Cybernetic Enriched Environment for Cognitive Rehabilitation

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1 BACKGROUND

Cognitive impairments in older adults is an important medical and social issue. 83% of people over the age of 60 complain of memory decrease. Cognitive decline is observed in 69% of the elderly on neuropsychological examinations. Most common causes of cognitive impairments are neuro-degenerative diseases and vascular cognitive impairments. Vascular cognitive impairments are revealed in 10% of cases in individuals from 70 to 90 years old. Post stroke cognitive disorders are observed in 30-70% of patients and they decrease rehabilitation outcomes and disease prognosis. In one year, mild cognitive impairments progress to Alzheimer disease in 10-15% of patients.

Along with drug therapy, there is active search for effective methods of rehabilitation and prevention of cognitive disorders worldwide. Cognitive rehabilitation includes correction and compensation approaches.

The purpose of correction is remediation of damaged cognitive functions in patients. As a rule, correctional medical training is performed by a neuropsychologists. An alternative method can be computer cognitive training (Prokopenko, 2013). In both cases, training sessons are time-constraint and the main principle of neurorehabilition – continuity – is failed to abide.

The aim of all compensatory approaches is increasing patients' adaptation, independence and safety in daily-life and decreasing their caregivers' burden. There are a lot of compensatory strategies, e.g. using diaries, cue cards, smart phones, pager systems. Recentlu a lot of studies in the area of cognitive rehabilitation investigate systems that are based on the smart home technology. These systems are aimed to facilitate patients' daily life via simplifying their interaction with electric and other devices by these appliances' automation. For example, the light turns on and off automatically due to motion sensors, the fridge can order food from a shop, the timer reminds of the time to take medications in. By so doing, the smart home minimizes patient's responsibility for satisfaction of his or her needs and forces him or her to follow a more passive lifestyle.

On the flip side, it has been proved in experimental studies that enriched environment produces a wide spectrum of indifferent and unconditional stimuli. Modeling of enriched environment is studies with experimental animals for studying of effects of more massive sensory physical, social and cognitive stimulation in comparison with conventional environment. Experimental studies with animals have shown that multi-stimuli environment restores damaged neurogenesis, apoptosis and and synaptogenesis, protein expression of astroglial contacts, improves training and memorization, maintains effective social interaction including both cases of physiological ageing and animal models of Alzheimer disease. It corresponds with observations of people with higher cognitive reserve which resulted from their profession or personal habits. Therefore, enriched environment exerts positive influence on neuroplastic processes, saving and restoring dominant mechanisms of brain's function realization (Kuvacheva, 2015).

The main hypothesis for using enriched environment for neurorehabilitation is that different permanent stimuli can activate reserve capacity of brain and form new connections. Otherwise speaking, if a patient with cognitive impairments is accommodated in the setting, where he has to solve cognitive tasks, it might improve his or her cognitive state and/or prevent induction of cognitive deficit.

2 OBJECTIVES

Development of a new proprietary method for cognitive rehabilitation based on Cybernetic Enriched Environment and assessment of its efficiency.

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3 METHODS

The study was conducted in a Neurorehabilitation Centre. Patients were exposed to Cybernetic Enriched Environment for 30-40 minutes daily for 10 days.

3.1 Intervention Methods

At the present time an experimental model of the Cybernetic Enriched Environment has been developed. It is a chamber that imitates patient's living environment. There are different domestic appliances: a kettle a microwave oven, a hairdryer, a TV-set etc. in the chamber. All the appliances are linked to a personal computer through an electric relay. The patient has to perform a computer task to turn on any of these appliances. The patient cannot use the device until he or she solves the task correctly. Computer tasks are represented by proprietary neuropsychological computer programs. Each of them is aimed to train different cognitive domains: memory, attention, visual gnosis and other. This computer complex of neuropsychological programs had already shown effectiveness in cognitive impairment restoration in post stroke patients in acute and recovery periods. In Cybernetic Enriched Environment conditions, only a part of the whole program is presented to the patient when he or she is required to switch on a particular appliance. In that way, using different appliances, a patient has to solve different tasks. Levels of task complexity can be regulated individually.

3.2 Examination Methods

On admission, all patients were examined by a neurologist, an internist, a physiotherapist and a neuropsychologist. Laboratory and instrumental examinations were conducted. Before (1) and after (2) training course quantitative assessment was used for examination of neurological, cognitive, affective and functional states: Montreal Cognitive Assessment (MoCA), Mini Mental State Examination (MMSE), Frontal Assessment Battery (FAB), Clock Drawing Test (CDT), Shulte's Tables, Hospital Anxiety and Depression Scale (HADS), Instrumental Activity of Daily-Living (IADL), National Institute of Health Stroke Scale (NIHSS), Global Impression Scale of Patient and Clinician (GISP, GISC).

4 RESULTS

A clinical case. Patient N. was admitted to the rehabilitation center with the following diagnosis: Ischemic stroke in the left middle cerebral artery circulation with mild right-sided hemiparesis, massive cognitive impairments in the late recovery period. She was 63 years old and complained of memory decrease which developed after stroke.

On extended qualitative neuropsychological examination (Luria A.) bilateral dysfunction of frontal lobes was observed. Patient N. was apathetic with executive function disorder and secondary memory decrease. On quantitative assessment score decrease was observed on every neuropsychological scale.

Table 1: Patient's N. results before and after training.

Examination	MoCA	MMSE	FAB	CDT	Shulte	IADL	HADS	GISP	GISC
1	7	19	7	5	86	12	14/5	2	2
2	14	22	7	8	69	15	4/4		

After Cybernetic Enriched environment training course there were improvements on all neuropsychological scales beside FAB (Table 1). Patient N. became more motivated and her voluntary attention improved; she could regulate her activity better during memory tasks.

5 DISCUSSION

The first experience of using of the Cybernetic Enriched Environment for cognitive rehabilitation has shown effectiveness and high prospects for this method despite the fact that the experimental model does not provide permanent stimulation yet. We expect to obtain better results using the pre-production model, in which the patient will be exposed to cybernetic enriched environment for 24 hours a day during a long period of time. Randomized control trials are required.

REFERENCES

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