Contents

1 Our brain's Post-it note

This chapter looks at:

- what working memory is, and why it's important
- how working memory relates to academic success
- the differences between working memory and IQ
- quick ways to help students with poor working memory.

Working memory is our ability to remember and manage information. The best way to think of working memory is as the brain's 'Post-it note'. We make mental scribbles of bits of information we need to remember. In addition to using it to remember information, we also need working memory to process or manage that information as well. Working memory is critical for a variety of activities at school, from complex subjects such as reading comprehension, mental arithmetic, and word problems to simple tasks like copying from the board and navigating around school.

One question I often get asked is whether working memory is the same thing as short-term memory. No, it is not. Here is an example of the difference. Imagine that you are driving to a new school for a meeting. You lose your way and stop at a store to ask for directions. You may repeat the information to yourself over and over again as you walk back to your car so you don't forget. At this point, you are using your **short-term memory** to remember the directions. Now you get back inside your car and start driving. As you recite the directions to yourself, you look around and match them to the road names. Is this where you make that right turn? Where do you make that second left? Now you are using your **working memory** as you are applying or using the information that you were given.

It is much the same in the classroom. When you give a student a set of instructions, they use their short-term memory to repeat it to themselves. However, by the time they get back to their desk and

have to carry out the first task in the set of instructions, chances are that if they have poor working memory, they will have forgotten what to do. The process of repeating the information and then carrying out the individual steps relies on working memory. Think of working memory as 'work'-ing with information to remember. The Try It box gives you an example of a working memory test.

Try It 

Read these sentences and decide if they are true or false:

1. Bananas live in water: True or False
2. Flowers smell nice: True or False
3. Dogs have four legs: True or False

Now, without looking at those sentences, can you remember the last word in each sentence in the correct order? If you were able to remember them, congratulate yourself. Your working memory is like that of an average 10-year-old. This test is an example of the Listening Recall test from the Automated Working Memory Assessment. It measures verbal (auditory) working memory. In this book, **verbal memory** is synonymous with **auditory memory**. In tests like this, the sentences are presented orally and the student repeats the required information out loud. We will look more closely at tests to diagnose working memory problems in Chapter 2.

Working memory in childhood

How much can we remember at each age and does this amount increase as we get older? I conducted a study of thousands of individuals from 5 to 85 years old in order to address this issue. Figure 1.1 on page 4, illustrates how much the average individual can remember at each age. The most dramatic growth is during childhood. These years are crucial as working memory increases more in the first 10 years than it does over the lifespan. You will notice a steady increase in working memory right up to our twenties. At this point, working memory reaches a peak and plateaus. The average 25-year-old can successfully remember about five items. As we get older, working memory declines to around three to four items. How does this relate to the classroom? The average five-year-old can hold one item in mind (list of words, instructions, etc.); a seven-year-old can remember two items, a 10-year-old can remember three items, and a 14-year-old can remember four items.

You may have noticed that there are two lines in Figure 1.1: one for verbal/auditory working memory and another for visual–spatial working memory. These two working memory skills develop at a similar rate. In the classroom, we use **verbal working memory** to remember instructions, learn language, and perform comprehension tasks. **Visual–spatial working memory** is used to remember sequences of events, patterns, images, and maths skills. My research has demonstrated that the way we use working memory to process information, whether verbal or visual–spatial, draws on some common skills. The Science Flash box details the parts of the brain that we use for different working memory tasks.

Working memory is a relatively stable construct and all working memory components are in place by four years of age. While working memory does increase with age, its relative capacity remains constant. This means that a student at the bottom 10 percentile compared to their same-aged peers is likely to remain at this level throughout their academic career. If a six-year-old with poor working memory is struggling initially, they are unlikely to catch up with their peers without intervention. By the time they are 10, the gap in learning between them and their same-aged peers will have widened. That is why early diagnosis and support is so crucial. Here is one mother's story.

Case Study

My name is Mary and my six-year-old daughter was tested via her school. I am not sure the name of the test, but her result in the working memory test was 63, way below average, in the borderline category. I of course started to research 'Working Memory' and have learned quite a lot … 95% of the information is due to you. The description of the symptoms fit her to a T. Every one actually. I feel I have answers now as to why she 'forgets' so many things. The school wants to have her repeat the 1st grade because of her lower grades in maths and reading. They also feel she needs more time to develop. As a mother, I feel that she is going to have the exact same issues, no matter what grade she is in. I do not see her 'growing out of it'. She hasn't thus far.

Limits to working memory

What can prevent us from using our working memory optimally? I will outline three limitations to working memory. Throughout the book, I

2 Diagnosing working memory

This chapter looks at:

- ways to test working memory
- the benefits and drawbacks of the tests available.

Students with poor working memory often struggle in classroom activities, simply because they are unable to hold in mind sufficient information to allow them to complete the task. Losing crucial information from working memory will cause them to forget many things: instructions they are attempting to follow, the details of what they are doing, where they have got to in a complicated task, and so on. In order to effectively support a student's working memory in the classroom, it is important to recognise different classroom activities that involve working memory. Here are some examples.

Classroom activities that involve verbal working memory

- Remembering sequences of three or more numbers or unrelated words, such as *5, 9, 2, 6*, or *cat, lion, kangaroo*, or even unfamiliar letter combinations such as '*sp*'.
- Remembering and successfully following lengthy instructions. Here is an example from a classroom of six-year-olds: *Put your sheets on the green table, put the arrow cards in the packet, put your pencil away, and come and sit on the carpet*. Often what happens is that students are able to perform the first part of the instruction and place their sheets on the green table and they are the first to sit down on the carpet. But they have forgotten the intermediate instructions and so have not done them. Even older students with poor verbal working memory can have difficulty recalling instructions.

- Remembering lengthy sentences containing some arbitrary content to be written down (e.g. *The speeding spider spied a spade*). If the sentence contains information that is not familiar to the student, they are more likely to forget it.
- Remembering sentences with complicated grammatical structure, such as *To save the princess, the knight fought the dragon.* It would help the student remember the sentence better if it were rephrased as *The knight fought the dragon* ***to save the princess.***
- Identifying digits on the 100 square/number line that follow a specific number pattern, for example odd/even numbers; multiples of 6; factors of 10, and so on.
- Identifying the missing numbers in a sequence: *0, 1, 2, __, 4, 5, __.*
- Playing '*Buzz'* to reinforce multiplication facts. Students all stand up and count in consecutive numbers from 1. If, for example, the game is focusing on multiples of 3, pupils must say '*buzz'* if their number is a multiple of 3 when it is their turn (*1, 2, buzz, 4, 5, buzz, etc).* Students sit down when they respond incorrectly.

Classroom activities that involve visual–spatial working memory

- Keeping track of the place reached in the course of multi-level tasks such as writing a sentence down either from memory or from the white board. Often what can happen is that a student can repeat or skip letters and words during sentence writing, or even miss out large chunks of a task.
- Using pictures or images to recall a story. They may get confused about the order of events in the story or even omit key events despite having a visual reminder.
- Retelling in chronological order a sequence of events from memory, using vocabulary words such as *first, second, next, last.*
- Remembering and performing rehearsed actions to lines of poetry.

In the previous chapter, we looked at the importance of working memory in learning. Here is a summary of what we know so far:

1. Working memory measures our ability to learn, rather than what we have already learned.
A key difference between working memory and IQ is that working memory is relatively impervious to environmental factors, such as the number of years spent in pre-school education and financial back-

ground. This means that students will not be disadvantaged in the classroom as a result of their home life or background. Each student has a similar ability to learn – as educators, we need to unlock their potential.

2. Working memory is the best predictor of academic attainment and is even more important than IQ.

Scientific studies, my own included, demonstrate that working memory predicts success in the classroom from language to maths to history to art, regardless of the student's IQ (Cowan and Alloway, 2008). Working memory is not just crucial in early education: surveys of college students also reveal that their working memory, not their IQ, determines their success.

3. 1 in 10 students suffers from working memory problems.

I have led government-funded projects to survey thousands of students and found that 10% struggle with poor working memory (Alloway, Gathercole, Kirkwood and Elliott, 2009a).

4. Without intervention, students with working memory problems will not catch up over time.

My research has demonstrated that Individual Education Programmes (IEP) are not enough to help students with learning difficulties catch up to the same level as their peers (Alloway, 2009a). While it is important to support the specific learning needs of students using IEPs, we must develop their ability to remember and manage information – their working memory.

5. Working memory impacts learning in students with disorders, such as dyslexia, dyscalculia, dyspraxia, Developmental Coordination Disorder (DCD), Attention Deficit Hyperactivity Disorder (ADHD), and Autistic Spectrum.

I have worked with all these different atypical groups and consistently found that working memory underpins their academic performance. Intervention programmes that target their symptoms do little to instigate lasting change in learning outcomes. Ultimately, in order to see improvements in learning, we must boost working memory. The remainder of this book will look at the working memory profile of each of these disorders and provide guidance on classroom strategies to support their learning needs (Alloway, Rajendran and Archibald, 2009).

Learning disorders

The incidence of learning disorders is increasing. Currently, almost three million schoolchildren in the US are classified as having a learn-

ing disability and receive special educational support, which translates to 3–7% of the public school population. In the UK, about 2% of the population is diagnosed with a learning disability. As students with learning disabilities grow older, the gap between them and typically developing peers widens with respect to attainment levels. In a government-funded study, I looked at a group of 5- and 11-year-olds with working memory difficulties (Alloway, Gathercole, Kirkwood and Elliott, 2009a). The older group performed much worse than the younger children in language and maths tests. The effect of poor working memory is cumulative across development, resulting in greater decrements in learning as a student gets older. This difference in performance can be explained in part by the classroom environment of the two age groups. Younger children are more likely to have additional adult support and memory aids made available for them in the classroom. However, as they get older, they are typically expected to be more autonomous in their learning and thus may be left to develop their own strategies. In older classrooms, teachers are also more likely to use longer and more complex sentences, which require the students to rely on their working memory. Their poor working memory means that they struggle to acquire key learning skills and concepts. Without these building blocks in place, they are unable to keep up with their peers. As they get older, the combination of the increasing difficulty of their class work and an insufficient learning foundation results in them lagging behind their peers.

This book provides guidance in supporting these students. Each learning disorder covered here – reading and maths disabilities, motor dyspraxia (Developmental Coordination Disorder), ADHD, and Autistic Spectrum Disorder – appears in the *Diagnostic and Statistical Manual of Mental Disorders (DSM)* (APA, 2004). This volume, published by the American Psychiatric Association, is the leading reference manual for disorders. The diagnostic criteria for each disorder provides a valuable and trusted resource used by clinicians, researchers, and related professionals around the world. Inclusion in the DSM goes some way in validating the existence of the disorder. As a result of being diagnosed with a disorder that appears in the DSM, the student can be entitled to special education needs provision. It is often the case that if a link can be demonstrated between the disorder and detrimental learning outcomes, then a case can be made for qualifying for support.

Each of the disorders included in this book have very different areas of difficulty. For example, students with dyslexia are charac-

terised by their trouble reading, those with dyscalculia find an assortment of maths problems tricky, students with dyspraxia have motor impairments, those with ADHD display troublesome behaviour, and students with Autistic Spectrum Disorder have limited social skills. Given their distinctive profile, what do these groups have in common? All of them have a weakness in working memory as illustrated in Figure 2.1. That is not to say that poor working memory causes the core deficit in their respective disorder. However, it coexists as a separate problem and ultimately leads to learning difficulties. For example, a deficit in working memory does not cause motor problems, but as we shall see in Chapter 5, working memory weaknesses in a student with dyspraxia lead to learning difficulties, regardless of their IQ. Throughout this book, we will learn that each group has a specific area of strength and weakness in working memory and it is important to know what this is in order to provide targeted support.

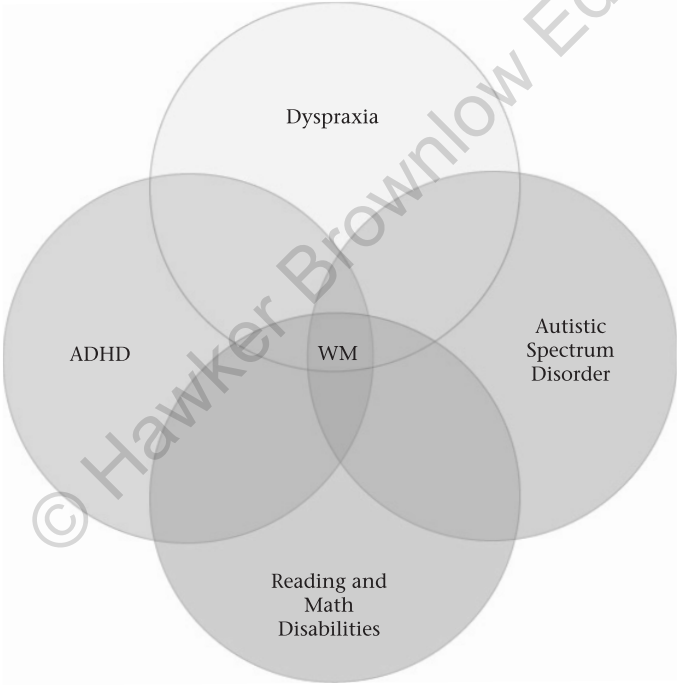

Figure 2.1 Learning disorders

Here is one parent's hope:

I am writing to you from the US. I have an 8-year-old daughter who was recently diagnosed with working memory problems. She also has ADHD. I

3 Reading disorder

This chapter looks at:

- how poor working memory affects students with dyslexia
- the dyslexic brain
- related disorders
- strategies to support dyslexic students.

Try reading the sentences below:

> *Pleeze nock on the door before you go on your jerney. My friend always siad she felt bule and wores becuase she wuld serch for you but you were gon.*

The spelling errors in the paragraph are typical errors made by an individual with reading difficulties or dyslexia. In addition to spelling words as they sound or jumbling up the spelling of words, many dyslexics also confuse upper and lowercase letters, such as writing '*numBers'*, reversing some letters and numbers, and mixing up the sequence of information, such as classroom instructions. Those with dyslexia also take longer to articulate information, which means that they easily forget words, especially in conversations. Alistair, a 16-year-old dyslexic, was telling me about his part-time job and didn't realise that he said 'winimum wage' instead of 'minimum wage'.

Dyslexia

According to the International Dyslexia Association, dyslexia is a specific learning disability characterised by unexpected difficulties in accurate and/or fluent word recognition, decoding, and spelling. Dyslexia is a problem with sounds, not the meaning of language. This can explain why students with dyslexia are often described as bright and articulate yet their written work shows little evidence of this.