Short-Term Memory

Written by Debbora Hall and Chris Jarrold, March 2015

Theoretical background

In Factsheet 1, we discussed Baddeley's (1986) model of working memory, and how it has served as a useful framework for thinking about domain specific stores for verbal and visuo-spatial material, with general 'executive' resources. We added speed of processing to this model, and the ability to resist distraction.

Here we will focus on the short-term memory aspect of working memory. Short-term memory is a core component of working memory (Colom et al., 2014). Short-term memory for verbal information is often measured using digit span, in which individuals are presented with increasing lists of digits, until they can no longer recall the list in correct serial order. The last point at which recall was perfect is called their span level.

To measure a child's visuo-spatial short-term memory, tasks like the Corsi span task can be used (Milner, 1971). In this procedure, children are presented with an array of randomly arranged blocks, and the psychologist points to a sequence of blocks. The child must recall the blocks in the order presented. Again, their span is the maximum number of blocks that they correctly tap in the correct sequence.

Our game 'Capacity Limits' provides a computer analogue of the digit span task and the Corsi span task. In the verbal memory game, children can be presented with increasing lists of digits. In the visual memory game, they need to remember the sequence of lily pads a frog hopped to and from. This game is based on work by Brock and Jarrold (2005), in which they used a game similar to this with children with Down Syndrome.

How *do we know that verbal and visual short-term memory are separate?*

Brock and Jarrold (2005) found that children with Down Syndrome performed poorly on the verbal short-term memory task, but performed relatively well on the visuo-spatial task (see Figure 1). The opposite pattern has also been seen in children with Williams Syndrome (Jarrold et al., 1999).

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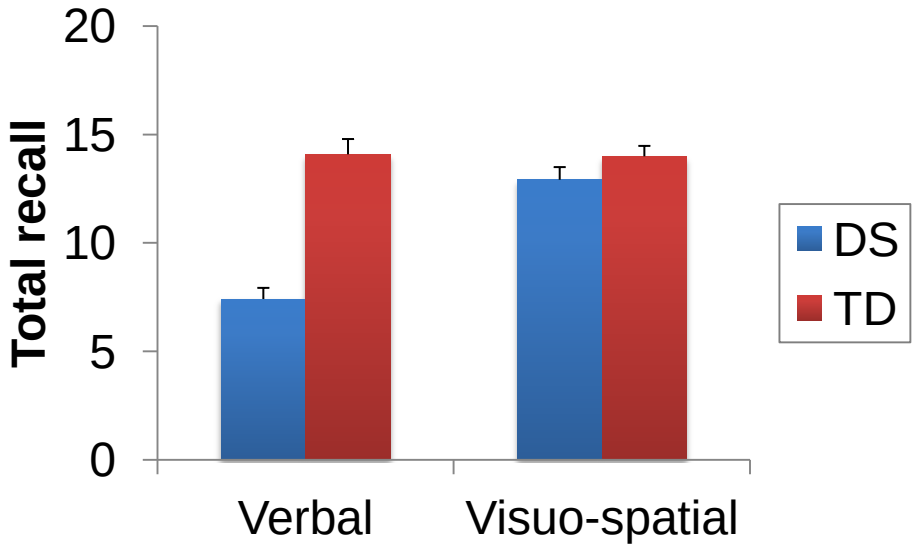

Figure 1: Graph showing impaired verbal short-term memory in Down Syndrome individuals, in contrast to relatively normal visuo-spatial short-term memory. DS = Down syndrome; TD = Typically Developing Individuals. Total recall across testing, not span level. From Brock and Jarrold (2005).

Children with Down Syndrome have relatively poor language ability, while children with Williams Syndrome have relatively poor visual skills. Further, work by Gathercole and Baddeley (1990) has shown that children with specific language impairment had impoverished verbal short-term memory and relatively good visual short-term memory. This all means that the profile of impairments seen in children's short-term memory can be echoed in their learning abilities.

Neuroimaging work has also shown that different brain areas are active during verbal tasks (typically left hemisphere) and visuo-spatial tasks (typically right hemisphere) (Smith & Jonides, 1997).

How does this relate to school achievements in typically developing children?

Children who have poor short-term memory may not present with language difficulties, or impairments to visual processing, but may still struggle with certain tasks in the classroom. We, and others, have found that verbal short-term memory is related to reading and mathematics (Bayliss et al., 2003; Bull et al., 2008; Alloway & Alloway, 2010; Hall et al., 2014). This means that children who have poor verbal short-term memory are also likely to struggle with learning to read and learning mathematics. Other work has shown that visuo-spatial short-term memory is related to mathematics, particularly in younger children (Holmes & Adams, 2006). These studies have shown that younger children use visuo-spatial short-term memory to solve problems, while older children start to use more verbal

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short term memory resources (Titz & Karbach, 2014). This means that visuo-spatial short-term memory may be particularly important to younger children when learning mathematics, and those with poor visuo-spatial short-term memory may struggle.

Classroom behaviour may also be associated with short-term memory capacity. Children who cannot retain information may become bored and restless, and their behaviour then becomes more of an immediate issue to the teacher (Gathercole & Alloway, 2007).

How can we support short-term memory in the classroom?

To answer this question, we would firstly like to direct you to much more detailed resources on support for children with memory difficulties, such as Gathercole and Alloway (2007) (see further reading), and the CALM clinic website. We have also provided information in Video 4 and Factsheet 4 on strategies that can be used to support short-term memory.

Three things Gathercole and Alloway (2007) have suggested to support children with poor short-term memory are:

1. To be aware of the memory load in a task. Children have very limited short-term memory capacities in general and those with poor short-term memory may struggle to retain 2 to 3 items. Stagger the rate of information to help reduce memory load.

2. Make sure children know that it is ok to ask for the information to be repeated.

3. Flashcards or memory prompts can be placed on the child's desk to help lift the demand on their short-term memory.

How do individuals perform on visual and verbal span tasks?

Memory span in adults is often thought to be around 7 items (Miller, 1956), but memory spans vary between individuals and are known to increase with age (Alloway et al., 2006; Bayliss et al., 2003; Gathercole & Pickering, 2001). In the table below, we show some guidelines for what you would expect on the tasks presented in *Game 2 – Capacity Limits*.

Please note that these tests are not standardised assessments. We are basing our numbers on averages of 708 children tested by Alloway et al. (2006), on their AWMA versions of digit recall (verbal short-term memory) and block recall (analogous to Corsi recall and testing visuo-spatial short-term memory). Please see Pickering and Gathercole (2001), or Alloway et al. (2008) for standard scores on these tests.

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Table 1: Mean span on verbal short-term memory and visuo-spatial short-term memory from age 4-11. Span reflects the longest sequence recalled. Standard deviations give an idea of scores around the mean. 68% of children fall within 1 standard deviation of the mean. Scores above or below this are more unusual. Averages are rounded to the nearest 0.5.

Age band (average age)	Verbal Short-term Memory			Visuo-Spatial Short-term Memory		
	Average (mean span)	Spans -1 standard deviation	Spans +1 standard deviation	Average (mean span)	Spans -1 standard deviation	Spans +1 standard deviation
4-6	4.5	4.0	5.5	3.0	2.0	3.5
7-8	5.0	4.5	6.0	3.5	3.0	4.5
9-11	6.0	5.0	7.0	4.0	3.5	5.0

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Smith, E.E. & Jonides, J. (1997) Working Memory: A View from Neuroimaging. *Cognitive Psychology* **33**, 5-42.

Titz, C., & Karbach, J. (2014) Working memory and executive functions: effects of training on academic achievement. *Psychological research*, **78**, 852-868.

Further reading:

Gathercole, S. E., & Alloway, T. P. (2007). *Understanding working memory: A classroom guide.* London: Harcourt Assessment.

The CALM clinic is based in Cambridge, UK, and is run by Dr Joni Holmes and Professor Sue Gathercole. They have a set of resources available on the website at:

http://calm.mrc-cbu.cam.ac.uk/

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