



# A Cognitive Therapy Intervention Programme Increases Working Memory in Students with Learning Disabilities

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## ABSTRACT

The present study aimed to determine whether students with Learning Disabilities (LD) are able to increase working memory capacity and information processing speed, after 12 sessions of a cognitive therapy intervention programme. Our sample consisted of 24 students with LD (10 males) aged 9-11 years joined the study. The students randomly assigned to an exercise group (n = 12) and a control group (n = 12). Working memory capacity and information processing speed were assessed by Daneman & Carpenter's Working Memory Test, at before and after the programme. Differences between the exercise and control groups in before and after the intervention were evaluated using ANCOVA tests. At the end of the study, exercise group showed an increase in working memory capacity, while no changes in information processing speed were observed. We observed no differences in the percentage of information processing speed between the exercise and control groups at before or after the intervention. Overall, 12 sessions of the cognitive therapy intervention was an effective programme for increasing working memory capacity in students with LD; however, no changes in information processing speed were observed.

**Key Words:** Cognitive Therapy, Working Memory Capacity, Information Processing Speed, Students With Learning Disabilities

**DOI Number:** 10.14704/nq.2018.16.2.1177

**NeuroQuantology 2018; 16(2):45-49**

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## Introduction

Nowadays, Learning Disability (LD) is the most important category of special education (Brandenburg *et al.*, 2015). More than half of all students identified in public schools for special education are affected by LD. Children with learning disabilities form a heterogeneous group. The shared point among all these students is that they all have difficulty in learning school lessons. LD often leads to academic failure. As defined by the Association of Learning Disabilities, LD is damage in one or more of the psychological processes necessary to understand, use language, writing or speech that may appear in the form of

incomplete ability to listen, think, speak, read, spell, or perform mathematical calculations (Schiff *et al.*, 2009). People with LD are common in some form of educational and social disadvantage. They are not able to do what others are doing at the same level of intelligence and need special education for academic achievement (Lerner, 2003).

Several reasons have been raised by experts to explain the causes of LD, but the most emphasis and study is on the executive functions problems. In this regard, more studies have focused on the role of working memory in LD. The results of most studies in this area reflect the

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**Relevant conflicts of interest/financial disclosures:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

**Received:** 31 December 2017; **Accepted:** 16 January 2018



fact that children with LD have weaker performance in working memory than other children and show defects in all the components (Mattison and Mayes, 2012; Swanson *et al.*, 2010). Baddeley (2010) believes that working memory consists of four components. Central executive is a monitoring component in the overall context that applies to allocate attention resources and involves in a range of regulatory functions such as cognitive coordination in conducting multiple simultaneous activities, allocating resources to other working memory areas, and retrieving information from long-term memory. In the Baddeley's model, temporary storage of information is carried out by two special-purpose storage units; Phonological loop that is responsible for temporary storage of verbal information, and the other, visue-spatial sketchpad that is responsible for maintenance and manipulation of visual spatial representation. The forth component is episodic buffer memory that is responsible for transforming the memory subsystems and information dimensions into integrated parts. Working memor is a system that processes and stores temporary information, and it is also essential for high-level cognitive functions and better regulation of emotional experiences (Kaneda and Osaka, 2008; Schmeichel and Demaree, 2010)

Learning strategies include cognitive and metacognitive strategies that help to transfer information from working memory to long-term memory. Therefore, working memory is the center of knowledge in the system and the repository of cognitive and meta-cognitive strategies for learning (Dembo, 1994, Zhiyang, 2017; Wang, 2017). Teaching cognitive strategies helps LD children that use appropriate strategies to deal with educational problems and can solve their educational problems (Chapman & Tunmer, 2004).

Studies on cognitive strategies have shown that the use of these strategies increases the level of learning and academic achievement of learners. Solaz & Sanjose (2007), for example, taught cognitive skills to students with learning disabilities third and fifth grade. The results showed that students who were trained in these skills (experimental group) showed better progress in their ability to read and understanding the content compared with those who did not benefit from the training of these skills (control group). Shiran & Breznitz (2011) examined the effectiveness of cognitive training

on reminder domain and information processing speed in the working memory of dyslexic and normal children and concluded that this training has been effective and the ability to store verbal and visual information in working memory has increased and decoding scores, speed, and reading comprehension have increased in both groups. All in all, evidence concerning direct relationships between cognitive strategies and working memory is weak.

Thus, the aim of the present study was to determine the effect of 6 weeks of a cognitive therapy intervention programme in working memory in students with LD. Based on the literature review, we used working memory capacity as an indicator of working memory and improved attention for the cognitive therapy intervention programme.

## Methods

### *Participants*

The sample consisted of 24 students with LD (10 males) aged 9-11 years at pre-training who were recruited from four elementary schools in Kunming (China). We randomly assigned twelve participants (6 males and 6 females) to an experimental group (performed a cognitive therapy program) and the remaining 12 students with LD participated in current study to a control group. We informed to all participants about the aims, benefits and procedures of our study. We received a written informed consent from all the students with LD participated in both groups. Our study was approved by a learning disorders clinic in Kunming (China).

### *Procedure*

Students with LD in the experimental group received the cognitive therapy intervention programme of this study, while participants in the control group received a usual care. At baseline and 1 week after the cognitive therapy intervention all 24 students with LD participated in both groups filled in questionnaires measuring the two variables: working memory capacity and improved attention. All participants completed outcome measures, and we observed no drop out.

### *Working memory capacity and information processing speed*

Total working memory capacity was determined from the Daneman & Carpenter's Working Memory Test (1980). The validity of the scale was demonstrated by Ivanova & Hallowell (2014), and

its reliability was demonstrated by DeDe *et al.*, (2014). The scale consisted of 27 sentences, divided into six sections (2-sentence, 3-sentence, 4-sentence, 5-sentence, 6-sentence, and 7-sentence). The sections were read in order for participants and they will be asked to listen to the sentences and then do two works, including 1) Is the sentence meaningful? 2) Write down the last word of each sentence. The first section measures information processing speed and the second section working memory capacity.

### Improved attention

Total improved attention was determined from the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV). This questionnaire consisted of 9 questions that have been ranged based on a four-dimensional scale from 0 (never) to 3 (usually). So, the score range for this questionnaire is from 0 to 27.

**Table 1.** The content of the training sessions of cognitive strategies

Session	Purpose
1	Familiarizing team members with each other and consultant, an explanation of how to work with people.
2	An introduction to the correct methods of study, its benefits, necessities, its definition, the explanation of training program and etc.
3	Techniques for pause time reduction, and increasing field of view using a card, measuring reading speed and exercising
4	Review and repeat of content, re-reading of content, and repeat of the main points of a story with loud or slow.
5	Working with students on selecting sections by drawing under them, summarizing in his own language, and taking notes
6	Working with students on using learned materials, teaching lessons learned to others, and using materials learned to solve problems.
7	Working with students on classifying new content, establishing hierarchical relationships for easy content and providing a list of titles with chapter
8	Working with students on classifying new information based on familiar categories, summarizing the main idea of a content and showing the relationship between them
9	Use of the two-way method in reading with the help of trainer and other students
10	Reading a story and its explanation to students and trainer
11	Methods of reading various texts, including easy, difficult, scientific, and literary (using the comments of relevant course trainer)
12	Methods of answering exam questions, preparing for exam and practice

### Training program

A 12-session cognitive strategy training programme were conducted on those students

with LD allocated in the experimental group twice a week. In each session, the contents of the previous sessions were repeated for the students. The content of the training sessions is presented in Table 1.

### Statistical analysis

We conducted all analysis of this study using the Statistical Package for the Social Sciences (SPSS) version 21. Changes between groups for physical characteristics at baseline were analyzed using student's t tests. Changes in the experimental group and the control group for working memory capacity and improved attention from baseline to after the cognitive therapy intervention programme were analyzed using analysis of covariance (ANCOVA). The statistical significance of this study was set at  $p < 0.05$ .

### Results

#### Completion of study and possible adverse effects

Completion of the study averaged  $91.7 \pm 5.3\%$ , ranged from 85% to 98%. In each of the exercise and control groups, one student (one female student in the exercise group and one male in the control group) did achieve less than 65% assistance to the cognitive therapy intervention programme and we excluded the data of our analyses. There was no drop out. Also, we observed no adverse effects and no health problem in the students with LD in the exercise and control groups over the 12-session intervention.

#### General characteristics

Table 1 shows baseline general characteristics of the participants in the exercise and control groups. There were no differences concerning age, IQ, and race. Furthermore, there were no differences concerning elementary grade (exercise group: about 41.7% third, 41.7% fourth and 16.7% fifth; control group: about 50% third, 41.7% fourth and 8.3% fifth).

#### Effects of intervention on working memory and attention

Table 2 gives the average scores, standard deviations and adjusted values of working memory capacity, information processing speed and improved attention in the exercise and control groups. The exercise group showed a



**Table 1.** Baseline descriptive characteristics of the students with learning disabilities

Descriptive characteristics		Participants in both groups (n = 24)	Exercise group (n = 12)	Control group (n = 12)
Age (years)		9.89 ± 0.71	9.91 ± 0.38	9.87 ± 0.54
IQ, N (%)	90-100	5 (20.8)	3 (25)	2 (16.7)
	100-110	16 (66.7)	7 (58.3)	9 (75)
	110-120	3 (12.5)	2 (16.7)	1 (8.3)
Race, N(%)	African American	7 (29.2)	3 (25)	4 (33.3)
	Caucasian/white	15 (62.4)	8 (66.7)	7 (58.3)
	Multiracial	1 (4.2)	1 (8.3)	0 (0)
	Missing	1 (4.2)	0 (0)	1 (8.3)
Elementary grade, N(%)	Third	11 (45.8)	5 (41.7)	6 (50)
	Fourth	10 (41.7)	5 (41.7)	5 (41.7)
	Fifth	3 (12.5)	2 (16.7)	1 (8.3)

**Table 2.** Values of working memory capacity and information processing speed measured by the Daneman & Carpenter's Working Memory Test, and Improved attention measured by the DSM-IV, before and after the training

Measurements	Exercise group (n = 12)			Control group (n = 12)			Time interaction effect
	Baseline	After intervention	Adjusted % change	Baseline	After intervention	Adjusted % change	
Working memory capacity, mean (SD)	30.27±6.32**	38.72±5.23**	6.38	29.19±7.11*	31.44±6.25*	1.11*	$\rho = 0.032$
Information processing speed, mean (SD)	36.25±5.79	34.11±6.34	5.27	37.54±6.33*	37.88±5.63*	-2.34*	$\rho = 0.074$
Improved attention, mean (SD)	62.37±7.21**	102.13±5.15**	5.62	60.26±6.84*	77.34±4.62*	0.84*	$\rho = 0.016$

\*  $\rho < 0.05$  control group vs. exercise group

\*\*  $\rho < 0.05$  pre vs. post

higher level of working memory capacity and a lower level of information processing speed in baseline and after intervention compared to the control group ( $\rho < 0.05$ ). Exercise group significantly increased working memory capacity after the intervention with no significant changes in information processing speed, control group significantly increased information processing speed ( $\rho < 0.05$ ). Changes in working memory capacity and information processing speed were significantly higher in the exercise group compared to control group. Furthermore, the exercise group showed a higher level of improved attention in baseline and after intervention compared to the control group ( $\rho < 0.05$ ).

### Discussion

Students with LD were able to increase working memory capacity and improved attention following 12 sessions of cognitive therapy intervention programme, whereas no effect in information processing speed were observed. Although previous studies, such as Shiran & Breznitz (2011) and Moreno & Saldaña (2005), evaluated changes in working memory in students with learning disabilities, the present study is the first study reporting changes in working memory capacity and information processing speed, in students with learning disabilities as a

consequence of a training intervention programme. Foy and Mann's (2014) study that examined the effect of adaptive cognitive learning on working memory indicated that cognitive training has a positive effect on self-regulation and memory skills, especially on information processing. Our study is not consistent with this study. As we have no drop out in the exercise group, can be seemed that the cognitive therapy intervention programme was attractive and easily adherent for the sample.

The findings of the present study showed that the cognitive training programme has a positive effect on working memory capacity among students with LD. The finding is consistent with the studies Dahlin (2011), Klingberg *et al.*, (2005) and Loosli *et al.*, (2012) that showed the cognitive computer-based practice focused on visual-spatial working memory has increased the visual-spatial performance of dyslexic children's working memory. Shiran & Breznitz (2011) also pointed to similar results to the present study on working memory. Their study showed that after working memory computer-based training, the ability to store spatial-verbal and visual information in working memory and decoding has increased.



## Conclusion

Our findings suggest that a 12-session cognitive therapy intervention programme is an effective method to increase working memory capacity in students with LD. The association between working memory capacity with improved attention makes these results promising for the students. Future studies should investigate other training programme using less family time.

## Acknowledgement

Shandong social science program research project (No. 15DGLJ01).

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