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Introduction to Cognitive Psychology

Motivations for studying cognitive psychology:

- Intellectual curiosity
- Cognitive psychologists strive to understand the mechanisms that make intellectual sophistication possible
- Artificial intelligence (AI) needs to pay more attention to how human thought functions
- Great feats of intelligence, such as scientific discovery, are the result of basic cognitive processes
- Implications for other fields
- The basic mechanisms governing human thought are important in understanding the types of behaviour studied by other social sciences
- An appreciation of how humans think is important to understanding:
 - A. Why certain thought malfunctions occur (clinical psychology)
 - B. How people behave with other individuals or in groups (social psychology)
 - C. How persuasion works (political science)
 - D. How economic decisions are made (economics)
 - E. Why certain ways of organising groups are more effective and stable than others (sociology)
- Practical applications
- Has been a long history of research on the reliability of eyewitness testimony that has led to guidelines for law enforcement personnel
- Number of applications of basic information processing to the design evaluations of various computer-based devices, such as modern flight management systems on aircraft
- Applications to education, including reading instruction and computer-based systems for teaching mathematics

History

- In Western civilisation, interest in human cognition can be traced to the ancient Greeks
- Plato and Aristotle speculated about memory and thought - their philosophical discussions developed into a debate between two positions:
 1. Empiricism: All knowledge comes from experience
 2. Nativism: Children come into the world with a great deal of innate knowledge
- Not until end of 19th century that the scientific method was applied to the understanding of human cognition (only in last 150 years has it been realised that human cognition could be the subject of scientific study rather than philosophical speculation)
- Wilhelm Wundt - established first psychology laboratory in Germany
- Wundt, his students and many other early psychologists used a method of inquiry called introspection
- Introspection: Highly trained observers reported the contents of their own consciousness under carefully controlled conditions
- Basic assumption = the workings of the mind should be open to self-observation
- Wundt's introspective method was not well accepted in America - rather it was largely an armchair avocation in which self-inspection was casual and reflective rather than intense and analytic
- Edward Thorndike (an important figure of early American scientific psychology) - developed a theory of learning that was directly applicable to classrooms
- Interested in the effects of reward and punishment on the rate of learning

- The 'irrelevance' of the introspective method and its apparent contradictions laid the groundwork for the great behaviourist revolution in American psychology that occurred around 1920
- Behaviourism held that psychology was to be entirely concerned with external behaviour and was not to try to analyse the workings of the mind that underlay this behaviour
- Behaviourism was not as dominant in Europe
- A number of German psychologists immigrated to America and brought Gestalt psychology with them
- Gestalt psychology claimed that the activity of the brain and the mind was more than the sum of its parts
- A theory of internal structure makes understanding human beings much easier
- Three main influences account for the modern development of cognitive psychology:
 1. Research on human performance - given a great boost during WWII when governments badly needed practical info about how to train soldiers
 - Information theory is an abstract way of analysing the processing of information
 2. Developments in computer science, particularly AI, which tries to get computers to behave intelligently
 3. Linguistics - studies the structure of language
 - Noam Chomsky's linguistic analyses proved critical in enabling cognitive psychologists to fight off the prevailing behaviourist conceptions
 - Fields of cognitive psychology and cognitive science overlap - cognitive science makes greater use of such methods as logical analysis and computer simulation of cognitive processes, whereas cognitive psychology relies heavily on experimental techniques for studying behaviour that grew out of the behaviourist era

Information-Processing Analyses

- Information-processing approach to studying human cognition has become the dominant approach in cognitive psychology
- Attempts to analyse cognition as a set of steps for processing an abstract entity 'information'
- Sternberg paradigm - participations shown a small number of digits to keep in mind. Then they were shown a probe digit and asked whether it was in the memory set, and they had to answer as quickly as possible
- Sternberg assumed that when participants saw a probe stimulus, they went through a series of information-processing stages
- Stimulus was encoded
- Stimulus was compared to each digit in the memory set
- Participant had to decide on response and generate it
- The time needed to recognise a digit increases with the number of items in the memory set

Cognitive neuroscience

- Many philosophers (Rene Descartes) have advocated a position called dualism: Posits that the mind and the body are separate kinds of entities
- This field is devoted to the study of how cognition is realised in the brain
- It's about developing methods that enable us to understand the neural basis of cognition

Neurons

- From an information-processing point of view, neurons are the most important components of the nervous system

- Neuron: A cell that receives and transmits signals through electrochemical activity
- Main body = the soma
- Attached to the soma are short branches = dendrites
- Extending from the soma is a long tube = the axon
- Axons provide the fixed paths by which neurons communicate with one another
- The axon of one neuron extends toward the dendrites of other neurons
- At its end, the axon branches into a large number of arborizations
- Each arborization ends in terminal buttons that almost make contact with the dendrite of another neuron
- Synapse: The near contact between axon and dendrite
- Neurons communicate by releasing chemicals (neurotransmitters) from the axon terminal on one side of the synapse, these chemicals act on the membrane of the receptor dendrite to change its polarisation, or electric potential
- Existence of a greater concentration of positive sodium ions on the outside of the membrane is particularly important to the functioning of the neuron
- Synapses that decrease the potential difference = excitatory
- Those that increase the difference = inhibitory
- If the reduction in potential is large enough, a depolarisation will occur at the axon hillock, where the axon joins the soma
- This depolarisation is caused by a rush of positive sodium ions into the inside of the neuron
- This sudden change (action potential) will propagate down the axon
- When the nerve impulse reaches the end of the axon, it causes neurotransmitters to be released from the terminal button, thus continuing the cycle
- Rate of firing - The number of action potentials, or nerve impulses, an axon transmits per second
- Neurons interact by driving up the activation level of other neurons (excitation) or by driving down their activation level (inhibition)
- Individual neurons respond to specific features of a stimulus
- There is evidence that synaptic connections do change during learning, with both increased release of neurotransmitters and increased sensitivity of dendritic receptors
- Information is represented by patterns of activity across many regions of the brain and by changes in the synaptic connections among neurons that allow these patterns to be reproduced

Organisation of the brain

- The central nervous system = the brain and spinal cord
- Major function of spinal cord is to carry neural messages from the brain to the muscles, and sensory messages from the body to the brain
- Lower parts of the brain are evolutionarily more primitive (responsible for more basic functions)
- Medulla controls breathing, swallowing, digestion and heartbeat
- Hypothalamus regulates expression of basic drives
- Cerebellum in motor coordination and voluntary movement
- Thalamus serves as relay station for motor and sensory info from lower areas to the cortex
- The cerebral cortex (neocortex): Account for a large fraction of the human brain (thought of as a rather thin neural sheet)
- Gyrus = a bulge of the cortex

- Sulcus = a crease passing between gyri
- Divided into left and right hemisphere
- Left hemisphere controls motor function and sensation in the right hand
- Cortical regions typically organised into 4 lobes:
 1. Frontal lobe
 - Two major functions = The back portion is involved primarily with motor functions. The front portion (prefrontal cortex) is thought to control higher level processes, e.g. planning
 2. Parietal lobe
 - Handles some perceptual function, including spatial processing and representation of the body
 - Also involved in control of attention
 3. Occipital lobe
 - Contains the primary visual areas
 4. Temporal lobe
 - Receives input from the occipital area and is involved in object recognition
 - Also has the primary auditory areas and Wernicke's area, which is involved in language processing
 - A particularly significant area for memory is the limbic system which contains a structure called the hippocampus (damage to the hippocampus and to other nearby structures produces severe amnesia)
 - Basal ganglia - subcortical structures, involved in basic motor control and in the control of complex cognition
 - Parkinson's and Huntington's disease result from damage to the basal ganglia
 - Many cognitive deficits have been observed in patients with damage to the cerebellum

Localisation of function

- The left and right hemispheres of the cerebral cortex appear to be somewhat specialised for different types of processing
- Left hemisphere seems to be associated with linguistic and analytic processing
- Right hemisphere is associated with perceptual and spatial processing
- Left and right hemispheres are connected by a broad band of fibers called the corpus callosum
- Split-brain patients: Whose corpus callosum has been surgically severed to prevent epileptic seizures
- Broca's area and Wernicke's area seem critical for speech, because damage to them results in aphasia, the severe impairment of speech
- Broca's aphasia: Speak in short, ungrammatical sentences
- Wernicke's aphasia: Speak in fairly grammatical sentences that are almost devoid of meaning (patients have difficulty with their vocab and generate "empty" speech)

Psychophysical Methods

- Gustav Fechner sometimes considered to be the true founder of experimental psychology
- Dualists hold that the mind has an existence separate from the material world of the body
- Materialists hold that the mind is not separate
- Fechner proposed to effectively split the difference by imagining that the mind, or consciousness, is present in all of nature