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Complex neural networks - a useful model of human learning?

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Background

Cilliers' (1998) discussion of complex neural networks draws on work in artificial intelligence to relate such networks to the mammalian brain. By invoking Hebb's law of neural pathway development Cilliers describes the way in which neural networks can be trained to recognise shapes and scenes and discusses the need to present varied training images in order that the neural system is able to recognise related input, through what Edelman (1987) calls 'Neural Darwinism'. Whilst Cilliers focuses on the issue of distributed representation, Jost (2003) further develops a quantitative model of a complex system in which learning takes place and discusses the optimisation of such a system.

Considering the brain as a complex neural network in which learning takes place through means of varied training exercises clearly has relevance to educationalists. There is implication that presenting varied contexts to learners is important in providing flexibility of understanding. Furthermore Jost's (2003) discussion of optimising neural networks suggests that a balance must be achieved between repetition of familiar contexts and the introduction of new situations. This may have implications for curriculum design, school environments, organisation of learning groups and classroom learning activities.

What is less clear however is the validity of applying what seems to be a simplistic model of brain function to the way humans learn. Only once this has been established can the implications of such a model for educationalist be discussed.

Research Questions

I intend to focus this paper on considering the implications for classroom practice, particularly the planning of learning activities by teachers. With this focus I intend to answer the following research questions:

1. How well is Cilliers' neural network model of learning supported by current neurological understanding?

2. What are the implications of such models for designing learning activities in the classroom?

Methods

The brain is not simply composed of a random distribution of neurons which develop through sensory experience, but develops according to genetic and environmental factors over a person's life. As such a mapping of neurological literature focuses on the relationship between the model of neural development proposed by Cilliers (1998) (drawing on Hebb (1949), Edelman (1987) and Changeaux et al (1984)) and the 'higher order' brain structure which determines how we experience and learn in the world.

From this mapping of literature is drawn an evaluation of the extent of support for a model of brain function based solely on a complex adaptation of systems of neurons. This will provide an exposé of the limitations of such a model with a view to further developments in the computational modelling of brain function. More importantly for educationalists however, the evaluation of complex neurological models will provide a theoretical framework (see below) with which to discuss the implications for classroom practice of learning through varied contexts, as well as for discussion of the limitations of conceptualising learning as analogous to the training of connectionist computational networks.

Frame

The theoretical framework developed presents learning as the recognition of and response to contexts similar to those experienced previously. Here ‘contexts' must be conceptualised in the broadest sense, including such diverse factors as the emotional state of the individual at a given time and even the availability of nutrients to the body.

Within this framework the model of connectionist neural networks developing through experience is situated in the broader workings of the brain. The influence of human evolutionary responses as well as developed responses to language and social norms mean that contextual learning is mediated and/or overridden by brain functions which are not included in a simplistic model of neural networks such as that proposed by Cilliers (1998).

Through critique of such simple models a theoretical framework of learning as the context driven development of connectionist neural networks, mediated by ‘higher order' brain functions is developed. This framework then forms the basis of discussion of the planning and implementation of learning activities in the classroom.

Research findings

Although further research into both neurological processes and computational modelling of neural networks will allow a greater understanding of how they might be related, there is at this stage support for considering learning as closely related to the self-organisation of neural networks within the brain. This implies that context is important in considering the learning that takes place in classrooms. However, this conception is limited unless it is accepted that the structure of the brain is determined not just by such contextual learning but by biological, environmental and social influences. Furthermore, the capacity of the human brain to ‘internalise' and process information long after the stimulus has ceased, means that a model of brain function as development of neural networks can only be useful if the notion of context is significantly redefined to include all of the above factors.

With respect to implications of classroom practice, specifically the planning of learning activities, this paper presents the hypothesis that varied and repeated learning contexts are required in order to adequately learn about a specific topic and a balance between repetition and variation should be sought according to teacher judgements of both the learners and the topic being presented. Recommendations for further research to support or falsify this hypothesis shall be discussed.