Working Memory and Learning Needs

BOOKLET 4
The Chicken AND the Egg: 
Working Memory and Learning Difficulties

We’ve all heard the age-old conundrum: “What came first, the chicken or the egg?” Have you ever tried to answer that question? If the egg came first, what made the chicken? If the chicken came first, where did it come from?

When it comes to the relationship between learning difficulties and Working Memory, the answer is still uncertain. Do Working Memory problems cause learning difficulties or vice versa? What we do know is that many students with learning difficulties also have Working Memory problems and that the two can be related. For these students, it is helpful to think about the chicken AND the egg.

In this booklet, you will find out:

• Working Memory problems are related to ADHD, Dyslexia, Autism Spectrum Disorder, and Dyspraxia

• Classroom demands affect students with these difficulties in unique ways

• Jungle Memory and Working Memory support can help students improve their classroom outcomes
The Case of the Flying Spaghetti: ADHD and Working Memory

The wet spaghetti flew through the air and landed with a loud SPLAT on the chalkboard. Tomato sauce landed on Mrs. Jones’ desk. She knew that, with Christmas holidays approaching, the class was always more excitable and a little harder to manage, but this was extreme, even for this time of year.

She quickly scanned the room for the perpetrator. She didn’t have to look long. Mark was jumping around from table to table with sticky red fingers, waving them in front of his friends’ faces. She sighed. Mark was the star player on the school soccer team. But in the classroom, it was a different story.

Mrs. Jones knew that Mark was a “busy” student, and she had to keep him occupied so that he wouldn’t wiggle and fidget as much. Usually she had lots of resources at her fingertips: silly putty, Velcro, stress balls, and even a reward chart. But today, Mark did not seem to be interested in any of these.

Mrs. Jones knew that Mark had been diagnosed with Attention Deficit Hyperactivity Disorder, or ADHD. But she didn’t realize that students with ADHD also have Working Memory problems. And his Working Memory was the key to helping him manage his behavior.

In a student without ADHD, John, this is how it works. John is sitting in class and wants to tell Sandra that he saw the new Transformers movie over the weekend. But his Working Memory kicks in and controls this impulse. His Working Memory reminds him that they are supposed to be listening to the lesson. So John waits until recess to tell Sandra.

Mark’s Working Memory is more limited. So when he gets a thought like “throw spaghetti,” his Working Memory doesn’t tell him to stop. When it comes to his grades, it is a similar story. Mark can usually remember what Mrs. Jones asks him to do because she always makes him say it back to her. But when he gets back to his desk, something else often catches his attention, and he gets distracted.
The Case of the Flying Spaghetti: ADHD and Working Memory continued...

He also struggles when he has to complete the instruction while remembering the next thing that he has to do in class. Although Mrs. Jones has tried writing this down for him, he still struggles to complete his activities.

Mark’s problems with poor Working Memory are very common in students with ADHD. We led a government-funded project on students with ADHD to understand more about their Working Memory. In almost 100 students with ADHD, the answer was clear: Over 90% of them performed very poorly on assessments of Working Memory.

This means if a student has ADHD, that student will get poor grades. Data like this suggests that educators and parents should prioritize supporting Working Memory in children with ADHD in order to see an improvement in grades.

FURTHER READING/REFERENCES
Brain imaging studies have shown that people with ADHD have a smaller Pre-Frontal Cortex. The Pre-Frontal Cortex (PFC) is the home of Working Memory in the brain, and a smaller PFC means that it can’t work as well as those with a larger PFC. For example, students with ADHD struggle to inhibit their behavior. But, this isn’t all.

The motor cortex, which is responsible for controlling motor functions, like movement, is overly active. So, the part of the brain that tells you to wiggle, jump, throw, and run is in high gear, but the part of the brain which inhibits behavior is underactive. For an ADHD student, it is like someone gave him a Corvette but forgot to put the brakes in. When the engine revs and the brakes aren’t there to stop it, spaghetti flies.

Mark’s smaller Pre-Frontal Cortex meant that he didn’t have a brake to suppress his thoughts of lunchtime. Although he knew that Science was next, his poor Working Memory meant that he couldn’t focus on the immediate goal of getting his science book to follow along with the lesson. His overactive motor cortex kicked in and his thoughts of lunchtime led him to open up his lunchbox and start flicking his spaghetti on the walls.

FURTHER READING/REFERENCES
Jungle Memory: 
*Putting the Brakes to Work*

To improve Mark’s performance in the classroom, he needs help to put the brakes on his Corvette. By doing so, he will be able to have a better chance to control his behavior, focus on classroom activities, and to be able to ignore distractions. Clinical trials show that Working Memory training can give students with ADHD a boost.

Jungle Memory trains them to use their Working Memory so that impulses no longer have such a hold on them, and distractions don’t take their eyes away from the task. How does Jungle Memory do this? In the first game, Quicksand, which asks students to click on the squares with the correct letter, they have to inhibit clicking on incorrect letters. Games 2 and 3 (Code Breaker and River Crossing) help them to improve their concentration and train them to remember and work with increasing amounts of information.

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**Other Benefits for Students with ADHD**

**GAME 1** helps them to filter quickly through incoming text and trains them to inhibit inappropriate responses to distracting information.

**GAME 2** trains Working Memory necessary for keeping relevant information in mind long enough to process and understand it.

**GAME 3** trains ADHD students who struggle with mentally organizing information to monitor successfully multiple tasks at the same time.
LESS WORDS: Long instructions are a big Working Memory load for students with ADHD. The shorter the instructions, the better. Instead of asking them to “Quietly walk down the hall to the water fountain and then come back to your seats,” ask them to “Get a drink and come back.”

ONE AT A TIME: Whenever possible, give students with ADHD one thing to do at a time. Instead of asking them to 1) take out their book, 2) open to page 54, and 3) begin problem number 9, let them complete the first instruction before you give them the next instruction.

SHORT AND SWEET: Students with ADHD struggle to do one thing for a long period of time, so help them by giving them breaks. If the class is working on math problems for 20 minutes, let them work on it for ten minutes, and then give them a two-minute break before they begin again.

FURTHER READING/REFERENCES

Lucy showed up to an empty class on Monday. Her teacher was not there. And her friends were not there either. Lucy did a mental check: It wasn’t Christmas, it wasn’t summer, it wasn’t a public holiday. So where was everyone?

Lucy went to the school office. The administrator smiled kindly at Lucy. “Your class is on a field trip, sweetie. Did you forget your permission slip?” Lucy was sure that she wrote down the day in her book. She checked again and then looked up. “Is today the 21st?” she asked. “No, it is the 12th.”

Lucy was not expecting that. “Well, the field trip is on the 21st. Look I wrote it down. So where is everyone?” The school administrator realized what had happened. Lucy had written down the wrong date. Such errors of transposing numbers—writing “21” instead of “12”—are common in students with dyslexia. But at the heart of Lucy’s problems was her poor Verbal Working Memory.

We use Verbal Working Memory to keep language in mind as well as process it. It takes considerable Verbal Working Memory space to keep in mind the relevant speech sounds and concepts necessary for identifying words and understanding text. Often, students with dyslexia don’t have enough space to do this.

Lucy’s teacher told them the date of the field trip and asked them to write it down. But Lucy was not at her desk. So she had to keep repeating the information to herself as a reminder until she sat down. But students with Dyslexia like Lucy can take much longer to repeat spoken information fast enough to remember it. Students with Dyslexia also get information mixed up and don’t always remember what they need to do in the correct sequence. So by the time Lucy got back to her desk and got out her notebook to write it down what her teacher said, she remembered “2” and “1”, but she did not the correct order.

FURTHER READING/REFERENCES
Lucy’s poor Verbal Working Memory means that she also struggles with reading because reading requires her to process letters to recognize words as well as remember those words as they form a sentence.

Will Lucy be able to improve her reading and her chances of success in school? Conventional wisdom says we should rely on IQ tests to answer this question. For a long time, people thought that if a student like Lucy has a high IQ, she can learn to read much better.

But conventional wisdom is wrong. A recent scientific study found that IQ scores were totally unrelated to how much a dyslexic student can improve their reading. What did make a difference, according to the study, was Working Memory.

The researchers gave students something to read and scanned their brains at the same time. They found that if the right side of the Pre-Frontal Cortex is being activated, students with dyslexia are much more able to improve their reading scores. This is why.

The home of Visuo-Spatial Working Memory is the right Pre-Frontal Cortex. When this area is being activated, it can act as a substitute for Verbal Working Memory. So, even if a student has poor Verbal Working Memory, the student’s Visuo-Spatial Working Memory can step in and do some of the processing necessary for reading.

While Verbal Working Memory works with information that you can hear, Visuo-Spatial Working Memory specializes in recognizing information that you can see, like shapes. So when it steps in, it helps students process how words look different from each other, for example how “HAT” has a different shape compared to “DOG”.
This works fine until students come across a new word that looks different from anything they’ve seen before—a word like “STOUT”. If they had good Verbal Working Memory, they would be able to match the letters to their sounds to say the word. They would then use their language center to see if they have heard this word before, or determine what it means.

But a student with Dyslexia like Lucy has poor Verbal Working Memory. So she will struggle to sound out the letters. And she won’t have any Working Memory “space” left to figure out what the word means.

FURTHER READING/REFERENCES
Jungle Memory improves the reading skills of students with Dyslexia.
Jungle Memory is designed to do this in two ways. All three games train Visuo-Spatial Working Memory so that it can offer more support to a student’s Verbal Working Memory. Game 1 also trains a student’s Verbal Working Memory so that it can learn to better manage Verbal information. By the end of the 8-week course, students with Dyslexia will see improvements in their Working Memory, and many classroom activities that require them to use language.

Other Benefits for Students with Dyslexia:

**GAME 1** improves processing speed for letters and words and helps make letter and word recognition more automatic

**GAME 2** trains Visuo-Spatial Working Memory skills necessary for reading comprehension

**GAME 3** teaches students to manage two tasks simultaneously and update relevant information in Working Memory
Top Working Memory Strategies for Dyslexia:

**WORTH A THOUSAND WORDS:** Students with Dyslexia have good Visuo-Spatial Working Memory, so use it to their advantage and present information visually wherever you can.

**MARK IT UP:** Imagine reading a novel without page numbers. You would never know where you left off when you need to begin again. In the same way, students with Dyslexia struggle to read text without clear boundaries. If you are writing instructions or lists on the board, use numbers next to them so that students with Dyslexia can keep their place.

**SLOW DOWN:** Students with Dyslexia struggle with Verbal Working Memory, so when directions are given too fast, they can’t process them. Slow down, and see how much better these students are able to follow you in class or at home.

**FURTHER READING/REFERENCES**


Brian closed his eyes. He was thinking of the question—find the diameter of the circle. That was easy. He opened his eyes and wrote down the answer in his book.

He loves geometry much more than algebra. It was easy for him to picture the shapes in his head. He looked back down at his math worksheet. Question after question about arcs and central angles of circles.

He was done in no time at all. He looked ahead in his textbook. Angles and tangents to circles were next. He started work on them. He could hear Mr. Grove talking. Something about English next. He reached into his bag and pulled out his book. But he was still thinking about angles of circles. So he kept working and writing.

“Well Brian, it looks like Shakespeare has lost his nose!” Mr. Grove was standing next to him now. Brian looked down. The picture of Shakespeare on his English textbook was covered in circles with angles and lines drawn on it. He was so engrossed in his geometry problems that he hadn’t even realized that he had written on his textbook.

Like most students with Autism Spectrum Disorder (ASD), Brian has excellent Visuo-Spatial Working Memory. He often visualizes things in the classroom and says that numbers have a shape that he pictures in his mind. He is usually the first to finish his math work. Sometimes Mr. Grove gives him assignments from a harder math textbook because Brian gets bored with his class.

When it comes to using his Verbal Working Memory, Brian finds it
more difficult. He can’t keep in mind all the necessary information for language processing. While he can remember some things, like how to spell difficult words, he struggles to use it correctly in a sentence.

Brian’s poor Verbal Working Memory can also make it difficult for him to shift his focus away from the details and look at the bigger picture. For example, he can get so absorbed with a fact in a story that he can’t always understand the purpose of story or even sometimes the meaning of a sentence.

Brian’s intense focus on a topic that he loves is very common in students with Autistic Spectrum Disorder. He says, “Sometimes I just get so caught up in a thought, and it’s hard to get it out of my head!”

FURTHER READING/REFERENCES
Scientists looked at the brain scans of people without ASD and those with ASD while they were doing a Verbal Working Memory test. They found very different results. While those without ASD used verbal information to complete the test, the ASD individuals relied primarily on the brain regions associated with processing visual information.

There is another crucial difference in how the brain works in people with ASD. Most classroom activities require students to keep a goal in mind while planning ahead, as well as filtering out distractions around them. To do all of this, the Pre-Frontal Cortex “talks” to other parts of the brain using neurological information highways. The largest of these highways is the Corpus Callosum. The larger the Corpus Callosum, the more information can pass between the Pre-Frontal Cortex and other parts of the brain.

When the ASD individuals completed a verbal comprehension task, the scientists found that they had a smaller Corpus Callosum. This smaller highway meant that their Working Memory was struggling to transmit information back and forth between other areas of the brain.

The scientists describe this as underconnectivity. Underconnectivity has important consequences for the student with ASD. It means that the information gets caught up in a bottleneck, and students with ASD, like Brian, fixate on this information. As their Visuo-Spatial Working Memory is excellent, they tend to focus on visuo-spatial information. As a result of focusing on one thing, they struggle to juggle multiple tasks.

FURTHER READING/REFERENCES
Jungle Memory improves the Working Memory skills of students with ASD. Jungle Memory targets the underconnectivity issue and boosts their ability to synchronize different parts of the brain. Each of the three games requires students with ASD to use their Working Memory together with other knowledge. Game 1 trains them to use their Verbal Working Memory together with their language skills. Game 2 links Visuo-Spatial Working Memory with spatial processing. Game 3 joins Verbal Working Memory with mathematical knowledge.

Other benefits for Students with ASD:

**GAME 1** trains them to quickly recognize and process words frequently used in communication, freeing them up to focus their attention on word meanings

**GAME 2** trains Working Memory to enhance their recognition of visual cues to help them follow the progression of conversation

**GAME 3** helps them to manipulate and recall randomized information in order to develop an expanded range of attention and a flexible approach to completing multiple tasks
One at a time: Students with ASD struggle to think about more than one thing at the same time. So if you are giving them instructions that require them to do multiple tasks, break it up into bite-size chunks.

Black and White: Abstract ideas are harder to understand with ASD, so make the tasks as clear as possible, with a concrete outcome. This is easy to do with math, where $2+2=4$. Do the best you can with language-based activities. For example, when doing a reading comprehension activity, ask them questions that have unambiguous answers, like “How many birds were there in the meadow?” or “Who pushed Jim out of the car?”

Structure, Structure, Structure: Students with ASD need to know where they are going, so if there is an activity that you do regularly, try to stick to routine as much as possible. Make sure that subjects are given in the same order every day. Also, try to make the physical environment as stable as possible: Check that it is not too hot, too cold, too dark, or too bright. Noise can also provide a disruption, so let them wear headphones if they need to when they are working on their own and are distracted by everyday classroom interruptions. This will limit their distractions and allow their Working Memory to focus on the task at hand.

Further reading/references

Owen stood in front of the board. He wished he didn’t put his hand up. He thought he knew the word, and now he had run out of time. Owen looked at his handwriting. He knew that it was messy. But he felt more annoyed that he couldn’t write the word he was supposed to—irrigation.

He took so long to form the letters that when his teacher said “Time’s up,” all he had written was “irag.”

Students like Owen who have motor difficulties, also known as Developmental Coordination Disorder (DCD), have trouble with writing. The hand movements required to form the letters are much harder as a result of the motor difficulties.

We now know that students like Owen also have Working Memory problems. In fact, their Visuo-Spatial Working Memory is very poor. Scientific studies confirm that, as a result of poor Working Memory, Owen will struggle in a range of activities in the classroom from language to math, to simple things like writing and following instructions.

In Owen’s case, activities that involve motor skills require a lot of effort because they are not automatic. For many of Owen’s friends, writing a word on the board would not be a problem. But Owen has to spend a lot of time thinking about how each letter looks. He spends so much effort on this task that it overloads his Working Memory, and he has no space left to work on another activity.

FURTHER READING/REFERENCES
When most students write letters or numbers, they are able to do so automatically, without relying on their Working Memory. But because students with DCD can’t automate the process of writing letters, their Working Memory steps in to take over the task.

Scientists scanned the brains of students with DCD while they were doing a writing task. They found that their Pre-Frontal Cortex—their Working Memory—was working overtime! They used so much effort to complete the writing task that they ran out of time and weren’t able to finish it.

Because a lot of everyday tasks require hand-eye coordination, students with DCD need to spend more effort to concentrate on doing these activities. When Owen was writing, his Working Memory gave the majority of its available space to the task of forming the letters. But writing requires us also to bring letters together to form words, and if students are so focused on writing the letters, they make mistakes in spelling the word correctly, or even finishing it.

Another problem is that students with DCD also have less space on their Post-It note than other students. This means that, when they are writing, they have even less space to give over to the correct formation of words and sentences.

FURTHER READING/REFERENCES
Jungle Memory improves the Working Memory skills of students with Dyspraxia. All three games in Jungle Memory train their Visuo-Spatial Working Memory skills to help them process information more quickly, as well as use their Working Memory more efficiently. The computerized element in Jungle Memory also develops their hand-eye coordination, while helping them to best use their Working Memory space. As their Working Memory improves, they will gain confidence and show an increase in self-esteem in the classroom and at home.

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**Other Benefits for Students with Dyspraxia:**

**GAME 1** helps them to speed up their visual skills in reading so that they can excel with assignments that require them to work quickly

**GAME 2** targets Visuo-Spatial Working Memory, which helps them to keep track of information on the board with information that they have written down

**GAME 3** hones their ability to work with numerous pieces of information, while keeping sight of the big picture
Top Working Memory Strategies for Dyspraxia:

**PASTE A PICTURE:** Students with Dyspraxia have poor Visuo-Spatial Working Memory, so any task that requires them to navigate around the classroom, like sharpening a pencil, is harder. Paste a picture of a sharp pencil on the pencil sharpener, then when they need to sharpen their pencil, hand them a copy of the same card. They will be able to match the two up and quickly complete the activity. This strategy also works at home very well. For older students, you can do this with colored dots that you find at an office supply store. Just ask them to match up the dots for the task they need to do. For example, if they are feeding the dog, put a red dot on the dog food and dog bowl and hand them a red dot so they can complete the task.

**BRING IT CLOSER:** Classrooms are full of great learning tools like multiplication tables, letters of the alphabet, the periodic table, and maps. But this is confusing for students with Dyspraxia because they have poor Visuo-Spatial Working Memory. If they have to look up to find the aid, they easily get lost in all the other images on the wall. So, bring it closer to them. Give them a small copy of the maps or alphabet that they can use at their desk.

**SPEAK AND WRITE:** Depending on the activity, it can be very useful for a student with Dyspraxia to use speech to text software. By speaking instead of writing, they are considerably reducing their Visuo-Spatial Working Memory load that they would usually be giving over to form the letters by hand. This frees them up to focus on the lesson at hand. The technology is constantly improving, so look at the web for the most appropriate technology for your student or child.

**FURTHER READING/REFERENCES**