Protocol for "Evaluation of a Conceptual Framework for Predicting Navigation Performance in Virtual Reality"

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Abstract

Previous research in spatial cognition has often relied on simple spatial tasks in static environments in order to draw inferences regarding navigation performance. These tasks are typically divided into categories (e.g., egocentric or allocentric) that reflect different two-systems theories. Unfortunately, this two-systems approach has been insufficient for reliably predicting navigation performance in virtual reality (VR). In the present experiment, participants were asked to learn and navigate towards goal locations in a virtual city and then perform eight simple spatial tasks in a separate environment. These eight tasks were organised along four orthogonal dimensions (static/dynamic, perceived/remembered, egocentric/allocentric, and distance/direction). We employed confirmatory and exploratory analyses in order to assess the relationship between navigation performance and performances on these simple tasks. We provide evidence that a dynamic task (i.e., intercepting a moving object) is capable of predicting navigation performance in a familiar virtual environment better than several categories of static tasks. These results have important implications for studies on navigation in VR that tend to over-emphasise the role of spatial memory. Given that our dynamic tasks required efficient interaction with the human interface device (HID), they were more closely aligned with the perceptuomotor processes associated with locomotion than wayfinding. In the future, researchers should consider training participants on HIDs using a dynamic task prior to conducting a navigation experiment. Performances on dynamic tasks should also be assessed in order to avoid confounding skill with an HID and spatial knowledge acquisition.

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Guidelines

This protocol was written for experiment instructors in the VR study "Evaluation of a Conceptual Framework for Predicting Navigation Performance in Virtual Reality". It is meant for use in a CAVE system with 3 screens and Vizard software.

Protocol

System start (before the participant arrives)

Step 1.
Open the window to air the room.

Step 2.
Turn on the three computers behind the right wall.

Step 3.
Turn on the projector with the remote control.

Step 4.

Get the 3D-glasses and marker from Computer-III where they are charging.

Step 5.

Check that the 3D-glasses and marker being used are working properly.

Step 6.

Turn on the screen on the table (if necessary).

Step 7.

Turn on the marker (button on the bottom side of the marker mounted to the glasses).

Step 8.

Move the glasses with the marker and check on the screen that marker 1 is moving accordingly in the 3D representation of the room. Ignore marker 3 (not relevant for this stage).

Step 9.

Log into the main screen with user: worldviz

Step 10.

Turn on the database (script file is in the left bottom of the main screen).

Step 11.

Start vizard client on the left screen

1. Move mouse to side screen
2. Press "Start"
3. Type "C" and press enter

Step 12.

Repeat step 11 for right screen and for main screen.

Step 13.

On the main screen in the Vizard master client (which you started in steps 11-12), put a tick mark next to the two clients WORLDVIZ-PC-LT and WORLDVIZ-PC-RT. Make sure that WORLDVIZ-PC-LT is listed above WORLDVIZ-PC-RT. Otherwise the left and right screens will be switched. If they are in the wrong order, you can change the order by dragging the entries in the list. If you cannot read the name, drag the box to enlarge it until the whole name appears (Excel-Style).

Step 14.

In the Vizard master client, set all the timeouts in the lower half of the window to the maximum by typing as many 9's as possible.

Step 15.

Start Vizard from the task bar. If hidden, move the mouse to the bottom of the screen.

Introduction for Participants

Step 16.

Introduce yourself and hand out the questionnaire to the participant. Inform the participant that the study will last 1 hour (but that it may take slightly longer) and ask whether he is okay with it (i.e., if the participant can stay longer without having a problem).

Step 17.

Hand out the description for the first stage of the experiment and ask the participant to read it carefully. In the following, the experiment is described in detail. This allows the experimenter to answer any questions the participant may have.

1. Stage 1 consists of 5 repetitions of a navigation task in a small virtual city. Six Buildings in the city are named with a sign in front of them. The participant's navigation task is to visit all places in a given order. The participant is asked to use the shortest route possible. In case the participant does not know where to go, he may press the trigger to activate a 3D arrow on the main screen that points to the direction to the destination destination. However, triggering the arrow decreases an energy bar which is displayed at the top of the main screen. Once the bar is empty, the arrow cannot be triggered for a couple of seconds. Aftter a few seconds, the bar slowly refills itself. The name of the current destination is shown at the top left corner. Whenever a destination is reached, the next destination will be announced with a pop-up text in the middle of the main screen.
2. A short break between the stages. Give the participant the handout for stage 2 of the experiment. Open the window for this time. Ask the participant to read it carefully again and ask whether he has any questions.
3. Stage 2 consists of 8 small tasks repeated 5 times. The first 8 repetitions are for training. The tasks are explained below. For all 8 tasks, the participant is situated on a green field surrounded by 20 spheres. In the base configuration, all spheres are white. To give the participant a hint of the task he is currently performing, the key verb of his current activity is written on the top left corner.

The tasks for Stage 2 are described below:

- For task 1, the participant has to turn to the sphere that is currently highlighted blue. No translation movement is involved. When the participant looks at the sphere, he should press the trigger to indicate that he has finished the task. Note that the sphere must not be centered on the screen, it is enough to merely face the highlighted sphere directly. When the task starts, a short text description will be displayed in the center of the screen: **'Look at the marked sphere'**. The hint in the top-left corner reads 'Look At'.
- For task 2, the participant has to turn to the sphere that is currently highlighted blue on a map in the top-right corner. No translation movement is involved. Note that no sphere is highlighted in the 3D environment. The map only appears for the task and is not shown otherwise. When the participants thinks he has identified the sphere and is looking at it in the 3D environment, he should press the trigger to indicate that he has finished the task. Note that the sphere must not be centered on the screen. It is enough to merely face the sphere. When the task starts, a short text description will be displayed in the center of the screen: **'Look at the sphere marked on the map'**. The hint in the top-left corner reads 'Look At'.
- For task 3, the participant has to walk to the sphere that is currently highlighted blue. A small yellow circle appears on the screen in front of the participant. The sphere should be inside this marked area when the participant presses the trigger to indicate that he has finished the task. The position of the yellow circle is dependent on the participant's head orientation. It moves always such that it is right in front of the participant. When the task starts, a short text description will be displayed in the center of the screen: **'Walk to the marked sphere'**. The hint in the top-left corner reads 'Walk To'.
- For task 4, the participant has to walk to the sphere that is currently highlighted blue on a map in the top-right corner. Note that no sphere is highlighted in the 3D environment. The map only appears for the task and is not shown otherwise. A small yellow circle appears on the screen in front of the participant. The sphere should be inside this marked area when the participant presses the trigger to indicate that he has finished the task. The position of the yellow circle is dependent on the participant's head orientation. It moves always such that it is right in front of the participant. When the task starts a short text description will be displayed in the center of the screen: **'Walk to the sphere marked on the map'**. The hint in the top-left corner reads 'Walk To'.
- For task 5, the participant has to look at two highlighted spheres sequentially. Then, all spheres disappear, and the participant has to turn towards the direction where he thinks the first highlighted sphere was situated. The first two parts of the task work the same as task 1 but are accompanied with another text. Looking at the first sphere is accompanied by **'Look at the first marked sphere'**, whereas looking at the second sphere is accompanied with **'look at the second marked sphere'**. After looking at the second sphere and pressing the trigger, all spheres disappear and the participant stands on an empty square. The participant should turn around until he thinks he is facing the first sphere again. No movement is involved. When the participant thinks that he is facing the first sphere again, he presses the trigger to indicate that he has finished the task. The hint in the top-left corner reads 'Look At'. The last prompt is **'Look at where you think the first sphere was'**.
- For task 6, the participant has to walk to a sphere that is highlighted blue. Unlike task 3, all of the spheres will disappear after the participant moves more than 1 meter. It is strongly recommended to first face the highlighted sphere and then move toward it as rotation alone does not trigger the disappearing of the spheres. A small yellow circle appears on the screen in front of the participant. The position where the sphere should be inside this marked area when the participants presses the trigger to indicate that he finished the task. The position of the yellow circle is dependent on the participant's head orientation. It moves always such that it is right in front of the participant. When the task starts, a short text description will be displayed

in the center of the screen: **'Walk to where you think the marked sphere is'**. The hint in the top left corner reads 'Walk To'.

- For task 7, the spheres are moving around the square freely. One sphere is highlighted blue, and the participant has to reach the sphere. A small yellow circle appears on the screen in front of the participant. The moving sphere should be inside this marked area when the participant presses the trigger to indicate that he finished the task. The position of the yellow circle is dependent on the participant's head orientation. It moves always such that it is right in front of the participant. When the task starts, a short text description will be displayed in the center of the screen: **'Walk to the marked sphere'**. The hint in the top-left corner reads 'Reach'.
- For task 8, the spheres are moving around the square freely. One sphere is highlighted blue on the map in the top-right corner. Note that no sphere is highlighted in the 3D environment but that a red arrow on the map indicates the participant's position and orientation. The map only appears for the task and is not shown otherwise. A small yellow circle appears on the screen in front of the participant. The moving sphere identified by the participant to be the highlighted sphere on the map should be inside this marked area when the participant presses the trigger to indicate that he has finished the task. The position of the yellow circle is dependent on the participant's head orientation. It moves always such that it is right in front of the participant. When the task starts, a short text description will be displayed in the center of the screen: **'Walk to the sphere marked on the map'**. The hint in the top-left corner reads 'Reach'.

Step 18.

Make sure the participant read and understood the experiment. Ask if any questions remain concerning the experiment.

Start Experiment

Step 19.

Select the tab called "main_launcher.py" in Vizard.

Step 20.

To start the experiment, either press "F5" or click on the play button in the top row.

Step 21.

Press "Yes" or "Enter" in the pop-up window to load the default experiment.

Step 22.

Close the window and blinds to darken the room and turn off the light.

Step 23.

Explain to the participant that he is now in the test phase. He can use the controls to explore the scene. Once the participants feels comfortable with the controls, he can start the real experiment. Explain controls and ask whether questions remain. From this point onwards, no questions may be answered anymore.

1. The participant moves around the world by pushing the joystick forwards and backwards. A

sidestep can be performed by pushing the joystick to the left or right.
2. Turning in the virtual world can be performed by twisting the joystick to the left or right, or rotating the head in the real world. Note that the walking direction is the direction that the participant currently faces, not the main screen.
3. The trigger at the front of the joystick is the trigger mentioned in the experiment description. It should be pressed only shortly.
4. Other buttons on the joystick are not in use.

End Experiment

Step 24.

When the participant has completed all tasks, the screen turns black until the operator presses ESC. You may leave the screen black until the participant leaves the CAVE.

Step 25.

Let the participant sign the participation paper (including the receipt for the money), and hand over the participation payment. Note that if the participant takes longer than the agreed hour, we have to pay him 15 CHF per 30 minutes overtime.

Step 26.

After the participant leaves, close the experiment by pressing ESC. On the desktop, a file called "participant-id.txt" contains the ID that the participant is identified with in the Database. Open the file and look for the start time of the experiment. The ID stated at the start time is the current participants ID. It is the last number after the colon. Add the ID to the survey so that survey information can be connected to the data collected.

Step 27.

Turn off the left computer and rapidly move the mouse to the center computer. Then, the center computer, but leave the right computer on. Connect the glasses and the marker to the USB cables at Computer-III to charge them.

Step 28.
Turn off the projectors.