Adaptation of the Morris maze task to human beings using an eye-tracking virtual reality environment: first steps

Jesús Moreno*
University of Jaén
Jaén, Spain
jarjonil@ujaen.es

Juan Manuel Jurado
University of Jaén
Jaén, Spain
jjurado@ujaen.es

José Enrique Callejas-Aguilera
University of Jaén
Jaén, Spain
jecalle@ujaen.es

Roberto Jiménez
University of Jaén
Jaén, Spain
rjimenez@ujaen.es

ACM Reference Format:
Jesús Moreno, Juan Manuel Jurado, José Enrique Callejas-Aguilera, and Roberto Jiménez. 2021. Adaptation of the Morris maze task to human beings using an eye-tracking virtual reality environment: first steps . In *MIG'21 Poster: Mo-tion, Interaction and Games.* ACM, New York, NY, USA.

1 INTRODUCTION

The Morris Water Maze (MWM) was defined 40 years ago as a device to investigate spacial learning and memory in laboratory rats. It has became one of the most widely used laboratory tools in behavioral neuroscience [D'Hooge and De Deyn 2001].

With humans, the study of this topic has the limitation of being performed in non-realistic environments, most of them carried out on computer screens. Recent advances in virtual reality (VR) allow the creation of more realistic environments partly solving this problem. Attention processes play a key role for spatial learning. At this respect, recent incorporation of eye-tracking in VR systems enables the attention measure on humans, which may suppose an important development at the knowledge of the processes governing spatial learning.

The main goal of this work is the adaptation of the Morris pool task to humans and the validation of a procedure for the study of spatial learning with them, using a VR technology that incorporates an eye-tracking system.

2 METHODOLOGY

2.1 Participants

Six students from University of Jaén participated in this research aged between 18 and 23 years old. They had no experience with ~~this specific~~ task before they started the experiment.

*~~Both authors contributed equally to this research.~~

MIG'21 Poster, November 10–12, 2021, Lausanne, Switzerland

2.2 Apparatus and stimuli

For the purpose of this study, a VR headset (model: HTC VIVE Pro Eye [HTC 2021]) and the unity game engine [Unity 2021] were used. As en environment to perform the executions, a realistic immersive environment that favors a natural behaviour of the user was selected. A Unity asset called "Forest Environment- Dynamic Nature" [NatureManufacture 2021] was used.

In the proposed task, participants had to find a hidden treasure. The exact position of this treasure was marked by two target cues (close to it) during the first phase (acquisition phase). During second phase (extinction phase), treasure position was modified with regard to target cues, being now far away from them. As result, a spatial learning function guided by target cues is expected during the acquisition phase, and this function to be disrupted during extinction phase.

For further analysis of the user's performance, 4 equal quadrants are defined. These quadrants are afterwards delimited zones (not perceptible by user during the training) within the search area that enables to export relevant information on the study variables (both, spent time and number of excavations by quadrant). For subsequent analysis, an objective quadrant is defined on which the statistical study of the values will be carried out. This target quadrant corresponds to the quadrant where the treasure is located in the acquisition phase cause its direct relationship with the random target cues during this phase allowed the initial spatial learning.

The data recorded and exported for the study where: user movements, user excavations, objects observed by the user (with their associated observation time). Due to hardware calibration problems at the experiment running, eye-tracking data was discarded for further analysis. In any case, Figure an image is included which shows the heat map obtained from the execution of a participant.

2.3 Procedure

Three types of trials were used at different points across experiment: Pretraining trial, Training trials and Probe trials. Pretraining trial was conducted with the presence of treasure but without cues. In this trial, digging is not allowed so users can't find the treasure. The objective was to familiarize the user with the movement and the environment. In training trials both treasure and cues were available; and in probe trials only cues, but not the treasure, were available to the user. In both, training and probe trials, participants were able to dig in the search area and move through the environment.

Maximum duration of each trial was 60 sec. In training trials if participants did not find the treasure after 60 sec, they were gently pushed to the treasure, where they remained for 10 additional seconds. When the user reached the treasure, he/she stayed there for 10 sec. Probe trials lasted 60 sec, after that, the user was removed from the search area.

Pretraining: During the pretraining phase, users were introduced into the environment with hidden treasure but without cues. This phase consisted of a single trial in which digging was not allowed and therefore participants can't find the treasure. It objective was to get the users used to the movement and the environment during the time the trial lasts. At the end of this trial, users were teleported to their friend's position were they are shown the treasure and advised to look around if they want to be able to find it earlier next time.

Acquisition phase: Participants received 8 training trials where treasure was hidden close and with the same distance relation to the random target cues (see Figure **??**. Every four training trials, a test trial was performed.

Extinction phase: Phase two was identical to phase 1 with the exception that now the treasure was far away from the random target cues.

3 RESULTS

Time spent in target quadrant. Figure 1 presents the mean time spent in target quadrant during the acquisition phase (left side) and the extinction phase (right side). As can be expected, time spent in target quadrant was increasing as the acquisition trials progressed, suggesting that participants learned that the target cues point to the position of the hidden treasure. Moreover, in the second extinction trial, a greater permanence is observed, something known in the literature as extinction burst (a transient increases in response rate in excess of those observed in baseline during the period immediately following discontinuation of reinforcement of a response, [Skinner 2019] [Lattal et al. 2020]). Finally, a decrease in the time participants spent in the target quadrant can be observed as extinction trials followed one after the other, suggesting that the extinguishing treatment was effective. These initial impressions were confirmed by the planned statistical analyses. Comparison of the time spent in the target quadrant between the first training trial in the acquisition phase (when participants do not yet know which cues may be relevant for treasure location) and the second training trial in the extinction phase (when behavioral expression is maximal as a function of prior learning during the acquisition phase) was statistically significant, $t(5) = 3.67$, $p = 0.01$. The comparison between the second training trial and the last test trial (when extinction should be higher) during the extinction phase was statistically significant too, $t(5) = 3.35$, $p = 0.02$. These results show that participants learned to relate the target cues to the treasure location during the acquisition phase, and then that this relationship was disrupted during the second training phase.

Diggings in the target quadrant. Figure 2 presents the mean diggings in the target quadrant in the same training and test trials than in the previous dependent variable. As can be seen, the number of excavations increased until it reached its maximum value in the second training trial during the extinction phase. Thereafter, the

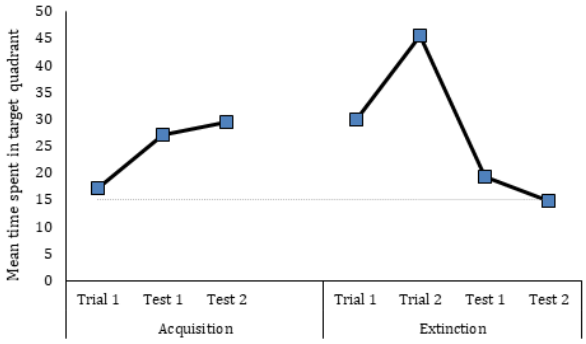

Figure 1

number of excavations decreased until reaching its lowest level at the end of the extinction phase. These impressions were confirmed by the planned statistical analyses. Comparison of the diggings in the target quadrant between the first training trial in the acquisition phase and the second training trial in the extinction phase was statistically significant, $t(5) = 3.20$, $p = 0.02$. Comparison between the second training trial and the last test trial (when extinction should be higher) during the extinction phase was statistically significant too, $t(5) = 2.88$, $p = 0.03$.

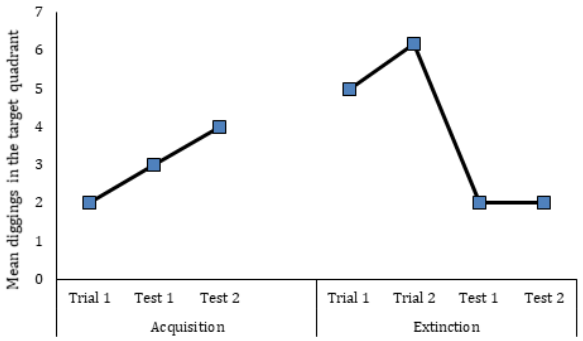

Figure 2

4 CONCLUSIONS AND FUTURE WORK

The present study attempts to validate a VR task for the study of spatial learning with human participants. For this purpose, a simple learning acquisition and subsequent extinction experiment was designed. The results obtained validated the task for the proposed purpose. However, the validity of the task relies on the confirmation of the results found from statistical analyses guided by theory and a posteriori planed contrast.

For best results, increasing the number of participants could help address the lack of statistical power. In addition, the number of irrelevant cues may have hindered the learning of the target cues. Therefore, increasing the number of training trials or decreasing the number of irrelevant cues should enhance the learning function during the acquisition phase. Finally, increasing the duration of

training trials should facilitate learning acquisition. Future work in our laboratory will aim at finding parameters that favor task sensitivity for the study of spatial learning and memory.

REFERENCES

Rudi D'Hooge and Peter P De Deyn. 2001. Applications of the Morris water maze in the study of learning and memory. 36, 1 (aug 2001), 60–90. https://doi.org/10.1016/S0165-0173(01)00067-4

HTC. 2021. HTC VIVE PRO EYE OVERVIEW. https://www.vive.com/eu/product/vive-pro-eye/overview/. Accessed on 2021-09-13.

Kennon A. Lattal, Toshikazu Kuroda, and Jemma E. Cook. 2020. Early extinction effects following intermittent reinforcement: Little evidence of extinction bursts. 114, 1 (jul 2020), 47–59. https://doi.org/10.1002/jeab.616 _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/jeab.616.

NatureManufacture. 2021. Forest Environment - Dynamic Nature. https://assetstore.unity.com/packages/3d/vegetation/forest-environment-dynamic-nature-150668. Accessed on 2021-09-13.

B. F. Skinner. 2019. *The Behavior of Organisms: An Experimental Analysis*. B. F. Skinner Foundation. Google-Books-ID: S9WNCwAAQBAJ.

Unity. 2021. Unity game engine. https://unity.com/es. Accessed on 2021-09-13.