

# Functional Neuroimaging of Place Learning in Computer-Generated Space

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## **Abstract**

We present fMRI data from three people learning to locate a place in computer-generated space. The first person, M.F., showed strong evidence of place learning while in the fMR, the second, A.H. appeared not to learn at all, and the third, T.L. learned moderately well.

M.F., who learned well, exhibited strong bilateral posterior parietal activation and strong left anterior cerebellum activation when viewing trials with the invisible target.

A.H., who appeared not to learn, exhibited strong unilateral (right) anterior parietal activation and no activation of the posterior parietal cortex or cerebellum when viewing trials with the invisible target.

T.L., who learned moderately well, exhibited no obvious evidence of parietal activation, but exhibited evidence of bilateral (left > right) activation of the anterior cerebellum when viewing trials with the invisible target.

These pilot data, to the extent they hold up, unexpectedly suggest that successful place learning in humans differentially involves both left and right parietal lobe (especially posterior parietal) and left anterior cerebellum.

## **Background**

The purpose of this poster is to illustrate differential activation of various brain structures during successful and unsuccessful place learning in humans.

We have previously shown that place learning, which occurs in the computer-generated (C-G) space being demonstrated here, enjoys good construct and external validity. That is, the learning a person shows in C-G space is a good representation of the place learning that same person shows in real space<sup>1</sup>.

We have also shown that people can learn the location of a place in C-G space simply by observing another locate that place<sup>2</sup>.

We took advantage of the apparent close correspondence between observational place learning in C-G space and real space to mount a fMRI examination of neural structures involved in human place learning.

## **Method**

Each participant was prepared and packed into the magnet with a pair of goggles covering the eyes. The participant viewed a) six trials of a successful search for an invisible target, b) six trials of a successful search for a visible target, and c) six trials of kaleidoscope color patterns through the goggles. The person saw a display similar to the one playing on the computer at this poster.

The person was then removed from the magnet, placed on a bed in another room with a pair of goggles covering the eyes. The person then used a joystick to produce movement through the same C-G space. We asked them to find the invisible target as quickly and efficiently as possible (you can try this task yourself if you are curious, just ask).

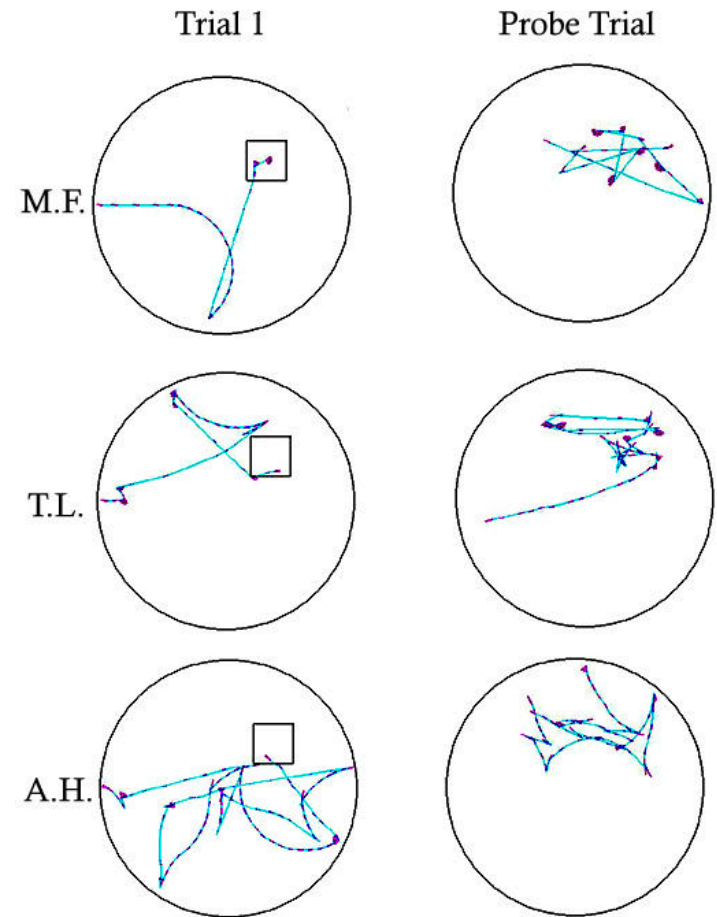
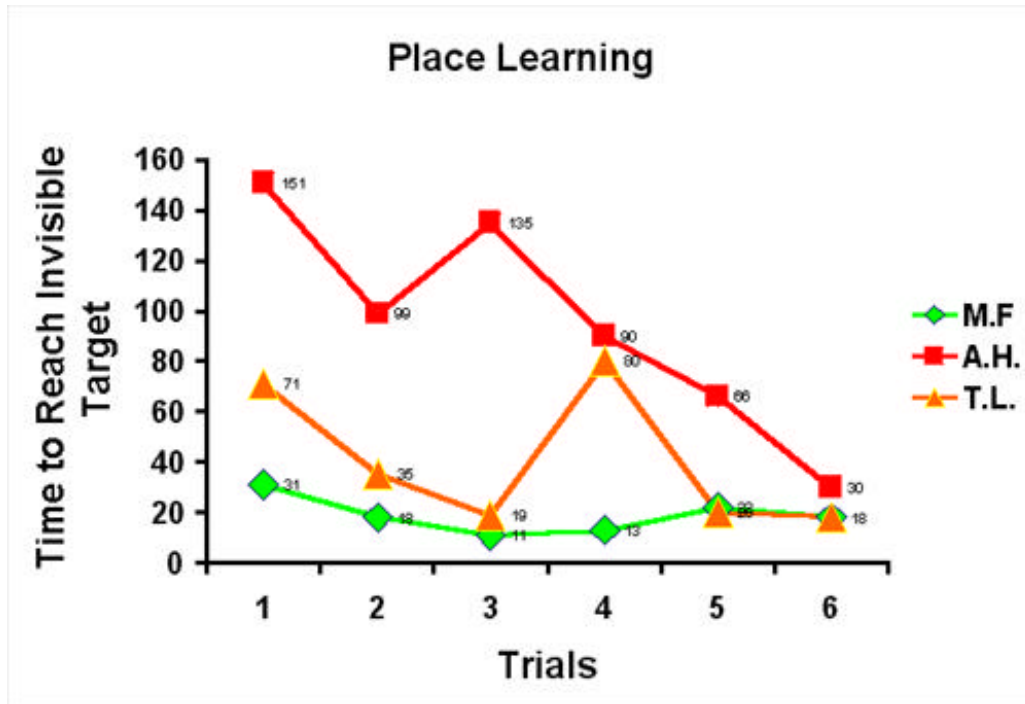
After searching for the invisible target seven times, the goggles were removed, the person sat up, and was given a set of icons representing the walls of the room, the objects on the walls, and the invisible target. We then asked them to use the icons to construct an accurate representation of the room.

## **Behavioral Results**

Following experience with the C-G space while in the fMRI, M.F. moved directly to the invisible target on the first and all subsequent test trials. Thus, M.F. learned the location of the invisible target while in the magnet.

Following the same experience, A.H. actively searched the C-G space on the first trial and only over trials became more efficient at finding the invisible target. Thus, A.H. did not appear to learn the location of the invisible target while in the magnet, but learned to locate the target during the test trials.

Finally, T.L., following experience with the C-G space while in the fMRI, did not efficiently find the invisible target on the first trial but became increasingly efficient at finding it across trials. Thus, T.L. appeared to learn the general location of the invisible target while in the magnet and refined that knowledge during the test trials.



Search Path

## **fMRI Results**

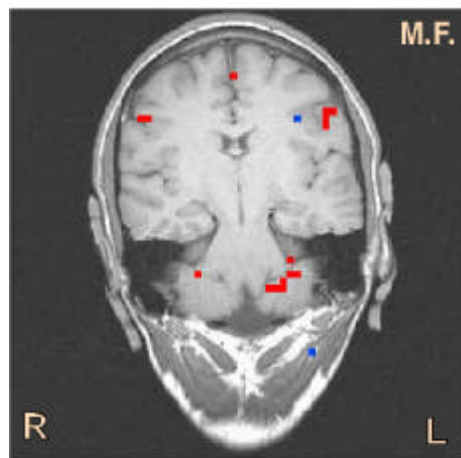
M.F., who learned the location of the invisible target while in the magnet, exhibited strong posterior bilateral parietal activation, some bilateral anterior parietal activation, and some activation of the posterior cerebellum. M.F. also exhibited striking activation of the anterior cerebellum, with the greatest activity on the left.

A.H. who did not learn the location of the invisible target while in the magnet, exhibited strong anterior right parietal activation with much less activation of anterior left parietal cortex. In contrast to M.F., A.H. exhibited no obvious activation of the cerebellum or posterior parietal cortex.

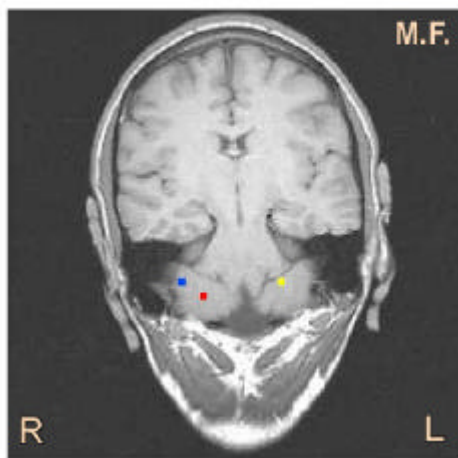
T.L., who seemed to learn the general location of the invisible target while in the magnet, exhibited no obvious evidence of parietal activation, but exhibited anterior cerebellum activation, with a greater activation on the left.

For each participant, activation of similar areas when viewing trials with the visible target was minimal compared to trials when the target was invisible. The only exception was T.L., who showed the same amount of activation of the cerebellum. This suggests there are differential brain activations between trials with visible and invisible targets.

### Anterior Parietal Cortex & Anterior Cerebellum

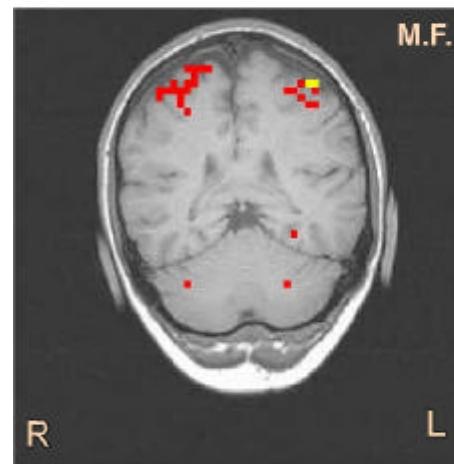


Invisible

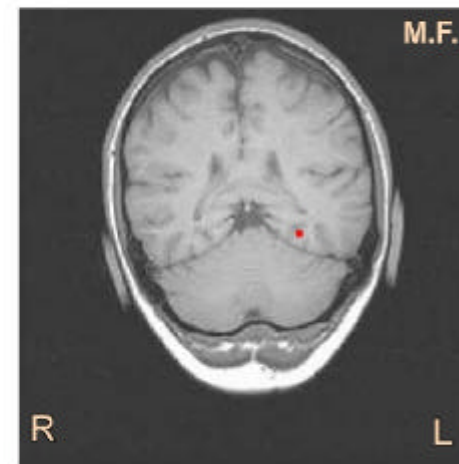


Visible

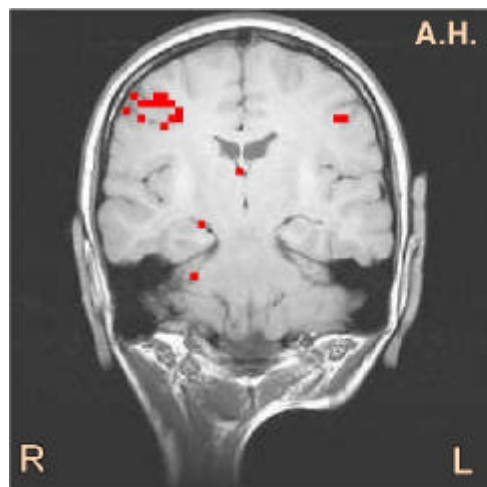
### Posterior Parietal Cortex & Posterior Cerebellum



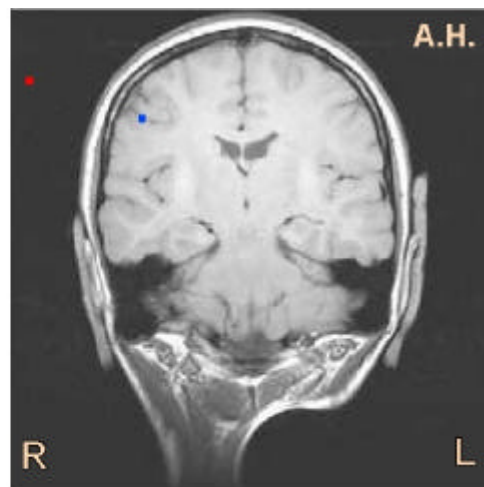
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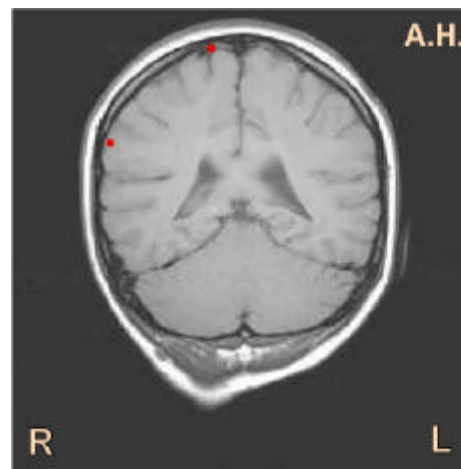
Visible



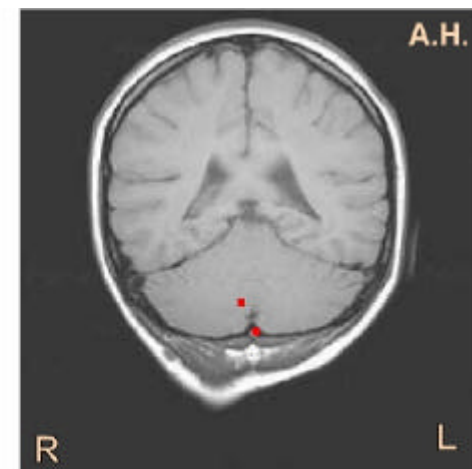
Invisible



Visible

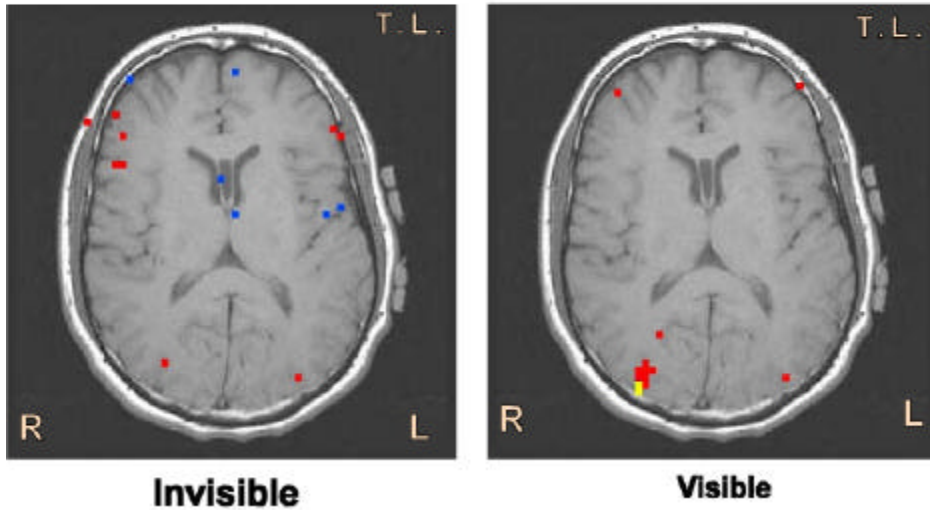


Invisible

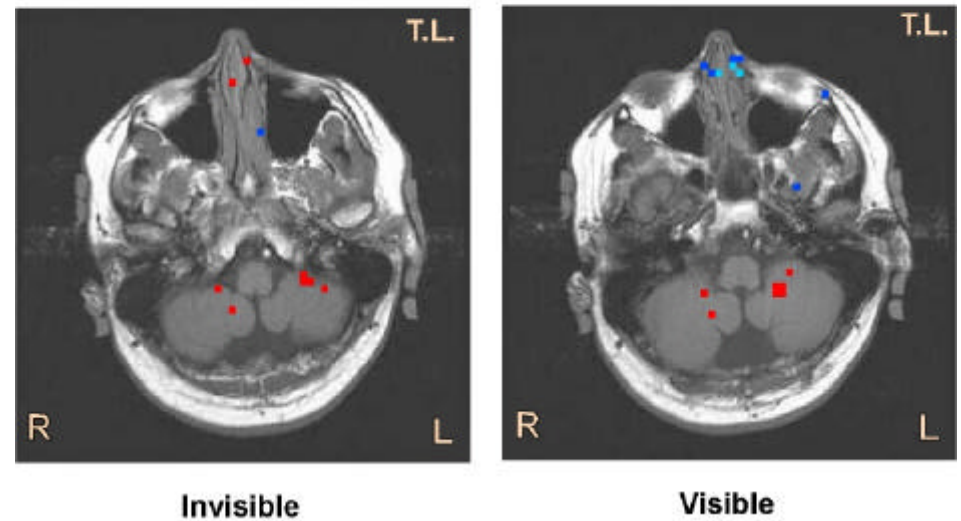


Visible

## Axial View of Parietal Cortex



## Anterior Cerebellum



## Conclusions

Although it is too early to offer conclusions, we shall offer a bit of speculation.

When people try to learn the location of an invisible target in C-G space, activation of the right parietal cortex occurs. This suggests involvement of the right parietal cortex in the subjective apperception of dynamic space.

When people successfully learn the location of an invisible target in C-G space, bilateral activation of posterior parietal cortex and some, mostly left activation of the anterior cerebellum occurs. This suggests involvement of posterior parietal cortex and perhaps left anterior cerebellum in highly exact place learning.

## References

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