



## WORKING MEMORY

### WHERE DID I PUT MY WALLET?

There are MANY different types of memory. There's remembering who the prime minister is, remembering someone's name you met earlier at a party, remembering a list of items to grab from the shop or remembering where you left your wallet. There's remembering how to make sushi, there's remembering the fun time you had at the snow last year and there's remembering your pin number. There's remembering the punch-line of a joke.

#### **Working memory, however, is different.**

Many children I have worked with over the years have had obvious and quite significant problems with their working memory. This is bound to affect how they can function and learn in the classroom and is an important factor to consider when a child is presenting with language, attention or learning problems.

For speech pathologists or educators working with these children, it is vital to understand about the different types of memory because if we want to help these children, we need to share with others exactly what we are talking about.

Many times when I have raised with a parent about their child's possible working memory problems, I've been met with comments such as; "No! He has a *fantastic* memory. He NEVER forgets when the Simpsons are on!" or "No, he remembers every detail of Nitro Circus's show and that was two years ago..."

These examples of memory are NOT examples of **working memory**.

### SO WHAT IS WORKING MEMORY?

**Working memory** is the type of memory that is used when we hold on to information for a short time in order for it to be used. It can involve verbal information (words or sounds that are HEARD) or visuo-spatial information (information that is delivered visually). It also involves an element that controls and coordinates this information. This is called the "central executive."

*Examples of working memory may include adding three numbers in our head that have been said to us, reading and then carrying out a list of instructions, silently repeating back an unfamiliar word as we attempt to spell it, copying a list of numbers from the board into a workbook.*

Working memory is different to short term memory in that it requires some **mental manipulation of the information that is briefly stored**.

Gathercole and Alloway (2008) explain that working memory is a “system of linked components consisting of short-term memory stores of verbal (language) and visual or spatial information, and a coordinating component that controls attention called the central executive.” This central executive gets the brain ready to remember and then coordinates the manipulation of the information stored in the short term memory so that the information can be used purposefully.

It is important to understand that working memory is not about information that was received earlier that day, nor is it remembering what a story was about when a passage has been read to us. Difficulties with working memory, however, may affect how a child can complete such tasks. If you have a lousy working memory, you may not have processed the information presented earlier that morning, or in the second example, you may have not been able to process and comprehend each sentence as it was read during the story. Although the problem here is working memory, it can end up looking like a different type of memory problem.

**Working memory problems can be the root of many learning and language problems in school.**

## **HOW MUCH CAN BE STORED IN SHORT TERM AND WORKING MEMORY?**

Miller (1956) came up with what he called the “magical number seven.” He proposed that the average adult could hold on to roughly seven units of information in their short term memory, where each “unit of information” was defined as a distinct and unrelated item.

An example: If I gave you seven numbers to remember, but the first four just happened to be those at the start of your phone number, your brain would quickly group these as a chunk. This chunk then becomes one unit. Therefore, you could probably go on to remember more than seven digits in this instance as the first four digits became one. (Remembering “chunks” is actually a useful memory strategy which we will look at later in this article...)

In The Auditory Processing and Assessment Kit (APAK), Dr Kathy Rowe, Dr Ken Rowe and Jan Pollard state that at school entry, the average digit span of a child is 4 digits. That is, they should be able to repeat back four numbers when they are presented roughly one second apart. They propose that the 7% that cannot recall 3 digits are at great risk for literacy underachievement and from my experience, not only this is true, but these children

usually have trouble concentrating in class, following instructions and learning new information that is presented verbally.

Working memory, however, is more complex than short term memory. In a recent lecture by Dr. Jarrad Lum, Senior Psychology Lecturer at Deakin University, he stated that that short term memory tests are not so good at predicting school achievement. He commented that often the children with poor short term memory would “catch up” whereas the children with poor *working memory* were the ones that really struggled.

One test of (verbal) working memory employed by many speech pathologists is the “Number Repetition – Backwards” subtest of the Clinical Evaluations of Language Fundamentals – Fourth Edition. (CELF 4). In this test, digits are said by the examiner and the child is required to repeat them back in reverse. For example, it starts with the examiner

saying “2...4” and the child is required to say “4...2” . Often you can almost see a child’s brain working when they are doing this. They will usually say the numbers forward (rehearsal) before saying them in reverse. The next stage of the test goes to three digits “3...6...8” and the child again, must say them in reverse; “8...6...3” . It continues from there. Some children fail this because they cannot hold on to the three digits even in their short term memory. When this is the case, they have little hope of manipulating the numbers and saying them in reverse. Some young children fail this because they don’t understand the instructions. For example, some children don’t understand what “*backwards*” means in relation to a string of numbers.

It should also be noted that this test is not performed well at the age of school entry by most children. In fact, according to the CELF-4 scoring, it is not until the age of six that an inability to repeat two digits back to the examiner in reverse order indicates that there may be a problem in working memory.

Backwards digit span is a good test to do with children from around the age of 8 years. By this age, most children are able to repeat back two numbers in reverse and are beginning to repeat back three. If they are unable to do so, it may be that working memory problems are at play, and could even be the root of language or learning problems.

## **WHAT AFFECTS WORKING MEMORY CAPACITY?**

- Stress. Don’t panic if you just had someone test you and you couldn’t repeat back three digits in reverse. You were probably stressed! Yes, stress is one of the factors that can affect how much we can hold on to in the short term. Fatigue can also affect our capacity.
- Distractions (for example, background noise) can affect attention and therefore working memory.
- Alcohol and some medication.
- Familiarity. If information is more familiar, it is more easily held in the short term.
- Age. Working memory increases with age and by adolescence most individuals have reached their optimal level. Unfortunately, it decreases as we get older.
- Multi-modality. If we think of working memory as a “system of linked components”, it holds that if the information is delivered using two modalities, we will remember it

more easily. For example, if I said the names of numbers while showing you a list visually, you may be able to recall more numbers.

- Rehearsal is an important part of verbal working memory and children around seven years of age will start to use this as a strategy to keep information fresh in the verbal short term memory as they “work on it”. The easier the verbal information is to repeat, the more easily it can be rehearsed and kept in the short term memory. Thus, a tricky sentence structure will be harder to rehearse and act upon, than a more straight forward one.
- Individual strengths and weaknesses. Some are simply blessed with great working memories, others are not so lucky...

## **THE CHILD WITH WORKING MEMORY PROBLEMS...**

- Often has problems learning to read and write and with maths.
- Can be reserved in social situations that include a lot of verbal interaction.
- Finds it hard to follow instructions.
- May find it difficult to multi-task. For example, looking at the board and copying down sentences as the teacher explains about homework.
- May become overwhelmed easily which leads to stress. Stress leads to even greater problems remembering. Instructions they could follow yesterday may be too difficult to comprehend today. This inconsistency can be puzzling and frustrating for teachers.
- When overloaded, may “switch off” or play up in class.
- May spend a lot of their time being confused, but sometimes may be totally unaware that they have misunderstood.
- May find it extremely difficult to focus on a task that taxes their memory while there are distractions. Distractions might be a noisy class next door or the view of children playing sports outside.

## **SPECIFIC CONDITIONS AND WORKING MEMORY**

### **Children with Middle Ear Problems (including children with Down Syndrome)**

- Short term memory of verbal information can be reduced in children who have had, in their younger years, repeated bouts of “serous otitis media” (fluid in the middle ear) or ear infections. This is thought to be because they have not had the experience of hearing to “build up” and “practise” using their verbal short term memory store.

Children with Down Syndrome are at particular risk due to high incidence of middle ear pathology. (Downs and Balkany, 1988).

### **Children with Dyslexia**

- Children with dyslexia tend to have poor verbal working memory. They often have trouble repeating complex multisyllabic words. For older students, an unfamiliar word such as “refractory” may be difficult for them to even repeat and thus spell. A

child without dyslexia, may not know this word, may not have heard it, but can hold it in their short term memory , repeat it, break it up and attempt to spell it.

Reading can be viewed in a similar light. For a dyslexic child who tries to sound out an unknown word, they must try and “hold on to” and then “blend” sounds or familiar chunks. This can be exceedingly difficult. For example, “/sp/.../oi/... /l/.../t/...” Other children can sound out and “pull” these chunks together with ease, making a meaningful word.

Some researchers propose that working memory is not a symptom of dyslexia but a result of it. Because the process of reading is so difficult for these children, they do it less and their working memory suffers. Good readers, on the other hand, are constantly increasing their familiarity with words and their blending skills through reading, and thus actively strengthening their working memory.

Nevertheless, there does seem to be a subgroup of poor readers who have poor short term memory problems that contribute to their reading difficulties (Snowling, 1991).

#### **Children with Specific Language Impairment**

- Children who have a specific language impairment often have difficulty in tests where they are asked to repeat multisyllabic non-words (eg. a word such as “paglinot” ). This is a direct example of poor verbal working memory. This inability to repeat novel nonsense words mirrors how a child learns the sound pattern new words, such as “envelope” or “verandah.” It only makes sense that if these children do not have the ability to hold on to these new words in the short term, they will have difficulty moving them into their long-term memory.

#### **Children with ADHD**

- Children with ADHD usually have problems with both visual/spatial and verbal working memory. They also have difficulty with inhibiting behaviour and may have trouble attending to information that needs to be remembered.

#### **Children with Autism Spectrum Disorder**

- Children with high functioning autism may have an average working memory profile. Some children have a reduced verbal short term memory which therefore impacts upon their understanding and learning of language.

#### **A FINAL NOTE:**

In summary, it is important to consider a child’s working memory abilities when assessing them for a possible language or learning impairment. Remember that sometimes working memory problems may present as disruptive behaviour, comprehension problems or long term memory problems.

Over the next three pages, you will find some strategies that can be printed off for parents or teachers. The strategies relate mainly to difficulties with VERBAL SHORT TERM MEMORY

AND VERBAL WORKING MEMORY. Employing these strategies can make a world of difference for the child with reduced working memory.

### References and Further Reading\*

\*Gathercole S.E., and Packiam Alloway, T. **Working Memory and Learning** Sage Publications, 2008

Granger, J **Children's behaviour, attention and Reading Problems**. ACER 1997

Miller GA (March 1956). "The magical number seven plus or minus two: some limits on our capacity for processing information". *Psychological Review* **63** (2): 81–97.

Oelwein, P.L., **Teaching Reading to Children With Down Syndrome** Woodbine House 1995

\*Packiam and Alloway, T., **Improving Working Memory** Sage Publications, 2011

Snowling M.J., "Developmental Reading Disorders". *Journal of Psychology and Psychiatry*,32, 49-77

*This article was written by Lucia Smith. July 2012.*

## VERBAL WORKING MEMORY

Many of the following strategies will assist a range of children, but are particularly vital for the child with working memory problems.

Before putting the strategies in place, it is important to have an accurate profile with regards to the child's working memory. Do they have an impaired verbal WM or is the impairment visuo-spatial or mixed? Note: If the child has visuo-spatial difficulties, some of the visual recommendations below may not assist.

After creating a profile for the student, ensure that everyone living and working with the child understands the nature of an impaired working memory.

### HOW TO HELP:

1. When speaking to the child, try and use words that they are familiar with. If you need to use new words, repeat them, and if possible, explain them.  
"It's near that *protea* bush... the *pink* bush... near the *pink protea*..."
2. When using long sentences, don't say them slowly, but break them into chunks with slight pauses. This is called **CHUNKING**.  
INSTEAD OF: "Your toothbrush needs to go in the container that's under the basin in the other bathroom."  
TRY: "Your toothbrush... needs to go in the container... that's under the basin... in the *other* bathroom."

In addition to chunking, use gesture and stress when you can. You might gesture **toothbrush** and **under** and you might **point** towards the other bathroom.

3. Children who have poor working memory will “hold on to chunks” in their short term memory as they process it. If you use sentences that contain tricky structures, they will be less familiar to the child and harder to hold on to. Longer words are harder to hold on to as well, so consider this.

**THESE ARE TRICKY STRUCTURES:**

\*If you don't get your hat within ten seconds, you're not going to go out on the play equipment. (*Instead try: “Get your hat now... and then you can out.”*)

\*Unless you start participating in class activities, you'll be on the sidelines when it comes to the school play. (*Instead try: You need to start joining in... class activities... If you don't join in... you won't be in the school play.”* )

\*You can stand next to the heater although make sure you're not too close with those pyjamas on. (*Instead try: You can stand by the heater... be careful of the pyjamas... don't get too close.”*)

Interestingly, difficult sentences are often delivered during times of discipline. These are times when the stress level of the child is UP and their working memory capacity is DOWN. Remember this.

4. Repeat important information. The more you repeat, the better it will be retained for processing.
5. Consider the speed and clarity of your speech. A clear message is also one that will be retained more easily. At the same time, you don't need to speak painfully slowly! Aim for clear, slowed speech with pauses between chunks.
6. Stressing important words means that the child can hold on to the main parts and disregard the “fluff”. This will mean there is less to remember. “After tennis... wait on the CORNER near the SHOP...”
7. Have the child repeat back to you important information. “Wait at the corner near the shop.”
8. Provide visuals where possible. This may be gestures or may be scribbles in a notepad that you train your child to use. Mobile phones provide a great way for adding visuals. If you want the child to grab some milk and some sugar from the shop, you could take a photo of the empty packets or write the words in a text.
9. Around the age of seven, you can start to talk to the child about their memory difficulties and teach them specific techniques to assist with remembering. One will be rehearsing (repeating things to keep the message in the short term long enough for it to be processed), adding visuals (repeating and gesturing or thinking of a

picture that goes with the words), using attention (actively attending to and thinking about the meaning of the words).

In reading, the child can be encouraged to stop at every full-stop and think about the sentence they have just read and what it meant. If they cannot remember or it doesn't make sense, they should read the sentence it again.

10. Acknowledge the frustration of the problem with the child. They have a real problem and it is not a result of laziness or defiance. Remember that reading, listening to the teacher and even engaging socially may take a lot more effort for the child with working memory problems. Stay positive and be creative in how you keep the child engaged and motivated.
11. Long term memory stores information that is learnt and cemented. It can support working memory because it allows the child to use less mental load for each word that is delivered. For example, if a child has learnt about BLENDS and knows what they mean in relation to spelling, they will use this knowledge to help sound out a word. Previously, they may have needed to sound out every sound in a new word "splint" and join them together. This is very taxing on working memory. "/s/... /p/... /l/... /i/... /n/... /t/". With the knowledge of blends that the child has learnt, they now know to look at "/spl/..." as a single chunk. This makes the task a lot easier. Another example is, a child may be asked to get ingredients out to make pancakes. The teacher might say: "You'll need flour, eggs, milk, and sugar." If the child already knows in their long-term memory how to make pancakes, they will not have to rely solely on their short term memory of the list.

Useful knowledge that is in the long-term memory will assist working memory problems in the older child. The challenge is to engage the child with effective teaching so that the information gets into the long term.

12. Show children, don't just tell them. This one is easy, but very important. After you have shown them, encourage them to show another child, while trying talk through each step.
13. Consider distractions. Reduce background noise and clutter. Think about where the child is seated in class.
14. Consider the visual presentation of school materials.
  - \* Some children may find it useful to read with a rolling ruler moving down a page of text.
  - \*Use numbers rather than bullets for a list of tasks as this can help a child remember where they are up to.
  - \*Alternatively, show the child how they can cover the part of the page that they have completed so they can quickly see where they are working at.
  - \*Avoid having the child copy from the board on to a page.



15. Make sure the child has lots of time engaging in activities where there is no pressure on using working memory. This is particularly important if they are stressed or tired.
16. Good old games like “I went shopping...” can be hard for children with poor working memory but can present a good opportunity to practise rehearsal if they are around 7 years plus. You can vary this game: “I went to the farm and I slipped in...”  
“I spied on my brother and saw him...” “I had a midnight feast and I ate...”
17. For older students listening to the information presented by a teacher in class may be too difficult. Ask the teacher whether you can record them. Recording can be done on a phone, an iPad, or using a recording pen such as a Livescribe SmartPen.

**In summary,**

- Reduce the load on the short term memory store.
- From seven years of age, teach the child about how to use strategies to keep information in the short term memory long enough to be processed.
- Repetition and chunking are two strategies that should be used by the person delivering the information and if they are old enough, the child receiving it.
- Endeavour to build up the child’s long-term memory store of knowledge and language.
- Consider other factors that reduce memory capacity and if possible, change them.