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Working out how working memory works: evidence from typical and atypical development

Introduction and background

Working memory is a key concept within psychology, education, and artificial intelligence. One reason for this interest is that measures of working memory tend to be strongly related to other important real-world abilities. However, there is ongoing debate about the different ways in which working memory performance can best be understood. Professor Chris Jarrold at the University of Bristol School of Experimental Psychology recently received an award from the UK's Experimental Psychology Society for his work in this area. This summary covers material from Prof Jarrold's award lecture as well as other research from his group looking at the development of working memory in children. It also provides a link to a range of resources based around working memory which will be of particular interest to teachers, SEND coordinators, and educational psychologists (see final section of summary).

Key points

What is working memory and why is it important?

- Working memory refers to our ability to hold in mind information - often in the face of distraction – so that we can guide our behaviour in line with our internal goals rather than being driven by external factors.
- Working memory is measured using tasks in which participants have to remember (or 'store') information while also engaging in additional distracting 'processing' activities. They then recall the information which they were asked to remember, often in the order in which it was presented. Previous research has indicated that performance on these tasks depends on individuals' storage capacity, their speed of processing, and their ability to resist interference from distraction. The above-mentioned activities are likely to develop with age in children.
- Overall performance on working memory tasks predicts measures of academic attainment, including aspects of reading and maths, and potentially also classroom behaviour. Part of Prof Jarrold and colleagues' research examines which components of overall working memory performance (storage, processing, resistance to distraction) drive these associations.

Storage of information and new word learning

- The ability to store information is one of the key components of working memory performance. Previous research suggests that there may be separate systems for the storage of verbal as opposed to visual or spatial material, and that our ability to store verbal information in the short-term links to new word learning.
- Children (and adults) who are able to hear and repeat in order relatively more verbal items (i.e., words in a memory list) also learn new vocabulary more quickly (either in their own or in a second language). In other words, short-term storage of verbal information links to longer-term vocabulary learning.
- The team working at Bristol University's School of Experimental Psychology have shown that even 3-year-old children show long-term learning of verbal information through repetition provided that the amount of information they have to learn falls within their short-term storage capacity.

Strategy choice

- One way in which children can improve their working memory performance is by employing strategies to help them store information in the face of potential distraction. One such strategy that has been the focus of considerable previous research is 'rehearsal' – the ability to say to-be-remembered items to oneself silently within one's head during any delay period.
- Previous studies have suggested that children younger than 6 or 7 years of age do not use this rehearsal strategy in the way that older children do. However, the Bristol team have critiqued this previous evidence and argued that it does not in fact show that young children cannot use rehearsal strategies.
- In addition, there may not be just a single rehearsal strategy. Rather children might engage in different forms of rehearsal, such as single word rehearsal of the just-presented item, multiple rehearsals of the just-presented word, or cumulative rehearsal of all of the items that have heard.
- In an EU-funded project which has developed new ways to accurately determine rehearsal strategies, researchers are currently exploring whether children of different ages engage in rehearsal and which forms of rehearsal they use for which tasks. This work on how children learn to adapt their strategies to the requirements of a task (i.e. the varying difficulty of a task) is particularly likely to have educational implications.

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- Initial results indicate that children of all age groups (from 6- or 7-year-olds to 10- or 11-year-olds) mostly use a mix of strategies including different forms of rehearsal. Older children are more likely to choose cumulative rehearsal and use this advanced strategy particularly in difficult tasks, while resorting to faster, but still sufficient strategies in easier tasks.

Working memory and classroom instructions

- In addition to the positive effects of verbal strategies, children's working memory may also benefit from non-verbal support.
- Although the concept of individual 'learning styles' has been heavily criticised, and is not supported by the Bristol team's work, all children's memory may benefit from opportunities to either 'encode' or to 'recall' that information in non-verbal forms.
- This has been examined in the context of children's ability to remember classroom instructions. For example, do children find it easier to remember a set of instructions (e.g. 'fold the paper and put it in the envelope when the bell rings') if they are able to enact these instructions when they first hear them, or if they are asked to recall them by carrying them out rather than simply repeating them ('what were you supposed to do'?)
- The Bristol research group have built on previous work by distinguishing between the effects of enactment on children's memory for either the actions ('fold', 'put') or the objects ('paper', 'envelope') in these instructions. Findings indicate that enacting instructions when they are first presented improves children's ability to remember the order in which these actions (but not the items) were presented.

Maintaining rules and control of behaviour

- Another area where working memory links to behaviour is in the context of following one's own, internal, goals. In any task an individual internalises a set of rules for how to complete that task, and how to achieve one's goals. However, our working memory capacity may limit the number of rules that can be simultaneously kept active at any one time.
- The Bristol research team have therefore examined whether children's limited (though developing) working memory capacity sets the limit on the number of task-relevant rules they can use. This was done by using a task-switching paradigm, in which children (and adults) had to make different responses to different items depending on which of two cognitive tasks they were instructed to complete at any given point.
- The findings show that young children behave like older children and adults when they only have to remember a small set of task rules. However, when the number of rules exceeds their working memory capacity they differ from older individuals. Specifically, they fail to benefit from these rules repeating during the task, indicating that the rules are not being held, and strengthened by repetition, in working memory.

Resources

- The School of Experimental Psychology has produced a set of resources of particular benefit to SEND coordinators, educational psychologists and any stakeholders in schools who may be seeking to gain a better understanding of working memory for their own professional development.
- The resources are divided into 4 sections as follows: What is working memory; short term memory; distraction; and strategies. Within each section, there is a short film, a fact sheet and an activity which can be used to measure an aspect of children's memory or memorisation strategies. The resources can be downloaded from: http://www.bristol.ac.uk/expsych/public-engagement/working-memory/

References

- Reports relevant to this summary are listed below.
- Jarrold, C. (2017). The Mid-Career Award: Working out how working memory works: evidence from typical and atypical development. The Quarterly Journal of Experimental Psychology, 70, 1747-1767
- Yanaoka, K., Nakayama, M., Jarrold, C., & Saito, S. (in press). Determining the developmental requirements for Hebb repetition learning in young children: Grouping, short-term memory, and their interaction. Journal of Experimental Psychology: Learning, Memory, and Cognition.
- Poloczek, S., & Jarrold. C. (2018). How children use verbal rehearsal in serial recall tasks of varying difficulty. Paper presented at the London Meeting of the Experimental Psychology Society. London: January.
- Makri, A. & Jarrold C. (2017). Deconstructing the Enactment Effect: Relational processing benefits from enactment but this effect is mediated by probe type. Paper presented at the British Psychological Society Developmental Section Conference. Stratford Upon Avon: September.
- O'Donnell, M., Jarrold C., Saw, R., & van 't Wout, F. (2017). Does working memory capacity contribute to age differences in task switching performance? Poster presented at the London Meeting of the Experimental Psychology Society. London: January.

The full document can be downloaded from:
http://www.hefce.ac.uk/pubs/year/2018/201805/