family Resemblance — things in a particular category resemble one another in a number of ways
    - E.g Chair: offer a place to sit, a way to support person's back, place to rest the arms while sitting
  - How similar an object is to some standard representation of a category
- Prototype approach: Finding the average class:
  - Prototype approach to categorization — membership in a category is determined by comparing object to a prototype that resembles category
  - Prototype — "typical" member of the category (not particular member, average representation)
  - Eleanor Rosch: "typical" prototype is based on average members of a category that are commonly experienced
    - High typicality — category member closely resembles category prototype
    - Low typicality — category member does not closely resemble typical member of category
    - 7-point scale: how closely related the member is to prototype
  - Prototypical objects have high family resemblance:
    - Rosch & Carolyn Mervis: Family Resemblance - write down overlapping characteristics of a few objects

- Large amount of overlap with characteristics → High family resemblance
- Strong relationship between **family resemblance** & **prototypicality**

- Statements about prototypical objects are verified rapidly:
  - Edward Smith: Sentence verification technique — how rapidly people could answer questions about an object's category
    - Yes/No Statements (e.g 1) An apple is a fruit ; 2) A pomegranate is a fruit)
      - Respond faster to apple (high prototypicality)
    - Typicality effect — Ability to judge highly prototypical objects more rapidly
- Prototypical objects are named first:
  - Subjects tend to list the most prototypical members of category first
- Prototypical objects are affected more by priming:
  - Rosch: prototypical members of a category are more effected by a priming stimulus than non prototypical members
    - Present with prime word (e.g *green*) → a pair of colors → indicate whether they are same or different colors
    - Result: Primary green reaction time faster than light green
      - When subjects hear the word green → image a highly prototypical green
      - Prime: Prime will facilitate subjects' response to a stimulus if it contains some of the info needed to respond to stimulus

Effect	Description	Experimental result
Family resemblance	Things in a category resemble each other in a number of ways	Higher ratings for high-prototypic items when people rate how "good" a member of category it is (Rosch)
Typicality	People react rapidly to members of a category that are "typical" of the category	Faster reaction time to statements for high-prototypical items than for low-prototypical items (Smith)
Naming	People are more likely to list some objects than others when asked to name objects in a category	High-prototypical items are named first when people list examples of a category (Mervis)
Priming	Presentation of one stimulus affects responses to a stimulus that follows	Faster same-different color judgements for high-prototypical items (Rosch)

- Exemplar Approach: Thinking about Examples:
  - Exemplar approach to categorization — determining whether an object is similar to other objects
  - Exemplars — actual members of the category that a person has encountered in the past
  - Explains typicality effect - objects that are like more of the exemplars are classified faster

- Which approach works better: Prototypes or exemplars?:
    - Advantage of exemplar approach: using real examples - more easily take into account atypical cases (ability to take into account individual cases, doesn't discard useful info later)
    - Exemplar - can deal more easily with variable categories (e.g games)
    - Use both info: initially learn about a category - average exemplars into a prototype → then later in learning,some exemplar info becomes stronger
    - Some studies - exemplar approach work better for small categories ; prototype approach better for large categories

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Is there a Psychologically "Privileged" Level of Categories?

- Hierarchical organization — organization, in which larger, more general categories are divided into smaller, more specific categories, creating a number of levels of categories
- Rosch's Approach: What's special about basic level categories?:
    - Different levels of categories - general → specific
    - 3 levels of categories:
        - Superordinate level:
            - Global level (e.g furniture)
            - Basic level (e.g table)
        - Subordinate level - specific level (e.g kitchen table)
    - Listing common features exercise:
        - 3 common features - <u>global</u> level
        - 9 common features - <u>basic</u> level
        - 10.3 common features - <u>specific</u> level
    - Naming things exercise: People tend to pick a <u>basic level</u> name
    - Whether picture was a member of the category - Respond faster to basic level categories
- How knowledge can affect categorization:
    - J. D. Coley: Name as specifically as possible, 44 different plants on a walk around campus
        - 75% - "trees" rather than more specific labels (e.g "Oak)
    - James Tanaka & Marjorie Taylor: Asked bird experts & non bird experts - name pictures of objects (including 4 bird pictures)
        - Experts responded specifically to bird species - learn to pay attention to features of birds

Representing Relationships between categories: Semantic Networks

- Semantic network approach — how categories or concepts are organized in mind - arranged in networks
- Introduction to Semantic Networks: Collins & Quillian's Hierarchical Model:
  - Ross Quillian: Goal to develop a computer model of human memory
  - Allan Collins & Quillian:
    - Consists of nodes (represents a category / concept) - connected by links
    - Hierarchical model — Different levels arranged - specific concepts (bottom), general concepts (higher)
    - Cognitive economy — Way of storing shared properties just one at a higher-level node
      - Problem - there may be odd exceptions
    - Measuring reaction time to different statements - Statements required further travel from one category to the next resulted in longer reaction times

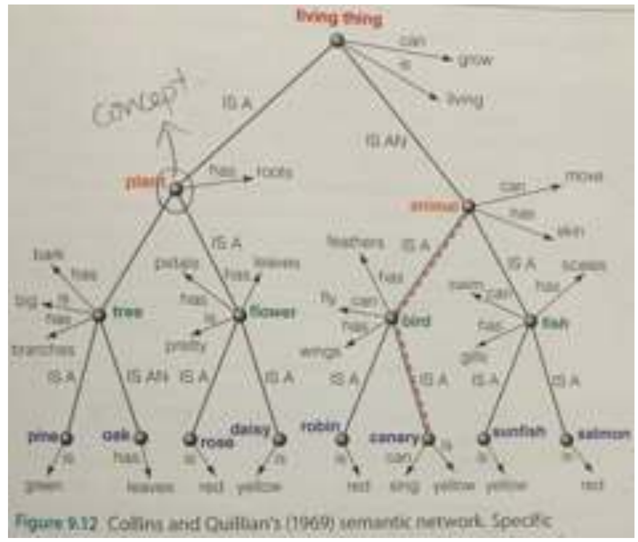
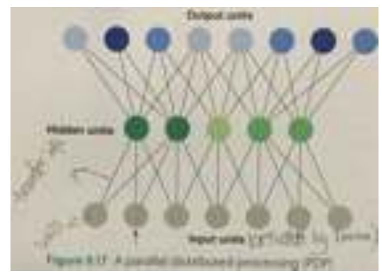


Figure 9.12 Collins and Quillian's (1969) semantic network. Specific

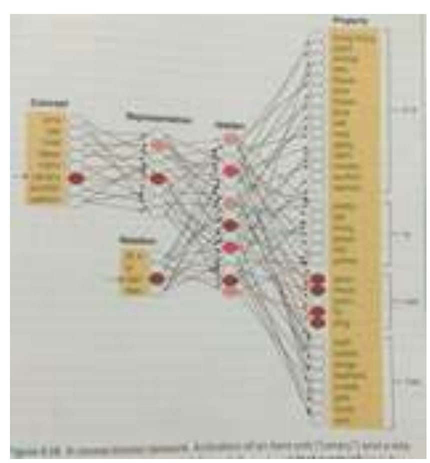
  - Spreading activation — Activation that spreads out along any link that is connected to an activated node
    - Additional concepts that receive this activation become "primed" → retrieved more easily from memory
    - David Meyer & Roger Schvaneveldt: Lexical decision task — Subjects read pairs of words (some words, some nonwords) → Indicate as quickly as possible whether it is a word or not
      - Result: Reaction time faster when words are closely associated (e.g Break & Wheat)
      - Retrieving one word from memory triggered a spread of activation to other nearby locations in a network
- Criticism of Collins & Quillian Model:
  - Couldn't explain typicality effect - reaction times for statements about an object are faster for more typical members of category than less typical members
  - Question concept of cognitive economy (people store specific properties of concepts right at node for concept)
  - Lance Rips: Sentence verification results:
    - "A pig is a mammal" - RT = 1,476 ms
    - "A pig is an animal" - RT = 1,268 ms
    - Predict - Pig is a mammal should be verified more quickly

Representing Concepts in Networks: Connectionist Approach

- James McClelland & David Rumelhart: Connectionism
  - (i) How info is presented in brain
  - (ii) Explain a number of findings (how concepts are learned, how damage to brain affects people's knowledge about concepts)
- What is a connectionist model?:
  - Connectionism — Approach to creating computer models for representing cognitive processes
  - Parallel distributed processing (PDP) — Concepts are represented by activity that is distributed across a network
  - Some units can be activated by stimuli from environment ⇒ Input Units, some activated by signals received from other units ⇒ Hidden Units → Send signals to Output units



  - Connection weight — Determines how signals from one unit either increase / decrease activity of next unit
    - High connection weight - strong tendency to excite the next unit
    - Low weight - cause less excitation
    - Negative weights - decrease excitation / inhibit activation of receiving uint
  - Activation depends on 2 things:
    - 1. Signal that originates in input units
    - 2. Connection weights throughout network
  - Activation of each hidden and output units - indicated by shading
    - Darker shading - more activation
    - Differences in activation + pattern of activity they create ⇒ **Basic principle of connectionism**: Stimulus presented to the input units is represented by the <u>pattern of activity</u> that is distributed across the other units
      - Similar to distribution representations in brain



- How are concepts represented in a connectionist network:
  - James McClelland & Timothy Rogers: <u>Connectionist network</u>
    - Components: Units, links, and connection weights (not shown)
  - Representing a canary:
    - Same concepts
    - Hierarchical network - represent properties at nodes
    - Connectionist network - indicates properties by activity in attribute units on far right; middle = hidden units

- Training a network:
  - Activation of property units + pattern of activation of network's representation & hidden units
  - Connectionist network has to be trained in order for result to occur - adjusting network's connection weights
  - Untrained case: connection weights the same ⇒ Activate many incorrect property units at the same time
  - Adjustment of weights - Learning process ~ occurs when erroneous responses in property units cause an error signal to be sent back through network ⇒ Back propagation (send backward in network from property units)
  - Corrected / Strengthen by experience - Error signals sent back through network → change in connection weights → new activation pattern
  - McClelland & Rogers: Computer simulation:
    - Activation of units and connection weights between units
    - Beginning - Connection weights - all the same (Learning trials = 0)
    - After 250 trials - patterns of hidden units change
- Idea of Connectionism:
  - 1) Operation of connectionist networks is not totally disrupted by change:
    - Info in network distributed across many units - damage to system does not completely disrupt operation
      - Graceful degradation — Disruption of performance occurs only gradually as parts of system are damaged
        - Like brain damage
  - 2) Connectionist networks explain generalization of learning:
    - Similar concepts ~ Similar patterns
    - Enables prediction of properties

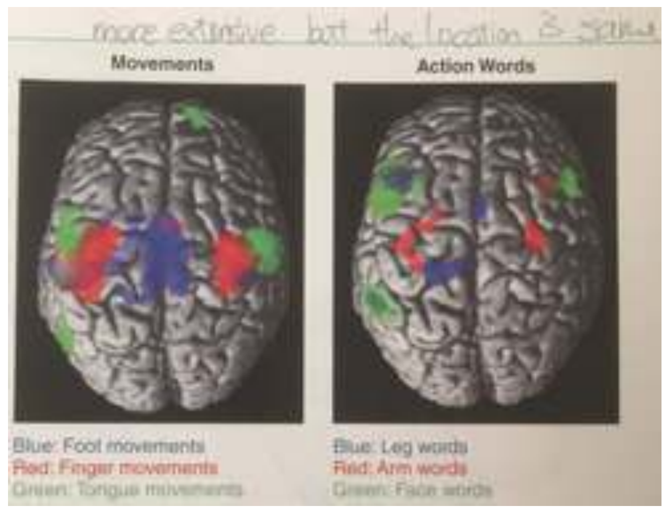
Representation of Concepts in Brain

- Sensory-functional hypothesis:
  - Elizabeth Warrington & Tim Shallice: 4 patients who suffered from memory loss from encephalitis
    - Category-specific memory impairment — lost ability to identify one type of objet but retained ability to identify other types of objects
    - Able to identify non-animals (*artifacts*) - impaired ability to identify living animals
    - Distinguish living things depends on perceiving their sensory features
    - Distinguish artifacts by function
    - Sensory-functional (S-F) hypothesis — ability to differentiate living things and artifacts depends on a semantic memory system that distinguishes sensory attributes and a system that distinguishes function

- Caramazza & Shelton:
    - Patient can't identify living things + impaired sensory abilities (S-F hypothesis) + but also had impaired functional ability (S-F wouldn't predict)
- Matthew Lambon Ralph:
    - Patient can't recognize artifacts but had an impaired sensory ability

- Semantic category approach:
    - Semantic category approach — Specific neural circuits in rain for some specific categories
    - Bradford Mahon & Alfonso Caramazza:
        - Limited number of categories that are innately determined because of their importance for survival
    - Alex Huth:
        - Brain activity measured as people viewed movies - how concepts activated different areas of brain
    - Jeremy Wilmer:
        - Areas of brain are innately specialized for specific categories of concepts - measuring face recognition ability in monozygotic (identical) and dizygotic (fraternal) twins
        - Correlation of scores for identical - twice as high as fraternal twins
            - Genetic basis for mechanisms that support face recognition
    - Hammer - activate areas respond to hammer's shape & color + how hammer is use and motion
        - Evolutionary
- Multiple-factor approach:
    - Multiple-factor approach — distributed representation - focuses not on brain areas but on searching for more factors that determine how concepts are divided up within a category
    - Paul Hoffman & Matthew Lambon Ralph:
        - Picked a number of features to categorize a large number of items
        - Results: Animals highly associated with motion & color compared to artifacts ; Artifacts more highly associated with performed actions (interacting with objects) ⇒ Conforms to S-F hypothesis
        - Results: Mechanical devices (e.g machines, vehicles, musical instruments) - overlap with artifacts + animals
            - Mechanical devices - have widely distributed semantic representation
        - Patients: Poor comprehension of smaller objects - better knowledge of large artifacts
    - Crowding — Animals tend to share many properties ; Artifacts share fewer properties
        - Patients with category-specific impairment ~ no impairment ⇒ they only have difficulty distinguishing between items that share similar features - animal more properties → harder to recognize

- Embodied approach:
    - Embodied approach — our knowledge of concepts if based on reactivation of sensory & motor processes that occur when we interact with the object
    - E.g Use hammer - sensory areas activated in response to hammer's size, shape, color etc + motor areas activated carrying out actions involved
    - Simple action involve back-and-forth interaction between pathways in brain involved in perception + actions
    - Vittorio Gallese: Mirror neurons — Neuron's response to watching is similar to response that occurs when performing action
        - Neurons in monkey premotor cortex fired both when monkey grasped for food on tray + monkey observed experimenter grasping food on try
        - Most mirror neurons - specialized to only one type of action
    - Olaf Hauk: Measured subject's brain activity using fMRI
        - 2 conditions: 1) Subjects moved right/left foot, left/right index finger, or tongue ; 2) Read action words (kick, pick, lick)
        - Results: Areas of cortex activated more extensive for actual movements, areas activated for reading words approximately the same
        - Semantic somatotopy — Correspondence between words related to specific parts of body and location of brain activated



    - Criticism: Compete explanation of how brain processes concepts?
        - Frank Garcea: Patient A.A: Stroke affected his ability to produce actions associated with various objects
            - Hand motions to indicate how to use objects like hammer - impaired
            - According to Embodied approach - impaired actions associated with objects should have trouble recognizing objects ⇒ but A.A can identify pictures of objects
        - Explain abstract concepts? - e.g "democracy" or "truth"
- Sorting out the Approaches:
    - Concepts is distributed across many structures in brain
    - Category-specific approach: emphasizes specialized areas of brain & networks connecting areas
    - Multiple-factor approach: emphasizes role of different features & properties
    - Embodied approach: emphasizes activity caused by sensory & motor properties of objects

Something to Consider

- The Hub and Spoke Model:
  - Semantic dementia — causes a general loss of knowledge for all concepts
    - Patients - equally deficient in identifying living things and artifacts
    - Anterior temporal lobe (ATL) is damaged
  - Hub and Spoke Model of semantic knowledge — areas of brain associated with specific functions are connected to ATL → served as a hub that integrates info
  - Damaged to one specialized brain areas (spokes) → cause specific deficits (e.g inability to identify artifacts)
    - But damage to ATL (hub) → cause general deficits ⇒ semantic dementia
  - Transcranial magnetic stimulation (TMS) — temporarily disrupt the functioning of particular area of human brain - applying a pulsating magnetic filed
  - Gorana Pobric: presented pictures of living things & artifacts - measure response time - use TMS
    - Result: Stimulating ATL → generalized effect: slowing in responding to both living things + artifacts
    - Stimulating parietal area → specific effect: slowing in responding to artifacts but not to living things

Chapter 10 — Visual Imagery

- Visual imagery — seeing in the absence of a visual stimulus
- Mental imagery — ability to recreate sensory world in the absence of physical stimuli (also occurs in senses other than vision)
- Friedrich August Kekuli: structure of benzene came to him in a dream
- Albert Einstein: Theory of relativity - imagine himself traveling beside a beam of light
- Imagery provides a way of thinking that adds another dimension to verbal techniques associated with thinking

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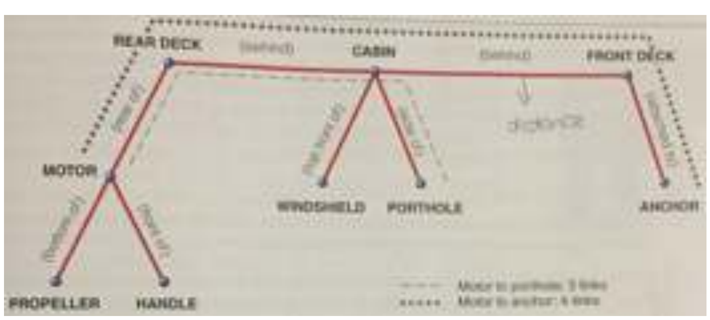
Imagery in the History of Psychology

- Early ideas about imagery:
  - William Wundt: Images - one of three basic **elements of consciousness** (+ sensation & feelings)
    - Images → thoughts → way of studying thinking
    - Imageless thought debate — link between imagery and thinking
    - Aristotle's idea - "thought is impossible without an image"
  - Francis Galton: People had difficulty forming visual images - still capable of thinking ⇒ imagery not required for thinking
  - Behaviourism: Study of imagery - unproductive ~ visual images are invisible to people except for person experiencing them
  - John Watson: images - "unproven" & "mythological"
- Imagery and the Cognitive Revolution:
  - Infer cognitive process
  - Alan Paivio: Memory - easier to remember concrete nouns that can be imaged, than abstract nouns
    - Paired-associate learning — subjects presented with pairs of words → later presented with first word from pair → subject has to recall the pairing word
    - Result: Memory for concrete nouns much better than abstract nouns
      - Conceptual peg hypothesis — concrete nouns create images that other words can "hang onto"
    - Roger Shepard & Jacqueline Metzler: Inferred cognitive processes - Mental chronometry — Determining amount of time needed to carry out various cognitive tasks
      - Mental rotation task - presented with 2 images - determine whether they are the same
      - Mental mechanism (manipulate perceptual & mental images) + brain mechanism (structures involved)

Imagery and Perception: Do They Share the Same Mechanisms?

- Mental images not as vivid or long lasting
- Mental & perceptual images - involve spacial representation of stimulus
- Stephen Kosslyn: Mental scanning — subjects create mental images and then scan them in minds
- Kossylyn's Mental Scanning Experiments:
  - Memorize picture of object → create an image in mind → focus on one part → ask to look for another part
  - Imagery like perception - spatial → longer to find parts that are located further from initial focus
  - Glen Lea: As subjects scan → encounter other interesting parts → increased reaction time
  - Kossylyn: Mental Scanning - state map:
    - Same result as above
    - Visual imagery is spatial in nature
  - Zenon Pylyshyn: Imagery debate — Whether imagery is based on spatial mechanisms (i.e involved in perception), or on mechanisms related to language - *Propositional mechanisms*
- Imagery Debate: Is imagery spatial or propositional:
  - Kossylyn: Spatial representation — Representation in which different parts of image can be described as corresponding to specific locations in space
  - Pylyshyn: Spatial representation is Epiphenomenon — something that accompanies the real mechanism but is not actually part of the mechanism
    - Mental image - indicate *something* is happening in mind, but don't tell us *how* it is happening
    - Propositional representation — Relationships can be represented by abstract symbols (e.g equation/statement)
    - Depictive representations — Parts of representation correspond to parts of the object
      - Appearance of Kossylyn's boat represented propositionally - Words indicate parts of boat, length of lines indicate distances between parts, words in parentheses indicate spatial relations between parts



- Subjects respond to Kosslyn's task based on what they know about what usually happens when they are looking at a real scene - know should take longer to travel longer distance
  - Tacit knowledge explanation — subjects unconsciously use knowledge about world in making their judgements
    - Criticisms: Ronald Finke & Stephen Pinker: 4 points randomly → a random arrow → whether arrow is pointing to any of the 4 dots
      - Took longer to respond for greater distance
      - Subjects no time to memorize distances between arrow and dot - x tacit knowledge explanation

- Comparing Imagery and Perception:
  - Size in the visual field:
    - Kosslyn: Relationship between viewing distance and ability to perceive details - mental imagery
      - Imagine 2 animals - elephant & rabbit next to each other
      - Ask question - "Does rabbit have whiskers" → answer asap
      - Imagine rabbit + fly → rabbit fill more visual field ⇒ Respond faster
      - Mental wall task — imagine that they were walking toward their mental image of an animal
        - How far they were away from animal when image filled visual field
        - Result: Subject move closer for small animals than larger animals
    - Images = spatial (just like perception)
  - Interactions of imagery and perception:
    - If imagery ⇄ perception - they both have same mechanism
    - Cheves Perky: Subjects create an image of banana → project a dim image of banana onto screen → subjects' description of image matches projected image
      - Mistaken actual picture for mental image
    - Martha Farah: Imagine *H* / *T* on screen → 2 squares flash (target → square // square → target) → indicate whether letter was in first or second square
      - Result: Detect more accurately when subject imaging same letter rather than different
      - Perception & imagery - share same mechanisms

- Is there a way to resolve the imagery debate?:
  - John Anderson: still can't rule out propositional explanation
  - Martha Farah: Difficult to rule out Pylyshyn's tacit knowledge explanation - results of behaviourism experiments

Imagery and the Brain

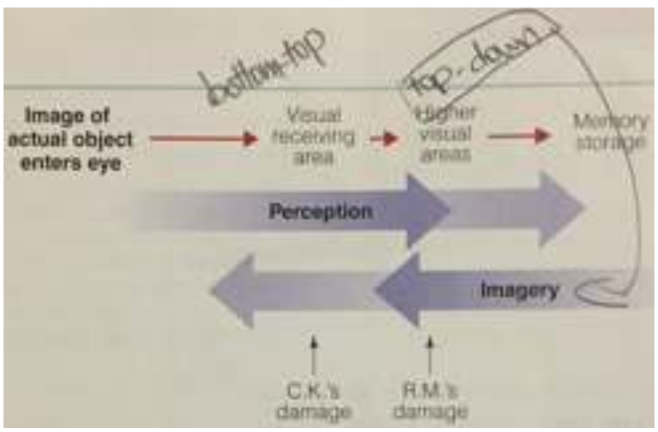
- Imagery neurons in the brain:
  - Gabriel Kreiman: Determine source of severe epileptic seizures (cannot be controlled by medication)
    - Study neurons in medial temporal lobe (hippocampus & amygdala)
    - Neurons respond to some objects but not others (e.g respond to baseball but not face)
    - Fired in the same way when person close eyes and *imagined* a baseball ⇒ Imagery neurons
    - Close relationship between perception and imagery
- Brain imaging:
  - Samuel Le Bihan: Both perception and imagery activate visual cortex
  - Same activity in striate cortex when person observed presentations of actual stimuli & when person imagining stimulus
  - Another experiment: Think about questions that involved imagery - generated greater response in visual cortex than non imagery questions
  - Stephen Kosslyn: imagery and perception result in topographically organized brain activation
    - Topographic map — specific locations on visual stimulus cause activity at specific locations in visual cortex that points next to each other on stimulus cause activity at locations next to each other on cortex
    - Looking at small objects - back of visual cortex
    - Looking at larger objects - activity to spread toward front of visual cortex
    - Imagine small visual images - activity near back of brain
    - Imagine larger images - activity move toward front of visual cortex
  - Giorgio Ganis: Overlap between perception & imagery?
    - Used fMRI to measure activation under 2 conditions:
      - 1) Perception - observe drawing of an object
      - 2) Imagery - Image a picture when they heard a tone
      - Then answer question: “Is the objet wider than it is tall?”
    - Result: Activations of 3 locations:
      - 1) Frontal lobe (Perception & Imagery) - Same activation
      - 2) Occipital lobe (visual cortex) - Perception activates more area
      - 3) Back
      - Show difference & overlapping patterns

- Amir Amedi: Similarities + Differences between brain activation for perception and imagery
    - When subjects viewing visual imagery - <u>non visual stimuli areas deactivated</u>
        - Visual images are more fragile than real perception ~ helps quiet down irrelevant activity that might interfere with mental image
- Sue-Hynn Lee: Use brain activation pattern - determine what subjects perceiving / imagining
    - Result: Activity in visual cortex in occipital lobe - best prediction for perceiving
        - Activity in higher visual areas - best prediction for imaging

- Transcranial Magnetics Stimulation: (TMS)
    - Pylyshyn: Spatial experiences + brain activity ⇒ Epiphenomenon
        - Brain activity - *Something* is happening but ay have nothing to do with causing imagery
    - Stephen Kosslyn: TMS
        - Measure reaction time in visual cortex when subjects carrying out perception / imagery task
            - Perception task - view stripe display of 4 squares → make judgement about stripes in 2 quarters
            - Imagery task - close eyes → make judgement based on mental image of display
        - TMS applied to visual area of brain - Faster reaction time
        - TMS applied to other part of brain - slower - for both perception & imagery
        - Brain activation occurs in response to imagery is not an epiphenomenon - brain activity in visual cortex plays a casual role in both perception + imagery

- Neuropsychological case studies:
    - How brain damage affects imagery + How brain damage affects both imagery and perception
    - Removing part of the visual cortex decreases image size:
        - Patient M.G.S: part of her <u>right occipital lobe</u> removed as treatment for a severe epilepsy
        - Martha Farah: M.G.S to perform mental walk task - imagine walking toward animal → estimate how close
        - Before operation: 15 feet → After operation: 35 feet
        - Reduces size of her field of view
    - Perceptual problems are accompanied by problems with imagery:
        - People lost ability to see color - also unable to create colors through imagery
        - Unilateral neglect — Patient ignores objects in one half of visual field
        - Edoardo Bisiach & Claudio Luzzatti: Imagery of patient with unilateral neglect
            - Describe things he saw - neglected left side of his mental image (just as he neglect left side of perception)

- Dissociations between imagery and perception:
  - Cecilia Guariglia: damaged had little effect on ability to perceive but caused neglect in mental images
  - Patient R.M: Suffered damage to <u>occipital & parietal lobes</u> - able to recognize objects + draw objects - unable to draw objects from memory + unable to answer questions depend on imagery
  - Marlene Behrmann: Patient C.K: Suffered from visual agnosia (inability to recognize objects), able to draw objects from memory
- Making sense of neuropsychological:
  - Paradox: cases that show parallels between perceptual deficits and in imagery + dissociation (normal perception but impaired imagery (R.M) or Impaired perception but normal imagery (C.K))
    - Different mechanisms? but contradict other evidences that show they share same mechanism
  - Behrmann: Mechanisms of perception & imagery overlap only partially
    - Mechanism for perception located at both lower & higher visual center ; Mechanism for imagery located mainly in higher visual centers



C.K - damage early in the processing stream, can still create images (higher-level areas intact)

R.M - damage to higher-level areas, difficulty in creating mental images (early processing stream are still functioning)

Can't explain M.G.S (changes in perception + imagery)

- Conclusions from Imagery Debate:
  - Imagery & Perception are closely related and share some (but not all) mechanisms
  - fMRI results - overlap between brain activation is not complete
  - Perception occurs automatically ; imagery needs to be generated with effort
  - Perception is stable (continues as long as observing stimuli) ; imagery is fragile (vanish without continued effort)
  - Deborah Chalmers & Daniel Reisberg: Harder to manipulate mental images than images that are created perceptually
    - Create mental images of ambiguous figures (rabbit / duck)
    - Result: can flip in perception, cannot in mental images

Using imagery to Improve Memory

- Placing images at locations:
  - Greek poet Simonides: organizational function of imagery
    - Banquet → roof of hall collapsed → need to identify bodies
    - Created mental picture of where each person seated at banquet table
    - Based on image of people's location → determine who had been killed
  - Method of Loci — method in which things to be remembered are placed at different locations in a mental image of spatial layout
- Associating images with words:
  - Pegword technique — Associate concrete words to different location
  - Rhyming - provides a retrieval cue
  - Pegword - create vivid image with object represented by word

Something to Consider

- Visual imagery and food craving:
  - Food craving — goes beyond ordinary hunger because of its intensity and specificity
  - Most common food craved - chocolate
  - Recurrent craving → overeating, eating disorders etc
  - Caused by: nutritional deficiencies, hormonal changes, emotions, proximity to enticing foods
    - Cognitive factor: Imagery
  - Kristy Harvey: female subjects rate intensity of craving (100 point scale)
    - *Food imagery group*: imagine favourite food ⇒ large increase in craving
    - *Holiday imagery group*: imagine favour holiday
    - Nonfood imagery decrease craving
      - *Visual imagery group*: create images based on visual cues
      - *Auditory imagery group*: create images based on auditory cues
      - Result: Food craving is reduced following both visual & auditory imagery (larger effect for visual)
        - Baddeley & Hitch's model of working memory - phonological (auditory), visuospatial sketch pad (visual)
  - Eva Kemps & Marika Tiggemann: Subjects look at dynamic visual noise every time they crave food
    - Result: Visual noise decreases food craving & related food consumption

Chapter 11 — Language

What is Language?

- Language — system of communication using sounds or symbols that enables us to express our feelings, thoughts, ideas, and experiences
- Creativity of Human language:
  - Language - a way of arranging a sequence of signals — sounds for spoken language, letters & written words for written language, physical signs for sign language
  - Structure - 1) Hierarchical, 2) Governed by rules
- Universal need to communicate with language:
  - Deaf children - use sign language
  - Human - follow rules (grammars)
  - Universal across culture - different languages but there isn't a single culture without language
  - Development - babies babbling (7 months), few meaningful words (first birthday), first multiword utterances (age 2)
  - All have nouns and verbs, a system to make things negative, ask questions, refer to past and present
- Studying language:
  - Greek philosophers: Socrates, Plato, Aristotle
  - Modern scientists: Paul Broca and Carl Wernicke: Areas in **frontal** and **temporal** lobes
  - Behaviourism: B. F. Skinner: published a book - proposed that language is learned trough reinforcement
  - Linguist: Noam Chomsky: published a book - human language is coded in genes
    - Despite wide variation across language, underlying basis of all language is similar
    - Child produce sentences that have never heard and that have never been reinforced (e.g I hate you Mommy)
  - Psycholinguistics — filed concerned with psychological study of language
    - 4 Major concerns:
      - 1) *Comprehension* — understand spoken & written language? conversation with one another?
      - 2) *Speech production* — physical processes of speech production & mental processes?
      - 3) *Representation* — presented in mind and brain? Group words into phrases? activation of brain?
      - 4) *Acquisition* — learn language? learn additional languages?
    - Importance of context

Perceiving Phonemes, Words, and Letters

- Lexicon — person's knowledge of what words mean, sound, and how they are used in relation to other words
- Components of words:
  - Smallest units of language:
    - Phonemes — sounds
    - Morphemes — meanings
  - Phonemes:
    - Phoneme — shortest segment of speech that, if changed, changes the meaning of a word
  - Morphemes;
    - Morpheme — smallest units of language that have a definable meaning or a grammatical function
  - Phonemes and Morphemes - building blocks of words
- How perceiving sounds and letters is affected by meaning:
  - Speech: Phonemic restoration effect:
    - Phonemic restoration effect — phonemes are perceived in speech when sound of their phoneme is covered up by an extraneous noise
    - Richard Warren: "The state governors met with their respective legislatures convening in the capital city"
      - Replaces /s/ in legi<u>s</u>latures with a cough
      - No subject recognized cough, didn't know /s/ missing
      - "Filling in" based on context ⇒ <u>top-down processing</u>
    - Influenced by meaning of words
  - Speech: Perceiving individual words in sentences:
    - People say words differently - accent, speed, relaxed approach when speak naturally
    - Taken out of context → words become more difficult to understand
      - Irwin Pollack & J.M Pickett: subjects record conversations → take out single words → subjects only identified half of the words
    - Consider words spoken in sentence not separated by spaces - continuous speech
    - Speech segmentation — ability to perceive individual words even though there are often no pauses between words in sound signal
      - When we know language - individual words stand out - knowing meanings of word helps us perceive them
      - Meaning is responsible for organizing sounds into words

- Reading: The word superiority effect:
  - Context - perceiving written letters
  - Word superiority effect — letters are easier to recognize when they are contained in a word than when they appear alone or are contained in a nonword
  - Gerald Reicher: tested word superiority effect
    - First stimulus (a word, a single letter, a nonword) → random pattern → 2 letters - pick which letter was presented in original stimulus
    - Result: more quickly and accurately when latter had been part of word
      - Letters in words are not processed one by one but each letter is affected by comet within witch it appears

Effect	Description	Conclusion
Phonemic restoration	Phoneme in a spoken word in a sentence can be perceived even if it is obscured by noise	Knowledge of meaning helps “fill in the blanks”
Word isolated from conversational speech	Difficult to perceive isolated words	Context provided by surrounding words aids in perception of word
Speech segmentation	Individual words are perceived spoken sentences even though there are usually no breaks between words in speech stimulus	Knowledge of meaning of words in language and knowledge of other characteristics of speech (e.g sounds that usually go together in word) help create speech segmentation
Word superiority	Letters presented visually are easier to recognize when in a word	Letters are affected by their surroundings

Understanding words

- Corpus of a language (sample of utterances or written text from a particular language) — indicates frequency with witch different words are used and frequency of different meanings and grammatical constructions in that language
- Word frequency effect:
  - Word frequency — frequency with which a word appears in a language
  - Word frequency effect — we respond more rapidly to high-frequency words than to low frequency words
  - Lexical decision task:
    - Given a list of words and indicate whether they are word / nonword
    - Slower responses for low-frequency words
  - Saccadic eye movements — movements of types from one place to another when looking at a scene
    - Stop briefly - fixation
    - By tracking eye movements - can track mental processes that are occurring as person is reading

- Keith Rayner: measure subjects' eye movements as they read sentences (contain high/low-frequency words)
  - Longer fixation time for low-frequency words
  - Readers need more time to access meaning of low-frequency words
- How past experience with words influences our ability to access their meaning

- Lexical ambiguity:
  - Lexical ambiguity — existence of multiple word meanings
  - Some meanings of a word are more likely than others in a particular language
  - Matthew Traxler: "many words have multiple meanings, but these meanings are not all created equal"
  - Meaning dominance — some meanings of words occur more frequently than others
  - Biased dominance — when words have two or more meanings with different dominances
  - Balanced dominance — word has more than one meaning but meanings have about same dominance
  - Difference between biased and balanced dominance - influences the way people access meanings of words as they read them
    - "*cast*" worked into the night (control: *cook*) - both meanings are take into consideration - longer fixation time
  - Meaning frequency - take context into account

Effect	Description	Conclusion
Word frequency	Words vary in frequency with which they are used in a particular language, this affects eas of understanding	High-frequency words are read faster than low-frequency words
Lexical ambiguity	Many words have more than one meaning. For words with biased dominance, one meaning is more likely. For words with balanced dominance, meanings are equally likely.	A word's meaning dominance and context in which it appears determine which meanings of the word are activated and how rapidly.

Understanding sentences

- Semantics & Syntax:
  - Semantics — meaning of words and sentences ; Syntax — rules for combining words into sentences
  - Brain areas for syntax and semantics:
    - Paul Broca & Carl Wernicke - localization of function
    - Paul Broca: area in **frontal lobe** (Broca's area) - involved in language **production** - syntax (structure of sentences)
    - Carl Werenicke: area in **temporal lobe** (Wernicke's area) - involved in language **comprehension** - semantics (understanding meaning)

- Broca's aphasia — slow, labored, ungrammatical speech (damaged to Broca's area)
  - Difficulty forming complete sentences + difficulty understanding some types of sentences
  - Difficulty processing connecting words (e.g was, by)
  - Problems in syntax - creating meaning based on word order
- Wernicke's aphasia — produce speech that was fluent and grammatically correct but tended to be incoherent
  - Meaningless speech
  - More widespread difficulties in understanding sentences

- Electrical signals for syntax and semantics:
  - Syntax and semantics can be distinguished - measuring *event-related potential (ERP)*
  - ERP - recorded with small disc electrodes placed on person's scalp, fast time scale of fractions of second
  - N400 - meaning of word ; P600 - grammar (form of sentence)

- Understanding sentences: Parsing:
  - Parsing — Grouping of words into phrases
    - Central process for determining meaning of sentence
  - Garden path sentences — Sentences begin appearing to mean one thing but then end up meaning something else
    - e.g After the musician played the piano … was wheeled off of the stage
  - Temporary ambiguity — Initial words of sentence are ambiguous - lead to more than one meaning - but meaning made clear by end of sentence
- Syntax-first approach to parsing:
  - Lynn Frazier: Syntax-first approach to parsing — People read a sentence, their grouping of words into phrases is governed by a number of rules that are based on syntax
  - Late closure — when a person encounters a new word, person's parsing mechanism assumes that this word is part of the current phrase, so each new word is added to the current phrase for a long as possible
    - e.g [After the musician played] [the piano … was wheeled off of the stage]
- Interactionist approach to parsing:
  - Interactionist approach to parsing — Information provided by both syntax and semantics is taken into account simultaneously when we read / listen to a sentence
  - Meaning of words in a sentence:
    - E.g The spy saw the man with the binoculars // The bird saw the man with binoculars
    - Knowledge influences the way we interpret relationships between words in the sentence

- Information in a visual scene:
  - Michael Tanenhaus: Visual world paradigm — determining how subjects process information as they are observing a visual scene
    - Measure subject's eye movements
    - 2-apple condition vs. 1-apple condition: "Place the apple on the towel"
      - 1. Relevant apple is on the towel ; 2. Move the apple onto the towel
    - Changing scene have effect on eye movements
- Making predictions based on knowledge about environment:
  - Take "statistics" what is most likely to occur - into determining meaning
  - E.g "Getting himself and his car to work on neighbouring island was time consuming. Every morning he drove for a few minutes, and then boarded the…" - "ferry"
    - People's knowledge that getting from one island → another island - involve boarding a ferry
- Making predictions based on knowledge of language constructions:
  - Knowledge of how language is constructed
  - Alex Fine: Readers change their predictions based on experience with new constructions
    - E.g Experienced soldiers warned about dangers before midnight raid (main verb) // Experienced soldiers [warned about the dangers] conducted the midnight raid (relative clause)
    - E.g Experienced soldiers who were warned about dangers conducted the midnight raid (Unambiguous)
      - Longer time for ambiguous sentences, compared to unambiguous sentences ⇒ Ambiguity effect
    - After 10 trials → subjects gain experience in reading RC construction - adapt to new sentence statistics → ambiguity effect vanished

Effect	Description	Conclusion
Semantics & Syntax are affected by damage to different brain areas	Broca: Frontal lobe damage affects syntax Wernicke: Temporal lobe damage affects semantics	Semantics and syntax are processed by different brain areas
Errors of semantics and syntax generate ERP responses	Semantic and syntactic errors cause ↑ in N400 (semantics) and P600 (syntax) components of ERP	Semantics and syntax are processed differently in brain
Words in sentence can affect processing of an ambiguous sentence	"The spy saw the man with binoculars" vs. "The bird saw man with binoculars"	Semantics can affect sentence processing
Information in visual scene can affect processing of an ambiguous sentence	Different scenes cause different processing of same sentence	Content of scene can affect sentence processing
Temporary ambiguity can be caused by expectations and can be changed by experience	Less likely sentence construction creates more ambiguity, but effect ↓ with experience	Past experience with statistics of language + ongoing experience affects sentence processing

Understanding Text and Stories

- Relationships between sentences → coherent story
- Inferences — determining what text means by using knowledge to go beyond information provided by text
- Making inferences:
  - John Brandsford and Marcia Johnson: read passages → try to remember
    - Never seen "hammer" but saw "pounding nail" - assume he was using hammer
  - Narrative texts — texts in which there is story that progresses from one event to another
  - Coherence — representation of text in a person's mind so info in one part of text is related to info in another part of text - created by different types of inference
  - Anaphoric inference: Anaphoric inferences — inferences that connect an object / person in one sentence to an object / person in another sentence
    - Use of pronoun - refer to subject/object from previous sentence
  - Instrument inference: Instrument inference — Inferences about tools / methods
  - Casual inference:
    - Casual inference — Inferences that events described in one clause / sentence were caused by events that occurred in a previous sentence
    - Making connections between sentences - essential for creating coherence in texts
    - Involves dynamic process that involves transformation of words, sentences, sequence of sentences → meaningful story
- Situation models:
  - Situation model — mental representation of what a text is about
  - Representation of situation in terms of people, objects, locations and events described in story
  - Mental representations as simulations:
    - Person simulates perceptual and motor (movement) characteristics of objects and actions in story
    - Robert Stanfield & Rolf Zwaan: sentences describing situation of object → indicate whether picture shows object mentioned in sentence
      - E.g Hammered the nail into wall // Hammered nail into floor
      - E.g (1) Eagle in sky // (2) Eagle in nest - outstretched wings faster for (1)
      - Result: respond "yes" more rapidly when picture's orientation matched situation described in picture
        - Subjects created perceptions that matched situation as they were reading sentences
    - Reader/listener stimulates motor characteristics of object in story

- Olaf Hauk: link between movement, action words, and brain activation - measuring brain activity using fMRI
    - 2 conditions: 1) Move right/left foot, left/right index finger / tongue ; 2) read "action words" (e.g kick, pick, lick)
    - Results: Areas of cortex activated by actual movements and reading action words
        - More extensive for actual movements
        - Activation by reading words occurs approximately in same areas of brain
        - Link between action words and activation of action areas - physiological mechanism related to creating situation model as person reads story

- Predictions based on knowledge about situations:
    - Measuring ERP when people read short passages
    - N400 - response to errors in word meaning
    - E.g He saw the group walk onto the …
        - *Stage* - "expected" // *Guitar* - "event-related" // *Barn* - "event-unrelated"
        - Expected - small response in amplitude of N400 ; Event-unrelated - large N400
    - Metusalem: knwoledge about different situation is continually being accessed

Effect	Description	Conclusion
Making inferences	Subjects infer meaning that extends beyond wording of sentence Number of was to create coherence in text (anaphoric, instrument, casual)	Creative process based on past experience adds meaning + help create coherence
Creating situation models	Listeners simulate perceptual & motor characteristics of objects and actions in story	Readers create perceptions that match situations described in sentences
Link between action words & brain activity	Motor areas of cortex are activated by action words	Readers' responses to words include simulation of actions
Prediction based on knowledge of situation	Readers access most likely word to fit story, and also related words	Readers' experiences with situations lead to predictions

Producing Language: Conversations

- Taking the other person into account:
    - Given-new contract — speaker should construct sentences so that they include two kinds of information:
        - (1) *Given information* — information that listener already knows
        - (2) *New information* — information listener is hearing for the first time

- Susan Haviland & Herbert Clark: consequences of not following give-new contract
    - Present pairs of sentences (given sentence does not match next sentence)
    - Need to make an inference → take longer
- Sharing process: Common ground — speakers' mutual knowledge, beliefs, & assumptions
- Ellen Isaacs & Clark: e.g doctor using common english to communicate with patient, but use medical terms to communicate with another doctor
    - Establish common ground - back-and-forth exchanges during conversations
    - Subject 1 describe pictures → Subject 2 arrange pictures in same order
    - Successive trials - needed fewer words - establishment of common ground (communication becomes efficient as conversation progresses)
    - Result: Both New York City residence → high percentage of name references + percentage ↑ on later trials
    - Common ground - determined by people's expertise + exchange of info during convo
- Syntactic coordination — Process which people use similar grammatical constructions

- Syntactic coordination:
    - Kathryn Bock: Convo between Robber & Lookout
        - Syntactic priming — hearing a statement with particular syntactic construction ↑ chances that sentence will be produced with same construction
    - Holly Branigan: Syntactic priming
        - Priming statement: 1) "The girl gave the book to the boy" ; 2) *"The girl gave the boy the book"*
        - Subject picks matching card that correspond to confederate's statement + describe to confederate
            - *"The father gave his daughter a present"* - match Vs. "The father gave a present to his daughter" - x match
            - Result: 78% match form
    - Conversations are dynamic & rapid
    - Semantic: People take other people's knowledge into account and help establish common ground if necessary
    - Syntactic: People coordinate/align syntactic form of their statements

Effect	Description	Conclusion
Given-new contract	Speaker provide given + new info in sentence	Providing given info facilitates comprehension
Common ground	Mutually recognized common knowledge	Speakers tailor info to listener's level of knowledge. People work together to achieve common ground in convo
Syntactic coordination	Similar grammatical constructions in sentences during convo	Person's speech patterns influenced by grammatical constructions used by other person in convo

Something to Consider

- Culture, Language, and Cognition:
  - Edward Sapir & Benjamin Whorf: Sapir-Whorf hypothesis — nature of culture's language can affect the way people think
  - Jonathan Winawer: Russian-speaking vs English-speaking - discriminate different shades of blue
    - 1) Same category (both *siniy*) vs. 2) Different categories (*siniy* vs. *goluboy*)
    - Results: Russian - respond more quickly in (2) ; English - no difference
      - Because Russian language distinguishes between *siniy* & *goluboy*
    - Aubrey Gilbert: Difference between how colors processed in left & right hemispheres
      - Language processed in left - if language affect color perception ~ more likely when color is viewed in right visual field
      - Present color wheel - a target color stands out from the rest of the colors
      - Need to press a button indicating which side (left/right?) the target color is on
      - Result:
        - Presented to left visual field - reaction time the same whether odd color was in same/different category as other colors
        - Presented to right - reaction time faster when odd was from different category
      - Conclusion: when language hemisphere activated → category effect occur ; nonlanguage hemisphere - no category effect

Chapter 12 — Problem Solving

What is Problem?

- Problem — there is an obstacle between a present state and a goal and it is not immediately obvious how to get around the obstacle

Gestsalt Approach: Problem Solving as Presentation and Restructuring

- Gestalt: Law of Perceptual organization
  - Problem solving- 1) How people represent problem in mind ; 2) How solving problem involves reorganization / restructuring of representation
- Representing a problem in mind:
  - Wolfgang Kohler: length of circle x if radius is r
    - Create rectangle on upper left quadrant → x = diagonal of rectangle = radius of circle
  - Restructuring — Process of changing problem's representation
- Restructuring and insight:
  - Insight — Sudden realization of problem's solution
  - Suddenly discovering crucial element → solution
  - Lack of evidence to support insight experience
  - Janet Metcalfe & David Wiebe: distinguish between insight and non-insight problems
    - Should be a difference in how subjects feel they are progressing toward solution in insight problems
    - make "warmth" judgements every 15 seconds as they work on problems - whether they are close to solution
    - Insight problems - subjects should not be good at predicting how near hey are to a solution (ans pop out suddenly)
    - Non insight problems - methodical process - know when they are getting close to solution
      - E.g algebra problems
    - Results: insight - jumped directly from 3-7 ; non insight - begins at 3 then gradually increases
- Obstacles to problem solving:
  - Fixation — peoples tendency to focus on a specific characteristic of problem that keeps them from arriving at a solution
  - Functional fixedness — focusing on familiar functions or uses of an object

- Karl Duncker: Candle problem — ask subjects to use various objects to complete task - mount candle on cork board burn without dripping wax on floor
  - Present materials inside match box vs. outside matchbox (empty matchbox)
  - Matchbox used as a support rather than container
  - Robert Adamson: subjects presented with empty boxes 2x more likely to solve problem
- Maier: Two staring problem - tie together 2 strings hanging from ceiling
  - Solution - tie pliers to one string - act as pendulum —> functional fixedness
  - Cannot solve → Maier "accidentally" brushed the string → triggered insight that plier could e used as weight to create a pendulum → 23/37 solved it
- Mental set — perceived notion about how to approach a problem (determined by experience)
- Luchins: Water jug problem - Use 3 jars to attain desired volume
  - Jar A - 21 quarts ; B - 127 quarts ; C - 3 quarts ; Desired - 100 quarts — B - A - 2C
  - 7: Desired quantity = A + C; 8: Desired quantity = A - C
  - Mental set group: Solve 1 first, then continue to 2-8
    - Subjects established mental set for using B - A - 2C
  - No mental set group: Solve 7 first, weren't exposed to B - A - 2C procedure
  - Results: Only 23% of mental set group used simpler solutions for Problem 7,8 ; All subjects from no mental set group use simpler solutions

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Modern Research on Problem Solving: Information-Processing Approach

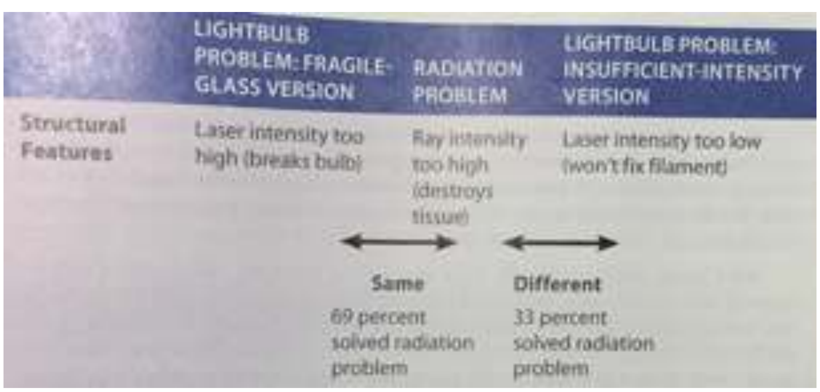
- Alan Newell & Herbert Simon: "Logic theorist" computer program for problem solving
- Tower of Hanoi Problem
  - Newell & Simon's Approach:
    - Initial state — conditions at beginning of problem ; Goal state — Solution of problem
    - Operators — actions that take problem from one state to another
    - Rules: Move one at a time + can only move top disc + larger disc cannot be on top of smaller disc
    - Involving a series of choices of steps ⇒ Intermediate state ⇒ Problem space
    - Means-end analysis: reduce difference between initial and goal states
    - Subgoals — intermediate states that are closer to goal
  - E.g Flight from Pittsburgh → Copenhagen

- Importance of How problem is stated:
  - Mutilated checkerboard problem: total 64 squares, dominos cover 2 squares in different colors, eliminate 2 corners of checkerboard (same color), can we cover remaining squares with 31 dominos ⇒ no
  - Craig Kaplan & Herbert Simon:
    - 4 versions: 1) Blank; 2) Color (black & pink) ; 3) Words (black & pink) ; 4) Words (bread & butter) - same layout + solution
    - Version 4 - very different but are also associated with each other (fastest)
    - Version 1 - provides no info - twice as slow as version 4 (slowest)
    - Think-aloud protocol — subjects asked to say out loud wha they are thinking while solving a problem
      - Determine what info the person is attending to while solving a problem
    - Similar to Gestalt idea of restructuring
    - *The Russian Marriage Problem*: Same situation as checkerboard, usually able to solve checkerboard problem if they realize connection between couples in story and alternating squares ⇒ Method of **Analogy**

Using Analogies to Solve Problems

- Analogy — using solution too a similar problem to guide solution of a new problem — Analogical problem solving
- Analogical transfer:
  - Analogical transfer — transfer from one problem to another
  - Target problem — Problem subject is trying to solve (e.g checkerboard); Source problem — Another problem that shares some similarities with target problem that illustrates a way to solve target problem (e.g Russian marriage)
- Analogical problem solving and Duncker Radiation Problem:
  - Karl Duncker: Radiation Problem
  - Tumour patient - need ray to destroy tumour
    - High ray - destroy healthy tissues
    - Low ray - does not affect tumour
  - Mary Gick & Keith Holyoak: only 10% of subjects arrived at correct solution
    - Correct solution: Bombard tumour with low-intensity rays from different directions
    - *Fortress Story*:
      - General dispatching small groups of army to avoid mines
    - After Fortress story, 30% were able to solve radiation problem
    - Ask them to think about story, success rate → 75%

- Process of analogical problem solving (3 steps):
    - 1) Noticing: analogous relationship between source problem and target problem
        - Most difficult out of the 3 steps
    - 2) Mapping: Correspondence between source story and target problem
        - Map parts of story onto test problem by connecting elements of source to target problem
    - 3) Applying: Generate parallel solution to target problem
- Surface features — Specific elements of problem
- Holyoak & Kyunghee Koh: Surface features similar to radiation problem
- Effect of making surface features more similar:
    - *Lightbulb problem*: Filament no longer work, use laser beam to fuse two parts of filament into one
        - High-intensity - break fragile glass surrounding filament ; Low-intensity - would not break the glass
    - 81% of subjects know about radiation solved lightbulb problem; 10% control solved it
- Effect of varying structural features:
    - Structural features — underlying principle that governs solution
        - E.g Strong rays (or laser) destroys tissue (lightbulb)
    - Keeping surface features constant, source problem (lightbulb), target problem (radiation)
        - Source Problem 1: Fragile-glass version - 69% solved radiation problem
    - Surface features different
        - Source Problem 2: Insufficient-intensity version - 33% solved radiation problem
    - Analogical transfer - improved by making structural features of source + target problems more similar



- Analogical encoding:
    - Analogical encoding — process by which two problems are compared and similarities between them are determined

- Dedre Gentner & Susan GoldinMeadow: possible to get subjects to discover similar structural features
  - Compare 2 cases that illustrate a principle - negotiation
  - 1) Negotiation strategies: trade-off ("I will give you A, if you give me B") ; contingency (person gets what he/she wants if something else happens)
  - 2) One group given trade-off solution cases; another group given contingency solution cases
  - 3) Given a new case - solved by either negotiating principles
  - Results: forces subjects to pay attention to structural features that enhance their ability to solve other problems

- Analogical in the real world:
  - Kevin Dunbar: Analogical paradox — while it is difficult to apply analogies in laboratory research, people routinely use analogies in real-world settings
    - *In vivo research*:
      - In vivo research — Observing people to determine how they solve problems in real-world situations
      - Advantage: Captures thinking in naturalistic settings
      - Disadvantage: Time-consuming, difficult to isolate and control specific variables
    - Biologists & Immunologists during lab meetings - use analogies 3~15 times in 1-hr meeting
  - Bo Christensen & Christian Schunn: Recorded meetings of design engineers - creating new plastic products for medical applications
    - How to create a continuer that would hold small liquid for few minutes before falling apart
    - Use analogy about every 5 minutes

How experts solve problems

- Experts — People who, by devoting a large amount of time to learning about a field and practicing and applying that learning
- Difference between how experts and novices solve problems:
  - Experts - usually solve problems faster with high success rate than novices (people who are beginners or who have not had the extensive training or experts)
  - Experts possess more knowledge about their fields:
    - William Chase & Herbart Simon: chess master performance
      - Experts able to reproduce positions of pieces on chessboard after looking at an arrangement for 5 secs
      - Experts excelled at this task when arranged in <u>actual game positions</u>
      - Experts no better than beginners when arranged <u>randomly</u>

- Chess master stored many patterns occurring in real game in LTM
    - See chess not in terms of individual pieces → 4~6 chunks (group of pieces that form familiar, meaningful pattern)
- Experts' knowledge is organized differently than novices:
  - Michelene Chi: Sort problems based on similarities
    - 24 physics problems → experts (professors) vs. novices (students)
    - Novices - sort problems based on similar objects (inclined planes)
    - Experts - sort problems based on similar physics principles (conservation of energy)
      - More effective problem solving
- Experts spend more time analyzing problems:
  - Slower at the beginning (understand the problem) → More effective approach to problem

- Expertise is only an advantage in the expert's specialty:
  - Differences between experts & novices only appear within expert's field
  - James Voss: Real world problem
    - Expert political scientists performed best ; expert chemists performed as poorly as novice political scientists
  - Expert - disadvantage when confronting a problem that requires flexible thinking

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Creative Problem Solving

- Niels Bohr: Instead of going for the right answer to physics problem, suggested some other ways
- What is creativity:
  - Divergent thinking — thinking that is open-ended, involving large number of potential "solutions"
  - James Kaufman: divergent thinking is cornerstone of creativity, but not all creativity can be
    - Creativity must be useful
    - Creativity — anything made by people that is in some way novel and has potential value or utility
- Practical creativity:
  - Examples of creative analogical problem solving:
    - George de Mestral: After hiking one day, saw many burrs covering pants and dog's fur
      - Saw many "hooks" on burrs → developed Velcro
    - Jorge Odón: Designed device when baby stuck in birth canal during delivery
      - Get cork out of bottle: Stuck plastic bag → blow it up → pull it out together with cork

- Problem solving as a process:
  - Trial-and-error development
  - 4 stages process:

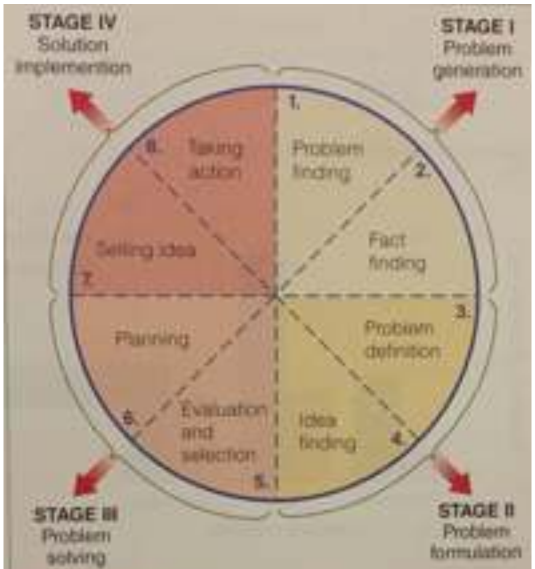

Figure 12.20 Problem solving process proposed by Basadur et al. (2000). Basadur proposes four steps, each of which is divided into two processes. For example, Stage II, problem formulation, consists of two steps: defining the problem and finding ideas. *(Source: Based on M. Basadur, M.*

  - Wright brothers' invention of airplane: 4 years of effort

- Generating ideas:
  - Steven Smith: Providing examples to people before they solve problem - influence nature of their solutions
    - Inventing, sketching and describing new toys
    - 3 examples group vs. no example
    - Results: Example group incorporated features from example - functional fixedness
    - Inhibit creativity
  - Ronald Finke: Creative cognition — technique to train people to think creatively
    - Randomly selects 3 objects → create a new object
    - Preinventive forms — ideas that precede the creation of a finished creative product
      - Need to be developed further before becoming useful "inventions"
      - People tend to come up with creative uses for preventive objects they had created themselves (similar to generation effect)

Something to Consider

- Creativity, Mental illness, and the open mind:
  - Highly creative people are more prone to mental illness (esp bipolar disorder & psychotic conditions)
  - Swedish study: close relatives of people with schizophrenia, schizoaffective disorder, and bipolar disorder
    - Higher average chance of being in a creative profession
    - Mental illness run in families
  - Latent inhibition (LI) — capacity to screen out stimuli that are considered irrelevant
  - Schizophrenia - LI impaired → enhance creativity
  - Shelly Carson: Fill out questionnaires that measured (i) creative achievement score ; (ii) Level of latent inhibition
    - Low LI → High creative achievement scores
    - Reduced LI → increasing unfiltered stimuli available to conscious awareness (increases possibility of creating useful combinations of stimuli)
  - Alan Snyder: what type of disorder can tell us about creativity
    - Savant syndrome — people with autism / other mental disorder are able to achieve extraordinary feats (e.g able to tell the day of week for any randomly picked date / great artistic/mathematic talent)
      - *Top-down inhibition*
      - Damage to anterior temporal lobe
  - Richard Chi & Synder: Present subjects with 9 dots problem
    - 4 straight lines that pas through all 9 dots without lifting pen from paper
    - Extending dots outside square
    - Brains are wired to think in a certain ways (based on past experience) - Gestalt grouping principles