



The Mathematical Brain



What's this about?

Welcome to the second of two articles that examine areas that can be difficult in a child's education. In this article we will discover a little about the Mathematical Brain - the brain parts involved, the importance of one idea at a time, sleep and why some children find Mathematics so hard.

We are born with a sense of number

Did you know that babies can do basic sums? Scientist, Karen Wynn (1992), has studied babies as young as 5 months, and has shown that they are able to predict the answer to simple Maths problems. For instance, when a toy is hidden behind a screen, and then another toy is also placed behind that screen, infants expect to see two toys when the screen drops. Researchers know this because if there are not two toys behind the screen, the baby stares for a long time or sucks extra hard on her dummy. It appears that her tiny brain is saying "That's not right! What's going on here?" If the correct number is behind the screen the baby glances at the two toys and then looks away as if to say "Yep, I expected that!"

Many studies have since confirmed these findings. This suggests that we are all born with a 'sense of number' - and there is a part of our brain already wired up for Maths!

"You take after me"

According to Brian Butterworth, a neuropsychologist who studies how the brain learns Mathematics, current evidence shows that mathematical ability comes from hard work and persistence rather than a natural born gift.

The "only statistically significant indicator of mathematical excellence is the number of hours put in." (2002)

It seems that talent in Maths comes mostly from early success and enjoyment, helped along by the encouragement from parents and teachers to keep trying. In fact, further studies (Seal, 2003) have shown that children achieve far better results if they

believe that 'talent' in a subject comes from hard work and persistence rather than being born with it.



Did You Know?

Current evidence suggests that success in Maths does not come as a result of natural born talent, but is instead the result of persistence, encouragement and the motivation to succeed.

Source: Kathy Seal

If your child is struggling with Maths study, try to avoid making statements such as "You take after me... I was always terrible at Maths." Saying this provides your child with a ready made excuse to give up when the going gets tough. Instead make a comment like "You're a smart kid - I know you can do this ... how about trying again?" - and offer to help, if appropriate.

The Hippocampus has limited capacity

Towards the centre of our brain is the Hippocampus. This area, combined with our frontal lobes, plays a major role in organising and storing information in our memory and, it appears, reinforcing memories while we sleep! However, not all information experienced in a day is reinforced - the brain only makes information permanent if it makes sense or has some meaning for us.

Because the hippocampus reinforces learning while we sleep (Blakelee, 2000), and only has a limited storage capacity, we should be careful about how many new ideas are experienced in one day. Eric Jensen (2005), states that the only subject in which increased exposure benefits new learning is Language acquisition. For other learning, studies suggest that a "Less is more" mentality is far more effective (Russell et al, 1984). This means that parents and teachers should present fewer new ideas, and should allow time for 'settling' and consolidation so that synaptic connections can be formed and reinforced before tackling the next new idea.

With this in mind, if helping your son or daughter with homework, be careful about pushing them on to the next topic before bed.

"Hey mum, I learnt how to add fractions".

"Show me "

"Great - you're obviously good at that - now let me

teach you how to multiply them!"

Instead, if your child has learned a new idea that day, reinforce it by making up some new questions or discussing where we might use that kind of Mathematics rather than racing ahead to the next idea or topic in the book. If you do this, they will go to bed with only one major mathematical idea in the hippocampus rather than a 'muddle' to be reinforced while they sleep. (Teachers should consider this too in their classroom teaching!)

So, learners need to 'settle' or sleep between new ideas. Sounds like a good excuse for power naps during the day!

Key Point



Remember the age old adage "Sleep on it." Even if your child appears to have thoroughly grasped a new concept, the chance of long term retention is far better if they wait a day before moving onto the next new idea.

Mathematics and the brain

Recent studies suggest that most Mathematical problem solving and permanent storage occurs in two main areas of the brain, the **left parietal lobe** and the **prefrontal cortex**.

Do you remember when you were young and had to repeat your times tables again and again until you remembered them by heart? "one 2 is 2, two 2s are 4, three 2s are 6.. "- Then someone could ask you 4 x 6 and you'd immediately have 24 in your head. (You may still have it there!)

The left parietal lobe seems to be the main storage centre for these number facts (Dehaene), and also for your instant ability to recognise that you are looking at 3 cars or 5 dogs. This part of the brain also holds the methods or ways that we do mathematical processes such as how to go about solving a long-multiplication problem - "... times by 4, equals 24, now carry the 2...".

These permanent 'facts' are stored through repetition - you sometimes need as many as 40 repetitions to make a permanent memory - and, when practised and used often, the synapses strengthen and eventually

The Mathematical Brain

they can be recalled 'instantly'. Most of our early Mathematics study at school is focused on storing these facts and methods so that they are quickly available to us for solving problems later.

Did you know that some people who have had the left parietal lobe removed because of cancer are unable to tell that they are looking at two cars in a car park? They need to count them. If there was another car park next to this one with 5 cars in it, they would be unable to tell which car park has more cars! Imagine living your life with no ability to calculate at all! You couldn't tell how much change to expect when you buy something or that five people won't be able to sit in the four seats around your dining table.



Did You Know?

Practise and repetition of number facts helps to create a Mathematical "bag of tricks" which is instantly available for use in problem solving. Having these facts readily available, without using a calculator, promotes tremendous confidence and competence in Mathematics!

Picture the number 3 in your head - now add 7, multiply by 2, and then subtract 4. What is your answer? How did you keep track? Research has shown that most people picture a number line in their head which runs from left to right and place the numbers on it, keeping track of each answer as they go. (Dehaene, 2004)

Problem Solving

The part of our brain that plays a large role in solving problems is the prefrontal cortex. Perhaps this is the "logical" centre of the brain. It seems that when we are trying to do a difficult Maths problem, our prefrontal cortex gets information, methods and calculations - our mathematical "bag of tricks" - from the parietal lobe and uses this stored knowledge to come up with an answer.

Consider the question below which was given to 11 year olds in a British study.

"Imagine a straight wooden pole that is stuck in the mud at the bottom of a pond. There is some water above the mud and part of the pole sticks up into the air. One half of the pole is in the mud; two thirds of the rest is in the water; and one metre is sticking out into the air. How long is the pole?"

How would you try to solve this? Draw a picture of it. Does that make it easier? What do you already know that will help you work it out? What facts do you have stored in your parietal lobe that will help you? Or does an emotional response get in the way that makes you give up without even trying? The answer is 6 metres. There are many ways to

solve the problem. Compare how you got the answer (if you did) with someone else. Did they go about it the same way?

Problems such as this get the *prefrontal cortex* working - you need to picture the problem and access stored knowledge to come up with a solution.

Children can exercise the prefrontal cortex from a very young age. An example of a prefrontal cortex problem for children as young as grade two is:

Find three consecutive numbers (eg. 2, 3, 4) that add up to 24.

Talk to your child about how they might come to an answer. You'll be amazed at what they understand and the variety of ways that kids use to find a solution. (The answer is $7 + 8 + 9$.) Did you notice that the middle number 8 is the average of 24 or that it is 24 divided by 3? - Some kids do! You could then get your child to investigate what other numbers are the result of three consecutive numbers... is there a pattern?

Questions such as those above exercise the prefrontal cortex, developing skills in problem solving and again, increasing Mathematical confidence.

So why do some children find Maths so difficult?

There seems to be two main reasons why kids experience difficulties in Maths. The first is that some children - estimates range between 3 and 6 percent - are born with a learning impairment called Dyscalculia. Children with Dyscalculia have difficulty learning, and particularly storing, the standard number facts and methods needed for solving Maths problems. Dyscalculia is a kind of 'dyslexia for numbers' - but unlike dyslexia, very little is currently known about the best ways to diagnose and 'treat' this condition. Brian Butterworth (2003) believes that understanding of dyscalculia is 20 years behind that of dyslexia. So if your child seems to understand concepts at the time of learning, and is clearly trying to learn, but doesn't appear to remember a week later, she may have dyscalculia. Be kind, these kids cannot help it and are not lazy. (For more information, see the dyscalculia website at www.dyscalculia.org).

Key Point



A small number of learners have dyscalculia; a 'dyslexia for numbers' which makes long term storage of numbers and methods really difficult.

The other major reason that students experience difficulties in Maths can occur when the subject is taught in a way that leaves the student failing to understand what they are doing or why. If

the Mathematics being taught seems irrelevant or meaningless, or the teacher or parent has no enthusiasm, some students do not see the point of working to find solutions. As a parent, reinforcing that Mathematics is a useful and valuable subject can make an enormous difference to your child's willingness to persist and his or her eventual success in the subject.

Summary



The least I need to know

It is important for learners to see the value of Mathematics and useful applications of ideas being taught.

John Joseph has pointed out how important healthy concepts are to learning (see Module 1). Help your children to grow healthy concepts by offering encouragement that Mathematics is a worthwhile pursuit and needs persistence to achieve mastery.

Even when some of the ideas presented are not immediately applicable to everyday life, Maths helps to develop skills in problem solving and exercises the logical and spatial centres of the brain.

References



(Items marked * are available from Mind Webs). Log on to www.mindwebs.com.au or call Cathy Joseph for a catalogue (08) 8358 6993.

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Next Issue - Concluding Article, Parenting - the long haul endeavour.