Testing Spatial Skills in a Virtual Reality Environment

By Nick Roe and Birendra Danuka De Alwis
Supervisor: Burkhard Wuensche
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Introduction

Spatial intelligence involves the processing, understanding, and mental manipulation of objects in space [1]. Traditional pen-and-paper spatial skills tests have existed for decades and have been useful in providing a marker for spatial intelligence. However, with advances in technology, specifically computer hardware and the development of virtual reality (VR) head-mounted displays (HMDs), a new opportunity has arisen to execute such tests in a VR environment.

Objectives

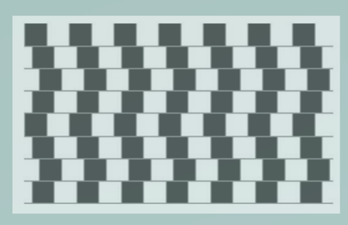
- Understand whether virtual reality spatial skills tests are as effective as traditional 2D tests.
- Design a VR game that tests spatial skills and is engaging and enjoyable to play.
- Design the VR game to be intuitive and natural feeling, such that there is a minimal learning curve.

Types of Spatial Skills

Mental Rotation

The ability to mentally represent and rotate 2D and 3D objects in space quickly and accurately, while the objects features remain unchanged [2]

Spatial/visuospatial perception



The ability to perceive spatial relationships with respect to the orientation of one's body despite distracting information [2]

Spatial visualisation

The ability to perform complicated multistep manipulations of spatially presented information. [2]

Spatial Working Memory

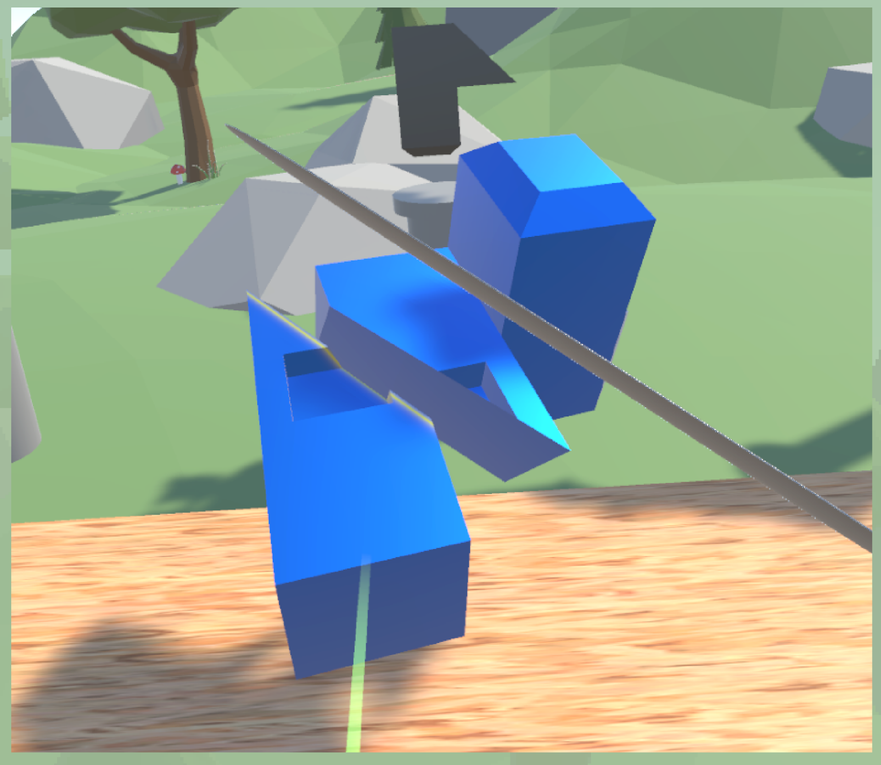
Provides the ability to temporarily store visual-spatial memories under attentional control, in order to complete a task [2]

Our Implementation

Our implementation focuses heavily on testing the mental rotation and spatial/visuospatial perception aspects of spatial skills.

The virtual reality game tasks the user with cutting an object into the provided matching shapes. They are scored based on the correctness of their cut, the time taken to complete the question, and the number of mistakes they made. Players interact with the shapes by grabbing them with their left hand controller, and cutting with their right.

We were able to make this possible by using the Unity Editor as our game development tool, along with blender for creating and designing the 3D objects for the game questions.



Measuring our results

To fully understand the feasibility of the virtual reality game as a testing tool for spatial skills, we tested all participants in both the 2D test and virtual reality game environments. For both tests, participants are given a score out of 10.

Considering that there will be differences in difficulty between the two tests, comparing the scores directly does not provide any useful information. However, by collecting data for the difference in scores between VR and 2D testing, we are able to establish if there is a consistent variance between the two types of tests, across all participants.

In terms of user reception, participants have viewed the virtual reality game positively, indicating that it is fun to play, but also mentally challenging.

UNIVERSITY OF AUCKLAND
Waipapa Taumata Rau
NEW ZEALAND

ENGINEERING
DEPARTMENT OF ELECTRICAL, COMPUTER, AND SOFTWARE ENGINEERING

[1] Lohman DF. 1996. Spatial ability and g. In: Dennis I, Tapsfield P, editors. Human abilities: Their nature and measurement. Erlbaum; Hillsdale, NJ. pp. 97–116.
[2] Donnon, Tyrone; DesCôteaux, Jean-Gaston; Violato, Claudio (2005-10-01). "Impact of cognitive imaging and sex differences on the development of laparoscopic suturing skills". Canadian Journal of Surgery. 48 (5): 387–393. ISSN 0008-428X. PMC 3211902. PMID 16248138.