IMPROVEMENT OF COGNITIVE EFFICIENCY THROUGH COGNITIVE TRAINING IN HEALTHY SUBJECTS

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SUMMARY – The aim of the study was to explore whether application of cognitive stimulation in young healthy subjects may improve their cognitive efficiency. The study included 12 healthy young subjects divided into two groups, experimental group and control group. Prior to cognitive stimulation treatment, both groups underwent baseline measurements with selected neuropsychological tests. The groups were matched with regard to the achievement on the baseline test. Only the experimental group underwent daily application of different computer-based cognitive tasks lasting for an hour a day for two weeks. After the treatment, both groups were tested with the same neuropsychological battery used at the baseline measurement. The experimental group showed a statistically significant difference between the measurements on the variables assessing immediate retention of visual material and recognition of verbal material. In addition, qualitative analysis showed that the experimental group also had better performance on the variables assessing delayed recall of visual material, visual and verbal range of attention, and delayed recall of verbal material. In conclusion, two-week cognitive stimulation in healthy subjects improves cognitive performance, expressed as higher average values of certain neuropsychological variables.

Key words: *Cognitive performance; Cognitive stimulation; Neuropsychological tests; Young adult; Cognitive stimulation – outcome*

Introduction

Cognitive training, or cognitive stimulation, is a set of different tasks designed to improve cognitive efficiency, i.e. to enable better performance of higher cognitive functions such as memory, thinking, attention, problem solving skills, and information processing speed. Efficiency and importance of cognitive stimulation is frequently a subject of debate, with its opponents arguing that cognitive stimulation is nothing more effective than other nonspecific intellectual activities, such as reading books, playing cards, or solving crossword puzzles[1]. However, despite the substantial criticism of its efficiency[2], cognitive stimulation has been increasingly employed in the process of cognitive rehabilitation of elderly individuals with some forms of cognitive deficits, usually dementia or mild cognitive impairment[3-6].

In the context of rehabilitation, cognitive stimulation is used primarily to rehabilitate functions that are most frequently susceptible to negative effects of aging, e.g., episodic memory, working memory, information processing speed, short-term memory, mental rotation, simultaneous processing, spatial orientation, and information/data manipulation skills. Another aspect of the practical utility of cognitive stimulation is reflected in the attempts at stimulating cognitive efficiency in healthy subjects as part of prevention of cognitive decline in older age or at improving work efficiency in young individuals[7-11]. Some studies have shown that daily cognitive training in healthy people

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contributes to improved cognitive efficiency, expressed as a larger capacity of working memory, increased perceptive speed, better verbal and visual memory, and improved general cognitive efficiency[10,12]. The importance of cognitive stimulation is corroborated by the results of the studies indicating the importance of cognitive and cerebral reserve, primarily in the context of brain plasticity[13-15]. A structural manifestation of this potential is an increased number of dendritic connections and increased synaptic density, which occurs as a result of stimulation by new experiences, even in the elderly population[16-20].

The principle on which the idea of efficiency of cognitive stimulation is based is called the transfer effect. This phenomenon presupposes that learning a new or exercising an existing cognitive skill has an indirect influence on another independent cognitive function. Depending on the degree to which the given cognitive functions/skills share a common neuronal and cognitive mechanism, we may differentiate between the near transfer and the far transfer. The near transfer refers to a situation in which stimulation of one cognitive function affects improvement of another cognitive function that has similar characteristics as the stimulated function[21-23]. The far transfer entails that stimulation/improvement of one cognitive function affects positively another function, although they basically do not have a mechanism/characteristics in common[10,24]. Therefore, it is considered that proper choice of stimuli and complexity of the very task significantly affect the intensity of the transfer effect[23,25]. Cognitive tasks that involve multitasking, a flexible and variable context and those closer to real life experience are more likely to cause the transfer effect than the tasks based on simple stimuli and their strict laboratory manipulation[26]. For the purpose of designing as effective cognitive tasks as possible, current recommendations abandon the attitude on intensive cognitive training of one cognitive ability only and instead suggest training that would simultaneously activate several cognitive abilities. Such an approach presupposes creation of individualized programs of goal-oriented cognitive activities, i.e. focusing on individual needs of each person[27]. In a narrow sense, such a customized program of cognitive stimulation would be used primarily in the rehabilitation treatment of individuals with cognitive impairment. However, if cognitive stimulation is observed in a wider context, i.e. in the context of stimulation of healthy subjects, its most common use is in the brain fitness programs available for public use at the Internet. A question that arises is the question of real efficiency of stimulation software[18]. In order to assess efficiency of one of these pieces of software, we selected several on-line exercises which have been created with the aim to improve efficiency of several cognitive functions, i.e. memory, attention, reasoning, and visuospatial organization. The aim of the study was to determine whether cognitive stimulation by means of the tasks available at the site may indeed promote cognitive efficiency in young healthy subjects.

Subjects and Method

Sample

The study included 12 healthy volunteers divided into two groups (experimental and control), with six subjects/university students in each group, matched for sex (six men and six women), age (mean=21 years, SD=0), and education (mean=15 years, SD=0). The study was carried out at the Department of Neurology, Clinical Center of Vojvodina in Novi Sad, Serbia. The study was approved by the institutional Ethics Committee, and all subjects signed an informed consent.

Instruments

Performance on neuropsychological variables before and after cognitive stimulation was assessed using the following instruments:

The Trail Making Test A and B (TMT A and B)[28,29]: the test consists of two parts, A and B, and each has a specific purpose. Part A is used to assess attention and concentration, visual perception, and visuospatial and visuomotor abilities. In addition to these abilities, Part B also assesses complex conceptual tracking, which is part of executive functions. We used two variables of this test, TMT A and TMT B, which referred to the number of seconds required to complete the task.

The Rey Auditory Verbal Learning Test (RAVLT)[29,30]: the test is used for assessment of verbal learning and memory. Within these functions, immediate memory (range of attention) is assessed, a learning curve is formed, proactive and retroactive interference is revealed, and recognition and retention are assessed. We used the following variables: RAVLT (A1-A5) – total number of words repeated from five attempts; RAVLT (B) – number of repeated words from list B; RAVLT (A6) – recall of list A after distraction; RAVLT (A7) – delayed spontaneous recall of list A; RAVLT (A – recognition) – recognition of list A; and RAVLT (B – recognition) – recognition of list B.

The Rey-Osterrieth Complex Figure Test (ROCF)[31,32]: this test is used for assessment of visuoconstructive abilities in two dimensions (graphically), as well as for assessment of visual memory (immediate and delayed). We used the variables ROCF (Copy) – copying of the complex figure; ROCF (3 min) – immediate recall of the complex figure after 3 minutes; and ROCF (45 min) – delayed recall of the complex figure after 45 minutes.

Wisconsin Card Sorting test (WSCT)[29,33]: this is the most famous test for detection of perseveration and mental rigidity (ability to form, change and maintain a mental set) and for evaluation of problem solving. We used one variable of this test, WCST (number of categories).

The Wechsler Memory Scale - Revised (WMS-R) – the Mental Control, Digit Span and Spatial Span subtests[34]: the subtests are used to assess the control of a relevant stream of associations, and visual and verbal range of attention. The sum of the weighted scores on the subtests enables calculation of the attention/concentration index. We used the variables Digit Span (backward) and Digit Span (forward) as measures of verbal attention range and immediate retention of verbal material, and Spatial Span (backward) and Spatial Span (forward) as measures of nonverbal attention range and immediate retention of visual material. We also used the variable Attention/Concentration Index.

Procedure

Both groups underwent baseline neuropsychological testing (pretest) aimed at assessment of the following neuropsychological functions: attention and

Table 1. Comparison of neuropsychological variables in the experimental and control groups using the nonparametric Mann-Whitney test at pretest

	U	Z	Exact Sig. (2-tailed)	Cliff's delta
TMT A	14.500	-0.561	0.619	0.250
TMT B	17.500	-0.080	0.981	0.556
RAVLT (A1 to A5)	15.500	-0.401	0.729	-0.083
RAVLT (A6)	6.000	-2.00	0.048*	0.667
RAVLT (A7)	17.000	-0.169	0.978	-0.055
RAVLT (B list)	18.000	0.000	1.000	0.000
RAVLT (A list - recognition)	18.000	0.000	1.000	0.000
RAVLT (B list - recognition)	16.000	-0.331	0.792	0.111
ROCF copy	14.500	-0.582	0.602	-0.194
ROCF 3 min	12.500	-0.885	0.429	0.333
ROCF 45 min	14.000	-0.642	0.558	0.222
Attention/Concentration Index	16.000	-0.320	0.818	-0.111
Digit span (forward)	14.500	-0.587	0.602	-0.194
Digit span (backward)	15.500	-0.414	0.823	-0.139
Spatial span (forward)	17.500	-0.085	1.000	-0.028
Spatial span (backward)	13.000	-0.848	0.502	0.278
WCST – number of categories	18.000	0.000	1.000	–

Level of significance *p<0.05, **p<0.01

concentration, immediate retention and delayed recall of verbal and visual materials, recognition of verbal material, visuospatial and visuoconstructive organization in two dimensions, as well as of certain aspects of executive functions (simultaneous conceptual tracking and ability to form a mental set). The groups had almost identical performance on the tested variables (Fig. 1).

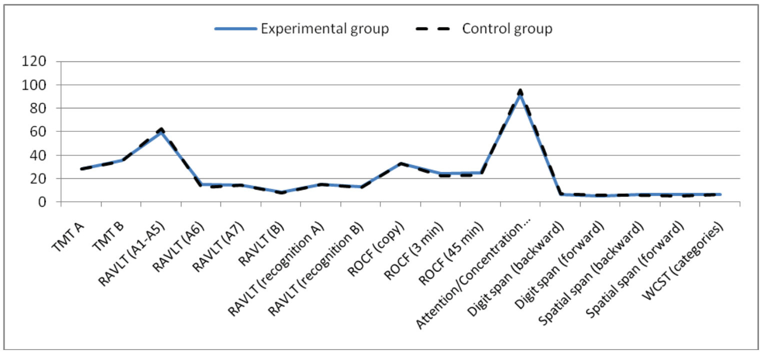

Fig. 1. Medians of neuropsychological tests in experimental and control groups at pretest.

Differences between the experimental and control groups in the studied neuropsychological variables were analyzed using the non-parametric Mann-Whitney test, and considering the small sample size, the exact level of significance was used (Table 1). There was a significant difference in only one studied variable of the RAVLT – delayed recall of list A6 ($U=6.0$, $p<0.05$, $Me_{EG}=15$, $Me_{CG}=12$, $\delta_C=0.667$), i.e. the experimental group showed better performance on this variable. These data indicate that the groups had comparable performance at the baseline measurement.

After the baseline measurement, the experimental group underwent a cognitive stimulation treatment lasting for an hour a day for two weeks. The treatment involved application of a computer version of different cognitive tasks available for public use (www.happy-neuron.com). The Internet site was selected at random. The study did not have a commercial character, it was funded solely by the researchers, and the subjects did not receive any financial compensation for their participation in the study. Each of the tasks was aimed at stimulating performance of individual cognitive functions (memory, attention and concentration, executive functions, and visuospatial organization). The instructions were in English; however, all subjects had an English language competence at least equivalent to the CEFR B1 level and were able to read and comprehend the instructions in English easily. Nevertheless, we selected the tasks that involved primarily the non-verbal factor, since English was not the subjects' first language. The following tasks were selected: *Objects, where are you?*, *Dance with fireflies*, *The towers of Hanoi*, and *Entangled figures*. More information about tasks can be found at the above mentioned Internet site. In addition, the treatment involved different levels of complexity. The subjects were asked to undertake a more complex task every other day, until they reached the most difficult level at the end of the two-week period (1-10 or 1-3 levels, depending on the type of task). The control group did not undergo the treatment. After completion of the two-week cognitive stimulation, both groups were tested again in order to see whether the performance on neuropsychological tests changed after the period of stimulation. The effect of cognitive stimulation was studied indirectly, i.e. through the performance on neuropsychological tests. The repeated testing in control group had the aim to determine the possible effect of learning the test. Considering that subjects had an opportunity to see how the tests looked like at the pretest, a somewhat better performance at the posttest after two weeks was expected. Therefore, a statistically significant improvement in performance in both groups could not be ascribed to the effect of cognitive stimulation, but to learning the test. Conversely, an improvement in the experimental group only would likely be a result of cognitive stimulation.

Statistical analysis

This research is conceptualized according to the classical experimental design with one experimental and one control group. The main issue in this research design is the internal validity that emerges from the interaction between the selection of respondents and testing, lack of homogeneity across the groups, and that individual differences can cause further assignment bias. This design is based on the comparison of experimental and no-treatment group in differences between pretest and posttest in neuropsychological status in order to assess the effect of the treatment. The nonparametric test was used at posttest because of the small (sub)sample size. Differences between the experimental and control group in the studied neuropsychological variables were analyzed using the nonparametric Mann-Whitney test, and considering the small sample size, the exact level of significance was used. Differences in performance on the pretest and posttest measurements were analyzed using the nonparametric Wilcoxon signed-rank test for each group with the exact level of significance determined by the sample size, and additionally Cliff's delta effect size was calculated.

Results

Differences in performance on the two measurements for each group were analyzed using the nonparametric Wilcoxon signed-rank test with the exact level of significance determined by the sample size, and additionally Cliff's delta effect size was calculated (Table 2).

A statistically significant difference in performance between the two measurements was found for the variable RAVLT (A1-A5) in both study groups (Z_{EG}=-2.201, p=0.031, d=-0.722; Z_{CG}=-2.207, p=0.031, d=-0.972). The effect of this difference was classified as large. Analysis of the median for the variable RAVLT (A1-A5) showed that both groups had statistically significantly higher average values at posttest compared with pretest, and the improvement was comparable in both groups. Therefore, the improved performance may be ascribed primarily to the effect of learning the test and not to cognitive stimulation.

Similarly, a statistically significant difference in performance between the two measurements was found for the variable ROCF (45 minutes) in both study groups (Z_{EG}=-2.201, p=0.031, d=-0.889; Z_{CG}=-2.201, p=0.031, d=-0.778). The effect of this difference was classified as large. Analysis of the median for the variable ROCF (45 minutes) showed that both groups had statistically significantly higher values at posttest compared with pretest. However, the experimental group had higher posttest scores; therefore, the im-

Table 2. Wilcoxon test of differences between pretest and posttest results in both groups

	Experimental group			Control group		
	Z	Exact Sig (2-tailed)	Cliff's delta	Z	Exact Sig. (2-tailed)	Cliff's delta
TMT A	-0.736	0.531	0.194	-0.944	0.438	0.167
TMT B	-1.997	0.063	0.389	-0.631	0.625	0.111
RAVLT (A1 to A5)	-2.201	0.031*	-0.722	-2.207	0.031*	-0.972
RAVLT (A6)	-1.089	0.500	-0.222	-1.473	0.250	-0.528
RAVLT (A7)	-1.857	0.125	-0.667	-0.707	0.750	-0.111
RAVLT (B list)	0.000	1.000	--	-0.406	0.750	-0.055
RAVLT (A list)	-1.732	0.250	0.361	-1.414	0.500	0.194
RAVLT (B list)	-2.271	0.031*	-0.555	-0.105	1.000	0.111
ROCF copy	-0.962	0.500	-0.222	-0.948	0.375	0.222
ROCF 3 min	-2.201	0.031*	-0.75	-2.014	0.063	-0.722
ROCF 45 min	-2.201	0.031*	-0.889	-2.201	0.031*	-0.778
Atten./Conc. Index	-1.997	0.063	-0.361	-0.105	1.000	-0.111
Digit span (forward)	-1.633	0.250	-0.361	0.000	1.000	--
Digit span (backward)	-0.322	0.906	-0.111	-1.000	0.625	-0.167
Spatial span (forward)	-1.518	0.250	-0.306	-1.633	0.250	0.667
Spatial span (backward)	-0.707	0.750	-0.222	-1.414	0.500	0.333
WCST (categories)	0.000	1.000	--	0.000	1.000	--

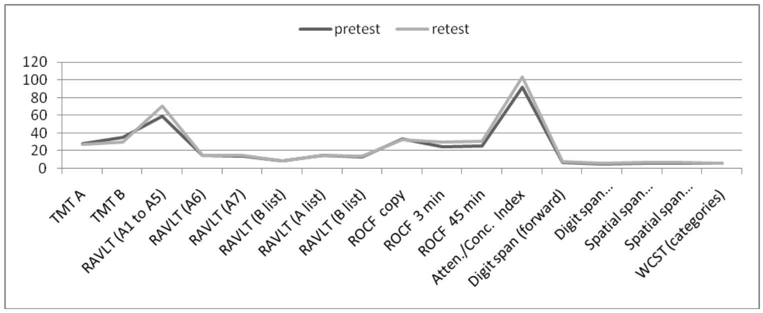

Fig. 3. Medians of neuropsychological tests in the experimental group at pretest and retest.

proved performance on this variable may be attributed to cognitive stimulation and not to the effect of learning the test.

A significant difference in performance between the two measurements for the variable ROCF (3 minutes) was found in the experimental group only (Z_{EG}=-2.201, p=0.031, d=-0.750). The effect of this difference was large. Analysis of the median for the variable ROCF (3 minutes) showed that the experimental group had higher scores at posttest. The improved performance on this variable may therefore be ascribed to the effect of cognitive stimulation and not of learning the test.

A significant difference in the experimental group only was found for the variable RAVLT (list B – recognition) (Z_{EG}=-2.271, p=0.031, d=-0.550, Me_{EG}=13, Me_{CG}=12.5). The effect of this difference was large. Analysis of the median for the variable RAVLT (list B – recognition) at pretest and posttest in both groups showed better results of the experimental group at posttest. Therefore, the improved performance on this variable may be attributed to cognitive stimulation and not to the effect of learning the test. Further interpretation of data included analysis of medians and corresponding confidence intervals (Fig. 2).

In the experimental group, there was an improved performance on the variables ROCF (copy), Digit Span (backward), Spatial Span (forward) and Spatial Span (backward). On the contrary, control group had poorer performance on these variables compared with the pretest. Both groups had better posttest performance on the variables Attention/Concentration Index, ROCF (45 min), and RAVLT (A7) as compared with pretest, and the improvement was higher in the experimental group. Both groups had poorer posttest performance on RAVLT (list A recognition), TMT A and TMT B as compared with pretest; however, control group showed better performance on the variable TMT B compared with the experimental group. The RAVLT (A1-A5), RAVLT (A6) and RAVLT (B) variables showed improved posttest performance in both groups, although the improvement was higher in the control group (Fig. 3).

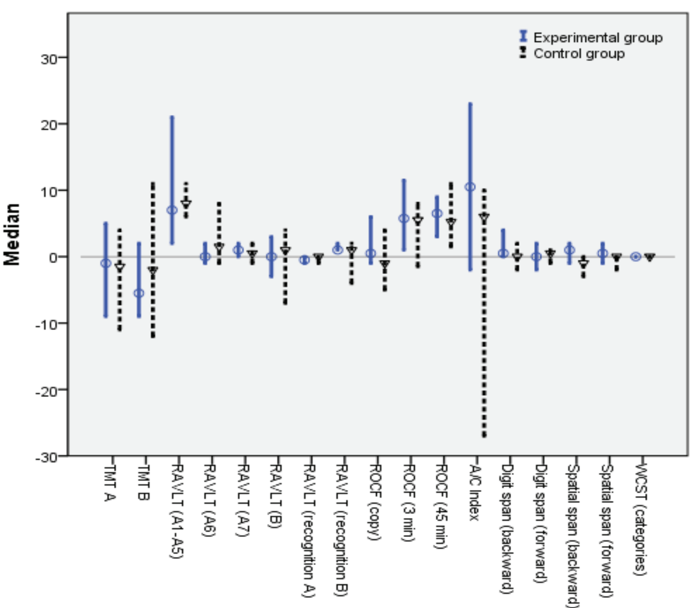

Fig. 2. Differences in medians (posttest-pretest) with 95% confidence interval for the studied neuropsychological variables in both groups.

Discussion

Cognitive stimulation with computer software available on the Internet has become very popular in recent years, both in clinical populations[35-37] and in healthy persons[36,38]. Therefore, research has started into real possibilities of this type of stimulation, and there is a question whether it is really effective or only a skilful propaganda aimed at commercial success[18]. We tried to answer the question whether the short-term effects of cognitive stimulation do exist and if yes, whether they manifest only in the stimulated cognitive functions, or they may reflect on the non-stimulated cognitive functions. In order to equate the two groups with regard to initial achievement before the cognitive stimulation treatment, we studied whether there were significant differences between the groups in performance on all neuropsychological variables. We found a statistically significant difference between the groups only on one variable (RAVLT – A6). This difference was taken into account in further interpretation of the results. Pretest comparison of the groups was performed in order to control the effects of cognitive stimulation and of learning the test, of which conclusions were made based on the difference between pretest and posttest results within each group. A statistically significant difference between pretest and posttest results in the experimental group was found for the RAVLT (recognition list B) and ROCF (3 min) variables, with better performance recorded at the posttest. This difference was not found in the control group. Further analyses showed a statistically significant difference between pretest and posttest results on RAVLT (A1-A5) and ROCF (45 min) in both groups, and the experimental group showed better posttest achievement on ROCF (45 min) compared with the control group. Therefore, the better performance on RAVLT (recognition list B), ROCF (3 min) and ROCF (45 min) may be ascribed to the effect of cognitive stimulation, and the improvement on RAVLT (A1-A5) may be attributed to the effect of learning.

Further qualitative analyses, i.e. insight into medians, showed that the experimental group had higher achievement between the two measurements on the variables ROCF copy, Digit Span (backward), Spatial Span (forward), Spatial Span (backward), Attention/Concentration Index and RAVLT (A7), compared with the control group. On these variables, there was no statistically significant difference between the two measurements in either group; however, qualitative analysis indicated that the experimental group showed better performance. We assume that in case of a larger sample, the observed difference would prove statistically significant. Both groups made progress on RAVLT (A1-A5), RAVLT (A6) and RAVLT (B), and the improvement was slightly higher in the control group, which we ascribed to the effect of learning the test. Surprisingly, both groups had poorer posttest performance on RAVLT (A list recognition), TMT A and TMT B, and the decline in performance was smaller in the control group compared with the experimental group.

On the basis of the data obtained, we determined that the two-week cognitive stimulation in healthy and young subjects improved their cognitive efficiency, particularly in the domain of visuospatial organization and visuoconstructive performance, visual and verbal range of attention, as well as in the domain of verbal memory, primarily delayed recall of verbal material. This finding was relatively expected, having in mind that the cognitive tasks we used involved mostly nonverbal components, i.e. they demanded primarily engagement of visual perception. We expected that the repetition of the tasks with visual perceptive stimuli through daily exercise would improve those cognitive functions that involve a common object of measurement (in this case verbal contents). This finding may be interpreted in the context of the hypothesis on the near transfer effect[24,38,39]. Similar to previous research, our results suggest that stimulation of cognitive functions depends on the type of stimuli used in the cognitive tasks[23,25].

Interestingly, cognitive stimulation in our study led to improved performance on some variables that involved verbal factor and referred primarily to verbal range of attention, immediate retention, and delayed recall of verbal material. This finding once again confirmed the hypothesis that there are no 'clear' cognitive functions, but rather each contains more or fewer different objects of measurement. In addition, this finding corroborates the hypothesis on the far transfer effect. Although most of the primarily verbal variables we used did not show a statistically significant difference between the measurements and within each group, the qualitative analysis of medians of these variables suggested a clear tendency for a progress in the experimental group. We would therefore recommend that future research should include a larger sample of subjects, under the assumption that in that case the difference would prove statistically significant. Our results are in agreement with a meta-study by Kelly *et al.* from 2014[40], who report improvement in performance on 19 out of 26 measures of memory in studies including two groups, an experimental group with cognitive training and a 'passive' control group. They also report that the transfer effect of the training was found in 5 out of 7 studies; in 4 studies, the transfer effect occurred in the tasks assessing the same cognitive function[15,41-43], and in one study the effect transferred to another cognitive function[42]. Our finding that both groups showed poorer posttest performance on three variables (TMT A, TMT B, RAVLT A recognition), with better performance in the control group, should be discussed as well. A possible explanation is that both groups, the experimental group in particular, lost motivation for training in the course of the demanding two-week stimulation. Considering that in two of the three variables performance is measured by reaction time, i.e. speed by which a task is correctly performed, we may assume that at the posttest the subjects were not motivated anymore to do the task as quickly as possible. The loss of motivation in the control group was explained by the subjects having to repeat the test after two weeks, without any benefit from it, which caused their loss of motivation. The results obtained indicate that two-week cognitive stimulation in young and healthy subjects may contribute to better cognitive efficiency of certain cognitive functions and point out the issues that need to be addressed in future research. These include primarily provision of alternative test forms, since in this way the effects of stimulation and of learning the test could be separated more easily. Then, it should be noted that the neuropsychological tests applied are probably not sensitive enough to detect such a subtle progress in cognitive performance, and use of additional tests or creation of new, more sensitive ones should be considered. Moreover, these tests are used primarily to assess cognitive deficits, and not performance of healthy subjects. This was supported by the complete absence of variability on the WCST's Number of Categories. While a clear decline in performance on this category would be expected in a population with cognitive dysfunction, most of our subjects had maximum scores. In addition, the effect of cognitive stimulation in our study was observed as a transverse cross-section, whereas future research should include a longitudinal follow up of the effects of cognitive stimulation.

The significance of this study lies in the finding that the spectrum of research in cognitive stimulation should not be limited to a population with cognitive dysfunction, but include young and healthy subjects as well. In addition, our results suggest that the availability of Internet softwares for cognitive stimulation should be exploited, as they are one of the possible ways of stimulating cognitive functions. Their importance should not be denied and attempts should be made to adequately select tasks in order to design an individualized program for each subject and create an individualized approach to research in this field. Our results are comparable with the results of previous similar studies[15,25,41-44]. Other studies also confirmed the hypothesis on the efficacy of cognitive training, especially in the domains of working memory and visual and verbal memory, where improvement of cognitive efficiency contributes significantly to better work efficiency, through better cognitive performance in a young and healthy population.

Conclusion

Cognitive stimulation in the young and healthy population may produce short-term improvements in cognitive performance, primarily in the stimulated cognitive domains and contribute to the transfer of the effect of stimulation to other related cognitive functions. In our study, stimulated functions were visual organization, visual and verbal range of attention, and their close but untrained functions, visual and verbal memory. It is recommended that future research should investigate duration of the recorded effects of stimulation, and such a research would need a larger sample size and inclusion of an 'active' control group in the study design, application of more sensitive measures for assessment of cognitive performance (test-retest), and inclusion of an additional subjective assessment of self-efficiency.

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Sažetak

UNAPREĐENJE KOGNITIVNOG POSTIGNUĆA PUTEM KOGNITIVNOG TRENINGA KOD ZDRAVIH ISPITANIKA

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Cilj istraživanja je bio ispitati može li primjena stimulacije kognitivnih funkcija među zdravim mladim ispitanicima dovesti do porasta kognitivne učinkovitosti. U istraživanju je sudjelovalo 12 ispitanika podijeljenih u dvije skupine, eksperimentalnu i kontrolnu. Prije primjene tretmana kognitivne stimulacije obje skupine su u okviru početnog mjerenja ispitane odabranim neuropsihološkim testovima. Skupine su bile ujednačene po postignuću na početnom mjerenju. Nakon toga je eksperimentalna skupina bila podvrgnuta tretmanu kognitivne stimulacije, što je podrazumijevalo svakodnevnu primjenu računalne verzije različitih kognitivnih zadataka u trajanju od jednog sata na dan tijekom dva tjedna. Kontrolna skupina nije bila podvrgnuta tretmanu. Nakon tretmana izvršeno je konačno mjerenje u obje skupine, koje je podrazumijevalo ponovnu primjenu neuropsihološke baterije, iste kao i na početku tretmana. Cilj ponovnog mjerenja u kontrolnoj skupini je bio utvrditi učinak učenja testa između dva mjerenja. Eksperimentalna skupina je zabilježila statistički značajnu razliku između mjerenja na varijablama za procjenu neposrednog upamćivanja vizualnog materijala i prisjećanja verbalnog materijala. Kvalitativnom analizom je ustanovljeno da eksperimentalna skupina ima bolje postignuće i na testovima odloženog prisjećanja vizualnog i verbalnog materijala, kao i vizualnog i verbalnog opsega pažnje. Spoznajna stimulacija u dvotjednom razdoblju u skupini zdravih ispitanika doprinosi poboljšanju kognitivnog postignuća izraženog kroz prosječne vrijednosti na određenim neuropsihološkim varijablama.

Ključne riječi: *Kognitivno postignuće; Kognitivna stimulacija; Neuropsihološki testovi; Mlada odrasla osoba; Ishod kognitivnog treninga*