Cognitive Psychology

Daniel Mao

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Chapter 1

Cognitive Neuroscience

1.1 Chapter Summary

(1) Cognitive neuroscience is the study of the physiological basis of cognition.

(2) Ramon y Cajal's research resulted in the abandonment of the neural net theory in favor of the neuron doctrine, which states that individual cells called neurons transmit signals in the nervous system.

(3) Signals can be recorded from neurons using micro-electrodes. Adrian, who recorded the first signals from single neurons, determined that action potentials remain the same size as they travel down an axon and that increasing stimulus intensity increases the rate of nerve firing.

(4) The idea of localization of function in perception is supported by the existence of a separate primary receiving area for each sense, by the effects of brain damage on perception (for example, prospoganosia), and by the results of brain imaging experiments.

(5) Brain imaging measures brain activation by measuring blood flow in the brain. Functional magnetic resonance imaging (fMRI) is widely used to determine brain activation during cognitive functioning. One result of brain imaging experiments has been the identification of areas in the human brain that respond best to faces, places, and bodies.

(6) Research on brain-damaged patients by Broca and Wernicke provided evidence for localization of function for language. Based on the patients' symptoms, they identified two different conditions, Broca's aphasia and Wernicke's aphasia, as involving problems in language production and language understanding, respectively. These two conditions were associated with damage to different areas of the brain.

(7) Recent research has resulted in modification of the Broca/Wernicke model. Behavioral research has shown that patients with Broca's aphasia can, under certain conditions, have difficulty understanding language. Physiological research, involving both studying brain-damaged patients and recording the event-related potential, suggests two processes for language processing, one involving the form of language and the other involving meaning.

(8) The idea of distributed processing is that specific functions are processed by many different areas in the brain. This principle is illustrated by the finding that faces activate many areas of the brain and by the simpler example of the rolling red ball, which also activates a number of areas.

(9) Distributed processing also occurs for other cognitive functions, such as memory, decision making, and problem solving. A basic principle of cognition is that different cognitive functions often involve similar mechanisms.

(10) Objects and properties of the environment are represented by electrical signals in the nervous system.

(11) Research indicating that individual neurons in the visual system fire to specific simple stimuli, such as oriented bars, led to the idea of feature detectors. This research suggests that a particular object is represented by the firing of many neurons, creating a unique "chorus" of electrical signals for that object. The pattern of neural firing that represents an environmental stimulus is called the neural code.

(12) Among proposals regarding the nature of the neural code are specificity theory, which includes the idea of grandmother cells, and distributed coding. Current evidence favors the idea of distributed coding. Thus, a particular face would be represented by the pattern of firing across a number of neurons. This is similar to the idea of a neural chorus.

(13) The idea of a distributed neural code also applies to memory and other cognitive functions. The code for memory involves stored information.

(14) Computer programs have recently been developed that can, with a surprising degree of accuracy, use data from brain imaging, collected as a person is observing pictures of different objects, to identify from a group of objects the specific object that a person is seeing.

1.2 Brain

DEFINITION (Lateral Geniculate Nucleus)**.** The lateral geniculate nucleus is a relay center in the thalamus for the visual pathway. The LGN receives information directly from the ascending retinal ganglion cells via the optic tract and from the reticular activating system. Neurons of the LGN send their axons through the optic radiation, a direct pathway to the primary visual cortex. In addition, the LGN receives many strong feedback connections from the primary visual cortex.

DEFINITION (Occipital Lobe)**.** The occipital lobe is the visual processing center of the mammalian brain containing most of the anatomical region of the visual cortex.

Chapter 2

Memory

2.1 How was the understanding of memory evolved?

2.1.1 Pioneer in Memory Research

- Hermann Ebbinghaus discovered that most information loss occurs relatively quickly. Afterwards, further forgetting occurs at a much slower rate.

2.1.2 Behaviorist Perspective

- Subsequently, psychology was dominated by the behaviorist perspective, which ignored the mind in their investigations, preferring instead to only study things that can be observed directly: Stimuli in the environment and the organism's behavioural response.
- Because behaviourists avoided studying the contents of the **Black Box**, topics like memory remained unexplored until the so called **Cognitive Revolution** in psychology.

2.1.3 Cognitive Perspecitive

- Cognitivists once again became interested in memory because they had a new metaphor for the mind. Instead of a mysterious black box, they likened the mind to an important new invention: A computer. To Cognitivists, the brain was like the hardware of a computer and the mind was like the software of a computer.
- The computer metaphor is particularly strong in modern approaches to memory, which is conceptualized to have three processes. Information must first be **Encoded** into memory. Then it must be **Stored** in memory, until finally it must be **Retrieved** from memory. Encoding enters information into memory; Storage maintains information

in memory; and Retrieval recalls information from memory in order to use it in some way that is useful to us.

- Although the metaphor for a computer has been useful for inspiring research, it does not perfectly describe how memory works. For instance, when you retrieve the file holding your class paper from your computer, you don't expect that it has changed at all since you last saved it. You would be surprised if passages were deleted, or had been changed in some way, or if new passages had suddenly been added. However, this is exactly the nature of memory.

2.2 How reliable is memory?

2.2.1 Errors in Memory

- Memories must be **Reconstructed** in your mind each time they are used.
- Memories can lose details, or change details in subtle ways, or even add details that never actually happened. These are called **Omissions**, **Substitutions**, and **Insertions** respectively.
- In fact, some memories can be entirely false, having never happened at all. This is called **Confabulation**. Confabulations can occur when you hear about someone else's experience and then you later mistake it as your own. This type of confabulation results from **Source Amnesia**. You recall the information, but forget where it came from, in this case, mistaking it as coming from you instead of someone else.
- Because memory is a reconstructive process, it necessarily accumulates errors over time.
- We tend to be over confident regarding the accuracy of our memories and oblivious to all the changes that are introduced over time.
- Our least accurate memories are those that we think about the most. Because memories must be reconstructed each time you use them, and errors are introduced each time a memory is reconstructed.

2.2.2 Eyewitness Testimony

- A **Leading Question** presupposes the truth about what kind of answer is likely to be correct. The problem with leading questions is that they influence memory reconstruction, introducing more errors.

2.3 The first process of memory: Encoding

- The first process of memory converts various types of information into neuronal impulses. This process is called **Encoding**.

DEFINITION (Passive Encoding)**.** Encoding is **Passive** when no effort is invested in remembering the information, which is typically what happens when you are watching television, or reading a book. Because this is a very shallow form of encoding, some information can be remembered, but most will be lost or remembered inaccurately.

DEFINITION (Active Encoding)**.** Encoding is **Active** when effort is expended to process the information for later use. This is more reflective of what happens when you are taking notes, reflecting on information, or studying for an exam. These forms of encoding lead to superior memory performance later on because they require deeper levels of processing.

- Some forms of active encoding can lead to deeper processing (and better memory) than others.
  - **Structural** encoding questions asked participants something about the physical structure of a word.
  - **Phonemic** encoding questions asked participants something about what the word sounds like.
  - **Semantic** encoding questions asked participants something about the meaning of the word.

DEFINITION (Elaboration)**.** Elaboration is a form of semantic encoding that aids the recall of new information by connecting it to existing information. For example, using a metaphor to draw parallels between new concepts and existing concepts.

DEFINITION (Self Referent Encoding)**.** Self Referent Encoding is a form of semantic encoding that aids the recall of new information by connecting it to oneself. Information that is connected to us is easier to remember. For example can you think of somebody

famous born on your birthday?

DEFINITION (Dual Encoding)**.** Dual Encoding is a form of semantic encoding that aids recall of information by producing redundant (more than one) codes. For instance, if you were tasked to remember the word "Frog", you might create a mental image of Kermit the Frog. Now you would have two codes for the same information, a word and a mental image. Either one (or both) can lead you back to the information.

2.4 The second process of memory: Storage

- Storage is the process by which information is maintained in memory.
- Research in psychology has identified three different memory stores: Sensory memory, Short-term memory, and Long-term memory. Collectively, these stores are referred to as the **Three Box Model** of memory storage.

2.4.1 Sensory Memory

- As the sensory organs collect information, it is held briefly in a sensory register. Collectively, these registers make up **Sensory Memory**.
- What kind of information is held in a sensory register? The answer is raw sensory information. As you visually search the world around you, light falls on the individual receptors that make up your retina and all of this information is transferred and held unchanged in the visual register. It is thought to be a complete reproduction of the visual field.
- The visual register is a part of sensory memory which contains visual images constructed by the visual system.
- Different registers maintain information for different durations. Visual information, for example, is held within the visual register for approximately $\frac{1}{4}$ of a second. Auditory information is held a bit longer, just under 1 second.
- In rare cases, an individual's visual register lasts longer than the typical $\frac{1}{4}$ second. This is called **Eidetic** or **photographic** memory.
- Information in sensory memory after the retention interval has elapsed decays. After $\frac{1}{4}$ second, the old visual image decays and is replaced by a fresh one.

2.4.2 Short-Term Memory

- Some of the information from sensory memory can be transferred to **Short-Term** or **Working Memory** for further processing, particularly if it is the focus of our attention.
- If rehearsal is used, then the information in short-term memory can be maintained indefinitely. As long as you continue to think about the information, you won't lose it. But once rehearsal ends, then the information will decay from short-term memory in approximately 20 seconds.
- Short-term memory has an extremely limited (small) capacity.
- **Chunking** occurs when bits of information are combined to create fewer but more meaningful chunks of information.
- More recent research indicates that the true capacity of Short-term memory is between 3 and 4 chunks of information (Cowan, Chen, & Rouder, 2004).

2.4.3 Working Memory

- Alan Baddeley's model of Working Memory replaces and expands upon earlier ideas of Short-term Memory by capturing attention and integrating it with storage. This model suggests that information is processed inside (instead of outside) short-term memory.
- **Central Executive**
  - Switches between tasks.
  - Deploys attention to slave systems.
- **Phonological Loop**
  - Auditory Store: Maintains auditory (verbal) information for a few seconds (speech and reading).
  - Articulatory Loop: Rehearses auditory information.
- **Visuo-spatial Sketch Pad**
  - The Visuo-spatial Sketch Pad allows us to work with and manipulate mental images, keeping track of what objects are present and where there are in relation to us, and each other.
  - The Visuo-spatial Sketch Pad is a part of working memory and contains mental images constructed by the nervous system.

- **Episodic Buffer**
  - The Episodic Buffer, integrates visual, auditory, and verbal information within a chronological order, thus creating a movie like experience or episode.
  - This system also holds information retrieved from long-term memory.
- Each of these systems requires attention in order to perform their job. Attention is the fuel that powers working memory. However, attention is limited and must be deployed to each system depending on the task at hand.

2.4.4 Long-Term Memory

- Some of the information from Short-term Memory can be transferred to **Long-term Memory**, particularly if it has received a deep level of processing.
- When information is present in Long-term memory but cannot be retrieved, the information is said to be **Inaccessible**.
- When information used to be present in Long-term memory but has since been lost, the information is said to be **Unavailable**.
- Most researchers agree that Long-term memory is unlimited.
- Information seems to be stored in information networks according to semantic meaning.
- This suggests that priming one concept also activates other related concepts in the network, a process called **Spreading Activation**.
- Long-term memory can first be divided into Prospective memory and Retrospective memory.

DEFINITION (Prospective Memory)**.** Prospective memory refers to a form of memory that involves remembering to perform a planned action or recall a planned intention at some future point in time.

DEFINITION (Retrospective Memory)**.** Retrospective memory refers to the memory of people, words, and events encountered or experienced in the past. It can be either explicit (declarative) or implicit (non-declarative).

DEFINITION (Explicit Memory (Declarative Memory))**.** Explicit memory refers to the memory that can be talked about and transferred from one mind to another. It includes episodic memory and semantic memory.

DEFINITION (Episodic Memory)**.** Episodic memory refers to the memory of past personal experiences that occurred at particular times and places.

DEFINITION (Semantic Memory)**.** Semantic memory refers to the memory of general world knowledge that we have accumulated throughout our lives (facts, ideas, meanings and concepts).

DEFINITION (Implicit Memory (Non-declarative Memory))**.** Implicit memory refers to the memory that cannot be transferred from one mind to another simply by talking about it. It includes procedural memory and conditioned memory.

DEFINITION (Procedural Memory)**.** Procedural memory refers to the memory that aids the performance of particular types of tasks without conscious awareness of these previous experiences. It is created through procedural learning, or repeating a complex activity over and over again until all of the relevant neural systems work together to automatically produce the activity.

2.5 The third process of memory: Retrieval

- Retrieval is the process by which information is retrieved from memory.
- Retrieval can be in the form of **Recall** or **Recognition**.
  - Recall: requires the respondent to retrieve the information without any cues to help him (e.g., short-answer question).
  - Recognition: requires the respondent to recognize the target information in the presence of distractor information (e.g., multiple-choice).

- Recognition generally leads to higher performance depending on how similar the distractor information is to the target information.

Chapter 3

Evolution

3.1 How Does Evolution Work?

3.1.1 Mechanisms of Evolution

- The principle of **Uniqueness** is sometimes referred to as **Variation**. It recognizes that individuals differ from each other in terms of their characteristics.
- The principle of **Heredity** recognizes that DNA can be passed from parent to offspring, and yet an offspring's characteristics are usually different from their parents.

DEFINITION (Recombination)**.** the parent's individual DNA is scrambled up when creating gametes (sperm and egg cells) and is then mixed together with their mates DNA during sex.

DEFINITION (Mutation)**.** the random mistakes in copying that are made during cell replication.

- Natural selection forces determine which characteristics are passed on to the next generation, and which characteristics go extinct. Consequently, species tend to possess characteristics that are well suited for their environments. These characteristics are called **Adaptations**.

DEFINITION (Speciation)**.** Speciation is the evolutionary process by which populations evolve to become distinct species.

- Humans are no more (or less) evolved than any other species.
- But evolution is a mindless process that has no goal. Evolution has no preference for one species over another.
- Evolution works at the level of the individual, not the species.

3.1.2 How is evolution applied in psychology?

DEFINITION (Intra-sexual Selection)**.** Intra-sexual selection is a form of sexual selection whereby individuals of one sex compete with each other for sexual access to members of the opposite sex.

DEFINITION (Inter-sexual Selection)**.** Inter-sexual selection is a form of sexual selection whereby members of one sex choose members of the opposite sex based on preferred characteristics.

Chapter 4

Visual Perception

4.1 How do properties of waves contribute to our perception?

A single sensation can lead to multiple perceptions, and multiple sensations can lead to the same perception.

4.1.1 Sensation

DEFINITION (Sensation)**. Sensation** is the process of detecting physical energy in the environment.

DEFINITION (Transduction)**.** The process of converting sensory information into action potentials is called **Transduction**.

4.1.2 Perception

DEFINITION (Perception)**. Perception** is the organization, identification, and interpretation of sensory information in order to represent and understand the presented information or environment.

4.1.3 Visual Perception

DEFINITION (Visual Perception)**.** Visual perception is the ability to interpret the surrounding environment through photopic vision (daytime vision), color vision, scotopic vision (night vision), and mesopic vision (twilight vision), using light in the visible spectrum reflected by objects in the environment.

PROPOSITION 4.1.1 (Properties of Light)**.**

- Wavelength determines **hue**: long waves appear red, medium waves appear green, short waves appear blue.
- Amplitude determines **brightness**: higher amplitude waves appear brighter. The color black is the zero amplitude wave.
- Complexity determines **saturation**: more complex waves appear less saturated. The color white is the most complex stimulus that we can see.

DEFINITION (Additive Mixing)**.** Additive mixing is a property of a color model that predicts the appearance of colors made by coincident component lights, i.e. the perceived color can be predicted by summing the numeric representations of the component colors.

DEFINITION (Subtractive Mixing)**.** Subtractive mixing predicts the spectral power distribution of light after it passes through successive layers of partially absorbing media.

PROPOSITION 4.1.2.

- Additive Mixing: Mixing lights together produces more complex stimuli.
- Subtractive Mixing: Mixing paints together produces less complex stimuli.

PROPOSITION 4.1.3 (Principles of Grouping)**.**

- **Figure or Ground**: Scenes are divided into either Figure or Background.
- **Proximity**: The principle of proximity states that "objects or shapes that are close to one another appear to form groups". Even if the shapes, sizes, and objects are radically different, they will appear as a group if they are close.
- **Similarity**: The principle of similarity states that perception lends itself to seeing stimuli that physically resemble each other as part of the same object. This allows for people to distinguish between adjacent and overlapping objects based on their visual texture and resemblance. Other stimuli that have different features are generally not perceived as part of the object.
- **Closure**: The principle of closure refers to the mind's tendency to see complete figures or forms even if a picture is incomplete, partially hidden by other objects, or if part of the information needed to make a complete picture in the minds is missing. This reaction stems from the mind's natural tendency to recognize patterns that are familiar and thus fill in any information that may be missing.
- **Good continuation**: When there is an intersection between two or more objects, people tend to perceive each object as a single uninterrupted object. This allows differentiation of stimuli even when they come in visual overlap. Humans have a tendency to group and organize lines or curves that follow an established direction over those defined by sharp and abrupt changes in direction.
- **Common fate**: When visual elements are seen moving in the same direction at the same rate (optical flow), perception associates the movement as part of the same stimulus.
- **Good form**: The principle of good form refers to the tendency to group together forms of similar shape, pattern, color, etc. Even in cases where two or more forms clearly overlap, the human brain interprets them in a way that allows people to differentiate different patterns and/or shapes.

4.1.4 Auditory Perception

DEFINITION (Auditory Perception)**.** Auditory perception is the ability to perceive sounds through an organ, such as an ear, by detecting vibrations as periodic changes

in the pressure of a surrounding medium.

PROPOSITION 4.1.4. When molecules compress together, they form the peak of the wave. The trough is located where molecules are pushed further apart.

PROPOSITION 4.1.5 (Properties of Sound)**.**

- The frequency of the sound wave is associated with **pitch**: higher frequencies correspond to higher pitch and lower frequencies correspond to lower pitch.
  - Humans can detect frequencies between 20Hz and 20,000Hz, but we are most sensitive to frequencies in 1,000Hz to 4,000Hz range.
- The amplitude of a sound wave corresponds to our perception of **loudness**: high amplitude waves carrying lots of energy being perceived as loud and low amplitude waves carrying very little energy being perceived as quiet.
  - Each time you increase the amplitude of a stimulus by 10 dB, you double its perceived loudness.
- The complexity of a sound wave corresponds to our perception of **timbre**.
  - The simplest sound wave has only a single frequency and is perceived as a pure tone
  - Timbre is why a piano and a violin sound different, even when they play the same note at the same volume.
  - The most complex sound includes all of the frequencies from the sonic range.

DEFINITION (Olfactory System)**.** Olfactory system, or sense of smell, is the sensory system used for smelling (olfaction).

DEFINITION (Gustatory System)**.** Gustatory system, or sense of taste, is the sensory system that is partially responsible for the perception of taste (flavor).

DEFINITION (Somatosensory System)**.** Somatosensory system is the network of neural structures in the brain and body that produce the perception of touch, as well as temperature, body position (proprioception), and pain.

DEFINITION (Synesthesia)**.** **Synesthesia** is a perceptual phenomenon in which stimulation of one sensory or cognitive pathway leads to involuntary experiences in a second sensory or cognitive pathway.

4.2 How do we perceive colour?