Spatial orientation decline in elderly population

A pilot study on healthy and Alzheimer's subjects in the VR Maze Test

Francesca Morganti
Department of Human Sciences
University of Bergamo
Bergamo, Italy
francesca.morganti@unibg.it

Giuseppe Riva
Department of Psychology
Catholic University of Milan
Milano, Italy
giuseppe.riva@unicatt.it

Abstract—**Wayfinding ability has a high adaptive value, allowing humans to efficiently explore an environment in order to have a goal-oriented activity. The ability to orient in space starts declining with age and it constitute one of the main signs of cognitive impairment in neurological patients. Spatial orientation decline constitutes however an high limitation for elderly population and it has a great impact on subject the day-life autonomy and on her/his relatives and caregivers. Despite this, the neuropsychological approach on spatial cognition does not allow researchers and clinicians to have an accurate assessment of patient's everyday wayfinding ability. This could be critical in a borderline situation, such as in an age-related cognitive decline, in which spatial stimuli can be correctly individuated even if wayfinding is compromised. The main aim of this contribution is to introduce preliminary data about a spatial evaluation procedure – the VR Maze test – on healthy elderly and Alzheimer's population. This will support the identification of specific treatments able to prevent the cognitive decline in elderly and the rehabilitation of spatial orientation in neurological patients.**

Enactive cognition; Spatial orientation; Cognitive decline; Neuropsychological assessment; Rehabilitation

I. INTRODUCTION

Topographical orientation is considered a high-level cognitive function due to the integration of different attentional, mnemonic and perceptual processes, which contribute to the ability to navigate in familiar and unfamiliar surroundings [1, 2]. This is made possible by a set of both egocentric and allocentric cognitive processes related to the subject's locomotion within an environment that allows the identification of its position in space and the target destination, and then outlines the planning of the act [3].

Despite these evidences, neuropsychological assessment uses spatial tests that are not extremely sensitive in the evaluation of age-related spatial cognition decline [4]. Several times, in fact, subjects who present average performances in classical neuropsychological tests report difficulty in managing everyday environments (e.g. getting lost in unknown spaces and/or being unable in plan complex paths).

II. THE PILOT STUDY

We present a pilot study on wayfinding ability in the VR Maze Test on healthy elderly and Alzheimer's patients.

The main aim of this study is to understand if a VR-based tool, such as the VR Maze test [5], will be able to detect specific components of spatial cognition decline in elderly population. Moreover we would like to detect if this more situated procedure of wayfinding abilities evaluation, together with a classical neuropsychological assessment, will be able to distinguish between an average age-related cognitive decline and a pathological one as in Alzheimer's disease.

In particular we are interested in the human ability of elaborate egocentric and motion information into allocentric representation of the environment.

Finally the principal aim of this research is to evaluate if this reduction could be the key factor of the spatial navigation ability decline in elderly and neurological population. The neural systems activated by route/survey spatial cognition, in fact, appear to be some of the neural systems showing the earliest changes in both normal aging and in the neuropathology of neurological disease, such as Alzheimer's dementia. Thus, the assessment of this ability in elderly at-risk populations may serve as a basis for early prediction of disease and may be a useful measure for evaluation of outcomes of intervention studies for prevent and/or rehabilitate cognitive impairment.

A. Experimental population

In this pilot study we evaluated in the VR-Maze test 6 healthy right-handed volunteers whose age ranged from 69 to 78 years old (Mean age 74; sd 4.43) and 6 Alzheimer's patients from 68 to 79 years old (Mean age 74.67; sd 4.5).

Participants were 3 females and 3 males with 5 to 18 years of education (Mean 8,66; sd 5,1) equally selected from the healthy and clinical population.

All subjects participated as volunteers and gave informed consent for their data treatment. They do not present mood disorders as anxiety, depression etc., in their clinical history.

B. Materials

In order to test participants' ability to enactively explore a complex environment in an egocentric way by using an allocentric map we used the VR-Maze test [5].

C. Procedure

First of all both for healthy and clinical population a neuropsychological examination was performed (see Table I for details). After the neuropsychological evaluation, participants were introduced to the VR Maze test.

In the VR-Maze test, participants were requested to first perform the paper and pencil (PP) version of the maze, and then to find the right way into the equivalent virtual reality (VR) version of the maze.

Execution times and performances were recorded.

D. Results

A first comparison between Alzheimer and healthy subject was performed on neuropsychological tests. Table I lists each test score and statistical differences between groups.

TABLE I.   NEUROPSYCHOLOGICAL ASSESSMENT

Nps Test	Table Column Head		
	Between groups analysis (T test)	*Alzheimer*	*Healthy*
MMSE	f = .872; p < .023	M 23.10 sd 2.3	M 26.00 sd 1.29
Rey's words immediate	f = .017; p <.001	M 3.86 sd 1.84	M 8.60 sd 1.88
Rey's words delayed	f = 1.11; p <.001	M 4.16 sd 1.83	M 10.83 sd 2.71
TMT (A)	f = 15.93; p <.003	M 245, 50 sd 98.53	M 35,83 sd 10.57
TMT (B)	f = 5.86; p <.001	M 496. 66 sd 82.00	M 148.88 sd 44.43
Tower of London	f = 8.79; p <.020	M 28.00 sd 3.94	M 32.83 sd 1.6
Corsi's span	f = 4.46; p <.796	M 5.5 sd 1.83	5.7 sd 0.43
Benton (H)	f = 3.02; p <.000	M 14.33 sd 6.43	M 28.83 sd 0.98
Manikin's	f = 3.46; p <.003	M 19.66 sd 5.24	M 30.66 sd 0.81

Specifically for the VR Maze test the average time of execution both for the PP and VR mazes was analyzed.

For what concerns the time of execution of the PP mazes, a between groups analysis showed a significant difference (Kruskal-Wallis analysis) for maze 1 (p = .019), maze 2 (p = .005), maze 3 (p = .000), maze 4 (p = .010) and a no significant difference for maze 5. No significant differences were detected for the VR mazes.

Then the correct execution of each maze was analyzed. Both for PP and for VR 1 point was attributed for each maze correctly performed, thus point range for performance execution is 0-5 (0 = none maze performed; 5 = all mazes performed).

For PP mazes a between groups analysis showed a significant difference among Alzheimer's and Healthy subjects (T test f = 10; p = .021) in mazes execution. For the VR mazes the same analysis revealed an highly significant difference between groups (T test f = 1; p =.002) in performing wayfinding within the provided virtual environments.

III. DISCUSSION AND CONCLUSIONS

Results reveal how only Alzheimer's patients require more time in the execution of wayfinding when an allocentric map of the environment was provided to them, as in the PP mazes. Instead both elderly and clinical population were compromised when an egocentric perspective on the environment was provided, as in the VR mazes.

The analysis of performances on mazes pointed out how a decreasing ability in performing VR mazes exists in Alzheimer's patients while this decrease is not so evident in the PP version of the test. These results highlight how there is a reduction in Alzheimer's patients in a task that requires them to perform wayfinding in an egocentric perspective while they simultaneously had an allocentric map according to which spatial knowledge could be referred to as demanded from the VR Maze Test.

We can partially conclude that this pilot study was able to evidence the differences between a non pathological cognitive decline in elderly and an impairment on this ability linkable with Alzheimer's disease.

This aspect will be the key element for developing new scenario for the treatment/rehabilitation of spatial cognition decline and topographical disorientation in elderly and neurological patients.

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