Neuropsychological and Virtual Reality Assessment in Topographical Disorientation

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Abstract. Although literature does not provide a unique explanation, the importance of hippocampus for human topographical learning and orientation is assumed to be relevant by most of the authors. There is considerable evidence that the hippocampus is necessary for acquiring cognitive maps of allocentric space, which includes topographical knowledge of large-scale real environments. This study aimed to investigate neuropsychological and behavioral characteristics of topographical disorientation in a 71 years old patient, affected by an ischemic bilateral occipital lesion involving the hippocampus. Several assessment methods have been involved: neuropsychological test, paper and pencil test for the evaluation of topographical abilities, and a Virtual Reality tool. Experimental evidences for the value of an integrated evaluation approach in underlying spatial orientation difficulties are provided.

Keywords. Topographical Disorientation, Hippocampus, Neuropsychological Assessment, Virtual Reality.

Introduction

Topographical Disorientation (TD) refers to the inability to find the way into familiar or unfamiliar environments [1,2].

There are relatively few studies including a comprehensive and situated assessment of the topographical abilities in patients with TD.

A number of cognitive dissociations within this disorder, involving the relative preservation or impairment of topographical and spatial abilities sub-components, has been found between retrograde and anterograde memory, egocentric and allocentric perspectives, visual imagery, and geographical abilities.

An exhaustive investigation of orientation abilities can be useful in order to identify specific disorders in patients affected by TD and to define focused and effective rehabilitation programs [3]. Virtual reality (VR) environments, in particular, constitute an interesting opportunity for the evaluation of topographical disorientation, providing a representation of a dynamic nature and interactive environments [4].
1. Case History

L.M. (71 years old, man) suffered from a cortico-subcortical bilateral ischemic lesion into occipito-temporal lobe involving bilateral hippocampus. Soon after the hospital discharging the patient referred the presence of topographical disorientation (TD): he was unable to find the right way into both familiar and novel environments.

After a two-month rehabilitation training focused on topographical abilities and the education of compensatory strategies, several improvements in functional aspects of daily living were observed, although topographical disorientation did not ameliorate.

2. Methods

Visuo-spatial and orientation abilities of L.M. were tested employing several approaches: typical neuropsychological tests, an assessment of topographical abilities by paper and pencil test and a virtual version of mazes.

2.1 Neuropsychological evaluation

A comprehensive neuropsychological evaluation assessing general cognitive abilities, verbal and visuo-spatial memory, language, praxic, attentional, perceptive and planning abilities, geographical abilities, Right-left orientation, forward and backward word spelling has been administered. The evaluation of topographical abilities consists of:

- **Ecological evaluation of retrograde/anterograde topographical memory**: the patient was asked to describe 32 of familiar and unfamiliar routes, starting from home, going to a certain place, and starting from a certain place going back home. Routes were temporally graded according to the life period they were learned and experienced (childhood, adolescence, adult life, late life).
- **Learning of subsequent paper and pencil mazes**: 8 mazes were presented three times each. The decrease in execution time during the successive presentations was calculated and conceived as due to implicit learning.
- **Map reading and route learning into a written map**: a written map, enriched with landmarks and labels, was presented, asking the patient to follow a spoken route. In a subsequent step, patient was asked to trace from memory the same route in a map without labels.

2.2 Virtual reality

The VR-Maze test was based on the Wisc-R Maze subtest [5]. Patient was requested to first perform the allocentric paper and pencil version of eight mazes (see figure 1), and after to use them in order to find the right way into the equivalent egocentric VR version of the maze (see figure 2). Execution times were recorded for each of the eight mazes.
3. Results

Not regarding standardized tests (manikin test, backward and forward word spelling, VR task, learning of paper and pencil mazes), a patient’s performance was compared to that of a 10-subject control group, matched for age and schooling.

L.M. showed impairment in visuo-spatial (Corsi Supra Span, Rey’s Figure Copy and Recall and Trail Making Test) and executive functions (Tower of London).

Deficits were more evident in the recovery of geographical information, in learning of new topographical information (learning of paper and pencil maze and route following/learning into the map), in spatial working memory abilities (backward spelling). In the VR task, a deficitary transfer of allocentric information to an egocentric perspective was found. The patient was able to perform the paper and pencil version, while he managed to complete only one virtual maze. Besides, execution times for both versions were slower with respect to control subjects.

The description of known and un-known routes was unimpaired.

4. Conclusions

Patient’s performance showed a clear dissociation between verbal learning abilities (preserved) and visuo-spatial and topographical memory capacities (severely impaired). This represents an unintuitive result, considering the bilateral hippocampal damage, which usually does not reveal a lateralization in the cognitive impairment.

TD resulted to be more evident in the recovery of geographical (Italy map test) information; in the learning of new topographical information (learning of paper and pencil maze and performance into the VR mazes task); in spatial working memory abilities (backward spelling) and in the map reading/route-learning task.

The unimpaired description of known and un-known routes can be due to the major involving of verbal memory abilities in this task, and only a minor role of spatial and topographical ones.

The integrated assessment approach allowed us to highlight patient’s everyday spatial disorientation and to contribute to the debate of the role of hippocampus in a selective impairment of visuo-spatial learning in TD [6].

References


