ORIGINAL ARTICLE

The Effectiveness of the Cognitive Training Via the Internet

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Abstract

The deficit of working memory is considered to be a central deficit in ADHD that is responsible for cognitive and behavioral problems. It is related to the defective function of the frontal cortex. The concurrent effect of working memory training is the impulsivity decrease in individuals suffering from ADHD. Patients with a diagnosed hyperkinetic disorder were first examined using IVA + Plus and Conners' Continuous Performance Test II. Then they underwent working memory training using COGMED program. Subsequently, IVA + Plus and Conners' Continuous Performance Test II were performed again. We managed to prove a statistically significant improvement especially in the visual part of the working memory.

Key words: working memory, cognitive training, ADHD

Introduction

Individuals suffering from ADHD have a significantly lower capacity of working memory in comparison with healthy peers (Wilcutt et al., 2005, Martinussen et al., 2005, Karatekin, 2004, Wilcutt, 2005). These deficits in ADHD individuals cannot be though explained by comorbid reading disorders, etc. (McInnes et al., 2003). Deficits in the area of working memory are, in addition to ADHD, also described in other mental disorders such as schizophrenia, autism and in the whole range of so-called "dys-" disorders (dyscalculia, dysgraphia, etc.). Many studies such as Cain, Oakhill and Bryant (2004), or Smith-Spark, Fisk, Fawcett and Nicolson (2003) point to the fact that dyslexia is also associated with working memory deficit. It is assumed that people with dyslexia have problems with the phonological loop because they fail in the tasks focused on remembering a certain range of numbers and letters; see, for example, Cain et al. (2004), etc. Other studies, such as Palmer (2000) and Swanson (1999), focused on deficits in the area of central executive. In people with dyslexia, problems in the area of attention are also encountered, as shown in studies such as Cain et al (2004) and Palmer (2000). In individuals suffering from dyslalia, deficits in the area of working memory were also found. These deficits were particularly evident in the tasks that measured the effectiveness of the phonological loop; see, for example, Dollaghan and Campbell (1998). The research of Gathercole et al. (1999) and others have proven that the capacity of the working memory is important both for learning and for using language. People suffering from dyslalia generally have problems with the capacity of the phonological working memory subsystem, as shown in the researches of Montgomery (2003), Gill et al. (2003) and many others.

Torkel Klingberg from the Karolinska Institute in Stockholm came to the conclusion that by training it is possible to increase the capacity of the working memory in children with ADHD. And because the working memory deficit is the core deficit in ADHD, he found out that working memory training could affect other symptoms of this disease. Until this study there was skepticism among scientists and experts focusing on memory. In his working memory model, Baddeley (2000) classifies the components of the working memory among so called fluid systems, i.e. systems that are genetically given and not subject to learning or training. Klingberg's study on children with ADHD was published in 2002. It was a double-blind, placebo controlled study. His research has shown that there has been a significant increase in the working memory capacity, both in the trained tasks on the visuo-spatial working memory capacity and in the non-trained tasks on the so-called spatial range; the performance has improved significantly also in Raven's and Stroop's tests. In the experimental group there was also a significant reduction in the number of involuntary movements of the head when compared to the control group. Based on this fact, we have also introduced the possibility of working memory training to the individuals who have been diagnosed with a hyperkinetic disorder in our facility. In our research, we have dealt with the question of whether the working memory training is actually effective in these individuals and, if so, what this effect is.

Method

COGMED is a computer program used for working memory training. It consists of visuo-spatial and verbal tasks. The program continually adapts to the current capacity of the individual, thus maintaining a constant optimal level of difficulty (success : failure = 50:50). The user cannot be overloaded or discouraged by repeated failures during training. Prior to the training, an examination and evaluation of the usefulness of working memory training for the patient is performed. The entire program consists of 25 sessions, lasting 30–45 minutes each. The patient trains at home on a computer with an internet connection 5 days a week for 5 weeks. After every 5 days of training, 2 days of rest follow. Adult clients usually train alone, eventually with a family support; child clients train under the supervision of a parent or another adult, and consult the course of training with a therapist once a week via Skype or during a personal meeting. The Coach monitors the course of the training on his or her computer through the web interface. Upon completion of the whole training, client meets with the therapist on a Wrap-up session and a Six months follow-up interview.

The design of our research was as follows: All patients were first tested by IVA + Plus and Conners' Continuous Performance Test II. After that they underwent Cogmed working memory training. Then they were tested with IVA + Plus and Conners' Continuous

Performance Test II again. Testing with IVA + Plus and Conners' Continuous Performance Test II at the beginning does not influence the results of these tests after the working memory training (according to the authors of these tests). The research sample consisted of ADHD patients who underwent the working memory training; it was a non-random choice. The basic socio-demographic variables of our research group are presented in Table 1.

Table 1 The basic socio-demographic variables

	Frequency	Percentage	Cumulative percentage
Men	22	66,7	66,7
Women	11	33,3	100
Total	33	100	

The sample was not gender or age balanced. The average age of our study population was 11,03 years with a standard deviation of 5,07 years. The youngest participant in our study was 6 years old and the oldest participant was 34 years old.

Results

In Table 2 we can see the statistics of the AQ scale of the IVA + Plus test (the global attention scale) before the training (line "AQ") and after the training (line "AQ retest"). This scale reflects the ability to concentrate attention on a stimulus and at the same time the ability to divide attention between two sensory modalities (vision and hearing). The deficit in this area correlates with ADHD syndrome. The results show a better average achieved score on this scale and, therefore, improvement in the overall attention after completing the training.

Table 2 Results of the IVA + Plus test – AQ scale

	Average	SD	N	df	t	Sig.
AQ	70,89	22,609	33	32	-3,288	0,004*
AQ retest	88,39	15,470				

Table 3 provides information on the statistics of the AQ Auditory scale of the IVA + Plus test (attention performance on auditory scale). This is the sub-scale of the AQ scale. The result in this scale is influenced by concentration of attention, the focus of attention and the speed of information processing. We can also see here a statistically significant improvement in the average value before the working memory training (line "AQ Auditory") and after the training (line "AQ Auditory retest").

Table 3 Results of the IVA + Plus test – AQ Auditory scale

	Average	SD	N	df	t	Sig.
AQ Auditory	72,06	22,311	33	32	-2,583	0,015*
AQ Auditory retest	82,06					

Another statistically significant improvement of the average value before the working memory training (line "AQ Visual") and after the completion of working memory training (line "AQ Visual retest) occurred on the AQ Visual scale of the IVA + Plus test (performance of the attention on the Visual scale), as shown in the Table 4. This is again the sub-scale of the AQ scale, where the result is also based on the concentration of attention, the focus of attention and the speed of information processing.

Table 4 Results of the IVA + Plus test – AQ Visual scale

	Average	SD	N	df	t	Sig.
AQ Visual	73,09	22,883	33	32	-4,899	0,001*
AQ Visual retest	92,61					

The scale of Prudence (deliberation) measures the ability of a person to stop, think and not to respond automatically to every stimulus from the environment. The proband is required not to respond to number “2”, the response to this impulse is considered an impulsivity error. As can be seen in Table 5, the average value achieved on this scale improved after completing the working memory training (line “RC A Prudence raw retest”).

Table 5 Results of the IVA + Plus test – RC A prudence raw scale

	Average	SD	N	df	t	Sig.
RC A Prudence raw	0,81018	0,091305	33	32	-3,050	0,005*
RC A Prudence raw retest	0,85867					

Tables 6 and 7 show the statistically significant changes in attention concentration (Vigilance). This scale measures the ability of an individual to respond to a target, in this case to the number “1”. The scale is divided into two sub-scales: auditory (A) and visual (V); the statistically significant improvement occurred in both of its sub-scales.

Table 6 Results of the IVA + Plus test – A A Vigilance raw scale

	Average	SD	N	Df	t	Sig.
A A Vigilance raw	0,83579	0,119184	33	32	-3,827	0,001*
A A Vigilance raw retest	0,91518					

Table 7 Results of the IVA + Plus test – A V Vigilance raw scale

	Average	SD	N	Df	t	Sig.
A V Vigilance raw	0,73673	0,193877	33	32	-4,828	0,001*
A V Vigilance raw retest	0,89967					

The speed of information processing (Speed) measures the average speed of the responses to the stimulus (target). Low performance on this scale can also be related to lower IQ or to the presence of mental disorder, such as depression. The scale is also divided into several sub-scales. As shown in the Table 8, the statistically significant improvement occurred in the visual component (V).

Table 8 Results of the IVA + Plus test – A V Speed raw scale

	Average	SD	N	Df	t	Sig.
A V Speed raw	589,12	92,024	33	32	4,326	0,001*
A V Speed raw retest	519,82					

Another scale that showed a statistically significant change was the "Clinical" scale of the Conners' Continuous Performance Test II. This scale indicates the probability of the ADHD syndrome occurrence in the individual (so called Confidence Index). When looking at Table 9, we can see that the average value has decreased after completing the working memory training (line "Clinical retest"). This means improvement because the higher the value of this scale, the more likely the occurrence of ADHD syndrome is.

Table 9 Results of the Conners' Continuous Performance Test II – Clinical scale

	Average	SD	N	Df	t	Sig.
Clinical	0,523906	0,1267582	33	32	2,412	0,022*
Clinical retest	0,470679					

The last Table (no. 10) provides information on the overall average speed of reaction time, which indicates the average of all reaction times per target throughout the whole test. The table shows that after completing the working memory training the reaction time decreased significantly (line "Hit RT retest).

Table 10 Results of the Conners' Continuous Performance Test II – Hit RT scale

	Average	SD	N	Df	t	Sig.
Hit RT	441,3588	57,77011	33	32	3,410	0,002*
Hit RT retest	470,0639					

Conclusion

We have confirmed that there has been a statistically significant improvement in the working memory capacity, especially in the visual component. However, a statistically significant improvement in the auditory component was not confirmed. This result is in accordance with our theoretical expectations, as Cogmed program focuses more on visual and spatial tasks rather than auditory tasks. Also, the parents subjectively reported that they observed reduction in hyperactivity symptoms in their children who underwent the working memory training.

Discussion

Several aspects could be reflected in the overall outcome of our study. Above all, it is necessary here to mention the fact, that the study was not randomized or double-blind. We did not compare the efficiency of this type of intervention to placebo. Another fact that could be reflected in the overall results is the low number of participants in the research and their heterogeneous age range. Our results are in accordance with the previously published findings on working memory training and effectiveness of this training, such as Westerberg et al. (2004; 2007a; 2007b), Thorell et al. (2009), Klingberg (2002; 2005) and many others. The existing researches confirm that working memory training positively affects the symptoms of ADHD, especially hyperactivity. However, for a more objective outcome, a larger research population would be needed and a comparative placebo study should be performed. Despite this, we believe that our work was meaningful and can stimulate further research in this field.

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