

A Resource for schools to support children who have or may have Special Educational Needs

Chapter: Understanding Memory Difficulties

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Working Memory Difficulties

Working memory difficulties affect all areas of learning from the acquisition of language and literacy skills such as reading, spelling and written composition, to mathematics and subject areas such as history. According to Alloway and Alloway (2015) working memory is a more reliable predictor of success in school than IQ scores. This is the case for children from school entry through to further education. They point out that poor working memory negatively impacts a child's potential to learn.

This has important implications for teachers in mainstream classrooms. If a teacher does not recognise teaching strategies and approaches that place demands on working memory, then children with poor working memory are seriously disadvantaged. It is also important to consider how learning is assessed to ensure that we are assessing reasoning and problem solving and not just memory capacity. To enable children to reach their learning potential, all teachers should be able to identify signs of working memory difficulties, particularly in cases with no recognised difficulty such as dyslexia, ADHD, ASD, or dyscalculia. Alloway and Alloway (2015) point out that there are children in our classrooms, who present with difficulties learning due to working memory difficulties, without other co-existing difficulties.

What is working memory?

Working memory is a cognitive process and not a passive store of information (IDA, 2020). Working memory refers to the retention of information in short term (temporary) storage while processing incoming information and retrieving information from long term memory. Short term storage within this working memory model refers to holding information in memory for 'seconds' before it fades away or is discarded. Alloway and Alloway (2015:6) conducted a study that found that working memory increases more in the first 10 years of life, than it does over the lifespan. There is a steady increase in working memory up to our thirties. Someone with average working memory, at 25 years of age, can hold five or six items in memory. As we get older working memory declines, with the average capacity being three to four items. Although working memory capacity increases as described above, those with poor working memory will

continue to have poor working memory compared to those who have good working memory.

According to Gathercole and Alloway (2008) and Alloway and Alloway (2015) if a child is distracted or interrupted while using working memory the process is lost and the child cannot resume from where they were interrupted. The child must start the task from the beginning again. They also point out that a teacher can expect, in a class of seven year olds, a six year range in working memory capacity. In a class of 30 seven year olds, 3 children will have the working memory capacity of a 4 year old and three children will have the working memory capacity of a 10 year old. These differences have a significant impact on learning and the ability to cope with various strategies used to promote learning. Alloway and Alloway (2015) advise that children with poor working memory disengage with learning because they cannot hold in mind all the information needed to complete an activity.

It is important to note that children can complete activities, and move on to more difficult work, if the working memory demands are supported. Children with poor working memory can learn if pedagogies are used that support working memory difficulties. Pedagogies that put a strain on working memory inhibit learning for this group of children.

Short Term Memory

It is important to clarify what is meant by various terms used to describe memory as some misunderstandings arise when we apply our everyday understanding to terms that have more precise meaning when used in psychological research. The most notable term requiring clarification is 'short term memory'. When difficulties in short term memory are referred to in relation to difficulties in dyslexia and literacy development, psychologists are referring to difficulties in short term memory within the working memory model, and not our everyday understanding of difficulties in remembering over a short period of time such as 30 minutes, an hour or a day. This should be remembered when reading various documents, articles and publications which refer to short term memory difficulties.

What is meant by short term memory when used by psychologists?

'Short term memory' simply refers to the storage of information (for a matter of seconds) without having to manipulate it in any way. If we have to manipulate what we are holding in short term memory to complete a task or whilst doing something else at the same time, we are using working memory. This distinction is very important. Alloway and Alloway (2015) point out that almost everything we ask children to do in the classroom involves 'working' with information and, therefore, involves working memory. A good example of this is remembering something on the whiteboard for long enough to write it down, for example 12 plus 24, this uses short term memory. Working out the sum uses working memory, for example, adding 2 and 4, holding 6 in mind, then adding 10 and 20, holding 30 and 6 in mind, then adding 30 and 6 to get 36. Another child might add 12 and 20, hold 32 in mind and then add 4 to get 36. Either way of solving the problem, uses working memory. Primary school teachers should bear in mind that mental maths puts a considerable strain on working memory. Children who struggle with this activity should be allowed to write down the step-by-step parts of the calculation as they work them out, rather than having to hold the first part of the calculation in mind while undertaking the second part and so on. This enables the child to demonstrate their mathematical ability and thinking, and not just their memory capacity.

What is short term memory in relation to our everyday understanding of the term?

The more common, every day, understanding of remembering in the short term is, therefore, quite different from the more precise definition used by psychologists when referring to short term memory within the working memory model. When using our everyday understanding of short term memory we may be referring to something that can be remembered 15 minutes later but can't be remembered after half an hour or half a day or two days later. This is a concept that many parents can relate to, that their child forgets some things easily and may require opportunities for 'over learning' so that something that is remembered, 2 minutes, 10 minutes or 15 minutes later, becomes a permanent memory. Some children will need a lot of repetition, at regular intervals, before information is transferred to long term memory. Other children will

need much less in terms of repetition and rehearsal. More than just repetition and rehearsal, however, are necessary for efficient storage in long term memory. It must also be understood that, whilst rehearsal aids storage of material (for example, to remember a telephone number) if rehearsal is used when working on a task, it disrupts working memory.

What is long term memory?

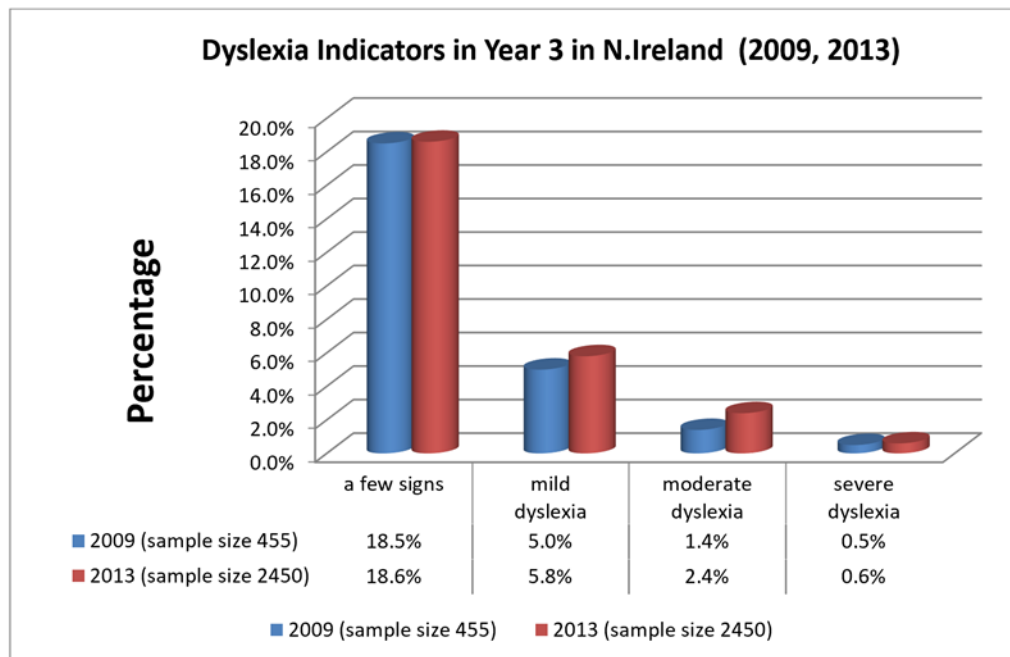
Long term memory refers to the permanent storage of knowledge in memory stores located in various parts of the brain. It should be remembered that retrieval from long term memory is aided by meaning. Unless meaning is attached to new learning, retrieval will be difficult, if not impossible. Children who learn sounds in isolation, for example, may forget them very easily because they have no associated meaning. It is working memory that searches long term memory to retrieve stored information when it is needed (Alloway and Alloway, 2015).

Working memory and literacy difficulties

Many children with learning difficulties have memory problems that make learning more difficult. Working memory difficulties are evident across a range of specific learning difficulties such as dyslexia, dyscalculia, ADHD and ASD. Although not all children with these specific learning difficulties have working memory difficulties, a significant proportion do, and understanding how working memory difficulties impact learning assists teachers in supporting children with these difficulties.

The presentation of literacy difficulties, within the normal range of ability, are mainly of a dyslexic-type. Many children with dyslexic-type difficulties may also have working memory difficulties. Table 1 below shows the prevalence of dyslexic-type indicators in a sample of N. Ireland schools, at the outset of Year 3. The measure used was the Dyslexia Screener (Turner and Smith, 2003). The Dyslexia Screener cannot be used to diagnose dyslexia but it provides an indication of children who should be monitored, within their mainstream class, because they are showing a few signs of dyslexic-type difficulties and children who require further investigation.

Table 1 The Incidence of Dyslexia Indicators in Year 3 in a Sample of Primary Schools in N.Ireland



Please note: 2009 data was collected for a study on Lexia software (McMurray, 2013); 2013 data was collected for the SEN Literacy Project (McMurray, McVeigh, Bennett and Finlay, 2015) A further 2% of the sample, who presented with indicators of literacy difficulties arising from more general difficulties, are not represented on this graph.

What do these statistics mean?

If we consider the 2009 and 2013 findings above, 18-19% of children in Year 3 will require monitoring. Within a dyslexia friendly classroom, that ensures strategies and programmes of intervention are not placing demands on working memory, this group of children should be able to reach their potential and no longer exhibit dyslexic-type difficulties. The group of children in the mild, moderate and severe range (between 7-9%) will require further investigation by the school's specialist teacher and may require one-to-one intervention. Children who prove to have very persistent difficulties, that are resistant to intervention despite one-to-one help (2- 3%), may require further investigation and support from a teacher with British Dyslexia Association Approved Teacher Status (ATS) or Associate Membership of the British Dyslexia Association (AMBDA). Many teachers in N. Ireland gained this qualification through participation

in the SEN Literacy Project funded by DE (2012-2015) and currently there are over 300 teachers in NI with ATS and over 50 with AMBDA.

These two Northern Ireland studies found that in Year 3 between 25.4% (2009) and 27.4 (2013) presented with indicators of dyslexia ranging from a few signs to profiles of dyslexic-type difficulties. The Dyslexia-Spld Trust (2009) research also found that 26% of children in Year 3 in England (equivalent year 4, NI) were at risk of dyslexia (page 6). Furthermore, an incidence of dyslexia in NI schools of approximately 9% is consistent with other national and international findings (BDA, 2020; Eastap, Gregory & Horobin, (2018); IDA, 2017; Brosnan et al., 2002; Shaywitz, 1996; Miles & Haslum, 1986).

Interventions that place demands on working memory can exacerbate rather than alleviate difficulties. It is, therefore, essential that teachers assess the memory demands of the strategies they are promoting and the intervention programmes they are using, as well as assessing a child's difficulties in learning.

It is interesting to note that research reported by Everett, Weeks, and Brooks (2008) found that compared to controls, children with dyslexia, specific language impairment and moderate learning difficulties showed significantly poorer performance on:

- Phonological awareness
- Rapid naming
- Verbal span

The performance of children with Dyspraxia, EBD and ADD was not significantly different to controls suggesting that an alternative causal pathway(s) may be needed to explain their poor literacy scores.

What is verbal span?

Verbal span is one of the measures used when assessing short term and working memory difficulties. For example, asking a child to repeat a simple sequence such as 2, 5, 8 utilises short term memory whereas presenting the child with a simple sequence for example, 2, 5, 8 and then asking him/her to repeat it backwards involves working

memory. The latter is a working memory task because the child has to hold the digits 2, 5, 8 in short term verbal memory whilst he/she works out how to repeat it backwards.

General principles of working memory intervention

Gathercole, S. and Alloway, T (2008: 70-90) suggest the following key principles of working memory intervention. Some examples are provided for clarification where necessary.

Recognise working memory failures

1. Incomplete recall
2. Failure to follow instructions
3. Place keeping errors
4. Task abandonment

Alloway and Alloway (2015) suggest the following guide for the number of classroom instructions, given at one time, that children can cope with at different ages:

- 5-6 years : 2 instructions
- 7-9 years : 3 instructions
- 10-12 years : 4 instructions
- 13-15 years : 5 instructions
- 16-29 years : 6 instructions

Monitor the child

1. Look out for the warning signs of working memory overload (see above)
2. Ask the child directly what he/she is doing

Evaluate the work demands of learning activities

1. Excessive length (under 10s with working memory difficulties struggle to hold 3 or more items in short term storage)
2. Content that is unfamiliar and not meaningful places considerable burden on working memory

3. A demanding mental processing activity (memory load plus processing a task, for example, identifying and blending individual phonemes in words where there are more than two phonemes is a demanding mental processing activity for children who have difficulties in working memory)

Reduce working memory load

1. Reduce the amount of material (for example, use shorter sentences or give instructions with accompanying actions to make the content of the instructions easier to remember)
2. Increase the meaningfulness and familiarity of the material (ensure use of pattern and meaningful associations)
3. Simplify the mental processing, for example:
 - simplify the grammatical structure of sentences
 - ensure children recognise larger units of sound for decoding and encoding, for example, initial blends and rhymes. Initial blends and rhymes can reduce working memory demands substantially. The working memory demands in one syllable words can be reduced to two units by using 'onset and rime'
4. Restructure complex tasks (break down tasks into independent steps)

Be prepared to repeat

Employ strategies that tailor repetition to the needs of individual pupils. Not all children require repetition. Encourage children with WM difficulties to request repetition or partner a child with WM difficulties with a child with good memory skills.

Encourage the use of memory aids for example, personal memory cards

- Writing aids (poster / spelling aids / what is a sentence?)
- Mathematical aids (multiplication grids, number lines, fingers, memory cards)
- Audio devices
- Computer software

Develop the child's use of strategies for supporting memory

- Request help (select a person to ask)
- Rehearsal (of small amounts of verbal information)

- Note-taking (check notes regularly as task is being performed)
- Using long term memory (meaningful chunks as opposed to lengthy sequences)
- Place keeping and organisational strategies (diagrams, flow charts to depict task structure)

Examples of the impact of working memory difficulties

1. ORGANISATION

According to Gathercole and Alloway (2008) to be organised we must be able to carry round, in our heads, a list of what we have to do or what we need throughout the day. If these details quickly fade from memory then not being able to remember makes many everyday activities very difficult and stressful. Many children with working memory difficulties present as being poorly organised.

They suggest that help with personal organisation should be given by providing:

- Daily timetables (visual)
- Checklists of items needed for various activities or classes
- Diaries
- File dividers / colour coding for subject areas
- Schoolbags with sections to aid organisation of books and materials needed
- Consider when secondary pupils will return to lockers and help them organise what they will need and when they will return next

2. ATTENTION

Gathercole and Alloway (2008) also stress the importance of recognising that children with limited working memory capacity can appear to be inattentive, asking their

neighbour what the teacher has just said or interrupting. This may be the result of limited working memory capacity.

They suggest that teachers BE PATIENT:

- Keep instructions simple, avoid complex instructions
- Allow extra time for thinking so that the child has time to process what has been said
- Agree with the child a discrete way of knowing if more time is needed
- Seat the child in a position that makes communication easier i.e. at the front of the class close to the teacher
- Repeat key words or phrases

3. WRITING

- The need for copying should be avoided, particularly from the board
- Allow alternative methods of recording for example, mind maps, diagrams, use of ICT for audio/video recordings, photographs
- Introduce joined handwriting as soon as possible as this reduces place finding and orientation difficulties. (McMurray, Drysdale and Jordan (2009) discuss the impact of motor processing difficulties on learning)

4. SPELLING *(Issues in the teaching of spelling are discussed in greater detail in the chapter in this resource entitled 'The importance of an integrated approach when learning to spell')*

Dictation

Dictation sentences are a good method for practising and testing spellings. Hornsby et al (2006) (Alpha to Omega) suggest the following approach to help with working memory difficulties.

- Dictate the whole sentence
- Ask the child to repeat it
- Dictate it again, saying each word very clearly
- Child writes the sentence saying it clearly as he or she writes it
- Child is asked to read aloud exactly what he or she has written
- Final corrections are suggested if the student has failed to discover them

Patterns and sequences

English is a deep orthography and CVC, CCVC, CVCC words can be spelled using phoneme to grapheme correspondence because the sounds in these words do not have multiple mappings. However, the majority of words in English cannot be spelled by phoneme to grapheme correspondence alone because sound/ symbol mappings can be multiple in both directions. Children require orthographic awareness to know whether the word they have spelled looks right.

The importance of teaching 'onset and rime' to reduce working memory demands is well established. Synthetic phonics and analytic phonics complement each other and should be used side by side. Some children are unable to synthesise phonemes into words because of poor working memory capacity and failure to develop recognition of onset and rime patterns can result in disadvantage by pedagogy.

Turner and Bodien (2008) draw on evidence from the case study of a 7 year old who failed to progress despite considerable phonics teaching at phoneme to grapheme level.

*'she was not segmenting words into their ONSET AND RIME. Consequently, each word appeared as a new item to her that she laboriously decoded phoneme by phoneme rather than decoding by ANALOGY for lists such as 'cat, fat, mat, sat, and hat' where just the first phoneme needed to be changed.'*p41

Teachers will recognise children in their class who read in this laboured and pedantic way and must ensure that they move away from this overdependence on decoding at phoneme level. If children cannot identify syllables as unified units, recognised on

sight, without the need to decode phoneme by phoneme, then they may experience memory and retrieval difficulties which manifest in dysfluent reading. If phonetically plausible spelling errors occur and are repeated and written several times, they may become embedded in memory. Continued dependence on encoding phoneme by phoneme may result in long term spelling difficulties. Teachers will also recognise children in their class who are good readers and poor spellers. This group of children do not know whether a spelling looks right. Their difficulties in spelling confound teachers because they fail to understand why children misspell words that they can read. Unfortunately, some children experience difficulties in spelling long after reading difficulties are remediated and these spelling difficulties can become lifelong (Trieman 1997, Frith 1980).

Recommendations

- Ensure spellings are consistent in the sounds they make and visual spelling pattern. For example consider the three groups of spellings below:

A. 'red, bed, fed, led'

B. 'bread, head, lead'

C. 'said'

A, B and C above should be treated as three separate groups even though they have the same rhyming sound. They should not be taught together. Even though the word 'said' appears frequently in reading books children with literacy difficulties often revert to a phoneme encoding strategy and draw on the individual phonemes that come to memory most easily for them. If children attempt to spell words by phonemes alone then the word 'said' could be spelled 'sed' and many teachers would recognise this as a common misspelling. Correct spelling retrieval is governed by meaning (consider 'their' and 'there') and visual recognition that a spelling looks right. The knowledge of whether a spelling looks right can only be achieved if the child has representations in memory of the correct pattern to which the word belongs.

Patterns and sequences which are consistent in sound and spelling are essential for the development of long-term memory and short term processing within working

memory. The mental lexicon (visual memory for whole words and letter patterns) is limited in capacity and children must recognise that if they can spell one word in a pattern they can spell many more words that belong to that pattern. If I can spell 'red' I can spell 'bed' by changing the initial sound (phoneme). Reasoning by analogy reduces the load on working memory.

- Discourage children from spelling by sound alone once they can spell simple CVC words. Spelling by sound without regard for orthographic knowledge (i.e. knowledge of whole words and 'onset and rime' patterns) results in phonemic spelling errors such as 'becos' for 'because'. Examples of other phonemic spelling errors are 'helpt' for 'helped', 'dancd' for 'danced', 'landid' for 'landed'. It is important to draw on spelling rules (morphological knowledge) to overcome this type of spelling error for example, adding 'ed' to regular verbs to make the past tense.
- Never group words visually without regard to sound for example, 'prove, glove, stove' children with dyslexia find these groupings confusing as they are not consistent in the sound they make.
- Trieman (1997) and Frith (1980) both point out that children with spelling difficulties cannot reliably choose from a range of plausible alternatives and their spelling errors are consistently phonetic. Avoid grouping spellings that have same sound, different spelling for example, vowel phonemes as in 'though, go, toe, show, note, boat'. These groupings are very confusing for children with poor orthographic processing.
- Irregular words should be learned using multisensory techniques for example, Look, say, cover, write, check; tracing on sandpaper and in the air; spelling words using wooden or magnetic letters; writing in joined handwriting.
- Irregular high frequency words should be taught in semantic groupings in the early stages of spelling development.

5. LEARNING LETTER NAMES AND LETTER SOUNDS

Turner and Bodien (2007) suggest that young children need to learn both their letter names and their letter sounds. Indeed, it is only a very small proportion of children who experience difficulty learning the names of the letters of the alphabet. Teaching letter names is important teaching at a whole class level. Carroll et al (2003) point out that there is an important reciprocal relationship between letter knowledge and phonemic awareness. For the small group of children who do experience difficulty Turner and Bodien (2007) suggest learning the letter names with the aid of wooden letters ('The alphabet arc' is well established as a successful method for doing this). They suggest that letter sounds should be taught when working with flashcards or magnetic letters.

'keeping the use of letter sounds and names apart physically like that helps the children know which response to give to each medium.' P27

6. READING COMPREHENSION *(Issues in teaching reading are discussed in greater detail in the chapter in this resource entitled 'The beginning reading programme, the importance of a balanced approach')*

The goal of reading is comprehension and this is greatly affected by limitations in working memory capacity. Gathercole and Alloway (2008: 54) explain the demands of the task required *'by holding the words that have been recognised from print for a sufficient period of time to enable the reader to link the words together to produce a meaningful interpretation of the clause or sentence, or even larger sections of text'*

If this process is further compounded by the need to decode then reading comprehension becomes an impossible task. The dyslexic reader has to interrogate the text many times to extract meaning. Children with dyslexia are recognised to have problems in the 'unitization' of sounds. Unitization (Bresnitz, 2006) is the ability to process increasingly larger units from letters to spelling patterns to whole words and connect them to phonological and semantic codes in memory. If children have to decode unknown words, taking each sound in turn, then the working memory demands of decoding may make the unitization of the sounds impossible. Children with working memory difficulties find blending sounds very difficult. When you add the demands of

decoding to the working memory demands of reading each word in a sentence the difficulties in reading comprehension experienced by some children are clear.

Warning signs (Turner and Bodien, 2007 pg 75)

- Decoding is so laboured that it consumes WORKING MEMORY capacity. As a result, a pupil can decode a sentence without having processed the meaning of the sentence.
- Punctuation is ignored.
- Inferences are missed.
- The pupil believes that decoding is the end goal of the reading process.
- The pupil does not 'engage' with the text.
- Key sentences and key words are not identified and attended to.

Suggestions

- Use cloze passages
- Sentence completion exercises
- Carry out paragraph analysis (sentence order, inferences, the way each sentence builds up detail cumulatively)
- Use key words highlighting the main ideas and how they link and make a diagram.
- Identify key words relating to inferences and link to the main key words.
- Use the diagram as a prompt to guide the child when writing the paragraph in sentences using his or her own words.

Conclusion

The aim of this paper has been to introduce teachers to memory difficulties, in particular working memory difficulties, and how they impact learning. It is hoped that class teachers will begin to identify memory difficulties and make appropriate modifications to strategies they are using. When planning learning activities for

children in their class, teachers should ensure that support for children with memory difficulties is included in their differentiated approach. Further recommended reading on the impact of working memory difficulties on DCD, ADHD, ASD, maths, reading and anxiety disorders can be found in Alloway, T.P. & Alloway, R.G. (2015). *Understanding Working Memory* (2nd edn). London: Sage.

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C=consonant, V=vowel (CVC = consonant, vowel, consonant for example, map; CCVC = slap; CCCVC=strap)

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