If you fire together, you wire together

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The intention of this paper is to stimulate discussion on Hebb's Law and its pedagogic implications.

At a basic cellular level, Hebb's Law states that is Cell A and Cell B persistently fire, the connection between them strengthens. Figure 1 illustrates the interactions. This is a cellular levels process, suggesting that brain processes that occur repeartedly tend to become grafted together [1].

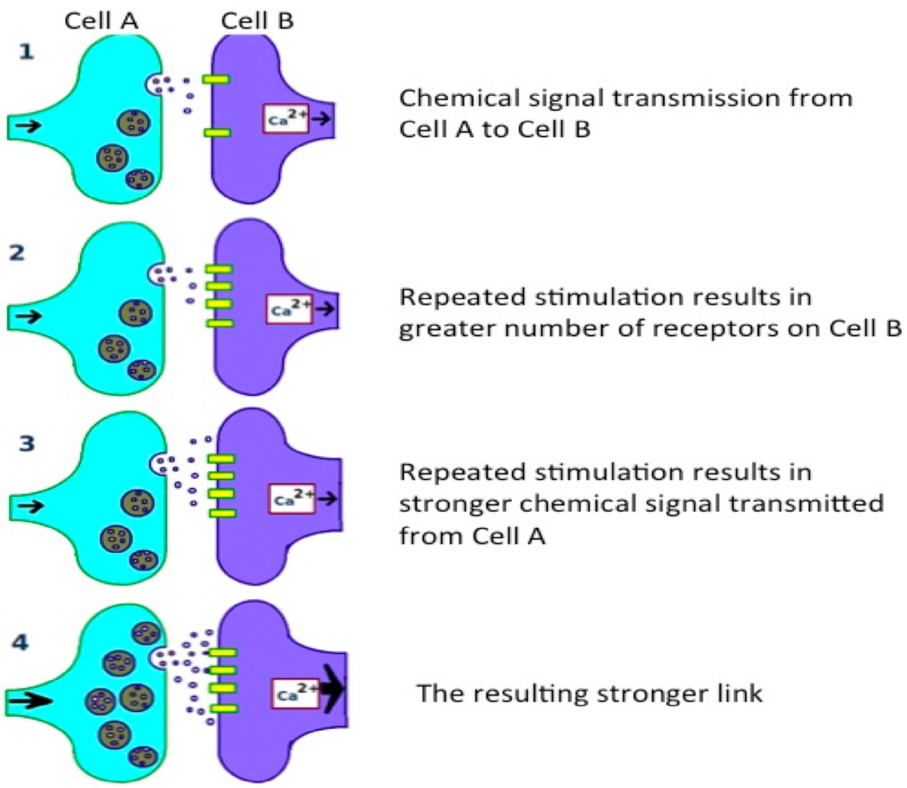

Fig 1. Hebb's Law. Repeated stimulation results in a stronger signal

This scientific theory explains the adaptation of neurons during the learning process. Importantly, this type of plasticity does not involve increasing the number of cells, but rather strengthening the existing cells' connectivity. Understanding such biological phenomena opens up new paradigms and laws that AI can utilise. The question is whether Hebb's law would stand at a higher level of abstraction? There are suggestive, but not conclusive indications. For example, a friendship is considered stronger with time, indicating a strengthening of wiring between the friends.

Models based on "firing together to wire together" have been suggested in health and therapy [2]. For example, if a patient presents with a mental trauma that causes extreme anger, the therapist introduces a counter and positive stimulus that occurs whenever the anger occurs. Both (anger and the positive stimulus) are repeated over and over again, thus following Hebb's Law and adding strength to this connection between the two stimuli, resulting in relief to the patient.

This also implies causal and temporal conjectures based on causality. The causality is in the firing sequence; that if A fires first and then B fires, A is the cause. If B fires before A, a reverse interpretation is possible that may decrease the strength between them. There seems evidence to suggest that the "firing" and "wiring" may be a sequential process.

Causality is a subject of intense philosophical interest from ancient times. Most causal models are rule-based systems. They demand descriptions of the world at two points in time – a before and an after. Two problems arise here: the practical computational compulsions make these rules crudely simplistic. In addition, it is challenging to incorporate temporal effects within the framework of rule based systems. Hebb's law, while suggesting causality, does not provide any quantification. Thus, it is unlikely that an alternative formulation of causation would emerge from Hebb's law alone. We may look for another, additional neural network perspective of causation here.

Nevertheless, causality as implied with Hebb's law has been used in scientific research and therapeutics to a large' extent. For example, oftentimes doctors complain of their patients being unable to add minor and incremental changes in their daily routines (such as exercise). Understanding Hebb's law will open new insights into why this might be so. It is possible that the patient is not yet "wired" in this activity and requires more "firing" before these changes can be established. An avenue for AI research is to aide in the development of tools to help such people to "re-wire".

Indeed, such tools exist to some extent to treat spinal cord injured patients who have lost motor control of their limbs. In a non-injured situation, the brain delivers pulses to the lower limbs in a rhythmic/patterned fashion to allow walking action. Once a spinal injury occurs, the connectivity from the brain to the limbs is lost, thereby leaving the patient immobile. Stimulators are often placed below the level of the injury, which deliver patterned pulses in a similar manner to what the brain was previously doing. Over a period of time, a spinal pattern generator emerges, which thus allows some motion of the lower limbs [3]. This area of research is as yet in its infancy and calls for a better, more intelligent systems to aide these patients.

Conclusions:

Artificial intelligence in health opens up chapters of great opportunities and exciting challenges. The logical calculus articulated by McCulloch and Pitts [4] forms the initial basis for both Symbolic and Connectionist AI. Since then a number of paradigms have emerged on all aspects of AI and relating to health and health care. The emergence of the convergence of computing and communication provides us boundless opportunities to exploit these paradigms and discover the new ones.

Referenceǎ:

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