GEOGRAPHY, LEARNING AND THE BRAIN: AN EXAMPLE OF LITERATURE-BASED RESEARCH

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‘Our present-day knowledge of the child’s mind is comparable to a fifteenth century map of the world – a mixture of truth and error... vast areas remain to be explored.’

Arnold L Gesell (cited in Fisher, 1990, 1)

Introduction

From the nineteenth century onwards scientists have been aware that specific parts of the brain control particular physical and mental activities. Although the early phrenologists (as those who proposed this view were called) were unable to locate the control centres with any accuracy, more recent studies have confirmed the value of this approach. Case studies of accident victims and patients with selective brain damage have shown how our sense of taste, smell and other cerebral functions can be traced to precise locations. Furthermore, new techniques like Positron Emission Topography (which measures the fuel intake of different areas of the brain using a radioactive marker in the blood) can show the areas which ‘light up’ when we do particular tasks. This has revolutionised our knowledge of how we think the brain works.

Brain-based research has potential implications for primary geography. As yet these are unexplored, and the purpose of this chapter is to set out some of the possibilities that might emerge from a review of the area. This is a literature-based survey that draws on a range of work in brain studies to set the scene and indicate the range and state of development in relevant brain research. It is selective and limited in scope, as an introduction to this developing area. The first part of this chapter focuses on providing a background understanding about the brain and its multifaceted role in our thinking, not on particular and detailed aspects of brain-based research in recent years, such as on the hippocampus and spatial cognition and skill (O’Keefe & Nadel, 1978; Millar, 1994). This provides a basis for illustrating some of the connections to teaching primary geography, which forms the latter part of this chapter. As such, this chapter is interpretative of research and speculative in making an argument relating this vitally important area of research to geography in primary education.
Some evidence from brain-based studies

How the brain works

The brain is divided into two linked hemispheres. Some activities, such as language processing, tend to be located in the left hemisphere, while the right often deals with music and spatial awareness. Whether this specialisation is biologically determined or whether it is influenced by social and cultural forces is not entirely clear. Whatever we are doing, however, both sides of the brain are nearly always involved in some way, and information flows back and forth in a continual dialogue. In addition, it also appears that there are different layers or areas of the brain relating to different periods in our evolutionary past. McLean (cited in Jensen, 1995) has proposed a threefold structure to explain this:

- The reptilian brain is the oldest part of the brain and is responsible for survival, motor functions, mating rituals, social hierarchies and role behaviour.
- The mid-brain or limbic system controls our emotions. It regulates our eating and sleeping cycles, sexuality and immune system and is the site of long-term memory.
- The upper brain or neo-cortex is the 'thinking' part of the brain. It is divided into four key areas dealing with problems and planning, sensory information, vision and hearing and language. The neo-cortex is much larger than the other areas and occupies about five sixths of the space in the cerebrum.

McLean believes that each part of the brain has a different agenda and behaves in its own way. It is the interplay between the three parts that accounts for some of the contradictions and complexities of human behaviour. Ultimately, though, the need for survival dominates, and when our lives are threatened the reptilian brain takes charge and we react instinctively.

Recent thinking has modified and extended McLean's theory. It seems that the limbic system plays a bigger part in processing information than was previously supposed and that we attribute value to data at the same time as we interpret it. The hierarchical structure has also been challenged and replaced by a more sophisticated notion of modules (Slywester1995). Nevertheless, McLean's ideas continue to be useful; not least because they provide a comprehensible model of what is in fact an enormously complicated and subtle structure.

Although the brain is only about a litre in volume, it contains 100,000 million active cells. The cells which create brain activity are called neurons and consist of a nucleus with a single shoot at one end (axon) and lots of root-like fibres at the other (dendrites), a little bit like a sprouting onion. The point of contact between cells is called a synapse. When a cell fires it sends an electro-chemical pulse up the shoot and excites the roots of another cell. Whether the cell actually fires or not depends on the balance of messages it receives. Some pulses are trying to urge it into action while others are trying to silence or inhibit it.
Learning and cognition appear to consist in establishing patterns between brain cells. Modern scientists believe that the cortex is organised into several hundred million neural networks or modules. These extend vertically through the cortex in small columns, which are then linked up into more complex structures. Once cells have fired together a few times a chemical change occurs which makes them more likely to trigger each other in future. This is called ‘Hebbian learning’ after the Canadian psychologist Donald Hebb.

**Brain-compatible teaching**

If this account of the brain is correct, it follows that experience has a vital part to play in promoting our development. The things that we see or do are sculpted into the pattern of connections between the neurons inside our heads. Rich experiences can promote brain growth while sensory deprivation can inhibit it. Furthermore, because the brain is actually physically changed by the circumstances in which it operates, we can mould it to our needs. Robertson, a psychologist, explains:

> .... it is the gift of natural selection, and the secret of our enormous success as a species, that we can programme and reprogramme the very apparatus that controls our behaviour. (Robertson, 1999, 138)

However, what is important as far as learning is concerned is not simply the quantity of crude stimulation. Feedback is also vital. By confirming the child's first tentative attempts to make sense of their experience, parents and teachers can reinforce the first weak connections in a new neural network. An unresponsive adult leaves the child uncertain and the newly formed links are not confirmed and may even be undermined. The notion of collaborative learning (Geekie et al., 1999), in which teachers and pupils co-operate to construct new knowledge, thus appears to be supported by research evidence. The value of fieldwork and first hand investigations also becomes apparent.

The role of experience in developing our knowledge and understanding is an issue that has been discussed by philosophers for centuries. The doctrine that human beings are born with innate ideas was strongly contested from the seventeenth century onwards by Locke and other empiricist thinkers. One of the notions for which Locke is famous is the idea that the human mind is like a ‘tabula rasa’ or blank sheet. He put it this way:

> Let us then suppose the mind to be, as we say, white paper, void of all characters, without any ideas; how comes it be furnished?.... To this I answer, in one word, from experience. In that all our knowledge is founded and from that it ultimately derives itself. (Locke, 1689 [1971], 89)

Discussing this same question three centuries later from the standpoint of a cognitive scientist, Hart (1983, 82) declares ‘as a general rule, the more brainpower an animal has, the more it learns after birth’.

http://www.geography.org.uk/eyprimary/primaryresearch/researcharticles/
As we know from comparative studies, one of the defining characteristics of human beings is that we are creatures with very large brains.

The role of emotions

Our growing knowledge about the structure of the brain has led to another highly significant conclusion. Learning does not simply occur in the neo-cortex, it also requires an input from our emotional or limbic system. Some of the evidence for this comes from neurological studies. For example, LeDoux (cited in Goleman, 1996) has demonstrated clinically how rats can learn emotional reactions without any cortical involvement. Furthermore, as Sylwester (1995) points out, there are many more neural fibres leading outwards from the limbic emotional centre of the brain into the cortex than there are going in the reverse direction. This suggests that, although the limbic system is relatively small, it has a powerful influence on the rational part of our brain. When we behave illogically it is often because we are making decisions on an emotional basis. Why else, for instance, do so many people purchase lottery tickets when they know they have a negligible chance of winning?

Even the recognition of simple sensory stimuli involves an emotional dimension. When we perceive an object for the first time it seems that the incoming stimulus, rather than going to a single destination, is split into several different streams. These are then processed in parallel in different parts of the cortex and limbic system assembled in an association area. Thus, when we recognise a knife we perceive not only its shape, colour, size and the material from which it is made; we also associate it with a range of concepts such as stabbing, eating and slicing. In this way our perception is the result of a combination of images. It follows that we construct different versions of reality from the same external stimulus depending on a range of factors such as our previous experience and natural disposition.

Theories such as these have led researchers to conclude that the limbic system plays a very important role in the operation of the mind. Indeed, as Jensen (1995, 27) observes, our mid-brain area may well be the ‘glue’ that holds the different parts of the brain together. Certainly, when the link with our emotional system is severed, the effect is devastating. Carter (1999) for example, describes the unfortunate case of a patient who lost part of his limbic system in an operation to remove a growth. Although his capacities were otherwise unaffected, the patient was no longer able to live a normal life. Carter reports:

He found it hard to make the simplest decision or to pursue any single plan to a fruitful conclusion......Once at work he might fritter away a whole day either trying to decide what to do first or attending diligently to some unimportant detail while urgent tasks went unheeded. (Carter, 1999, 81)

It seems that emotions are crucial because they focus our attention, which in turn drives our learning and memory systems. The strong implication is that teachers need to get their pupils to engage
emotionally as well as cognitively in learning activities. Damasio (cited in Jensen, 1995) goes further than this. He argues that the brain, mind, body and emotions form a linked system. Certain aspects of emotion and feeling are indispensable for rationality. Emotions he says, are not separate, but rather enmeshed in the neural networks of reason.

One aspect of emotional learning which is particularly important for teachers concerns attitudes and prejudices. Robertson (1999, 174) talks about how some emotional events are particularly potent since they can create links in the brain which are more or less indelible. Traumatic events are, as he puts it, woven into our minds with stitches of 'steel thread'. Just as phobias can be contagious, so hate can be passed from person to person, infecting whole groups.

Carter (1999) is rather more hopeful pointing out that the cortex can control the emotions emanating from the limbic system. However, the connections take time to grow. It is the relative weakness of cortical signals which causes children to have far more emotional outbursts than adults. 'The young brain,' she declares, 'is essentially unbalanced – the immature cortex no match for the powerful amygdala' (Carter, 1999, 90).

It seems then that Descartes, and other rationalist philosophers whose thinking ultimately provides the philosophical underpinning for the National Curriculum (Naish 1996), may well have been mistaken when they argued that the mind could be separated from the body. The two are, it would seem, inextricably linked. Furthermore, there is good reason to suppose the brain is poorly designed for academic models of learning that focus chiefly on the intellect. What appears to be needed is a more holistic approach that involves the mind, heart and body. Hart sums up the matter when he declares that the way that:

... curriculum builders and teachers try to devise logical methods of instruction, assuming logical planning, ordering and presentation of the content matter or skills, is the plainly correct and only respectable approach to take.... It can be stated flatly, however, that the human brain is not organised for linear, one-path thought. (Hart, 1983, 52)

Hart (1983, 56) concludes with some scathing criticism of the 'undeserved respect' educators have given to Greek-type sequential logic which he believes in practice 'guarantees severe learning failure' for most young students. Robinson (2001) too expresses similar concerns and argues that the school system conflates academic ability with intelligence. Education, he contends, needs to take account of the creative abilities of all people. Apart from anything else, this will be vital to our success as a nation in the knowledge-based economies of the future.

There are other reasons to be optimistic. Those who believe intelligence is located in the cerebral cortex have often argued that it is genetically determined and cannot be changed by life experiences. If, however, we admit there is a significant emotional component, then there may be other
opportunities for enhancing performance. Goleman (1995) highlights a number of abilities which he believes are significant qualities in those who excel. Encouragingly, they can all be taught to children.

**Changes with age**

Research into neuro-biology is also beginning to shed light on how the brain changes with age. One key finding is that children have many more synapses than adults do. These are gradually pruned back through learning and experience as we grow older. Another discovery, is that during the first twenty years of life nerve pathways acquire a kind of insulation called myelin which helps keeps pulses confined and allows them move much faster. These two processes may go some of the way towards accounting for the plasticity which researchers note in the brains of children and young adults.

Until recently it was believed that the number of neurons in the brain decreased from birth onwards. However, the latest research suggests that there may also be an unsuspected period of neural growth in early adolescence. This could provide a 'critical window' for learning which needs to be used when it is available before the opportunity is lost (Giedd, 1999). The development of the pre-frontal lobes is another factor that accounts for the differences between age groups. Research by the Soviet scientist, Luria (1975) indicated that the pre-frontal lobes only fully mature in the late teenage years. It is this area of the brain which is responsible for our concept of future time and ability to concentrate.

It is instructive to relate these findings to established learning theory. Thus, when Piaget suggested that children only become capable of formal or abstract thought in adolescence he may well have been responding to what we now know are physiological changes in the structure of the mind. As Hart (1983, 115) remarks, 'it is easy here to see a probable relation to Piaget's stages or periods, and again to realise that individual variations have great practical significance'.

Indeed many key theorists such as Vygotsky, Bruner and Gardner appear to have illuminated our understanding in a way that is entirely consistent with our new neurological knowledge. If educational theory can be matched to empirical findings the implications could be very considerable, especially as it is now established that the first ten years of childhood are 'highly significant in the development of the brain's capacity to learn.' (Gipps and MacGilchrist, 1999, 51)

**Some implications for geography teaching**

Any future geography curriculum will need to take account of recent research about the functioning of the brain by cognitive scientists. If we wish to accelerate learning then we will need to adopt strategies that reflect our increasing knowledge about the workings of the mind. Some important conclusions appear already to be emerging. For example, it seems that we learn in highly individual ways and extract meaning from our environment in a rather random manner, rather as young children acquire
What we learn is heavily influenced by previous experience and involves an emotional as well as an intellectual content. Our brains work particularly well in rich, multi-modal environments. We cope rather badly with sequential logic and the manipulation of symbols, and are much better adapted to activities that have a practical outcome. Some of the evidence from research to support this perspective is outlined in Figure 1.

<table>
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<th>Fig 1</th>
<th>What we know about the brain</th>
<th>Implications for geography teaching</th>
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<tr>
<td>1</td>
<td>We learn in highly individual and often random ways and our understanding develops in fits and starts (Hart, 1985, 52).</td>
<td>Identify broad teaching objectives, rather than step-by-step stages.</td>
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<td>2</td>
<td>Children learn at very different rates. For example, all five-year-olds should not be expected to perform at the same level (Jensen, 1995, 12).</td>
<td>Use whole class instruction judiciously and try to differentiate activities for different ages and abilities.</td>
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<td>3</td>
<td>The optimal learning pattern for ten-year-olds consists of 10 minutes focused work followed by a short diffusion activity (Jensen, 1995, 48).</td>
<td>Do not devise lessons where children have to listen to the teacher for long periods without a break.</td>
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<td>4</td>
<td>All new learning is heavily influenced by previous experience via stored biases in the neurons (Hart, 1983, 100).</td>
<td>We need to discover children's existing knowledge and abilities and tailor our teaching to this.</td>
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<td>5</td>
<td>Children need to actively engage in what they are learning (Robertson, 1999, 44).</td>
<td>Provide children with practical activities and first hand experiences and encourage them to take charge of their learning.</td>
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<td>6</td>
<td>The novelty, challenges and feedback of the real world help to promote brain growth (Hart, 1983, 102).</td>
<td>Use a variety of learning strategies, especially fieldwork and real world environments.</td>
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<td>7</td>
<td>Questions generate sustained and enriching brain activity (Jensen, 1995, 168).</td>
<td>Use enquiry questions to draw children into a problem and makes them restate it.</td>
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<td>8</td>
<td>The most effective learning often leads to practical outcomes (Hart, 1983, 124).</td>
<td>Focus on real-life problems and get pupils to make models and plans as well as written reports.</td>
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<td>9</td>
<td>Learning needs to be associated with a purpose which the learner has set (Smith, 1996, 17).</td>
<td>Help children to identify questions and strong personal goals which they think are meaningful.</td>
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<td></td>
<td>Repeating what we have learnt helps our limbic (emotional) system to feel it is true (Jensen, 1995, 131).</td>
<td>Give pupils plenty of opportunities to reinforce their learning by presenting it in different ways, eg by teaching a peer, by role-play, by writing a journal.</td>
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<td>11</td>
<td>Try to make children aware of their thinking skills and strategies (Robertson, 1999, 159).</td>
<td>Transferring programs from one situation to another greatly speeds learning.</td>
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<td>12</td>
<td>Intellectual learning and emotional involvement are linked together in the fabric of the brain (Carter, 1999, 81).</td>
<td>Provide pupils with material that is appropriate to their interests and which they can relate to personally.</td>
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<td>13</td>
<td>A learner under stress is likely to resort to primitive responses and be resistant to innovation or new information (Hart, 1983, 110).</td>
<td>Try to create a supportive classroom environment and use techniques such as team building which develop self-esteem.</td>
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<td>14</td>
<td>Male and female brains are structurally different (Jensen, 1995, 87).</td>
<td>We need to acknowledge the differences between the sexes, as well as providing equal opportunities for learning.</td>
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<td>15</td>
<td>We learn with our minds, hearts and bodies (Jensen, 1995, 38).</td>
<td>We need to pay good attention to the social, emotional and physical well being of our pupils.</td>
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**Figure 1**: Applying new knowledge about the brain to geography teaching

While it may be tempting to produce a 'brain-compatible' curriculum based on the different stages in our evolutionary history, this approach is fraught with difficulties. Not only is the approach backward looking, it is also runs into the dangers of bio-determinism. How we use and apply our mental powers is heavily influenced by social and cultural factors, as Vygotsky (1962), Geekie (1999) and others have demonstrated. A knowledge of the mechanics of the mind says nothing about how our capacities should be applied. That is why it is so important to recognise that the curriculum is underpinned at a fundamental level by a set of common values and beliefs.

On the other hand, there are clear advantages in understanding the structure of the brain. We now know, for example, that there are neurological differences between the sexes. Females show a faster rate of language development and score better at some language tasks than males. By contrast males generally appear to perform better at spatial tasks (Jensen 1995, Baron-Cohen in Carter 1999). Whether these differences are culturally transmitted or biologically determined is still unresolved. What matters is that teachers are alerted to these differences. Similarly, while there are still great areas of uncertainty about the nature of learning, our increasing understanding of the operation of the mind should help us to devise modes of instruction which favour the acquisition of knowledge.

http://www.geography.org.uk/eyprimary/primaryresearch/researcharticles/
Geography educators have a long tradition of linking classroom learning with the outside world to make schooling more personal and meaningful. They have also pioneered methods of learning which encourage pupils to ask questions, test hypotheses and transfer ideas from one situation to another. Practitioners know these techniques are effective (Geographical Association, 2002). The new discoveries from cognitive science about the workings of the mind are beginning to explain why they work. This can be illustrated in the following ways.

Mapwork
Mapwork develops spatial awareness, which is a key survival skill. In the wild, creatures have to be able find their way around their environment in order to locate food and safe places in times of danger. This propensity appears to have been built into human capabilities through evolution. It is developed uniquely through geography which the only subject that distinctively explores the notion of location. Practical mapwork activities in the classroom, school grounds and surrounding areas are established features of good practice in geography teaching.

Fieldwork
Fieldwork engages children with the real world on many different levels. This matches the way the brain appears to work best, since we are designed to process information from a variety of different modes – sight, sound, smell and so forth – simultaneously. Furthermore, fieldwork provides an essentially free setting in which pupils can respond in different ways according to their needs. Fieldwork is fundamental at all levels of geography.

Geographical enquiry
Enquiry questions draw pupils into a problem so that they relate new learning to their previous knowledge and understanding. Without this link, the patterns between brain cells are not properly established. Enquiry questions have long been advocated by geographers and are used extensively in the QCA geography schemes of work (DfES/QCA, 1998/2000).

Direct experience
First hand experience provides immediate feedback which is a key component in learning, as it allows children to check whether the connections they are making are valid. Over a period of time, first hand experience can gradually remould children's thinking. Practical activities are given a high profile in geography and serve to underpin many of the components of the Geography National Curriculum. As a recent Ofsted subject report observed, some of the best work in geography 'involved pupils in practical activities linked to relevant and real issues.' (Ofsted, 2002, 3)

Role play and drama
Role-play and drama involve children emotionally. This is vital because we all need to engage in what we are learning, and we achieve much better results when fully engaged and motivated. Role plays
also help pupils to see other viewpoints, thus extending their understanding. Leat (1998) uses strategies such as these in his innovative work on geography thinking skills.

Real-life problems
Thinking about real-life problems harnesses the brain's natural capacities, especially if they involve practical skills and abilities. The most effective learning is often associated with a tangible outcome or a goal that learners have set for themselves. Geography, being the study of the contemporary world, involves the study of current issues. Introducing problems and conflicts in a meaningful way to young children is one of the challenges which geographers have begun to take extremely seriously over the last few decades. However, as Catling (2003) argues, there is much more to be done.

Teamwork
Teamwork helps to develop intrapersonal and social skills. Geography, along with other subjects, provides contexts in which pupils can work to investigate an issue, communicate findings or solve a problem. The importance of collaborative learning and groupwork is also extolled in the current debate about creativity and thinking skills.

Communicating
Communicating findings helps to consolidate learning and make it meaningful. Indeed, one of the best ways of learning something is to explain it to another person. There are frequent opportunities for children to report their findings in geography lessons. Higgins (2002) is one of a number of researchers who argues that one of the best ways to enhance children's thinking is to encourage them to talk about their findings.

Graphical and visual presentations
Charts, diagrams and other visual presentation techniques serve to extend pupil's skills beyond the rather narrow confines of linguistic and logico-mathematical thought and to explore links and connections that might not otherwise be apparent. They are employed extensively by geographers who use the term to graphicacy to cover a wide spectrum of non-verbal communication techniques.

Generic concepts
Over-arching concepts such as change, pattern and process provide pupils with notions that help to structure their experience. Labelling and sorting are fundamental parts of learning. Introducing children to appropriate categories helps to organise their thoughts and raise their level of attainment. Identifying concepts is also important if we are to build progression into the geography curriculum in a meaningful way.
Conclusion

The current interest in creativity and thinking skills is pointing the way ahead. Leat, an enthusiast for cognitive acceleration, is clear that 'learning needs to be made more visible to pupils in classrooms' (Leat, 2000, 150). Interestingly, he argues strongly in favour of big concepts and skills, not only because they emphasise connections between subjects but also to promote better practice in assessment. Further research is needed into ways of raising levels of achievement. The ways in which findings from neuro-science can be applied to primary geography also needs to be explored much more fully. Both these areas appear to offer exciting possibilities for the future and provide good links with the current interests and concerns.

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