UDC 159.9.015 **doi**: 10.21702/rpj.2020.1.1 ***Systematic review***

Towards a Choice of Correctional Computer Programs for Cognitive Rehabilitation of Cardiac Patients

Anton V. Solodukhin[1,2*], Mikhail S. Yanitskii[2], Andrei V. Seryi[2]
[1] Research Institute for Complex Issues of Cardiovascular Diseases, Kemerovo, Russian Federation
[2] Kemerovo State University, Kemerovo, Russian Federation
[*] Corresponding author. E-mail: mein11@mail.ru
ORCID ID: http://orcid.org/0000-0001-8046-5470, http://orcid.org/0000-0003-3049-8594, http://orcid.org/0000-0002-9318-4333

Abstract
Introduction. The present review aims to examine computer programs used in psycho-correctional practice for cognitive rehabilitation of cardiac patients. Currently, there is a high prevalence of cognitive disorders among the elderly population in Russia. The disease has an impact on cognitive functioning of cardiac patients, which leads to difficulties in social adjustment and reduces their quality of life. In this regard, assessing the performance of existing computer programs for cognitive rehabilitation of cardiac patients is important.
Theoretical Basis. This paper presents an overview of the main criteria for choosing cognitive rehabilitation programs for patients suffering from cardiac diseases, as well as characteristics of cognitive rehabilitation. The analysis of previous studies enabled the authors to develop a number of recommendations and restrictions for using cognitive rehabilitation programs.
Results and Discussion. The authors (a) provide a description of the structure of cognitive impairment in cardiac patients, (b) describe specific patterns of cognitive impairment in cardiac patients, and (c) concentrate on impairments of frontal lobe functions, including goal choice, concentration, and attention switching. The following platforms are currently used for cognitive rehabilitation: Constant Therapy, Cognifit, Brain +, My Aphasia Coach, Lingraphica, Prologue2go, Tactus therapy, Soch Genie, Lumosity, Neuro Nation, Memorado, Wikium, Brain Apps, and B-trainika. When choosing a correctional computer program, it is important to take into account the presence of a flexible system of settings and modular architecture, as well as the possibility of changing the complexity of tasks in accordance with the degree of cognitive impairment in patients.
Conclusion. This paper may be of interest to physicians, medical psychologists, defectologists, and programmers when choosing or developing the programs for cognitive rehabilitation of cardiac patients.

Keywords
cognitive functions, cognitive rehabilitation, cognitive dysfunction, methodological principles, mobile applications, computer systems, technology platforms, programming, computer programs, cardiac diseases

Russian Psychological Journal, 2020, Vol. 17, No. 1, 5–14. **doi**: 10.21702/rpj.2020.1.1

Highlights

- When choosing a program for cognitive rehabilitation, it is important to take into account the presence of a flexible system of settings.
- When choosing a program for cognitive rehabilitation, it is important to take into account the degree of cognitive impairment.
- It is recommended to pay attention to the presence of a flexible modular architecture in correctional computer programs.

For citation
Solodukhin, A. V., Yanitskii, M. S., & Seryi, A. V. (2020). Towards a choice of correctional computer programs for cognitive rehabilitation in cardiac patients. *Rossiiskii psikhologicheskii zhurnal (Russian Psychological Journal)*, *17*(1), 5–14. doi: 10.21702/rpj.2020.1.1

Received: November 20, 2019
Revision received: January 29, 2020
Accepted: February 1, 2020

Introduction

Currently, diseases of the cardiovascular system prevail in the structure of general disease incidence and disability of the population (Makarov, Maksimov, Shapovalova, Stryapchev, & Artamonova, 2019). Medical assistance for cardiac patients has improved significantly, which has affected the increase in life expectancy. However, old age is associated with a number of changes occurring in the human body, including an increase in cognitive deficit. The all-Russian program for the study of epidemiology of cognitive disorders in the elderly ('Prometheus') accompanied by examination with the use of the Mini-Mental State Examination (MMSE) scale and the Clock Drawing Test (CDT) covered 3210 patients (mean age, 69.5 ± 5.5 years). The findings indicate that 2677 (83.4 %) individual participants had memory complaints. Neuropsychological examination confirmed cognitive disorders in 2190 individual participants (68.2 %). The findings from the study carried out with the use of the Mini-Mental State Examination (MMSE) scale indicated that 810 individual participants (25.2 %) had a pronounced cognitive decline (Starchina, 2017). This speaks in favour of a high prevalence of cognitive impairment in the elderly Russian population.

Diagnostics and correction of cognitive disorders in cardiac patients is important, because these mental disorders may lead to difficulties in basic processes of life and social adjustment. The question arises, what are the methods that can be used for correction of cognitive impairment? Currently, there are no clear criteria for the choice and application of cognitive rehabilitation programs, which makes it difficult to find the most effective computer training among many alternatives. Thus, it seems important to analyze and evaluate the existing computer programs for cognitive rehabilitation for cardiac patients.

Theoretical Basis

Cognitive functions are the functions in the brain that provide rational cognition of the world, including: attention, perception, gnosis, memory, praxis, as well as thinking, intelligence, and speech, as more complex cognitive processes (Lokshina, 2015). Cognitive dysfunction manifests

itself as a decrease in the processes of obtaining, processing, and analyzing information in result of pathology in the cerebral hemispheres (Yakhno, Zakharov, & Lokshina, 2005). There is a potential for spontaneous cognitive rehabilitation, for example, in functional cognitive disorders associated with cerebral vascular insufficiency, intoxication, depression, and other disorders. However, the use of cognitive rehabilitation programs that accelerate this process and help patients adapt to new living conditions is important for cognitive rehabilitation.

Previous studies report that when choosing computer programs with an intuitive interface for elderly individuals with cognitive impairment, it is necessary to take into account their decreased perception, impaired motor skills, and mental processes (Lu & Yueh, 2015; Lu, Lin, & Yueh 2017). For example, the decrease in perception requires thoughtful use of visual design, scenery or animated images (Shawn Green et al., 2019).

Other principles for choosing computer programs relate to the consideration of auditory feedback, tactile feedback, and the presence of memory prompts (Binder et al., 2015; Harada, Sato, Takagi, & Asakawa, 2013; Sauve, Renaud, Kaufman, & Duplaa, 2015; Werner, Werner, & Oberzaucher, 2012). The presented works suggest the following five basic principles that should be considered when choosing and applying programs for cognitive education of elderly patients with cognitive impairment: (1) provide clear, multi-sensory instructions and appropriate interaction with them; (2) when compiling tasks, use the content and topics that are familiar to users from everyday life; (3) apply several different tasks corresponding to the training of various cognitive abilities; these tasks should be easy to perform and have various modes of operation; (4) give the opportunity to provide feedback on the results of training; and (5) involve users and persons concerned to evaluate the design.

In order to improve the quality of patient trainings, the following parameters should be taken into account when choosing a correction program (de Melo-Neto, Stroppa-Marques, & de Campos Gomes, 2016): (a) *Difficulty levels*. The tasks should be organized according to three levels of difficulty (easy, medium, and difficult). (b) *Interruption criteria*. It is recommended for to create interruption criteria at each of the three difficulty levels, which may provide a format of adaptation to patient performance. Adaptation is used to reduce the consequences of fatigue in patients and increase their motivation to participate in cognitive training. (c) *Number of attempts*. Most tasks should include elements classified as a 'second attempt' or 'second stimulation'. They should be preceded by a series of interventions (instructions/tips/cognitive strategies) aimed at improving the efficiency of completing tasks.

Previous studies evaluating the impact of cognitive training on cognitive recovery suggest that trainings mainly involve patients with mild to moderate cognitive impairment (Al-Thaqib et al., 2018; Gates et al., 2019; Orgeta et al., 2015). In rare instances, cognitive training programs involve patients with mild dementia (Küster et al., 2016; ten Brinke, Davis, Barha, & Liu-Ambrose, 2017). The duration of the training session should be from 20 minutes to 2.5 hours depending on a patient's age, the degree of cognitive impairment, and the presence of concomitant diseases. The duration of the course is from 2 weeks to 2 months, 2–5 lessons per week (Bahar-Fuchs et al., 2017; Barbera, et al., 2018; Bott et al., 2018; Heffernan, et al., 2019; Küster et al., 2016; Motter, Grinberg, Lieberman, Iqnaibi, & Sneed, 2019; Naismith, Redoblado-Hodge, Lewis, Scott, & Hickie, 2010; ten Brinke, Best, Crockett, & Liu-Ambrose, 2018; Walton et al., 2019). Cognitive training can be carried out both in the form of independent work, and in combination with physical exercises (Lipardo & Tsang, 2018; Sobol et al., 2018; Yu et al., 2018). The findings of studies suggest

Russian Psychological Journal, 2020, Vol. 17, No. 1, 5–14. **doi**: 10.21702/rpj.2020.1.1

significant improvements in cognitive functions in patients with mild cognitive impairment and a slight dynamics of cognitive recovery in groups of patients with moderate cognitive impairment (Bahar-Fuchs, Martyr, Goh, Sabates, & Clare, 2019; Ge, Zhu, Wu, & McConnell, 2018; Kudlicka, Martyr, Bahar-Fuchs, Woods, & Clare, 2019; Peretz et al., 2011; Turunen et al., 2019; Zhang et al., 2019a, 2019b). Cognitive recovery was insufficient for mild dementia patients. However, cognitive training had a positive effect on their psycho-emotional state. Thus, at the moment there is a significant amount of research that has proven the efficiency of such trainings for cognitive rehabilitation, which indicates that evaluating the available programs for cognitive rehabilitation is very important.

Results and Discussion

Frontal lobe disorders are principal disorders among vascular cognitive disorders caused by cardiological diseases (Vakhnina, 2014).

Operating (executive, regulatory) functions include the following three parameters: (a) *Goal choice* as the ability to voluntarily choose and set a goal for the activity. Impairment of this ability leads to the decrease in the activity of mental processes and the level of motivation, as well as to emotional indifference. (b) *Concentration* as the ability to perform behavior and cognitive activity in accordance with the goal. Moreover, concentration implies the ability to inhibit motivations that are less important in a current situation. If this function is impaired, a patient's behavior becomes impulsive, he/she is often distracted from the activity plan, and the degree of criticism of is reduced. (c) *Attention switching* as the ability to change the paradigm of activity under changed conditions, to move from an already achieved goal to a new one. Impairments of this function lead to inertia and perseverations in ongoing activities.

Cognitive disorders that occur in cardiovascular diseases are accompanied by one or more of the above stated parameters. The studies indicate that these disorders are observed in patients with arterial hypertension, discirculatory encephalopathy, and coronary heart disease after coronary artery bypass grafting (Vakhnina, 2014; Petrova, Prokopenko, Eremina, Mozheiko, & Kaskaeva, 2015). Thus, according to the results of a survey of 122 patients with coronary artery disease aged from 37 to 70 years, carried out in the Federal Center for Cardiovascular Surgery, Krasnoyarsk, indicated that the average score by the frontal dysfunction scale (FAB) after coronary bypass grafting was 15.2 ± 1.17 ($p < 0.001$). After 6 months, the average score increased to 15.8 ± 0.09 ($p < 0.001$). However, patients did not achieved normal scores of 16.2 ± 1.33 ($p = 0.001$), which were before surgery (Petrova et al., 2015). The results of the studies indicate the need for rehabilitation of impaired executive functions in cardiac patients.

Large-scale studies aimed at evaluating the programs for cognitive rehabilitation of cardiac patients using computer technology in Russia have not yet been conducted. Currently, there is evidence for the effectiveness of both independent cognitive trainings and their combination with the use of microcirculatory and nootropic drugs (Shapovalova, 2002; Zakharycheva, Moroz, & Drozdova, 2006). The question arises, how should we choose the most effective computer-based cognitive training for cognitive rehabilitation of cardiac patients?

The following platforms used for cognitive rehabilitation are available to Russian users: Constant Therapy, Cognifit, Brain+, My Aphasia Coach, Lingraphica, Prologue2go, Tactus therapy, and Soch Genie. These programs are available for download and can be used for the recovery of both mild to moderate cognitive impairment (Cognifit, Brain +, and SochGenie) and severe post-stroke

disorders, including aphasia and apraxia (Constant Therapy, My Aphasia Coach, Lingraphica, Prologue2go, and Tactus therapy).

The following platforms are used for training cognitive functions: Lumosity, Neuro Nation, Memorado (Memorado: memory training), Wikium, Brain Apps, and B-trainika. These applications can be used individually and require only registration. This makes them accessible to all categories of the population, regardless of social status.

We studied the results of the use of these programs in the rehabilitation process to choose the most useful for the correction of cognitive disorders in cardiac patients.

The Proloque2Go program is intended for the rehabilitation of severe post-stroke disorders, as well as for the development of language skills. The application is used by individuals with autism, Down syndrome, cerebral palsy, Angelman syndrome and other patients with severe speech disorders. This program is recommended for the recovery of cognitive functions and speech impairment in children (Tvardovskaya & Efremov, 2018).

The Tactus therapy program is used for speech rehabilitation, including reading skills and speech perception. It is recommended for corrective work with adolescents and adults suffering from speech disorders. There is no Russian version of this program, which makes it difficult for using by Russian users (Shamardina, 2018).

The Lumosity application is a widely-distributed program for training cognitive functions. Developers note the high efficiency of this game application when training memory, attention, speed, and accuracy of decision-making. However, the study, which involved 128 individuals aged 18 to 35 years, showed the absence of statistically significant differences between the results with the Lumosity application and common computer games (Kable et al., 2017). On the one hand, the results from this study confirm the improvement of cognitive functions after trainings. However, the effect for the presented program is not unique.

The Wikium online platform is another available simulator, based on the techniques of neuropsychologists. Currently, Wikium is recommended both for the recovery of mild cognitive disorders, as well as severe ones caused by cerebral infarction (Zlobina, Epaneshnikova, & Zinov'eva, 2018). A similar online platform B-trainika is also used to train cognitive functions. Moreover, this program can be recommended to improve the cognitive activity of students (Usamov, Shabazova, & Namaeva, 2019).

The CogniFit program stimulates and enhances cognitive functions using memory training games, various puzzles, logical, educational, and training tasks. The application uses psychometric tests in order to assess the level of cognitive impairment and provide an appropriate training program. Working with this application helps train memory, attention, concentration, executive functions, thinking, planning, coordination, and many other important cognitive functions. This program was developed on the basis of a number of studies examining the impact of psychocorrectional programs on the cognitive functions in the elderly (Shatil, Mikulecká, Bellotti, & Bureš, 2014; Gard, Hölzel, & Lazar, 2014; Shatil, 2013).

Thus, the Wikium and CogniFit programs are the most relevant applications for cardiac patients. These programs are available in Russia; they are intended for cognitive rehabilitation and training of various cognitive parameters and have a flexible settings system for a specific user.

The examination of corrective computer applications and the requirements for their use enabled authors to develop and take out a patent for the aPHASIA Program for the Neurorehabilitation of Individuals with Dynamic Aphasia after Stroke and Other Brain Injuries (Trubnikova, Seryi,

Yanitskii, Solodukhin, & Barbarash, 2018). The program consists of 6 blocks aimed at cognitive disinhibition in patients with dynamic aphasia and frontal lobe syndrome. Given the frequent impairment of operating functions in patients suffering from cardiac diseases, we can predict its effectiveness in the rehabilitation of severe cognitive disorders in patients with discirculatory encephalopathy and in those with coronary heart disease who have severe cognitive impairment after coronary artery bypass grafting. This program follows the above stated principles of the development and application of computer programs, which enables its effective use in neurorehabilitation practice.

Conclusion

When choosing corrective computer programs for cognitive rehabilitation of cardiac patients, the following conditions should be considered: (1) The presence of a flexible settings system, which makes it possible to adapt tasks for a specific user and characteristics of his/her cognitive impairment. (2) The choice of a cognitive training or a program should depend on the degree of cognitive impairment. (3) The presence of a flexible modular architecture that enables patients and physician to carry out rehabilitation work, both independently and jointly, while storing all the information on the server or in the database.

The conditions stated above provide us an opportunity for choosing the most optimal program for the diagnosis and correction of cognitive impairment in cardiac patients.

Acknowledgments

This work was financially supported by a grant from KemSU (project no. 476/08-02, February 26, 2019).

References

Al-Thaqib, A., Al-Sultan, F., Al-Zahrani, A., Al-Kahtani, F., Al-Regaiey, K., Iqbal, M., & Bashir, S. (2018). Brain training games enhance cognitive function in healthy subjects. *Medical Science Monitor Basic Research*, 24, 63–69. doi: 10.12659/MSMBR.909022

Bahar-Fuchs, A., Martyr, A., Goh, A. M. Y., Sabates, J., & Clare, L. (2019). Cognitive training for people with mild to moderate dementia. *Cochrane Database of Systematic Reviews*. doi: 10.1002/14651858.CD013069.pub2

Bahar-Fuchs, A., Webb, S., Bartsch, L., Clare, L., Rebok, G., Cherbuin, N., & Anstey, K. J. (2017). Tailored and adaptive computerized cognitive training in older adults at risk for dementia: A randomized controlled trial. *Journal of Alzheimer's Disease*, *60*(3), 889–911. doi: 10.3233/JAD-170404

Barbera, M., Mangialasche, F., Jongstra, S., Guillemont, J., Ngandu, T., Beishuizen, C., … Kivipelto, M. (2018). Designing an internet-based multidomain intervention for the prevention of cardiovascular disease and cognitive impairment in older adults: The HATICE trial. *Journal of Alzheimer's Disease*, *62*(2), 649–663. doi: 10.3233/JAD-170858

Binder, J. C., Zöllig, J., Eschen, A., Mérillat, S., Röcke, C., Schoch, S. F., … Martin, M. (2015). Multidomain training in healthy old age: Hotel Plastisse as an iPad-based serious game to systematically compare multi-domain and single-domain training. *Frontiers in Aging Neuroscience*, 7, 137. doi: 10.3389/fnagi.2015.00137

Bott, N., Kumar, S., Krebs, C., Glenn, J. M., Madero, E. N., & Juusola, J. L. (2018). A remote intervention to prevent or delay cognitive impairment in older adults: Design, recruitment, and baseline

characteristics of the virtual cognitive health (VC Health) study. *JMIR Research Protocols*, *7*(8), e11368. doi: 10.2196/11368

de Melo-Neto, J. S., Stroppa-Marques, A. E. Z., & de Campos Gomes, F. (2016). Profile of pneumopathic elderly persons admitted to a pulmonary rehabilitation center. *Revista Brasileira de Geriatria e Gerontologia*, *19*(5). doi: 10.1590/1809-98232016019.150143

Gard, T., Hölzel, B. K., & Lazar, S. W. (2014). The potential effects of meditation on age-related cognitive decline: A systematic review. *Annals of the New York Academy of Sciences. Advances in Meditation Research: Neuroscience and Clinical Applications*, *1307*(1), 89–103. doi: 10.1111/nyas.12348

Gates, N. J., Vernooij, R. W. M., Di Nisio, M., Karim, S., March, E., Martínez, G., & Rutjes, A. W. S. (2019). Computerised cognitive training for preventing dementia in people with mild cognitive impairment. *Cochrane Database of Systematic Reviews*, 3, CD012279. doi: 10.1002/14651858.CD012279.pub2

Ge, S., Zhu, Z., Wu, B., & McConnell, E. S. (2018). Technology-based cognitive training and rehabilitation interventions for individuals with mild cognitive impairment: A systematic review. *BMC Geriatrics*, 18, 213. doi: 10.1186/s12877-018-0893-1

Harada, S., Sato, D., Takagi, H., & Asakawa, C. (2013). Characteristics of elderly user behavior on mobile multi-touch devices. In P. Kotzé, G. Marsden, G. Lindgaard, J. Wesson, M. Winckler (Eds.), *Human-Computer Interaction – INTERACT 2013. Lecture Notes in Computer Science* (Vol. 8120, pp. 323–341). Berlin, Heidelberg: Springer. doi: 10.1007/978-3-642-40498-6_25

Heffernan, M., Andrews, G., Fiatarone Singh, M. A., Valenzuela, M., Anstey, K. J., Maeder, A. J., … Brodaty, H. (2019). Maintain your brain: Protocol of a 3-year randomized controlled trial of a personalized multi-modal digital health intervention to prevent cognitive decline among community dwelling 55 to 77 year olds. *Journal of Alzheimer's Disease*, *70*(s1), S221–S237. doi: 10.3233/JAD-180572

Kable, J. W., Caulfield, M. K., Falcone, M., McConnell, M., Bernardo, L., Parthasarathi, T., … Lerman, C. (2017). No effect of commercial cognitive training on brain activity, choice behavior or cognitive performance. *Journal of Neuroscience*, *37*(31), 7390–7402. doi: 10.1523/JNEUROSCI.2832-16.2017

Kudlicka, A., Martyr, A., Bahar-Fuchs, A., Woods, B., & Clare, L. (2019). Cognitive rehabilitation for people with mild to moderate dementia. *Cochrane Database of Systematic Reviews*, 8, CD013388. doi: 10.1002/14651858.CD013388

Küster, O. C., Fissler, P., Laptinskaya, D., Thurm, F., Scharpf, A., Woll, A., … Kolassa, I.-T. (2016). Cognitive change is more positively associated with an active lifestyle than with training interventions in older adults at risk of dementia: A controlled interventional clinical trial. *BMC Psychiatry*, 16, 315. doi: 10.1186/s12888-016-1018-z

Lipardo, D. S., & Tsang, W. W. N. (2018). Falls prevention through physical and cognitive training (falls PACT) in older adults with mild cognitive impairment: A randomized controlled trial protocol. *BMC Geriatrics*, 18, 193. doi: 10.1186/s12877-018-0868-2

Lokshina, A. B. (2015). Modern ideas about non-dementia-related cognitive disorders. *Effektivnaya farmakoterapiya (Effective Pharmacotherapy)*, 1, 36–44. (in Russ.).

Lu, M.-H., & Yueh, H.-P. (2015). An usability study of the automatic ticket vending machines for the middle-aged and elderly patrons: The case of the Taipei mass rapid transit system. *Journal of Library and Information Studies*, 13, 67–97. doi: 10.6182/jlis.2015.13(2).067

Lu, M.-H., Lin, W., & Yueh, H.-P. (2017). Development and evaluation of a cognitive training game for older people: A design-based approach. *Frontiers in Psychology*, 8, 1837. doi: 10.3389/fpsyg.2017.01837

Makarov, S. A., Maksimov, S. A., Shapovalova, E. B., Stryapchev, D. V., & Artamonova, G. V. (2019). Mortality from diseases of the circulatory system in the Kemerovo region and the Russian Federation in 2000–2016. *Kompleksnye problemy serdechno-sosudistykh zabolevanii (Complex Issues of Cardiovascular Diseases)*, *8*(2), 6–11. doi: 10.17802/2306-1278-2019-8-2-6-11 (in Russ.).

Motter, J. N., Grinberg, A., Lieberman, D. H., Iqnaibi, W. B., & Sneed, J. R. (2019). Computerized cognitive training in young adults with depressive symptoms: Effects on mood, cognition, and everyday functioning. *Journal of Affective Disorders*, 245, 28–37. doi: 10.1016/j.jad.2018.10.109

Naismith, S. L., Redoblado-Hodge, M. A., Lewis, S. J. G, Scott, E. M., & Hickie, I. B. (2010). Cognitive training in affective disorders improves memory: A preliminary study using the NEAR approach. *Journal of Affective Disorders*, *121*(3), 258–262. doi: 10.1016/j.jad.2009.06.028

Orgeta, V., McDonald, K. R., Poliakoff, E., Hindle, J. V., Clare, L., & Leroi, I. (2015). Cognitive training interventions for dementia and mild cognitive impairment in Parkinson's Disease. *Cohrane Database of Systematic Reviews*, 11, CD011961. doi: 10.1002/14651858.CD011961

Peretz, C., Korczyn, A. D., Shatil, E., Aharonson, V., Birnboim, S., & Giladi, N. (2011). Computer-based, personalized cognitive training versus classical computer games: A randomized double-blind prospective trial of cognitive stimulation. *Neuroepidemiology*, *36*(2), 91–99.

Petrova, M. M., Prokopenko, S. V., Eremina, O. V., Mozheiko, E. Yu., & Kaskaeva, D. S. (2015). Long-term results of cognitive impairment after coronary bypass surgery. *Fundamental'nye issledovaniya (Basic Research)*, 1–4, 814–820. (in Russ.).

Sauve, L., Renaud, L., Kaufman, D., & Duplaa, E. (2015). Ergonomic criteria for creating online educational games for seniors. In O. Sourina, D. Wortley, S. Kim (Eds.), *Subconscious learning via games and social media* (pp. 115–134). Springer, Singapore.

Shamardina, A. P. (2018). Using applications for iOS/Android devices in speech therapy with adolescents and adults with speech disorders. *Akademik (Academician)*, 3. Retrieved from http://academic-journal.ru/ru/3-2018_Shamardina (in Russ.).

Shapovalova, S. A. (2002). *Effectiveness of correction of cognitive disorders in the rehabilitation of patients with dyscirculatory encephalopathy in the elderly* (Doctoral dissertation). Nizhny Novgorod State Medical Academy, Nizhny Novgorod. (in Russ.).

Shatil, E. (2013). Does combined cognitive training and physical activity training enhance cognitive abilities more than either alone? A four-condition randomized controlled trial among healthy older adults. *Frontiers in Aging Neuroscience*, 5, 8. doi: 10.3389/fnagi.2013.00008

Shatil, E., Mikulecká, J., Bellotti, F., & Bureš, V. (2014). Novel television-based cognitive training improves working memory and executive function. *PLOS One*. doi: 10.1371/journal.pone.0101472

Shawn Green, C., Bavelier, D., Kramer, A. F., Vinogradov, S., Ansorge, U., Ball, K. K., … Witt, C. M. (2019). Improving methodological standards in behavioral interventions for cognitive enhancement. *Journal of Cognitive Enhancement*, 3, 2–29. doi: 10.1007/s41465-018-0115-y

Sobol, N. A., Dall, C. H., Høgh, P., Hoffmann, K., Frederiksen, K. S., Vogel, A., … Beyer, N. (2018). Change in fitness and the relation to change in cognition and neuropsychiatric symptoms after aerobic exercise in patients with mild Alzheimer's disease. *Journal of Alzheimer's Disease*, *65*(1), 137–145. doi: 10.3233/JAD-180253

Starchina, Yu. A. (2017). *Non-dementia-related cognitive impairment: A modern view. Nevrologiya, neiropsikhiatriya, psikhosomatika (Neurology, Neuropsychiatry, Psychosomatics)*, *9*(2), 71–76. doi: 10.14412/2074-2711-2017-2-71-76 (in Russ.).

ten Brinke, L. F., Best, J. R., Crockett, R. A., & Liu-Ambrose, T. (2018). The effects of an 8-week computerized cognitive training program in older adults: A study protocol for a randomized controlled trial. *BMC Geriatrics*, 18, 31. doi: 10.1186/s12877-018-0730-6

ten Brinke, L. F., Davis, J. C., Barha, C. K., & Liu-Ambrose, T. (2017). Effects of computerized cognitive training on neuroimaging outcomes in older adults: A systematic review. *BMC Geriatrics*, 17, 139. doi: 10.1186/s12877-017-0529-x

Trubnikova, O. A., Seryi, A. V., Yanitskii, M. S., Solodukhin, A. V., & Barbarash, O. L. (2018). *APHASIA program for neurorehabilitation of individuals with dynamic aphasia after stroke and other brain injuries*. Certificate of registration of the computer program RU 2018614893. (in Russ.).

Turunen, M., Hokkanen, L., Bäckman, L., Stigsdotter-Neely, A., Hänninen, T., Paajanen, T., … Ngandu, T. (2019). Computer-based cognitive training for older adults: Determinants of adherence. *PLOS One*, *14*(7), e0219541. doi: 10.1371/journal.pone.0219541

Tvardovskaya, A. A., & Efremov, A. A. (2018). Mobile applications as a means of development the speech activity of the preschoolers' with complex impairments. *Izvestiya Dagestanskogo gosudarstvennogo pedagogicheskogo universiteta. Seriya "Psikhologo-pedagogicheskie nauki" (Dagestan State Pedagogical University. Journal. Psychological and Pedagogical Sciences)*, *12*(3), 35–39. doi: 10.31161/1995-0659-2018-12-3-35-39 (in Russ.).

Usamov, I. R., Shabazova, Z. M., & Namaeva, M. M. (2019). Using modern electronic educational resources to improve cognitive activity in students: Problems and prospects. *Kontsept: nauchno-metodicheskii elektronnyi zhurnal (Concept: Scientific and Methodical Electronic Journal)*, 4, 1–11. doi: 10.24411/2304-120X-2019-11025 (in Russ.).

Vakhnina, N. V. (2014). Cognitive disorders and their treatment in patients with arterial hypertension. *Meditsinskii sovet (Medical Council)*, 5, 30–37. (in Russ.).

Walton, C. C., Lampit, A., Boulamatsis, C., Hallock, H., Barr, P., Ginige, J. A., … Valenzuela, M. (2019). Design and development of the brain training system for the digital "Maintain your brain" Dementia Prevention Trial. *JMIR Aging*, *2*(1), e13135. doi: 10.2196/13135

Werner, F., Werner, K., & Oberzaucher, J. (2012). Tablets for seniors – an evaluation of a current model (iPad). In R. Wichert, B. Eberhardt (Eds.), *Ambient Assisted Living. Advanced Technologies and Societal Change* (pp. 177–184). Berlin, Heidelberg: Springer.

Yakhno, N. N., Zakharov, V. V., & Lokshina, A. B. (2005). Syndrome of mild cognitive impairment in dyscirculatory encephalopathy. *Zhurnal nevrologii i psikhiatrii im. S. S. Korsakova (S. S. Korsakov Journal of Neurology and Psychiatry)*, *105*(2), 13–17. (in Russ.).

Yu, F., Lin, F. V., Salisbury, D. L., Shah, K. N., Chow, L., Vock, D., … Jack Jr., C. (2018). Efficacy and mechanisms of combined aerobic exercise and cognitive training in mild cognitive impairment: Study protocol of the ACT trial. *Trials*, 19, 700. doi: 10.1186/s13063-018-3054-0

Zakharycheva, T. A., Moroz, E. V., & Drozdova, I. P. (2006). *A method for treating cognitive disorders in individuals with cerebrovascular diseases*. Patent RU 2268723 C1. (in Russ.).

Zhang, H., Huntley, J., Bhome, R., Holmes, B., Cahill, J., Gould, R. L., … Howard, R. (2019). Effect of computerised cognitive training on cognitive outcomes in mild cognitive impairment: A systematic review and meta-analysis. *BMJ Open*, *9*(8). doi: 10.1136/bmjopen-2018-027062

Zhang, H., Wang, Z., Wang, J., Lyu, X., Wang, X., Liu, Y., … Yu, X. (2019). Computerized multi-domain

cognitive training reduces brain atrophy in patients with amnestic mild cognitive impairment. *Translational Psychiatry*, *9*(1), 48.

Zlobina, Yu. V., Epaneshnikova, N. V., & Zinov'eva, N. P. (2018). Effectiveness of cognitive training in patients with acute cerebral circulation disorders in the acute period: a pilot study. *Vestnik YuUrGU. Seriya "Psikhologiya" (Bulletin of the South Ural State University. Series: Psychology)*, *11*(3), 64–73. doi: 10.14529/psy180308 (in Russ.).

No conflict of interest