Working Memory in the Classroom

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Working memory in the classroom

In her Presidents' Award Lecture at the Annual Conference, **Susan E. Gathercole** looked at identifying and supporting children with poor working memory

Poor working memory skills are relatively commonplace in childhood, and have a substantial advance impact on children's learning. This article describes the profile of cognitive and behavioural characteristics associated with working memory, methods for assessing working memory skills, and ways of supporting the learning needs of children affected by this problem.

question

What kinds of classroom activities impose heavy demands on working memory?

resources

Gathercole, S.E. & Alloway, T.P. (2008). *Working memory and learning: A practical guide for teachers.* London: Sage.

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Nathan is a six-year old child in his second full-time year of school. He is working in the lowest ability groups in both reading and maths, and is struggling with many classroom activities. He often fails to follow instructions such as 'Put your sheets on the green table, arrow cards in the packet, put your pencil away and come and sit on the carpet'; typically, he will complete the first part of the instruction and proceed no further. He also makes errors in activities that involve remembering even small amounts of information at the same time as processing other material. Often he loses his place in complex tasks, making errors such as skipping important steps or repeating them. Nathan's teacher says that he has a short attention span, and is easily distracted.

Many teachers have pupils with similar profiles of behaviour and achievement to Nathan's, but are unlikely to know that they have poor working memory, a problem shared by approximately 10 per cent of children. Nathan, a child who came to our attention through routine screening, has not been diagnosed as having a developmental disorder but is making only slow progress in most areas of classroom learning. In the years to come, it is likely that he will be identified as having special education needs in reading and maths in primary school, and he is at risk of poor educational achievements at secondary level, and of entering adult life with few academic qualifications. Nathan is typical of the hundreds of children that we have encountered in schools in recent years as part of our research on the consequences of poor working memory on learning and behaviour.

Before considering the detailed characteristics of such children more systematically, it is important to describe what is meant here by working memory. This is a term that is widely used to refer to a memory system that provides a kind of mental jotting pad storing information necessary for everyday activities such as remembering telephone numbers, following directions and instructions, and keeping track of shopping list items while in the supermarket. Working memory consists of several interacting subsystems that include specialised stores for verbal and visuo-spatial material, and an attentional component that controls activity within working memory (see Baddeley, 2000).

Working memory may be useful and flexible, but information held in working memory is easily lost through distraction or overload. There is also a substantial variation in working memory capacity between individuals. Those with poor capacities will therefore struggle to meet the heavy working memory demands of many situations, of which the classroom is a prime example.

Recognising poor working memory in the classroom

Most of the children who fall in the lowest 10 per cent in terms of their working memory show the characteristics outlined in the box opposite. When identified via routine screening, the gender balance is fairly even, with a slightly greater proportion of males than females. The behavioural profile of the children is fairly constant and unlike disorders such as ADHD, tends not to fluctuate markedly from time to time or day to day. The children also do not show the high levels of either oppositional or hyperactive and impulsive behaviour associated with ADHD (Gathercole, Alloway et al., in press). However, it should be noted that the majority of children with the combined subtype of

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ADHD – the most commonly diagnosed category in the UK – do have working memory problems and the associated cognitive problems of the children described here (Holmes, Gathercole, Place et al., 2008).

The majority of children with poor working memory are slow to learn in the areas of reading, maths and science, across both primary and secondary school years (Gathercole & Alloway, 2008; Gathercole & Pickering, 2000; Gathercole et al., 2004; Jarvis & Gathercole, 2003). The key issue is: Why? We suggest that the learning difficulties faced by these children arise because they are unable to meet the memory demands of many structured learning activities (Gathercole & Alloway, 2008). As a consequence, their working memory becomes overloaded and the crucial information that is needed to guide the ongoing activity – such as the sentence they are attempting to write, or the sequence of instructions they need to follow – is lost (Gathercole, Durling et al., in press). Because information is permanently lost from working memory through overload or distraction, it will not be possible for the child to proceed with the activity and to see it through to a successful conclusion unless they are able to access again the critical task information that is needed. The child is therefore forced either to guess at this point (a strategy that is likely to lead to errors) or to abandon the task before its completion. Activity failures such as these represent missed learning opportunities for the child, and the more frequent they are, the more that learning will be delayed.

One striking finding across many studies has been that the children with poor working memory that we have identified via routine screening are rarely described by their teachers as having memory problems (Gathercole et al., 2006). Rather, they typically report the children as having attentional problems, using descriptions such as 'it's in one ear and out of the other' and 'just doesn't listen to a word I say'. These descriptions fit well with recent evidence that individuals with low working memory spans were much more likely to engage in mind-wandering when performing demanding cognitive activities (Kane et al., 2007). This phenomenon has been termed 'zoning out', and appears to be a hallmark of situations in which working memory is so overloaded that it is no longer possible to keep in mind the information needed to guide an ongoing mental activity. It seems likely that the inattentiveness of children with poor working memory arises for just this reason: the children lose the crucial information needed to guide the ongoing activity, and so shift attention away from the task in hand. In this way, memory loss may masquerade as failures of attention.

Poor working memory profile

- **Normal social relationships with peers**
- **Reserved in group activities**
- **Poor academic progress in reading and maths**
- **Difficulties in following instructions**
- **Problems with learning activities that require both storage and processing**
- **Place-keeping difficulties**
- **Appears to be inattentive, to have short attention span, and to be distractible**

Brian Mitchell/Photofusion

Do children face difficulties because they are unable to meet the memory demands of many structured learning activities?

Assessing working memory problems

Techniques developed in recent years provide a reasonable degree of choice in the nature and level of detail of the working memory assessment, which are now also open to a wider range of users. One new development is that working memory problems can now been assessed indirectly, using knowledge of the children's classroom behaviours. Behaviour rating scales are now available that require teachers to rate the frequency of problem behaviours associated with poor working memory. The two scales that are available are the Working Memory Rating Scale for Children (Alloway et al., 2008), and the working memory subscale of the

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Kane, M.J., Hambrick, D.Z., Tuholski,

Principles of the classroom-based working memory approach

Principles	Further information
Recognise working memory failures	Warning signs include incomplete recall, failure to follow instructions, place-keeping errors, and task abandonment
Monitor the child	Look out for warning signs, and ask the child
Evaluate working memory loads	Heavy loads caused by lengthy sequences, unfamiliar and meaningless content, and demanding mental processing activities
Reduce working memory loads	Reduce the amount of material to be remembered, increase the meaningfulness and familiarity of the material, simplify mental processing, and restructure complex tasks
Repeat important information	Repetition can be supplied by teachers or fellow pupils nominated as memory guides
Encourage use of memory aids	These include wall charts and posters, useful spellings, personalised dictionaries, cubes, counters, abacuses, Unifix blocks, number lines, multiplication grids, calculators, memory cards, audio recorders, and computer software
Develop the child's own strategies	These include asking for help, rehearsal, note-taking, use of long-term memory, and place-keeping and organisational strategies

Behaviour Rating Inventory of Executive Function (Gioia et al., 2000).

The remaining methods assess working memory skills more directly. Many standardised ability test batteries include two measures of working memory: forward and backward digit span. Of the two, backward digit span provides the more sensitive assessment of general working memory capacity. This is due to its requirement not only to store the digits but also to mentally reverse their sequence, which imposes substantial burden on the attentional component of working memory. A child scoring at low levels (say, more than 1 SD below the mean) on backward digit recall has a high likelihood of having poor working memory. Of the general ability test batteries, the most comprehensive assessment is provided by the Working Memory Index (WMI) of the Wechsler Intelligence Scales for Children (4th edn, Wechsler, 2004), based on three subtest scores – forward and backward digit recall, and letter–number sequencing. In our experience, almost all children with poor working memory will obtain low WMI scores (Alloway et al., 2008).

One limitation of the working memory measures from general ability test batteries is that they are almost exclusively verbal in nature and typically use digits as memory items. The problem with such assessments is that individuals who have particular problems in processing numerical information are likely to underperform on such assessments for reasons other than poor working memory capacity. These tests also fail to incorporate other aspects of the child's working memory, such as the ability to store and manipulate non-verbal material.

To provide a broader evaluation of a child's profile of working memory strengths and weaknesses, specialised working memory test batteries such as the Working Memory Test Battery for Children (Pickering & Gathercole, 2001) and the Automated Working Memory Assessment (AWMA: Alloway, 2007) can be used. Both include verbal memory tests involving digit and non-digit stimuli, and also incorporate tests of non-verbal memory using stimuli such as spatial patterns and movement sequences. The AWMA is is a computerised assessment with automated scoring that is appropriate for use by teachers as well as psychologists, and also incorporates visuo-spatial complex memory tests. This breadth of assessment produces a working memory profile for the child that can, for example, distinguish between core working memory deficits that generalise across all domains (which is most typical for children with poor working memory) and less balanced patterns of deficit that are more severe for either verbal material (Archibald & Gathercole, 2006) or visuo-spatial material (Archibald & Alloway, in press). Knowing the profile of working memory strengths and weaknesses is particularly useful in identifying effective learning support for individual children. Finally, it should be noted that these working memory assessments provide valuable prospective indicators at school entry of children at risk of poor academic progress over the coming school years (Gathercole et al, 2003).

Providing learning support

The next step after establishing that a child has poor working memory is to find ways of overcoming the slow learning progress that accompanies this condition. There have been important recent advances in such support and, although their efficacy and practical impact on classroom learning has still to be fully evaluated, they appear to offer considerable promise either singly or in combination.

Classroom-based support

With Professor Julian Elliott and Dr Tracy Alloway of the University of Durham, I have been involved in developing a classroom-based approach to supporting children with poor working memory problems. This approach is designed to avoid working memory overload in structured learning activities, and is

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organised around the set of principles derived both from cognitive theory and from classroom practice that are summarised in the box opposite. Following training and support, teachers learn how to recognise task failures due to working memory overload, monitor the child for these failures, evaluate working memory loads and reduce as necessary when memory failures arise, re-present information to the child if necessary, encourage the use of memory aids, and develop the child's strategies to support memory. Working examples and case studies in our book *Working Memory and Learning: A Practical Guide for Teachers* (Gathercole & Alloway, 2008) illustrate the ways in which this can be achieved. A particular strength of this approach is that it is integrated with the current delivery of the curriculum, and has been effectively applied for groups of children with poor working memory as well as individuals.

Working memory training

An alternative approach that also looks very promising involves the direct training of working memory skills. Robomemo, produced by CogMed, Stockholm (www.cogmed.com), is a computerised training programme designed to enhance working memory through intensive practice in activities that tax working memory. Key features of this programme are that the child works at their maximum working memory capacity on a near-daily basis for about 35 minutes a day for six weeks, in a high-quality graphics environment with multiple motivational features. Working memory performance has been found to be substantially enhanced by Robomemo both in children with ADHD (Holmes, Gathercole, Place et al., 2008; Klingberg et al., 2005) and in children with poor working memory (Holmes, Gathercole, Dunning et al., 2008). Inattentive behaviours are also reduced by the training. As yet, the precise source of the improvement in working memory performance in training is not fully understood, and may arise from enhancement in basic memory capacity, strategies, or both.

> "Memory loss may masquerade as failures of attention"

Summary

Working memory problems are relatively common during childhood, and are typically associated with poor academic learning. This article has described a number of important recent advances in understanding the problems faced by these children and in identifying ways of supporting them in education. It demonstrates the exciting opportunities that cognitive approaches to learning can bring, if researchers are willing to broaden their methods and interests to meet those of the non-scientific community. Cognitive theory is important not only for the experimental laboratory but also for practical application in vital contexts such as the classroom.

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