Research article

Almeria spatial memory recognition test (ASMRT): Gender differences emerged in a new passive spatial task

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HIGHLIGHTS

• A new recognition task discloses gender differences.
• Task difficulty modulates dimorphism.
• The simplicity of the task makes it a good candidate for screening studies.

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ABSTRACT

Many different human spatial memory tasks were developed in the last two decades. Virtual reality based tasks make possible developing different scenarios and situations to assess spatial orientation but sometimes these tasks are complex for specific populations like children and older-adults. A new spatial task with a very limited technological requirement was developed in this study. It demanded the use of spatial memory for an accurate solution. It also proved to be sensitive to gender differences, with men outperforming women under high specific difficulty levels. Thanks to its simplicity it could be applied as a screening test and is easy to combine with EEG and fMRI studies.

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1. Introduction

Spatial memory is an ability that permits human beings to orientate themselves through space and reach targets effectively. Nowadays, spatial memory is frequently studied using virtual reality-based tasks. Virtual reality allows the development of different environments, depending on the necessity of each study. Participants can adopt an active or a passive role during the spatial exploration. Therefore, they can play an active role if the task makes it possible an interaction between the participant and the environment. Under these circumstances, subjects could take decisions about paths and routes while compiling contextual information [1–3]. On the other hand, participants are sometimes demanded only to observe what is happening. Thus, they can take a passive role without interacting with objects or places [4–6]. This alternative reduces the technological demands of the task, thus being very suitable for people who are outdated or could have problems using new technologies.

Recognition was frequently used to prove cognitive skills. Some neuropsychological visuospatial tests demand focusing on one scene or stimulus before making decisions about those stimuli in a recognition test. Hence, in the Spatial Cognitive Style test designed by Nori and Giusberti [7] participants have to recognize images of buildings or abstract symbols. Nevertheless, these tasks usually require object recognition but not place recognition since, as is generally known, place and objects are processed by different brain circuits [8,9]. Furthermore, spatial-memory-based tasks showed great sensitivity to medial temporal lobe disturbances, when traditional neuropsychological tests did not detect any problem [10].

It is worthy to note that gender differences frequently arise on spatial memory tasks, primarily under specific difficulty levels, thus not being usually registered under very low or very high task demands [4,11,12]. Since this dimorphism commonly appears in spatial memory tasks, it could be taken as an index of spatial memory demands, since this differentiation rarely appears in others visual tasks.

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Recently, the combination of video presentation and a spatial recognition task disclosed a differential performance between groups [13]. Nevertheless, in an attempt to create a spatial memory test in a format similar to traditional neuropsychological tests, the video presentation of the experimental environment was replaced by a room image.

This study was aimed to develop a test based on a previous virtual reality-based task [11] sensitive to spatial memory abilities, useful for screening purposes in neuropsychology and easily compatible with brain activity studies as well. Different levels of difficulty were used by adding locations to be remembered. The order, increasing/decreasing, in the number of places to remember was also taken into account since it could modulate performance. Our prediction was that it would be easier to start with low difficulty in order to increase it gradually afterwards. Gender is here reported to be an important variable explaining performance in the task.

2. Material and method

2.1. Participants

The sample was made up by 108 undergraduate students from the University of Almeria. They were divided into two groups balanced by gender: Increasing difficulty level, with 78 students (21.76 ± 4.38); and decreasing difficulty level, with 30 students (22.17 ± 3.43). Exclusion criteria included any circumstance that could potentially interfere with performance. This study was conducted in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans.

2.2. Apparatus

The task was presented on a Hewlett Packard 2600-MHz notebook equipped with 3 GB of RAM and a 15.4 Thin Film Transistor (TFT) color screen (1920 × 1200 pixels).

2.3. Procedure

The Almeria Spatial Memory Recognition Test (ASMRT) was created with images from the original Boxes Room task [11]. The virtual room contains 9 brown boxes in three rows. A trial consisted of two phases: In the sample phase a picture of a virtual room full of boxes—all of them of brown colored but one of green—was displayed. Afterwards in the recognition phase, ten different pictures of the virtual room were presented one by one containing one green box and several brown boxes (see Fig. 1). Participants had to decide if the green box shown in the recognition image is located in the same position as in the sample picture. Half of the pictures were correct. Pictures were selected according to their informative value showed in previous studies [4,6]. Participants provided affirmative responses whether the location of the green box was correct or answered negatively if it was wrong. Responses were registered manually by the experimenter avoiding pressure over response time. Students were given ten seconds during which they had to memorize the sample photo. No time limit was imposed in their responses during the recognition phase, although it took less than one minute per trial (ten pictures). Hence, one, two, and three green boxes were used in the sample picture to create three difficulty conditions. Nevertheless, all pictures contained only one green box in the recognition phase and they could show similar or different viewpoints in relation to the sample picture. At each level of difficulty four trials were implemented. As a way to determine how the previous experience could interfere with the difficulty, one group completed the task in an increasing order of the difficulty (one, two and three positions to remember) and another group in a decreasing order (three, two and one positions).

2.4. Statistical analyses

Analyses were executed with the statistical package STATISTICA – version 7. Mean number of correct answers in each condition was analyzed applying a three-way ANOVA (Gender × Order × Difficulty) with repeated measures in the last variable. A Tukey test was applied for post-hoc comparisons. Differences were considered significant for p < 0.05.

3. Results

An ANOVA (Gender × Order × Difficulty, with repeated measures in the last variable) revealed a significant main effect of Gender F(1,104) = 12.60, p < 0.05 (mean number of correct answers 37.34, SD = 34.37 and 34.57, SD = 0.53 for men and women, respectively) and Difficulty F(2,208) = 52.26, p < 0.001 (mean number of correct answers 38.2, SD = 35.37, SD = 0.49 and 34.27, SD = 0.47 for one, two and three positions, respectively) but no effect of Order factor F(1,104) = 1.88, p > 0.05.

Interactions Order × Difficulty F(2,208) = 30.69, p < 0.001 and Gender × Difficulty F(2,208) = 5.34, p < 0.05 were found statistically significant, but neither Gender × Order F(1,104) = 0.017, p > 0.05 nor Gender × Order × Difficulty interactions F(2,208) = 1.38, p > 0.05.

Post-hoc analysis of the interaction Gender × Difficulty revealed that in the increasing order, participants obtained higher scores when it came to memorize three positions (mean number of correct answers 35.71, SD = 4.82 and mean 32.26, SD = 3.86 for increasing and decreasing conditions, respectively, p < 0.001; see Fig. 2).

Post-hoc analysis of the interaction Gender × Difficulty revealed that men outperformed women when they were to memorize two or three spatial positions (mean number of correct answers in two green boxes condition 37.56, SD = 3.49 and mean 33.85, SD = 5.23 for men and women, respectively, p < 0.001; mean number of cor-

![Fig. 1. Representation of the Almeria Spatial Memory Recognition Test (ASMRT). (A) Sample phase. A sight of the room is shown with one box in green. Participants have to memorize the location of this box. (B) A picture of the recognition phase. Participants have to decide if the colored box is located in the same position as in the sample image. In this example the box is in an incorrect location. (C) Another example of the recognition phase. Now the green box occupies the correct location. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.](image-url)
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