Research article
Ερευνητική εργασία

A pilot study and brief overview of rehabilitation via virtual environment in patients suffering from dementia

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Dementia is one of the increasing problems of modern societies. The immediate cure is not a possible solution, at least at the moment, but science has found a number of new ways to retard and under specific conditions to halt its development. A potential, and constantly evolving scientific field is the use of Computerized Cognitive Rehabilitation (CCR) and Virtual Environments (Vr.E). According to the existing literature, subjecting patients to various neuro-rehabilitative conditions within 3D virtual environments, allows them to obtain significant therapeutic benefits in which both transferability and durations over time are observed, in relation to the training period of the intervention. In the present study we examine whether "Serious Games (SGs)" – (learning and rehabilitating games in virtual and augmented reality) – have utilitarian value in the field of cognitive neurorehabilitation, concerned with demented population. For research purposes, we have conducted a number of case studies, based on 10 elderly patients, suffering from moderate or mild severity impairment of higher cortical functions, attributed to various types of dementias (Vascular, Alzheimer's disease, DLB dementia and mixed dementia). Each participant underwent rehabilitative intervention through our SG for a total of 10 hours within 4–5 weeks period. At the end of the cognitive rehabilitation program, patients' performance was assessed based in standard neuropsychological tests (measuring: working memory, memory retention, attention, problem solving, rigid thinking and executive function) and the results were compared with measurements taken before, during, and at the end of the intervention. Our experimental hypothesis states that there will be a significant difference between the results of cognitive performance of the patients between the pre- and post- rehabilitative period, consequential of the Interactive Computer-based Training (ICT). In conclusion, a review and brief analysis of the relevant literature was carried out in order to investigate the specification of potentially beneficial variables and to appreciate as much as possible the multifactorial causes related to this particular rehabilitation method of the corresponding suffering population. The ultimate purpose of our research is the design and creation of a prospective interactive cognitive rehabilitation training SG, able to combine both the neuro-rehabilitative character of the controlled virtual environment, as well as the potential realism that is also attributed to it (factual validity under high experimental realism). The results showed a relative improvement in the total of the cognitive variables under consideration after the completion of the neuro-rehabilitative program, while a parallel review of the literature on the subject revealed methodological considerations similar to those of the present study.

Key words: Dementia, serious games, neurorehabilitation, virtual environments, Interactive Computer Training.

Introduction

Population aging leads to an increase in the prevalence of neurodegenerative diseases and in particular of dementia, characterized as a major problem with multidimensional features.[1–3]

In order to address dementia at all levels, maintenance of patients' potential greater operational capacity, for as long as possible, remains crucial. This effort comprises two parts. Firstly, delay of the progression of dementia and secondly, operational aiding and functional rehabilitation of the patients.[4–7]

Cognitive enhancement has been proposed and widely used for functional assistance, concerning demented population.[8–14] Intrinsically, significant acknowledgement is obtained by SGs and ICTs associated with the field. The term Serious Games mainly refers to "digital games used for purposes other than those of personal and collective entertainment".[15] Centered on the theory of interactive cognitive complexity, it is proposed that simulation games (VR SGs) are more effective than other instructional methods, because they simultaneously engage trainees' affective and cognitive processes.[16]

Studies in recent years indicate the beneficial effect of SGs and ICTs on patients with dementia,[9,11,17–19] with the participants reporting that by following their training-rehabilitation, they were not only more attentive and focused on the trained skills, but also on other daily procedures.[18] The findings underline the improvement, even in just 12 sessions during a total the period of four weeks.[19]

In Greece, studies in the use of Personal Computers, video games, and its effect, have been conducted predominantly in the teenage population,[20] limiting considerably the reports on elders. In a characteristic study conducted in 2014, according to which a virtual environment was created on the basis of "the experience in a virtual supermarket", the editorial team concludes that their software is able to diagnose mild cognitive impairment (MCI), adequately depending on the degree of adaptation of the patients within the virtual environment.[21]

Aim

The present study examines the effect of CCR and ICT on the potential cognitive enhancement and rehabilitation, in patients with mild dementia.

In addition, we want to combine enjoyment with learning, which can be originally translated briefly in "intrinsic transference".[22] In particular, the aim of the research could be defined as the study of the effect of the virtual environment and game experience, in which the content of the information that should be taught, can be synthesized naturally with some content relevance, in elderly population facing moderate or minor executive functions decline.

Research methodology

Participants

Participants consist of elderly patients suffering from either incipient or mild dementia. A total number of 10, with an average age of 73.6 years old.

The reference was made based on the diagnosis by the treating neurologist and characterization of severity according to Mini Mental State, using the Greek population criteria, as set by Solis et al (2014).[23]

Exclusion criteria were:

1. Photosensitive epilepsy.
2. Color Blindness and/or other major vision problems.
3. Acute or chronic immobility impairments that prevent proper operation of the computer.
4. Presence of major psychiatric comorbidity.
5. Coexistence of other neurodegenerative disease.

Materials

A personal computer that will host the virtual environment. As input device we have selected a classic controller with indications for the direction buttons (arrows), and bright colors for the action buttons (blue and green). Moreover, the computer is connected with speakers to help with auditory stimuli for the automated voice directions.

Software

Patients were trained in three main tasks. The first task is based on the activity of shopping from a supermarket. The second task, is based on the preparation of breakfast, and the third task requires the patient to tide up and clean their house. All tasks are performed within the virtual environment and are designed for high resemblance with everyday activities that demented patient face. For each level the difficulty changes. Starting from the 1st level of each task, with plenty of aids, concerning working memory, attention, problem solving, motivation, organization and impulsivity, with the form of screen inventories, verbal and written directions and in-game arrow indications. Each time the participant completes a level, the aforementioned aids are removed, level by level, with the three last levels of each "Main Task", being of the highest resemblance to real life experience. The gradual release of the patient from the aids and cues is based on the learning process of scaffolding.[24,25]

For the development of the Virtual Environments and the tasks included, we have used a combination of three programming platforms named 3D Rad (www.3drad.com/open access), for the 3D game approach, Google Sketch Up (www.sketchup.com/open access) for the 3D modeling, and Adobe Photoshop (www.photoshop.com/paid software) in order to edit graphics. End result of the computerized project are the three "Main Tasks" represented by 30 levels, with 10 levels corresponding for each "Main Task".

Procedure

The duration of the experiment is almost seven weeks, a total of 48 days. The experiment took place at the facilities of General Hospital of Evangelismos after approval of the protocol from the Scientific Council.

Phase 1, Familiarization: Training period, during which participants will attend three sessions, one hour each. During the first session all Neuropsychological tests are performed. In the second and third session familiarization with the software and the device is completed.

Phase 2, Training: After familiarization standard training starts. The second phase includes training in the three "Main Tasks" based on our interactive software (SG, ICT). In the middle of training, patients are resubmitted for neuropsychological testing again, similar to that of the first week, in order to objectify their progress.

Phase 3, Final Assessment: During the last sessions, for the third time, the Neuropsychological tests are administered once again, in order to obtain the final data.

Sessions start from the task "Shopping in Grocery" for 20 minutes, where participants have to complete as many levels as possible. Then, they move to the second task "Make Breakfast" for another 20 minutes, with the last task being "Clean the House". The purpose of those alterations within the time period of a session, is to preserve the interest of the participant. In each of the following sessions, the patients continue from the previous levels of their last session. Every level has a specific completion time, which has been established after trials in healthy familiar and not first person video games and computer use, aged from 20 to 65. The mean completion time for each level is the basis upon which demented patients have five additional minutes to complete their tasks. Nevertheless, if the participant exceeds the allowed time, he or she returns at the beginning of the level and –in case of a repeated error– at the first level of the analogous task.

Design

We carried out six nonparametric statistical analyses with data from the participants before, in the middle, and after a relevant training period.

In this case our experimental methodology wants to follow a Friedman analysis of variance, repeated measurements and, therefore, dependent samples, between the three levels of the independent variable (IV). The null hypothesis supports that there won't be any significant difference between the results of the cognitive tests of the participants administered at the beginning, the middle and the end of our intervention. The independent variable (IV) is the training period on the software that reproduces the virtual tasks. Variable's measurement levels are without training, at the midterms of the four weeks, and the third, after the training. The units of measurement of the dependent variables (DVs) are the individual results (scores) in the respective diagnostic tests that the participant performed. The DVs are listed in 6 types with reference in Working Memory (Digit Span Forward & Backward), Memory Retention (Babcock story recall test), Attention (Trail Making Part A), Problem Solving (Hanoi Tower), Rigid Thinking (Wisconsin Card Sorting Test x64), and the executive functions (FAB). The proposed methodology has been chosen because of the small sample size and the fact of multiple dependent variables.

Results

The descriptive statistics concerning the results of the neuropsychological tests in the start, in middle and at the termination of our ICT are presented in table 1.

As shown in table 2 statistical significant difference in perceived scores, concerning Digit Span Test (Working Memory) is presented with $X^2(2)=6.500$, $p=0.039$. Unfortunately, while using Wilcoxon single-rank tests, as post hoc test, no significant differences were apparent, especially with the Benferroni correction set at $p<0.017$ ($0.05/3=0.0168\approx0.017$). Probably, the reason for such incompatible results is due to small sample size and low power. Thus, we can support that the training did have an effect on the outcome over time, with the significant difference occurred after our intervention with the compare of time means based, mainly, on Friedman Mean Ranks and means from the descriptive statistics. Consequently, we can support the overall effect of our training software based on the fact that mean values increase as the project's timeline occurs.

Regarding Babcock Test (Memory Retention), statistical significant difference is revealed, which rose in perceived effort in the pre-training scores versus the post-training scores ($Z=-2.615$, $p=0.009$) as shown in table 3.

However, no statistical significant improvement was observed in Trail Making scores (Attention) and Hanoi Tower Task (Problem Solving) since p-values correspond in higher values than significant levels. Despite the aforementioned results, there is still, a clear reduction in time needed to complete the tests as we can see in tables 4 and 5, respectively.

In the neuropsychological assessment of FAB battery (Executive Functions) a statistically significant improvement is observed in pre-training and mid-training diagnostic scores ($Z=-2.565$, $p=0.010$), as well as, in pre-training and post-training trails ($Z=-2.219$, $p=0.007$) (table 6).

Table 1. Descriptive statistics concerning the results of the neuropsychological tests in the Start, in Middle and at the termination of our ICT.

Descriptive Statistics of Neuropsychological Tests				
Name of test		**N**	**Mean**	**SD**
Digit Span High score proves better performance	Start	10	18.80	5.770
	Middle	10	20.60	6.257
	End	10	20.00	8.393
Babcock Story Recall High score proves better performance	Start	10	2.30	1.337
	Middle	10	3.45	1.674
	End	10	4.65	3.055
Trail Making A Low score proves better performance	Start	10	96.50	51.569
	Middle	10	95.90	57.357
	End	10	101.60	81.863
Hanoi Tower Low score proves better performance	Start	10	175.10	118.850
	Middle	10	152.40	111.415
	End	10	136.20	111.145
FAB High score proves better performance	Start	10	12.20	2.098
	Middle	10	14.00	2.582
	End	10	14.00	2.582
WCST-64 High score proves better performance	Start	10	19.10	7.094
	Middle	10	24.70	6.945
	End	10	32.90	13.755

Table 2. Results of the Friedman analysis and Wilcoxon post-hoc test at the beginning, middle and end of the training with the ICT, regarding the neuropsychological test of short-term memory.

Neuropsychological test	df	X^2		Friedman Ranks	Wilcoxon Asymp. Sig.
Digit Span	2	6.500	*Start	1.45	0.107 Start -> Middle
			*Middle	2.30	0.892 Middle -> End
			*End	2.25	0.160 Start -> End

Table 3. Results of the Friedman analysis and Wilcoxon post-hoc test at the beginning, middle and end of the training with the ICT, regarding the neuropsychological test of active memory.

Neuropsychological test	df	X^2		Friedman Ranks	Wilcoxon Asymp. Sig.
Babcock Story Recall	2	9.892	Start	1.35	0.036 Start -> Middle
			Middle	1.95	0.024 Middle -> End
			End	2.70	0.009 Start -> End

Table 4. Results of the Friedman analysis and Wilcoxon post-hoc test at the beginning, middle and end of the training with the ICT, regarding the neuropsychological test of attention.

Neuropsychological test	df	X^2		Friedman Ranks	Wilcoxon Asymp. Sig.
Trail Making A	2	1.400	Start	2.30	0.646 Start -> Middle
			Middle	1.80	0.541 Middle -> End
			End	1.90	0.541 Start -> End

Table 5. Results of the Friedman analysis and Wilcoxon post-hoc test at the beginning, middle and end of the training with the ICT, regarding the neuropsychological test of problem-solving.

Neuropsychological test	df	X^2		Friedman Ranks	Wilcoxon Asymp. Sig.
Hanoi Tower	2	3.161	Start	2.25	0.398 Start -> Middle
			Middle	2.15	0.207 Middle -> End
			End	1.60	0.106 Start -> End

Table 6. Results of the Friedman analysis and Wilcoxon post-hoc test at the beginning, middle and end of the training with the ICT, regarding the neuropsychological test of executive functions.

Neuropsychological test	df	X^2		Friedman Ranks	Wilcoxon Asymp. Sig.	
FAB	2	15.500	Start	1.15	0.010	Start -> Middle
			Middle	2.40	1.000	Middle -> End
			End	2.45	0.007	Start -> End

Finally, in WCST (Rigid Thinking) we notice that there is a statistically significant difference in perceived scores, as observed in the pre-training scores versus the post-training scores ($Z=-2.449$, $p=0.014$) (table 7).

Discussion

Based on one of the most important dysfunctional aspects of dementia, cognitive decline, and the possible non-pharmacological approaches that may help to restore or retrain the demented population, ICTs and/or SGs have achieved an impressive acceptance from the scientific community, with several researches demonstrating the beneficial features of their implementation.[9,11,18,19]

Overall, we observe that the use and effects of SGs have a strong theoretical background concerning the enchantment of cognitive schemata. This is based mainly on a fundamental principle, typical to most information-processing approaches that wants the various complex daily tasks performed by most of as to be broken, deconstructed into mere key actions/operations. By extending this theory, in 2002, Anderson introduced the "Decomposition Hypothesis", according to which the daily presented tasks that we face in our life, complex and non-complex, can be degraded, decomposed, into equally fundamental actions, and by training ourselves in those actions/operations, we can get improved overall.[17] Thus, repetition of procedures and even behaviors lead to specialization and adoption over the fields we devote that time, and maintain mental clarity.

This notion is heavily supported from our research, as our observations point improvement in the performance of each cognitive test, verifying the portion of the literature that supports the use of SGs and ICTs as rehabilitation tools.

Our theoretical background leads to the selection of six main levels in the construction of our SG. The first level is based on the pedagogical and restorative goals. The second is based on the simulation of the virtual environment, the third in the interaction with the virtual environment, the fourth is based on the problems and how progress is being made in the development of the game, the fifth on the decoration of the environment, and the sixth level is based on the conditions under which the SG is applied.[26] In order to have a better guidance by following the above six levels, we are led to a corresponding model, by Winn (2006),[27] who uses an equally usable and well-coded table system, which follows the most basic levels,

Table 7. Results of the Friedman analysis and Wilcoxon post-hoc test at the beginning, middle and end of the training with the ICT, regarding the neuropsychological test of rigid thinking.

Neuropsychological test	df	X^2		Friedman Ranks	Wilcoxon Asymp. Sig.	
WCST-64	2	6.368	Start	1.45	0.033	Start -> Middle
			Middle	2.00	0.044	Middle -> End
			End	2.55	0.014	Start -> End

but –on the other hand– combines other levels in a broader category called "gameplay experience". The privilege of Winn's model, although older than the first, expresses a more complete and user-friendly classification, not only for the levels of the SG structuring, but also on the correlation of learning styles and forms of entertainment that can be involved as stimuli, in addition to the gender of computer game that can be applied. Accordingly, learning levels are separated in three parts. The cognitive, emotional and kinesthetic part. The SG developed for our study is based on Bloom's Taxonomy of Educational Objectives.[28] Therefore, as an excellent tool, by combining Bloom's classifications during learning with the forms of training, and game types, appear to meet the theoretical criteria regarding the format and type of our virtual environment, which will be used for the neurocognitive rehabilitation of demented population.

Another study, which shares much resemblance to ours, was conducted in 2011 by University of Quebec, in Canada, essentially focusing on patients suffering from dementia and the potential therapeutic benefits that can be obtained from the exploitation of CCR. In the study, researchers used an excellent diagnostic tool as a basis, reproducing processes in the virtual environment in comparison with the already existing extensive database from the Naturalistic Action Test (NAT). The challenge was breakfast-making process in a two-dimensional virtual environment, where the research eventually concludes that for the correct approach to their experimentation should focus on four areas, those of memory, organization, motivation and attention perseverance.[29]

Another study, of close resemblance, was conducted in 2014, and despite of the two-dimensional environments used, the excellent experimental design and programming development, proved that participants showed improvement in conditions requiring mental flexibility, multiple manipulations, stimulation of organizational mechanisms and reduction of the information processing time.[30] Of course, the game was developed specifically to train the participants, while the investigation concludes that rehabilitation, as targeted, improved the attention of patients.

On the contrary, Kristjansson (2013),[31] despite the fact that he accepts the potential benefits from game playing, supports that the causal influence of action video game-play upon vision and attention is rather absent in most of conducted studies until 2013. With longitudinal studies being completely absent, Kristjasson concludes that "how videogame training modulates attentional abilities should make as treat it with more caution instead of how we react now".

At the same time, the literature shows extensive top-down cognitive processes, such as strengthening of the control capacity of the top-down approach in attention and action learning. These indications seem to be consistent with the results of a study conducted by Bavelier & Davidson (2013),[32] according to which avocation with video games tend to lead in better top-down cognitive information processing regarding situations that need usage and guidance of attention for the potential location of targets within an environment. The same findings were also supported by Wu & Spence (2013)[33] whose study shows improved classic visual search and strengthening visual spatial attention in dual search that mimics certain aspects of an action videogame, with focus to the top-down enhancement of spatial selective attention via increased inhibition of distractors.

Furthermore, a fairly recent study highlights the bottom-up cognitive processes when dealing with action video games. Such cognitive processing capabilities represent the visual-perceptual processing and the process of attention. Finally, the research shows that the benefits of training with commercial computer games are more specified and less universal, with wide transferability in various aspects of daily life.[34] This conclusion stresses the importance of reasonable ecological validity of these interventions.

In the present study 6 categories were tested. Those of functional memory, memory retention, attention, problem solving, executive functions and cognitive flexibility. Four of them showed a statistically significant difference (Functional memory, Memory Retention, Executive Functions and Rigid Thinking) while the remaining 2 showed marginal changes (Attention and Problem Solving). They are considered "marginal", despite the absence of significant statistical difference, based on the average distribution by analyzing fluctuations and descriptive statistics, and because of the fact that the average performance increase throughout the entire progression of the training period. The diversification of the results in two groups centered in the specificity or not of the tested functions is also essential. From the 6 tests used, the

3 are related to basic cognitive functions: operational memory, which is part of executive functions and was tested by digit span test· memory retention, which in turn is part of both operational and short-term memory, and was checked with the use of Babcock history recall· finally, that of rigid thinking, part of problem solving and executive processes, which was tested using the Wisconsin card sorting test. The other three tests are related with more generalized and complex cognitive functions, which contain the aforementioned basic functions. For example, the executive cognitive processes include functions such as planning, working memory, cognitive response inhibition, cognitive flexibility, maintenance of attention, emotional self-control, postponement of satisfaction and several more. Problem Solving, which is considered the most complicated mental function, requires the control of both executive functions and a plurality of fundamental and common skills.[35] Similarly, attention, which is enclosed in each of the above functions, but is also divided into general (vigilance), selective, alternating and fragmentary. Consequently, we understand that the results seem to be analogous and in line with the research by Oei & Patterson (2014),[34] who support that the results from CCR tend to be more specific and less universal.

The present study has also some methodological limitations. The low number of samples (N=10), did not allow us to use a control group, neither the option of a parametric variance analysis (MANOVA). Therefore, to meet the necessary conditions, we chose to use a non-parametric analysis based on Friedman. This choice initially underestimates the statistical power of our analysis, while the absence of a control group limits the evaluation of the variable's "therapeutic effect" throughout the training period. Also, a possible evolution of the present research protocol should focus on the development of new software, which would allow potential automatic environmental adjustments for each level, according to the capabilities of each participant. Equally important is to create a code that allows real time calculation of correct routes, and the setting of cues and aids during navigation in the virtual environment.

Conclusion

Keeping up with technological development, cognitive rehabilitation and restoration of demented population with the use of Interactive Computer Training (ICTs) is seeking for a position. Positive samples of our study, despite severe restrictions, support both incorporation and research in this field, and seems to verify the specificity of the beneficial effects of computer games, but also the universality that we can achieve through SGs. Finally, the same findings indicate the need for future researches, with larger number of participants and better designed, both from a structural and infrastructural perspective.

Πιλοτική μελέτη και βραχεία ανασκόπηση για τη χρήση εικονικού περιβάλλοντος στην αποκατάσταση ασθενών με άνοια

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Η άνοια αποτελεί ένα από τα συνεχώς επιδεινούμενα προβλήματα της σύγχρονης κοινωνίας. Η άμεση ίαση δεν αποτελεί πιθανή λύση προς το παρόν, η επιστήμη όμως έχει ανακαλύψει πλέον μια σειρά από τρόπους για να επιβραδύνει και, υπό προϋποθέσεις, να ανακόπτει την εξέλιξή της. Ένα διαρκώς αναπτυσσόμενο επιστημονικό πεδίο είναι η γνωστική ενδυνάμωση ή/και αποκατάσταση με τη χρήση ηλεκτρονικών υπολογιστών (Computerized Cognitive Rehabilitation) και εικονικών περιβαλλόντων (Virtual Environments). Σύμφωνα με την υπάρχουσα βιβλιογραφία, υποβάλλοντας τους ασθενείς σε διάφορες νευροαποκαταστασιακές συνθήκες στο πλαίσιο τρισδιάστατων εικονικών περιβαλλόντων, είναι δυνατόν να αποκτηθούν σημαντικά οφέλη, όπως η δυνατότητα επιστροφής στην καθημερινή ζωή του ατόμου (transferability), αλλά και η διατήρηση του όποιου θεραπευτικού οφέλους σε βάθος χρόνου σε σχέση με το χρονικό διάστημα της νευροαποκαταστασιακής παρέμβασης. Στην παρούσα μελέτη εξετάζεται κατά πόσον τα «ηλεκτρονικά παιχνίδια εκπαίδευσης και μάθησης» (ΗΠΜΕ – Serious Games) έχουν χρηστική αξία στον τομέα της νευρογνωστικής υποβοήθησης πασχόντων από άνοια. Για τις ανάγκες της έρευνας έχουμε διεξαγάγει μια σειρά περιπτωσιολογικών μελετών, βασιζόμενοι σε 10 ηλικιωμένους ασθενείς οι οποίοι πάσχουν από μέσης ή ήπιας βαρύτητας έκπτωση των ανωτέρων λειτουργιών, περιλαμβανομένων διαφόρων τύπων άνοιας (Αγγειακή, Νόσος του Alzheimer, LewyBD, και συνδυασμός). Οι συμμετέχοντες υποβλήθηκαν σε αποκαταστασιακή παρέμβαση μέσω ΗΠΜΕ για ένα σύνολο 10 ωρών σε διάστημα 4–5 εβδομάδων. Με το πέρας του προγράμματος γνωστικής αποκατάστασης, εκτιμήθηκε η επίδοση των ασθενών σε τυποποιημένες νευροψυχολογικές δοκιμασίες (αφορούν: ενεργούσα μνήμη, συντήρηση μνήμης, προσοχή, επίλυση προβλημάτων, άκαμπτος τρόπος σκέψης και επιτελικές λειτουργίες) και συγκρίθηκε με μετρήσεις που πραγματοποιήθηκαν πριν την έναρξη της παρέμβασης, κατά τη διάρκειά της, και με το πέρας της. Η πειραματική μας υπόθεση αναζητεί μια σημαντική διαφορά μεταξύ των αποτελεσμάτων της γνωστικής επίδοσης των ασθενών μεταξύ της προ- και μετα-αποκαταστασιακής περιόδου, απότοκη της διαδραστικής αποκατάστασης με βάση τους ηλεκτρονικούς υπολογιστές (Interactive Computer-based Training, ICT). Εν κατακλείδι, πραγματοποιήθηκε ανασκόπηση και σύντομη ανάλυση της σχετικής βιβλιογραφίας με στόχο τη διερεύνηση της συγκεκριμενοποίησης των δυνητικά ωφελούμενων μεταβλητών, αλλά και για την όσο το δυνατόν καλύτερη κατανόηση των πολυπαραγοντικών αιτιών που σχετίζονται με την αποκατάσταση και επανεκπαίδευση του πάσχοντος πληθυσμού. Σκοπός ήταν ο προοπτικός σχεδιασμός γνωστικής αποκατάστασης μέσω ΗΠΜΕ, ικανός να συνδυάζει τόσο τον νευροαποκαταστατικό χαρακτήρα του ελεγχόμενου εικονικού περιβάλλοντος, όσο και τον δυνητικό ρεαλισμό που του αποδίδεται (πραγματολογική εγκυρότητα). Τα αποτελέσματα έδειξαν σχετική βελτίωση στο σύνολο των υπό εξέταση γνωστικών μεταβλητών μετά την ολοκλήρωση του προγράμματος νευροαποκατάστασης, ενώ η παράλληλη ανασκόπηση της βιβλιογραφίας επί του θέματος ανέδειξε μεθοδολογικούς προβληματισμούς αντίστοιχους με αυτούς της παρούσας μελέτης.

Λέξεις ευρετηρίου: Άνοια, ηλεκτρονικά παιχνίδια εκπαίδευσης και μάθησης, νευροαποκατάσταση, ψηφιακή διαδραστική αποκατάσταση.

References

1. Price M, Albanese E, Guerchet M, Prina M. *World Alzheimer's Report – Dementia and Risk Reduction*, Alzheimer's Disease International (ADI), 2015. London. Available from https://www.alz.co.uk/research/WorldAlzheimerReport2014.pdf
2. Duthey B. *A Public Health Approach to Innovation "Priority Medicines for Europe and the World"*. Update on 2004 Background Paper 6.11 written by Saloni Tanna – Alzheimer Disease and other Dementias, 2013
3. Halliday G, Less A, Stern M. Milestones in Parkinson's Disease – Clinical and Pathological Features. *Movem Disord* 2011, 26:1015–1021, doi: 10.1002/mds.23669
4. Hardy J. A hundred years of Alzheimer's disease research. *Neuron* 2006, 52:3–13, doi: 10.1016/j.neuron.2006.09.016
5. Gaugler J, James B, Johnson T, Scholz K, Weuve J. Alzheimer's Disease Facts and Figures. *Alzheim Dement* 2015, 11:45–56, doi: 10.1016/j.jalz.2016.03.001
6. Selkoe D, Mandelkow E, Holtzman D. Deciphering Alzheimer Disease. *Cold Spring Harb Perspect Med* 2012, 2:1–9, doi: 10.1101/cshperspect.a011460
7. Lundbeck H. *Life with Parkinson's*. European Parkinson's Disease Association (EPDA), 2011
8. Zucchella Ch, Sinforiani E, Tassorelli Ch, Cavallini E, Tost-Pardell D, Grau S et al. Serious games for screening pre-dementia conditions: from virtuality to reality? A pilot project. *Funct Neurol* 2014, 29:153–158, PMID: 25473734
9. Robert PH, Koning A, Amieva H, Andrieu S, Bremond J, Bullock R et al. Recommendations for the use of Serious Games in people with Alzheimer's disease, related disorders and frailty. *Front Aging Neurosci* 2014, 54:1–13, doi: 10.3389/fnagi.2014.00054
10. Appelbaum LG, Cain MS, Darling EF, Mitroff SR. Action video game playing is associated with improved visual sensitivity, but not alterations in visual sensory memory. *Attent Percept*

Psychophys 2013, 75:1161–1167, doi: 10.3758/s13414-013-0472-7

11. Chiappe D, Conger M, Liao J, Cardwell JL, Vu KPL. Improving multi-tasking ability through action videogames. *Appl Ergonom* 2012, 44:278–284, doi: 10.1016/j.apergo.2012.08.002
12. Brox E, Fernandez-Luque L, Tollefsen T. Healthy Gaming - Video Game Design to promote Health. Appl Clin Informat 2011, 2:128–142, doi: 10.4338/ACI-2010-10-R-0060
13. Mayeux R. Alzheimer's Disease, Epidemiology. In: Aminoff MJ, Daroff RB (eds) *Encyclopedia of the Neurological Sciences*, Elsevier Science, USA, 2003, 1:96–102
14. Schreiber M, Schweizer A, Lutz K, Kalveram K. T, Jancke L. Potential of an Interactive Computer-based Training in the Rehabilitation of Dementia: An Initial Study. *Neuropsycholog Rehabilit* 1999, 2:155–167, doi: 10.1080/713755596
15. Susi T, Johansson M, Backlund P. *Serious Games: An Overview*. IKI Technical Report 2007
16. Sitzmann T. A meta-analytic examination of the instructional effectiveness of computer-based simulation games. *Person Psychol* 2011, 64:489–528, doi: 10.1111/j.1744-6570.2011.01190.x
17. Anderson JR, Bothell D, Fincham JM, Anderson AR, Poole B, Qin Y. Brain Regions Engaged by Part- and Whole-task Performance in a Video Game: A Model-based Test of the Decomposition Hypothesis. *J Cognit Neurosci* 2011, 23:3983–3997, doi: 10.1162/jocn_a_00033
18. Buss B. *Virtual Reality Training System for Patients with Dementia. Master Thesis*. Institute of Neuroinformatics, Swiss Federal Institute of Technology, Zyrich 2009. Available from http://e-collection.library.ethz.ch/eserv/eth:205/eth-205-01.pdf
19. Green CS, Bavelier D. The Cognitive Neuroscience of Video Games. In: Messaris P, Humphreys L (eds) *Digital Media: Transformations in Human Communication*. Peter Lang Publishing, Inc., New York, USA, 2004
20. Kokkevi A, Stavrou M, Kanavou E, Fotiou A. Addictive behaviours in adolescence: Part B. Other addictions. Series of Short Reports. University Mental Health Research Institute (UMHRI), 2015
21. Papamakarlos G, Glakoumis D, Vasileiadis M, Drosou A, Votis K, Tzovaras D. Monitoring activities of daily living and physical exercise for support of MCI and AD patients. *HJNM* 2014, 17(Suppl1):73. Available from: http://www.nuclmed.gr/magazine/eng/suppl1/72.pdf
22. Fabricatore C. Learning and Videogames: an Unexploited Synergy. AECT National Convention – a recap 2002. Long Beach, CA: Secaucus, NJ: Springer Science & Business Media, 2002
23. Solias A, Skapinakis P, Degleris N, Pantoleon M, Katirtzoglou E, Politis A. Mini Mental State Examination (MMSE): Determination of cutoff scores according to age and educational level. *Psychiatriki* 2014, 25:245–256
24. Ράπτης Α, Ράπτη Α. *Μάθηση και Διδασκαλία στην Εποχή της Πληροφορίας, Ολική Προσέγγιση*. Τόμος Α΄. Αθήνα, 2007:112
25. Kim J. The effects of a Constructivist Approach on Student Academic Achievement, Self-concept, and Learning Strategies. *Asia Pacif Education Rev* 2005, 6:7–16, doi: doi.org/10.1007/BF03024963
26. Marne B, Wisdom J, Huynh-Kim-Bang B, Labat JM. The Six Facets of Serious Game Design: a Methodology Enhanced by our Design Pattern Library. In: Ravenscroft A, Lindstaedt S, Kloss C, Hernandez-Leo D (eds) *21st Century Learning for 21st Century Skills*. Springer Publishing, Saarbrücken, Germany, 2012:208–221
27. Winn BM. *Serious Games Construction Worksheet 2006. Michigan State University*. Available from http://gel.msu.edu/winn/Serious%20Game%20Construction%20Worksheet.pdf
28. Krathwohl DR. A Revision of Bloom's Taxonomy: An Overview, *Theory Into Practice* 2002, 41:212–218. Available from: https://www.depauw.edu/files/resources/krathwohl.pdf
29. Imbeault F, Bouchard B, Bouzouane A. Serious Games in Cognitive Training for Alzheimer's Patients. IEEE 2nd International Conference on Serious Games and Applications for Health (SeGAH), Braga 2011:1–8
30. Montani V, De Filippo MD, Zorzi M. "A new adaptive videogame for training attention and executive functions: design principles and initial validation." *Front Psychol* 2014, 5:409, doi: 10.3389/fpsyg.2014.00409
31. Kristjansson A. The case for causal influences of action videogame play upon vision and attention. *Attent Percept Psychophys* 2013, 75:667–672, doi: 10.3758/s13414-013-0427-z
32. Bavelier D, Davidson RJ. "Games to do you good." *Nature* 2013, 494:425–426, doi:10.1038/494425a
33. Wu S, Spence I. Playing shooter and driving videogames improves top-dawn guidance in visual search. *Attent Percept Psychophys* 2013, 75:673–686, doi: 10.3758/s13414-013-0440-2
34. Oei AC, Patterson M. Are videogame training gains specific or general? *Front Syst Neurosci* 2014, 54:1–6.doi: 10.3389/fnsys.2014.00054
35. Goldstein FC, Levin HS. Disorders of reasoning and problem-solving abilities. In: Benton AL, Meier MR, Diller L (eds) *Neuropsychological Rehabilitation*. Guilford Press, New York, 1987:327–344

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