

Cognition and Neuroscience

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1 Introduction

1.1 Definitions

Neuroscience Study of the nervous system (structure aspects) on various levels of detail: Neuroscience

Molecular Proteins and molecular signaling of the nervous system.

Cellular Morphological and physiological properties of neurons.

Neural system Creation and functioning of networks of neurons.

Cognition Mental processes (function aspects) that react to inputs. It involves processes regarding the acquisition, storage, manipulation, and retrieval of information. Cognition

Perception Information from the environment.

Attention Focus on a specific stimulus in the environment.

Learning Merging new information with prior knowledge.

Memory Encoding, storing, and retrieving information.

Action Interact with the environment using perceived information.

Language Understanding and producing spoken or written thoughts.

Higher reasoning Decision-making and problem-solving.

Biomimicry Solving problems by taking inspiration from elements of nature. Biomimicry

As proof of general intelligence¹, the human brain is taken as the model for artificial intelligence. Moreover, a successful brain-inspired AI application can provide a possibly plausible explanation of the functioning of the brain.

However, a brain differs from a computer in many aspects:

- Hardware and software are distinct while mind and brain are not.
- Machines learn by exploiting the capability of using a large memory while brains have limited capacity but high generalization ability.
- Brains produce both electrical and biochemical signals and have feedforward, feedback, and recurrent connections while machines typically only employ feed-forward connections.

Structure emulation Mimic or reverse engineer the structure of the brain (e.g. Blue Brain Project).

Function emulation Mimic a neural system on the algorithmic level (e.g. Deep Mind).

Cognitive neuroscience Study of the relationship between the physical brain and the intangible mind (thoughts, ideas). In other words, it studies the relationship between structure and function. Cognitive neuroscience

¹  Doubt

Example (Severed Corpus Callosum²). Normally, the right and left hemispheres of the brain can communicate. Moreover, the left visual field is sent to the right hemisphere and the right visual field is sent to the left hemisphere.

In patients where the hemispheres are split, a text shown on the right visual side is recognized as the speech capabilities are located in the left hemisphere, while a text shown on the left visual side does not trigger any speech reaction.

1.2 Neuroscience history

Two main schools of thought emerged and are still the subject of ongoing debates:

Localizationism Specific regions of the brain are responsible for particular faculties. Localizationism
Assuming localizationism, 52 distinct regions with different neurons can be identified.

Aggregate field theory The brain works as a whole for mental functions. Aggregate field theory

1.2.1 Neuron doctrine

The nervous system is made of a discrete amount of individual neurons (and not a continuous tissue). Neuron doctrine

Principle of dynamic polarization Electrical signals in a neuron flow only in a single direction.

Principle of connectional specificity Neurons do not connect randomly but make specific connections at particular contact points.

Synapse Point of contact of two neurons. A synapse can be chemical or electrical. Synapse

1.3 Cognitive science history

Rationalism All knowledge can be derived through reasoning, without sensory experiences. Rationalism

Empiricism The brain starts as a blank slate and knowledge is added through sensory experiences. Empiricism

Associationism Inspired by empiricism. Learning happens by correlating individual experiences (e.g. actions followed by a reward will be repeated). Associationism

Behaviorism Inspired by empiricism. Everyone has the same neural basis that is improved through learning. Learning only involves observable behaviors. Behaviorism

Remark. Associationism and behaviorism are not able to explain all types of learning (e.g. language).

Cognitivism The psychological and biological levels of an individual cannot be separated. Learning is based on the biology of the neurons. Cognitivism

²<https://www.youtube.com/watch?v=1fGwsAdS9Dc>