Connectionism

General

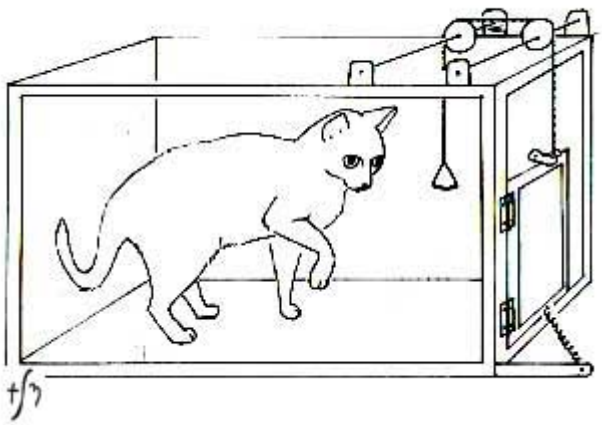
Connectionism, today defined as an approach in the fields of artificial intelligence, cognitive psychology, cognitive science and philosophy of mind which **models mental** or **behavioral phenomena** with **networks of simple units**[1], is not a theory in frames of behaviorism, it **preceded** and **influenced behaviorist school**. Although it is today used in different contexts (mostly referring to neural networks and artificial neural networks that have not emerged until second half of the 20th century) it has origins dating as far back as Greek philosopher Aristotele, who claimed that memory is composed of simple elements connected in a variety of ways[2].

What is connectionism?

Connectionism represents psychology's first comprehensive theory of learning[3]. It was introduced by Herbert Spencer, William James and his student Edward Thorndike in the very beginning of the 20th century. Connectionism was then **based on principles of associationism** which claimed that[4]:

- Mental elements or ideas become associated with one another through experience
- Experience consists of such things as spatial and temporal contiguity and (dis)similarity of ideas
- Complex ideas are composed and can be reduced to a set of simple ideas
- Simple ideas are sensations
- Simple additive rules are sufficient to predict complex ideas

But connectionism **expands** this **ideas of associationism** by introducing ideas like distributed representations or supervised learning[5] and should not be confused with associationism.



At the very end of 19th century Thorndike performed experiments first on chickens and later on cats and dogs. In one experiment he placed a hungry cat inside a *puzzle box*, which had a mechanism that would open the doors of the box every time a string would be pulled or a button pushed. Behavior which resulted in opening the doors was slowly increased as the cat after each successful attempt to open the door needed a bit less time to repeat the same action after being put back into the box. Based on this experiment Thorndike concluded that learning is **incremental** and **not insightful**,

since the learning of the correct response occurred only through repetition *trial and error* forming of associations between situation and response. Established connections or knowledge, according to Thorndike also cause and determine intelligence.

To explain observed properties of learning, Thorndike introduced three laws of learning. The first law is the ***law of exercise*** (also referred to *as law of use* or *law of frequency*), which states that **stimulus-response** (S-R) **associations** are **strengthened through repetition** or weakened through lack of repetition. His second law, ***law of effect***, states that the consequence or **outcome** of a situation-response event **can strengthen or weaken** the **connection** between situation and response. If an event is followed by a reinforcing stimulus, the connection will be strengthened and vice versa. The third law, ***law of readiness***, which claims learning is facilitated by learner's readiness (emotional and motivational) to learn. This potential to learn leads to frustration if not satisfied.

Thorndike later changed some of his views admitting that he was wrong and that negative reinforcement (punishment) does not really lead to any kind of learning. This had great influence on educational process helping to end the practice of punishing the students for incorrect answers. This laws have set the **basic principles** of **behaviorist stimulus-response** views on **learning**.

Another point of Thorndike's interest in the first two decades of 20th century was the **transfer of practice**, later often referred to as *transfer of learning*. Idea of transfer of practice is to generalize the knowledge or skills and apply them for another problem. Thorndike performed experimental studies by which he showed knowledge transfer is specific rather then general and will not occur unless learned problem and given problem share many characteristics. This was the opposite of what school systems mostly suggested at the time, that some school subjects like Latin language and mathematics improve student's mind in general (*doctrine of formal discipline*).

Guided by the principle that "*whatever exists at all exists in some amount*"[6)]Thorndike has introduced a number of tests of knowledge and intelligence. His *CAVD* (completion, arithmetic, vocabulary and directions) test set the major principles and standards of modern intelligence tests.

What is the practical meaning of connectivism?

Connectionism was at its time considered a general theory of learning for both humans and animals. Thorndike's ideas which could well be applied for learning are the idea that rewards promote learning and that repetition enhances learning.

In his book on learning of mathematics[7)], Thorndike suggested problems children are expected to solve and learn from should be realistic. For example learning to multiply by three should be learned in context of converting feet to yards. He also emphasizes importance of **repetition** and insists on repetitive practice of basic arithmetic operations. Some of the principles in this book even seem inconsistent with his views on learning: here he refers to learning as meaningful and insightful. Well-learned basic skills enable learning of higher-order skills.

Thorndike tried to apply this to learning **mathematics**[8)], **spelling and reading** [9)], measurement of **intelligence** [10)] and adult learning [11)] mostly through his laws of learning. He was one of the pioneers of **active learning**, proposing children should learn by themselves rather than being thought.

Criticisms

Thorndike tried to prove that all forms of thoughts and behaviors can be explained through S-R relations with use of repetition and reward, without need for introducing any unobservable internal states, yet this is **today** generally **considered incorrect**. This *learning through response* was later in 20th century replaced by *learning as knowledge construction*. Connectionism was in the first decades of 20th century succeeded by behaviorism, but Thorndike's experiments also inspired gestalt psychology.

Keywords and most important names

- **Connectionism**, **stimulus-response**, **S-R**, **networks of simple units**, **associationism**, **supervised learning**, **law of exercise or use or frequency**, **law of effect**, **incremental learning**, **trial and error**
- Herbert Spencer, William James, Edward Thorndike

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