

# A workout for working memory

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New research suggests that mental exercises might enhance one of the brain's central components for reasoning and problem-solving.

People may be able to remember a nearly infinite number of facts, but only a handful of items--held in working memory--can be accessed and considered at any given moment. It's the reason why a person might forget to buy an item or two on a mental grocery list, or why most people have difficulty adding together large numbers.

In fact, working memory could be the basis for general intelligence and reasoning: Those who can hold many items in their mind may be well equipped to consider different angles of a complex problem simultaneously.

If psychologists could help people expand their working-memory capacity or make it function more efficiently, everyone could benefit, from chess masters to learning-disabled children, says Torkel Klingberg, MD, PhD, an assistant cognitive neuroscience professor at the Karolinska Institute in Sweden. Children with attention-deficit hyperactivity disorder (ADHD), for example, might especially benefit from working-memory training, says Rosemary Tannock, PhD, a psychologist and psychiatry professor at The Hospital for Sick Children in Toronto.

" It could be that working-memory problems give rise to observable behavioral symptoms of ADHD: distractibility and also poor academic achievement," she says. Working-memory deficits might also underpin some reading disabilities, as it controls the ability to recall words read earlier in a sentence, says Tannock.

But how--or even if--working memory can be expanded through training remains a topic of hot contention among psychologists. Some argue that working memory has a set limit of about four items, and that individual differences in working memory arise from the ability to group small bits of information into larger chunks. However, new research suggests that working-memory capacity could expand with practice--a finding that could shed new light on this central part of the mind's architecture, as well as potentially lead to treatments for ADHD or other learning disabilities.

#### Functional limitations

One such study--by researchers at Syracuse University--hit upon the potential trainability while attempting to resolve a debate in the literature on the limits of working memory.

Since the 1950s, psychologists have found one aspect of working memory--sometimes referred to as the focus of attention--to have severe limitations. For example, George Miller, PhD--a founder of cognitive psychology and a psychology professor at Princeton University--established that people generally can't recall lists of numbers more than seven digits long.

Those who exceeded that limit tended to make smaller groups of numbers into larger ones, using a process called " chunking." For example, people familiar with U. S. intelligence agencies would see the letter group " FBICIA" as two chunks, rather than the six letters, and that set of letters would only occupy two slots in a person's memory, rather than six.

In recent years, however, evidence is mounting that the limitation of working memory is somewhere between one and four information chunks.

The downward revision results from new techniques to keep people from chunking information, which can create the illusion of greater fundamental storage capacity, says Nelson Cowan, PhD, a psychology professor at the University of Missouri-Columbia. In one common chunking-prevention method, participants repeat meaningless phrases over and over while performing working memory tasks such as memorizing lists of numbers.

A recent literature review by Cowan, published in *Behavioral and Brain Sciences* (Vol. 24, No. 1, pages 87-185), makes the case that a variety of working-memory measures all converge on a set limit of four items.

Other researchers have suggested that working-memory capacity is limited even further--to just a single item. In a study by Brian McElree, PhD, a psychology professor at New York University, participants underwent a test of working memory called "n-back."

In the task, the participants read a series of numbers, presented one at a time on a computer screen. In the easiest version of the task, the computer presents a new digit, and then prompts participants to recall what number immediately preceded the current one. More difficult versions might ask participants to recall what number appeared two, three or four digits ago.

McElree found that participants recalled the immediately preceding numbers in a fraction of the time it took them to recall numbers presented more than one number ago--a finding published in the *Journal of Experimental Psychology: Learning, Memory and Cognition* (Vol. 27, No. 1, pages 817-835.)

" There is clear and compelling evidence of one unit being maintained in focal attention and no direct evidence for more than one item of information extended over time," says McElree.

In an attempt to reconcile the two theories, psychology professor Paul Verhaeghen, PhD, and his colleagues at Syracuse University replicated McElree's experiment, but tracked participants' response times as they practiced at the task for 10 hours over five days. (See November Monitor, page 35.)

" We found that by the end of day five... their working memory [capacity] had expanded from one to four items, but not to five," says Verhaeghen. " It seems that both theories are correct."

The focus of attention might expand as other working-memory processes become automated, Verhaeghen says. Perhaps practice improves the process of attaching a position to a number, freeing up the mind to recall up to four numbers, he notes.

Some researchers believe the practice effect uncovered by Verhaeghen reflects more efficient information encoding rather than expanded working-memory capacity. According to McElree, the response time measures used by Verhaeghen do not provide pure measures of memory-retrieval speed, and the changes in response time with practice could indicate that participants in his study simply became more practiced at encoding numbers vividly, he says.

If Verhaeghen's findings can be replicated using other tasks, it could change how scientists conceptualize working-memory limitations. Rather than there

being a set limitation, working-memory capacity could improve through practice--suggesting that those with working-memory problems could improve their capacities through repetition. However, practice would need to occur on a task-by-task basis, says Verhaeghen, and, as he points out, " It is doubtful that practice on n-back generalizes to anything in real life."

### Stretching the limits

New research on children with ADHD, however, might show tasks such as n-back can improve working memory in general, and could help children with the condition.

People with ADHD tend to have difficulty with working-memory capacity, and that deficit could be responsible for their tendency to be distracted and resulting problems at school, says Tannock.

Seeking to alleviate such difficulties with his research, Klingberg ran a randomized controlled trial of 53 children with ADHD in which half of the participants practiced working-memory tasks that gradually increased in difficulty.

The other half completed tasks that did not get harder as the children became better at them. Both groups of children--who were 7 to 12 years old--practiced tasks such as recalling lists of numbers for 40 minutes a day over five weeks.

The children who practiced with increasingly difficult memory tasks performed better on two working memory tests--which were different than the practice tasks--than the control group, reported Klingberg in the Journal

of the American Academy of Child & Adolescent Psychiatry (Vol. 44, No. 2, pages 177-186.)

In addition, the parents of children with memory training reported a reduction in their children's hyperactivity and inattention three months after the intervention, while the parents of the control group participants did not.

Subsequent, yet-unpublished experiments build on those results, Klingberg says.

" We have looked at other groups too: adults with stroke, young adults without ADHD, children with... traumatic brain injuries," he says. " A general pattern [we've found] is as long as you have working-memory problems and you have the ability to train, you can improve your abilities."

Some researchers suggest that memory training may have more of an effect on motivation than working memory.

" It seems to me that children in the training group may have learned to have a better attitude toward the testing situation, whereas children in the control group--who repeated easy problems--may have learned that the testing situation was boring and uninteresting," says Cowan. " The differences that emerged on a variety of tasks could be the result of better motivation and attitude rather than a basic improvement in working memory."

Or, says Klaus Oberauer, PhD, a psychology professor and memory researcher at the University of Bristol in England, the practice effect in both Klingberg's studies might result from people learning to use their limited

working-memory capacity more efficiently--perhaps by grouping information into larger chunks or by enlisting long-term memory.

" I think the practice effect [they found] basically is just an ordinary practice effect, in that everything gets faster," he says.

So, even if working memory can't be expanded, adults with grocery lists and children with ADHD may be able to make better use of what little space is available by practicing the task itself or repeating tests of general working memory. And, in the end, the milk gets bought and the reading assignment finished.

Reference:

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