



Is this a unified theory of the brain?
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- 1983, Geoffrey Hinton brain could be seen as a machine making decisions based on the uncertainties of the outside world
- 1990s, Peter Dayan, Geoffrey Hinton & Richard Zemel brain represents knowledge of the world in terms of probabilities and made specific proposals for tractable neural processes that could manifest such a 'Helmholtz Machine'
- 1990s, Karl Friston & Geoffrey Hinton began examining the concept of 'free energy'
- 2005, Karl Friston free energy principle - a unified brain theory : everything the brain does is designed to minimise free energy or prediction error

- Thomas Bayes [1702-1761.4.17] Bayes' theorem
- Geoffrey Hinton [1947.12.6-]
 - Education
 - BA in experimental psychology from Cambridge in 1970
 - PhD in Artificial Intelligence from Edinburgh in 1978
 - AI 连接主义的代表人物
 - 主要学术贡献: back-propagation algorithm, Boltzmann machines, Helmholtz machines...
 - Helmholtz Machine
 - a class of neural networks which learn the hidden structure of a set of data by being trained to create a generative model which can produce the original set of data
 - by learning economical representations of the data, the underlying structure of the generative model should reasonably approximate the hidden structure of the data set. This is an unsupervised learning algorithm.

脑功能成像分析软件SPM(statistical parametric mapping)

- Helmholtz/亥姆霍兹 1821-1894, 德国物理学家、数学家、生理学家、心理学家
- free energy 把化学反应中的“束缚能”和“自由能”区别开来, 指出前者只能转化为热, 后者却可以转化为其他形式的能量。

Richard Feynman / 理查德·费曼 1918-1988, 美国物理学家

→ Hermann Haken / 赫尔曼·哈肯 1927-, 1951获数学博士, 德国物理学家, 1995退休

Synergetics/协同学

系统科学老三论: 系统论、控制论和信息论; 新三论: 耗散结构论、协同论、突变论

源起 The interpretation of the laser principles as self organization of non equilibrium systems paved the way at the end of the 1960s to the development of synergetics

研究协同系统从无序到有序的演化规律

协同系统: 由许多子系统组成的、能以自组织方式形成宏观的空间、时间或功能有序结构的开放系统。

主要是用演化方程来研究协同系统的各种非平衡定态和不稳定性(又称非平衡相变)

对非远离平衡态系统实现的系统演化提出了方案。哈肯在研究中发现有序结构的出现不一定要远离平衡, 系统内部要素之间协同动作也能够导致系统演化(内因对于系统演化的价值和途径)。他认识到熵概念的局限性, 提出了序参量的概念。序参量是系统通过各要素的协同作用而形成, 同时它又支配着各个子系统的行为。序参量是系统从无序到有序变化发展的主导因素, 它决定着系统的自组织行为。当系统处于混乱的状态时, 其序参量为零; 当系统开始出现有序时, 序参量为非零值, 并且随着外界条件的改善和系统有序程度的提高而逐渐增大, 当接近临界点时, 序参量急剧增大, 最终在临界域突变到最大值, 导致系统不稳定而发生突变。序参量的突变意味着宏观新结构出现。

役使原理(slaving principle) 系统演化过程中, 在接近状态变化的临界点时, “快变量”由于变化太快, 以致在未对系统施加影响以前就消失或变化了, 而极少数“慢变量”变化相对缓慢, 成为支配和主宰系统演化的序参量。序参量由子系统的竞争与协同产生出来, 同时它又支配子系统, 子系统服从于序参量、序参量协同合作形成有序的宏观结构

- books
 - <协同学: 大自然构成的奥秘(1981, 1995~2005中)>
 - <大脑工作原理: 脑活动、行为和认知的协同学研究(1996, 2000中)> 大脑是一个以物理学定律为基础的复杂巨系统, 经由不同层次的自组织过程调节控制参量

- the free-energy principle
- the Bayesian brain hypothesis
- the principle of efficient coding
- other theories
 - the cell assembly and correlation theory
 - biased competition and attention
 - Neural Darwinism and value learning
 - optimal control theory and game theory

conclusions and future directions many global theories of brain function can be united under a Helmholtzian perceptive of the brain as a generative model of the world it inhabits