Virtual Reality for Persons with Dementia: an Exergaming Experience

Mauro Colombo [1,2]*, Eleonora Marelli [1,2], Roberta Vaccaro [2], Eleonora Valle [2], Savina Colombani [1], Elisabetta Polesel [1], Sabrina Garolfi [3], Silvia Fossi [2], and Antonio Guaita [2]

[1] Geriatric Institute "Camillo Golgi", Abbiategrasso (Milan), Italy
[2] "Golgi Cenci Foundation", Abbiategrasso (Milan), Italy
[3] Geriatric Institute "Piero Redaelli", Milan, Italy
** Corresponding author (m.colombo@golgiredaelli.it)*

Purpose Cognitive stimulation may improve quality of life for people with light to moderate dementia. We explored feasibility and results of video gaming for persons with dementia, in terms of acceptability and pleasure. We argued that participants could experience fun and engagement in a context of supervised physical activity. As a secondary goal, participants' cognitive performance might benefit from such exercise. **Method** A total of 10 patients in our long-term special care units were screened according to their ability and their will to engage with videogames; cognitive impairment ranged from severe to mild [crude Mini Mental Status Examination (MMSE 11-24); balance ranged from impaired to almost normal (Tinetti balance 6-15), and gait ranged from impaired to normal (Tinetti gait 3-12). Withdrawal and social interactions were measured by a-MOSES scale and ranged from 25 (worst) to 17 (best). Persons with dementia were invited by a trainer to exercise their upper limbs by blowing up blue bubbles from a screen that captured the image of the person. Sessions were held twice weekly in quiet rooms. Exergames were shown stepping through increasing difficulty levels (different colours, speed of movement, bi-manual dexterity required). Exergames (EyeToy: play for PlayStation2) were played from a console that had an USB-camera placed on the top of the TV reproducing the person on the screen. The screen displayed a background on which the target stimuli, the blue bubbles, were presented together with red bubbles that must not be scratched. When the first stages of the game were executed correctly, the game proceeded to levels of increasing difficulty. In the easier levels the player had to make a visuospatial analysis and attentional monitoring of the action: in this stage the arm movements can be inaccurate. In the upper levels, problem solving, action planning, praxis abilities, motor coordination and psycho-motor speed are also involved. **Results & Discussion** Subjects played from 2.416" to 14.400" (mean 8.535", SD 4.098"); they achieved difficulty levels ranged from 3rd (moderate) to 7th (top level), during sessions lasting from almost 4' up to 20' (longest duration allowed). Highest difficulty levels achieved correlated to spared ability levels in activities of daily living; no correlation was found with motor, cognitive or behavioural variables. Balance, gait and behaviour were no different at the end of the trial. Adjusted mean MMSE increased from 16.4±4.6 to 18.0±4.6 ($p<0.05$ by Wilcoxon paired sample test). Overall, persons with dementia participated well; they took an interest in the game. Technical subjects appreciated the game, which they perceived as a tool to improve their health and mobility, when playing them they usually implicitly remembered previous sessions. Motor performances improved especially in subjects interested in the game from the outset. No adverse events occurred, with special regard towards behavioural and psychotic symptoms, staff created a pleasant atmosphere while supervising and gently helping when needed, so that the behaviour was appropriate and cooperative. In conclusion, our preliminary experience shows that exergaming for persons with dementia may be proficient towards selected patients. Both our intended outcomes (acceptability-leisure, and cognitive benefit) were achieved. Results concerning cognitive improvement must be considered with caution.

***Keywords**:* virtual reality, persons with dementia, exergames, leisure

INTRODUCTION

BACKGROUND

Patients with Alzheimer's disease are notable for the wide range and severity of their cognitive deficits. Neuropathology may support deficits in visuospatial selective attentional mechanisms that are affected in specific dementing diseases like Alzheimer's disease[1]. Testing the processing of motion cues by computer animation sequences (random-dot cinematograms), mild to moderate Alzheimer's disease has significant effects on the perception of structure from motion, with relative sparing of motion direction discrimination. Such deficits – based onto cerebral and retinal degenerative changes – have the potential to affect navigation and the recognition of objects in relative motion, as encountered during walking and automobile driving[2]. In Alzheimer's disease patients, the working memory store is impaired, slowing mnemonic consolidation and destabilizing feedback circuitry[3]. Attentional control in Alzheimer's disease is characterized by specific dual-task processing deficits[4]. More, demented persons generally have shorter step lengths, reduced gait speed, lower

stepping frequencies, and greater step-to-step variability than cognitively intact older adults[5]. Individuals with Mild Cognitive Impairment perform worse than normal elderly on tasks involving fine and complex motor function, like tracking and manual dexterity. Early Alzheimer's disease patients exhibit motor dysfunction on tasks assessing relatively more rudimentary motor control[6]. In early stages of Alzheimer's disease, response latencies prior to gesture execution is longer, the effect being prominent for transitive tasks and nondominant hand use[7]. Imputing the words "virtual environments dementia" in PubMed retrieved 18 results, exploring a wide array of issues, spanning from neuropsychological assessment, to neuroimaging; special regard is devoted to spatial navigation and way-finding abilities, as well as to outdoor environment evaluation. Ethical issues are concerned, aside with rehabilitation of special functions, like visuo-constructional abilities. Literature supports the possibilities of computer stimulations to bring leisure, a feeling that is seldom experienced by persons with dementia[8-10]. Usually - even early in the course of the illness - their lives are disrupted by behavioral and psychotic symptoms, which often upset their caregivers too. According to latest Cochrane Dementia and Cognitive Improvement Group Specialized Register (called ALOIS – updated 6 December 2011), cognitive stimulation may improve quality of life of people with light to moderate stages of dementia.

Purpose

Therefore, we aimed primarily at exploring the feasibility and the results of video gaming for persons with dementia, in terms of acceptability and pleasure. We argued that participants could experience fun and engagement in a context of supervised physical activity[11]. As a secondary goal, participants' cognitive performance might benefit by such exercise[12].

METHOD

10 patients assisted in our Long Term Special Care Units were screened according to their ability and their will to engage with videogames; cognitive impairment ranged from severe to mild [crude Mini Mental Status Examination (MMSE[13]) min = 11/30 - max = 24/30]; balance ranged from impaired to almost normal (Tinetti balance[14] min = 6/16 – max = 15/16), gait ranged from impaired to normal (Tinetti gait [14] min = 3/12 – max = 12/12). Withdrawal and social interactions were measured by MOSES[15] scale: ranges spanned from 25/34 (worst behavior) to 17/34 (best behavior). Persons with dementia were invited by a trainer to exercise their upper limbs by blowing up blue bubbles from a screen where the image of the person was captured in. Sessions were held twice weekly in quiet rooms. Exergames were shown stepping through increasing difficulty levels (i.e.: different colors, speed of movement, bi manual dexterity required). Exergames (Eye Toy: play for PlayStation2) are played from a console that has an USB camera placed on the top of TV reproducing the person on the screen. The camera detects the movements of the person allowing to interact with the action on the screen. The screen displays a background on which the target stimuli, the blue bubbles, are presented together with red bubbles that must not be scratched. If a large number of red bubbles is scratched, the game is over but you can try again in a new game session. When the first stages of the game are executed correctly, the game proceeds to levels of increasing difficulty. In the subsequent levels stimuli come casually from the top or bottom of the screen, from right to left and vice versa. In addition, they move with increasing speed. In the easier levels the player must make a visuospatial analysis and attentional monitoring of the action: in this stages the arm movements can be inaccurate. In the upper levels, problem solving, action planning, praxis abilities, motor coordination and psycho-motor speed are also involved.

RESULTS

Subjects played from 2.416" to 14.400" (mean 8.535", s.d. 4.098"); they achieved difficulty levels ranged from 3rd (moderate) to 7th (top level), during sessions lasting from almost 4' up to 20' (longest duration allowed). Highest difficulty levels achieved correlated to spared ability levels in activities of daily living; no correlation was found with motor, cognitive or behavioral variables. Balance, gait and behavior didn't change at the end of the trial. Adjusted mean MMSE (s.d.) increased from 16.4/30 (4,6) before virtual environment engaging to 18/30 (4,6) after it: $p < .05$ by Wilcoxon paired sample test. Overall, we got a good level of involvement by persons with dementia, who looked interested towards the game and tech. Subjects appreciated the game, which they perceived as a tool to improve their health & mobility, by playing; they usually implicitly remembered previous sessions. Motor performances improved especially in subjects interested in the game since the beginning. No adverse events occurred, with special regard towards behavioural and psychotic symptoms: staff created a pleasant atmosphere while supervising and gently helping when needed, so that the behaviour was appropriate and cooperating.

DISCUSSION

Recent literature remarks that patients with Alzheimer's or vascular dementia who engaged in physical activity had fewer neuropsychiatric symptoms than those who did not. When compared to the control group, the caregivers of patients with vascular dementia who engaged in physical activity had a reduced burden[16]. In conclusion, more and more

sophisticated exergames are on the rise in the marketplace as well as in academic research. Our preliminary experience show that exergaming for persons with dementia may be proficient towards selected patients. Both our intended outcomes (acceptability-leisure, and cognitive benefit) were achieved. Our proposal looks feasible and welcomed, as other technological engaging environments[17]. Technology may help in creating proper environments, capable to drive favourably behaviours determined by damaged brains. In dementia, the perception of the environment stems from lower hierarchical brain levels compared to normal people. Environmental incentives have to be simplified, in order to prevent misunderstanding and related misbehaviours, and to empower the control of perception by persons with dementia[18]. Exergames may build up pleasant virtual environments benefiting both wanderers and passive subjects. Results concerning cognitive improvement must be considered with caution. Yet, moderate intensity aerobic exercise is effective at reversing hippocampal volume loss by 1-2 years, in late adulthood, which is accompanied by improved memory function[19]. Cybercycling improved composite executive functions over and above traditional exercise, and achieved a 23 % relative risk reduction in progression to clinical MCI (Mild Cognitive Impairment). For the same effort, cybercycling enhanced neuroplasticity, as from higher BDNF (Brain Derived Neurotrophic Growth Factor)[20]. Low intensity coordination exercises can benefit cognitive function of older adults[21]. The "prosthetic approach" we envision is focused on well being[22]: yet, cognitive advantages may follow, according to the literature. As in any rehabilitation effort, besides compensatory procedures to improve activities of daily living despite perceptual limitations, therapy may be directed to actual restoration of perceptual dysfunctions through stimulating central nervous system change [23]. Motor stimulation – within a highly standardized multicomponent group intervention conducted in a nursing-home setting – was able to postpone a decline in cognitive function in patients with primary degenerative dementia[24].

CONCLUSIONS

Improvements in motor performances through this arm-raising paradigm of upstanding focal rapid reaching movements towards a target agrees with recent results demonstrating that feed-forward control to predict and compensate for self-generated perturbations may be improved in frail elderly.

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