

## Working Memory Training - A Cogmed Intervention

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**Abstract.** This study of working memory training investigates the impact of intervention with memory training on students' school performance. The training consisted of 25 occasions spread over five weeks. A total of 32 students from the first grade of primary school participated in the study, with 16 students in the intervention and 16 in the control group.

Before and after the intervention, all the participants were tested on word decoding skills, reading comprehension, and automated mental arithmetic. The results showed that both groups had improved on all tests after the intervention, but that the intervention group performed significantly better on the word decoding test than the control group. However, this study demonstrated no differences due to memory training with regard to mental arithmetic between the intervention group and the control group. A possible interpretation of the result is that structured memory training is beneficial for students' reading development.

**Keywords:** working memory; intervention; inclusion; motivation; word decoding

### **Introduction**

Working memory (WM), the ability to process and remember information, plays a crucial role in supporting learning, including reading. Working memory can also be described as the ability to keep information current for a short time, which is necessary for cognitive tasks such as reading comprehension and problem solving (Baddeley, 2000). WM is composed of four components whose

coordinated activity is responsible for the storage and manipulation of information (Alloway & Alloway, 2010). Three components were proposed by Baddeley and Hitch (1974) with a fourth component added later on by Baddeley (2000, 2003).

The crucial role that WM is considered to play is related to scholastic achievement and to learning support (Alloway & Alloway, 2010; Alloway, Gathercole, Kirkwood, & Elliot, 2009; Swanson & Sachse-Lee, 2001). A great many students in today's schools have difficulties in reading and writing. Some students find it difficult to concentrate and focus on their work for long periods and are easily disturbed by external stimuli. This background can be a factor affecting the word decoding ability, which in turn affects comprehension and reading fluency.

An example of our use of working memory in everyday life is mental arithmetic and problem solving. When students visualize the internal mental ruler to make an actual calculation, a connection to the working memory is necessary, according to Klingberg (2013). Working memory is required to remember the different stages in maths and problem solving and for keeping several operations in mind. Until recently it was believed that working memory could not be influenced by stimulation or training. However more recent research has shown that working memory capacity can be improved through cognitive training. (Lohaugen, et.al., 2011; Thorell, Lindqvist, Bergman Nutley, Bohlin & Klingberg, 2009). Another study by Gathercole shows that students with impaired working memory also had difficulties in mathematics. The difficulties excelled in both visuospatial and verbal working memory (Gathercole & Pickering, 2000; Gathercole 2013). Another study that used working memory tests with students diagnosed with dyscalculia showed that their difficulties primarily concerned visuospatial working memory (Landerl et al., 2009). These studies unanimously show that visuospatial working memory and mathematics are related. This applies especially to problem solving and long mental arithmetic operations.

For the purposes of the current study, it is important to understand how deficits in WM impair reading skills. According to research, decoding requires a great deal of energy when not automatized and then also affects the working memory (Ehri, 2007). Given the importance of the WM system in reading acquisition and development (Gathercole et al., 2006; Nevo & Breznitz, 2013), it can be hypothesized that training WM abilities may affect the enhancement of reading skills. The aim of this study is to investigate the impact of structured memory training related to word decoding and reading comprehension among children in grade one.

Dahlin (2013) shows the relationship between good reading acquisition and working memory in a study where students improved working memory capacity after a five-week intervention with Cogmed. The results of the study also showed significantly improved results in terms of reading comprehension. The chief gains, according to this study, occur in the visuo-spatial area. These

improvements remained three years later when compared with the control group. According to researchers, the visuospatial ability and literacy skills are related to each other (Smith, Spark & Fish, 2007). Among the consequences for students with low capacity in working memory may also be the difficulty of remembering instructions and planning one's tasks (Dahlin, 2013; Gathercole & Alloway, 2008). In a study by Gathercole and Alloway (2008) it was found that students with low working memory had difficulties in both mathematics and reading comprehension. Difficulties with low working memory can be compensated for by shorter instructions to students, and supportive images can facilitate for students and to a lesser extent burden the working memory.

Being able to read a text includes a variety of features that need to be mastered, for example, the reader has to be able to maintain concentration on the text, understand the words and content, remembering the beginning of the sentence and linking auditory representations (Klingberg, et al., 2005). Klingberg states that the same areas of the brain are activated during the reading and the working memory tasks. This area is activated by both verbal and visuospatial working memory. The area is important for focusing on attention, which is essential when reading. There is a correlation between concentration and reading skills, and concentration, in turn, depends on the working memory (Gathercole & Alloway, 2008; Klingberg, 2013). On the other hand, when it comes to reading acquisition, Melby-Lervåg (2012) reported in her study about the benefits of working memory training for providing power for tasks that are close to what has been trained but did not see any transfer effects to other capabilities, such as reading. For students with reading and writing difficulties she emphasizes the importance of training phonology to automate the decoding instead of spending time on working memory training. However, in this context working memory is important because it determines how many audio segments can be stored and processed during the synthesis process while reading (Lervåg, 2012).

### **Aim and Research question**

The aim of this study is to investigate the impact of structured memory training related to word decoding and reading comprehension.

The research question is: What impact does structured memory training have on the word decoding ability and reading comprehension among students in grade one at primary school?

### **Method**

#### **Participants**

A total of 32 students participated in the study, divided into two classes in grade one at primary school. The classes belonged to two different schools, comprising a total of 16 students in one of the classes, and a total of 21 students in the other. The two classes were randomly assigned into one experimental group and one comparison group with 16 students in each. In the class with 21 students, 16 were randomly selected by lottery to participate in the study. Both classes come

from areas with similar conditions in terms of socio-economics, study culture and school organization.

### **Test procedure**

All tests were administered by one of the authors (L. J.). All participants were tested on three different occasions with the same test. The first test session (T1) took place immediately before the intervention started. Test session 2 (T2) took place right after the intervention was carried out, and was followed up (Test session 3, T3) 8 weeks after the intervention ended.

### **Test Materials**

The tests used were chosen on the basis of the students' age. The number of decoding tests for seven-year-olds is limited. As tests take a short time only they require no further moment of concentration, which favours students who are easily disturbed by external stimuli and have difficulty with the executive system (Baddeley, 2000). When the same test is used several times, the possibility of a certain recognition factor must be taken into account. On the other hand, the ratio was equal for both groups.

'Words and Image' is a screening test for word decoding for grades 1 and 2 (Söderberg- Juhlander & Olofsson, 2013). The test takes 2 minutes to perform, and standardization results are available for grades 1 and 2. It consists of six pages with a total of 60 words, each word having four pictures attached, only one of which is correct. The pupil's task is to choose the correct picture to the given word and mark it by drawing a cross. The maximum score is 60.

'AG1' is a test in basic arithmetic (Skolverket, 2009) consisting of additions and subtractions within the number range of 1-9. The diagnosis showing the students' ability to handle basic mental arithmetic contains six different sections that represent different aspects of addition and subtraction. The test consists of 36 tasks. For students who have mastered these tasks, it takes about 2-3 minutes to complete. The test is recommended to be discontinued after 6 minutes. The maximum score is 36.

### **The intervention program - Cogmed**

The intervention group used a computerized program for working memory training called Cogmed (Klingberg, 2007). The program, which was developed at Karolinska Institutet, is described as providing enhanced concentration, attention and impulse control, as well as contributing to improved results in students' reading comprehension and mathematical ability (Klingberg, 2013).

The program is web-based and consists of a variety of game-format tasks that affect the auditory and visuospatial working memory and that are adaptive, which means that difficulty level is being adjusted automatically to match the WM span of the child on each task. The program includes 12 different visuospatial and/or verbal WM tasks, eight of these tasks (90 trials in total) are being completed every day (Klingberg et al., 2005). The students followed a standard protocol which means following the computer training program for 5 weeks, five times a week, ~45 min a day. The program was provided via the

internet on a laptop in a separate room. The students were trained individually at school, guided by a coach trained in the method and who was supervised by a certified Cogmed Coach.

### Procedure

The training took place on 25 occasions distributed over five weeks, with five days per week and was led by a trained coach (class teacher). The training, which is web-based, was done with iPad and headphones for each pupil. It was carried out in groups of 8 students per session with the teacher present all the time. The exercises were constructed to enable the students to conduct them on their own without any help from the teacher.

### Result

	T1 Mean (SD)	T2 Mean (SD)	T3 Mean (SD)
Intervention group	24.3 (8.1)	37.7 (6.1)	42.1 (6.9)
Control group	23.4 (7.5)	28.3 (7.9)	31.5 (8.1)

**Table 1. Means and SD for the intervention and control groups at test 'Words and images', on three test sessions**

The results of 'Word and images' showed an increase of 17.8 points from the first to the last test session for the intervention group. The groups had similar means at the pretest. The control group increased by an average of 8.1 points on the test performed during the same time.

	T1 Mean (SD)	T2 Mean (SD)	T3 Mean (SD)
Intervention group	29.3 (5.6)	34.2 (5.8)	33.2 (5.2)
Control group	20.6 (8.2)	25.6 (7.0)	30.5 (7.1)

**Table 2. Means and SD for the intervention and control groups at the mathematic test 'AG1', on three test sessions**

Test results for the 'AG1' mathematical test showed an increase of 3.9 correctly solved tasks for the intervention group. This may seem remarkable when compared to the comparison group, which increased by 9.9 points. On the other

hand, the average value of the intervention group performance on the pretest was high from the beginning and also produced a ceiling effect. The maximum results for the test are 36 correctly solved tasks, which some students in the intervention group achieved already at T2.

## Discussion

The memory training was conducted in groups of eight students in order to strengthen the motivation of an inclusive approach. Students who are easily disturbed by external and internal stimuli were supported in continuing to practise in the focused environment among comrades. It should be noted that, unlike the students in the comparison group, those in the experimental group did not receive any additional adaptations in the form of reading training along with special education teachers.

The results for 'Word and Image' showed that at the end of the intervention almost all students in the intervention group had acquired a good decoding ability for their grade. The improvement was significantly greater than that of the control group. One pupil still had a low result on the decoding test, which may be due to a lack of vocabulary, as the test 'Words and images' is based on reading a word and emphasizing the right picture. To find out the pupil's decoding ability, another test that only measures decoding ability had to be used. For students with no difficulty in comprehending the meaning of words, memory training had a good influence on the decoding (Høien, & Lundberg, 2013). Automatized word decoding, which relieves poor working memory, is necessary to achieve fluency in reading (Høien & Lundberg, 2013). Our results indicate that the opposite view may also obtain. Training the working memory facilitated word decoding and can thus easily be automatized.

A study by Dahlin (2013) also showed improved results in reading comprehension after Cogmed intervention. For the results to become permanent, time on task is required for continued reading training (Klingberg, 2013). There are now good opportunities for students with reading difficulties to continue training to offset the negative spiral of the Matthew effect (Stanovich, 2000). It would be preferable to implement working memory training early in the fall semester of the first grade of primary school in order to develop the increased literacy skills through conscious reading training for all students. To read a text requires different features such as being able to maintain concentration on it to understand the meaning of words, remembering the beginning of the sentence and linking auditory representations (Klingberg, 2011). Working memory tasks and reading activate the same area of the brain. As visuospatial ability is related to reading disabilities (Smith-Spark & Fish, 2007) training in the visuospatial area improves results in reading comprehension (Dahlin, 2013), as also emerges from our study. Contrary to this, Melby Lervåg (2012) remains critical of memory training. She argues that other parts of the brain are more crucial when it comes to reading skills. Of course, we must remain humble about the results obtained in this study, as the number of participants is small. Still, the results

show that memory training may also give a boost to literacy skills, which can then be developed by maintaining various forms of reading training.

As even mathematical difficulties and the lack of working memory are interrelated (Gathercole & Pickering, 2000), we had expected improved results even on the 'AG 1' math test. This could, however, not be substantiated. The reason may nevertheless be that students in grade 1 are only seven years old and the tasks they received only showed their ability to handle the most basic arithmetic calculation operations (National Agency for Education, 2009). Visuospatial working memory is primarily related to the problem-solving ability (Klingberg, 2013), and this is not tested within AG1. Furthermore, the results were positive on this pre-test (Test Session 1). A limitation in this study is that since the intervention was only made in a group of 16 students, the substrate is too small for drawing any general conclusions. However, the results showed a significant difference in reading skills between the intervention and the control groups, which we cannot explain otherwise than that memory training has an impact on literacy skills, mainly with regard to word decoding, but also in reading comprehension.

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