

## GRASP Visual Displays for Review

The GRASP experiment is designed to probe for changes in eye-hand coordination on orbit.

Subjects (astronauts) perform a video game-like task using virtual reality that consists of shooting a projectile out of a hand-held tool toward a target. The target and the projectiles are presented as a line of sphere that can have different orientations in space. Since the line of targets and projectiles are long and narrow, the tool must be placed at the same orientation as the target to achieve success.

GRASP studies the mental representation of the target's orientation by having subjects shoot the projectile to the **remembered** target orientation. The target is presented only briefly, then disappears. The subject then triggers the projectiles after a waiting period of about 5 seconds.

GRASP goes further to study how the brain represents objects in extra-corporal space. On most trials, the subject is required to move the head between the time that the target is present and the moment of the response. The subject must take into account that the object would no longer be at the same orientation with respect to the eyes when producing the response.

Trials vary in terms of what can seen and felt during the execution of the task, organized into three different experimental paradigms:

- In the main task (Visual-Manual) the subject can see the target but must trigger the projectiles without being able to see the orientation of the hand.
- In one variant (Visual-Visual) the subject can see both the target and the hand.
- In a second variant (Manual-Manual) the subject is not presented with an oriented visual target. Instead, he or she is guided by color cues to place the hand at the desired target orientation. The subject must memorize this orientation, lower the hand, wait for 5 seconds, and then reproduce the remembered orientation.

In practical terms, subjects perform repeated trials of one of these paradigms during each of three sub-sessions.

The subject also performs the experiment in two different postural conditions:

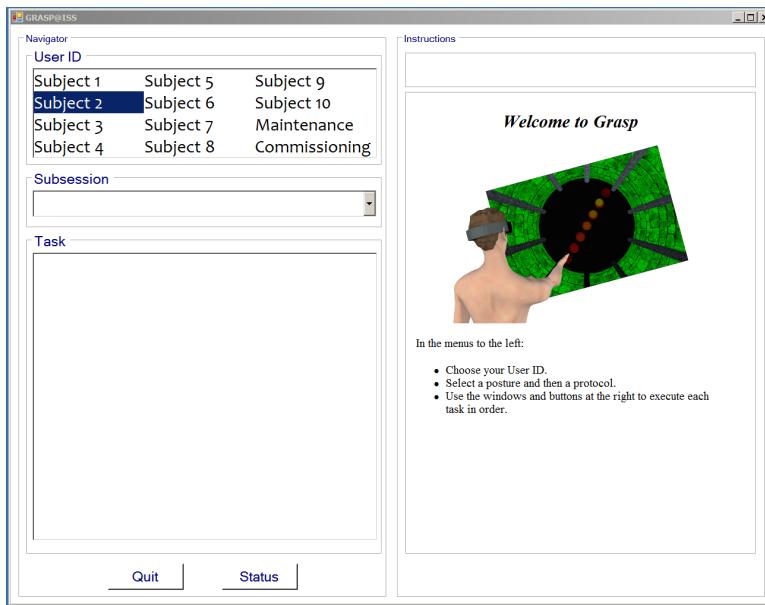
- On orbit, subjects are either strapped in an upright, seated position with respect to the ISS module, or for other trials, are maintained in a state of quasi-freefloating with no contact with the floor, walls or ceiling of the ISS module.
- On the ground subjects perform the experiment seated securely in a chair that may be upright or may be tilted with respect to gravity.

The details of the experiment design can be found elsewhere (e.g. the ESR). In this document we present the different visual displays that subjects and operators will see when performing the GRASP experiment. The document is organized as follows:

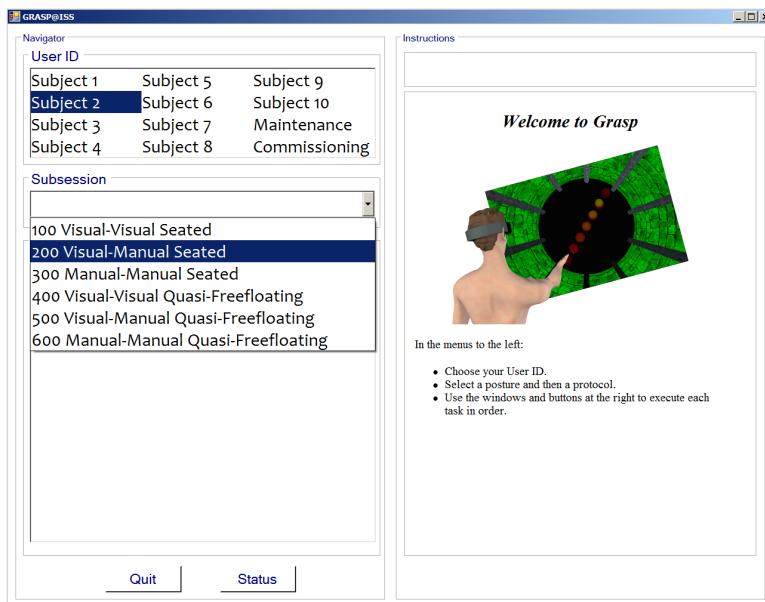
- This Introduction
- Graphical User Interface that controls the experiment on the Perspectives laptop computer.
- Instructions presented to the operator during hardware preparation.
- Screens for the Visual-Visual Task

- Instructions (presented in the GUI)
- VR Scenes (presented in the Virtual Reality Helmet)
- Screens for the Manual-Manual Task
  - Instructions (presented in the GUI)
  - VR Scenes (presented in the Virtual Reality Helmet)
- Screens for the Visual-Manual Task
  - Instructions (presented in the GUI)
  - VR Scenes (presented in the Virtual Reality Helmet)
- Additional messages that the subject may see inside the VR display.

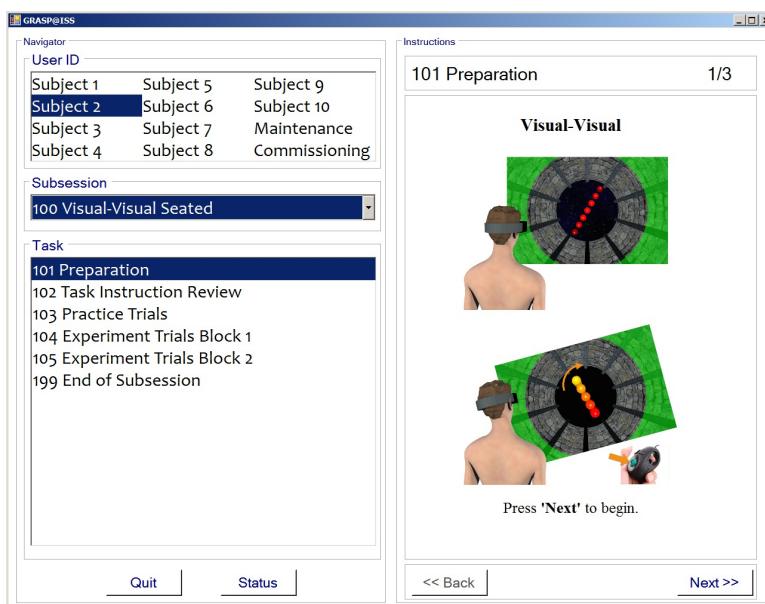
A crew member initiates Grasp activities by selecting his or her designated subject ID in the upper-left panel of GRASP@ISS:



The sub-session to be performed at any given time is communicated to the crewmember via an Execution Note. The desired sub-session ID sub-session is selected via a pull-down menu:



Selecting the sub-session protocol brings up a list of tasks to be executed in a defined order. The first task is automatically selected:



The panel on the right then guides the crew member through the steps required by each task. The panel may take one of four different forms.

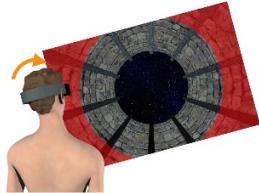
First, the crew member is presented with one or more pages of instructions. Once the instructions have been read the subject proceeds to the next step by pressing the 'Next' button. It is also possible to return to the previous step (except when at the first step) by pressing the 'Back' button.

Instructions

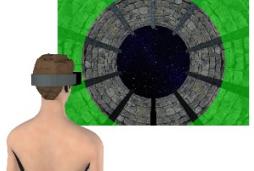
**202 Task Instruction Review** 1/5

**Step 1: Straighten Head**

- If your head is laterally tilted with respect to the trunk, the halo will be red.



- Align the head to your body axis, this will make the halo turn bright green.



<< Back Next >>

The crew member may then be prompted to launch a particular action. In the example shown here, the system is ready to perform the tracker alignment. The crew member presses the 'Execute' button to initiate the action. He or she may also press 'Back' to return to the previous action or instruction (except when it is the first step in a task). In exceptional cases, the subject may be told by POCC to press 'Skip' to move on to the next step without performing the action.

Instructions

**201 Preparation** 2/3

**Tracker Alignment**

Ready to perform the alignment procedure for the 3D tracker:

- Verify that the equipment is installed as shown:

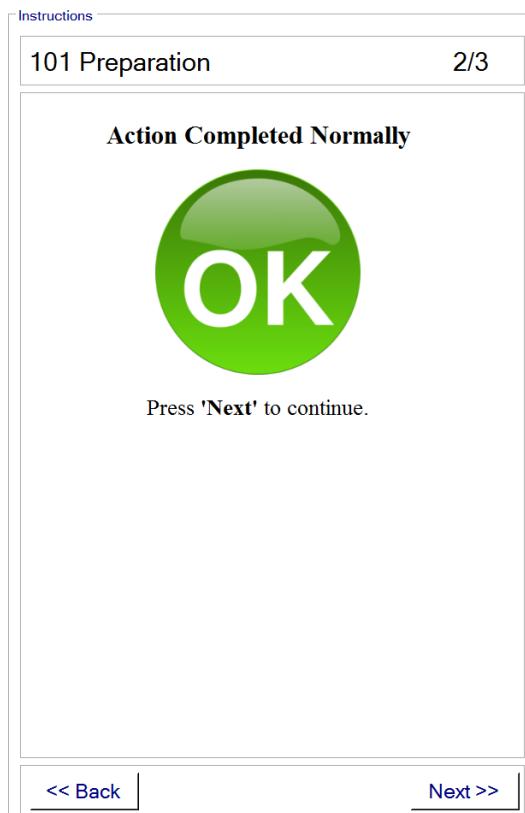


- Check that the field of view of the tracker cameras is free of obstructions.
- Confirm that the chest markers are positioned properly on the chair.

Press '**Execute**' to perform alignment.

<< Back Skip >> Execute

Pressing 'Execute' typically causes a new program to execute, which will activate specific popup windows outside the GRASP@ISS main window. When execution of the task terminates, focus will return to the GRASP@ISS main window and the termination status of the task is displayed. If the task was successful, the crew member will typically see the following message allowing them to confirm and move on to the following step (by pressing 'Next') or to return and repeat the task (by pressing 'Back').



If the task did not complete successfully, an alert will be displayed that shows the error return code (in the 'Error Code' box) and that typically includes a graphical or text explanation of the anomaly. Shown here is the generic message that may be used for any anomalous condition, but more specific messages may also be displayed (see below).



In these circumstances, the crew member is invited to repeat the task by pressing 'Retry'. If a second attempt also fails, the crew member has the option to move on to the next step anyway, by pressing 'Ignore' or to repeat the entire task from the beginning by pressing 'Restart'.

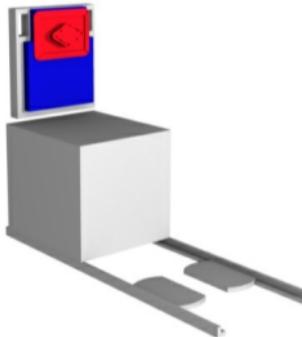
The full set of possible instruction, status and alert screens are included in the following sections.

## Tracker Alignment

Ready to perform the alignment procedure for the 3D tracker:

- Verify that the ***GRIP Chair*** is installed as shown with the seat back deployed and the ***Chest Marker Support*** attached with velcro to the backrest.

**Note:** Alignment of the ***Chest Marker Support*** on the backrest is critical. Please ensure that the top edge of the marker structure is aligned with the top edge of the backrest.



- Check that the field of view of the ***Tracking Cameras*** is free of obstructions.

Press '**Execute**' to perform alignment.

## Action Completed Normally



Press 'Next' to continue.

## Action Completed with Errors



Press:

- '**Retry**' to repeat this action.
- '**Ignore**' to ignore and move on.
- '**Restart**' to restart this task or select another.

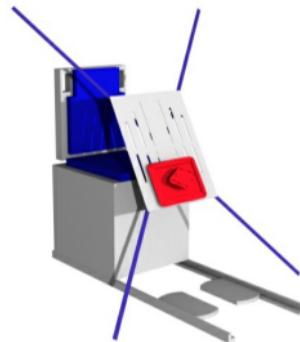
**Recommendation:** Attempt '**Retry**' no more than once or twice before consulting with POCC. '**Ignore**' and '**Restart**' should not be used without POCC authorization.

## Tracker Alignment

Ready to perform the alignment procedure for the 3D tracker:

- Verify that the quasi-freefloating ***Free-floating Restraint*** is installed as shown with the ***Chest Marker Support*** attached with velcro to the restraint plate.

**Note:** Alignment of the marker structure on the restraint plate is critical. Please ensure that the top edge of the ***Chest Marker Support*** is aligned with the edge of the plate nearest the deck of the ISS module.



- Check that the field of view of the ***Tracking Cameras*** is free of obstructions.

Press '**Execute**' to perform alignment.

## Action Completed Normally



Press 'Next' to continue.

## Action Completed with Errors

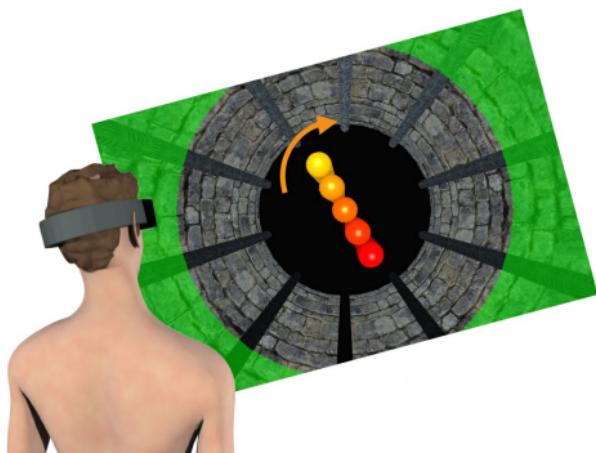
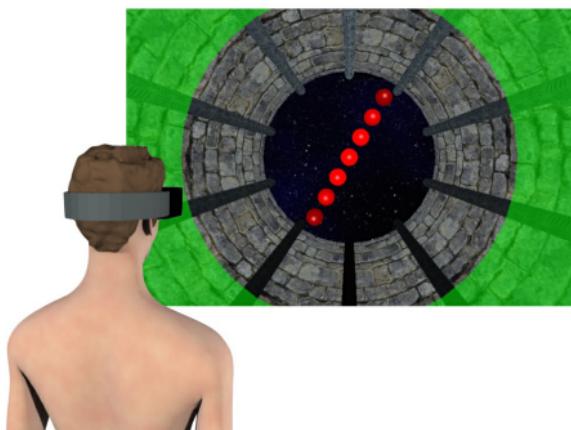


Press:

- '**Retry**' to repeat this action.
- '**Ignore**' to ignore and move on.
- '**Restart**' to restart this task or select another.

**Recommendation:** Attempt '**Retry**' no more than once or twice before consulting with POCC. '**Ignore**' and '**Restart**' should not be used without POCC authorization.

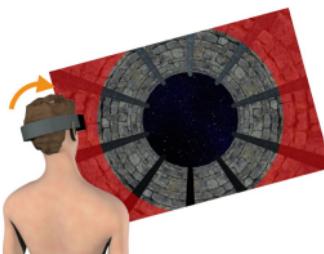
## Visual-Visual



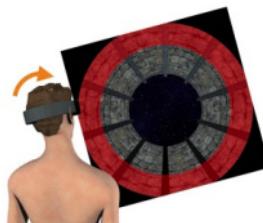
Press '**Next**' to begin.

## ***Step 1: Straighten Head***

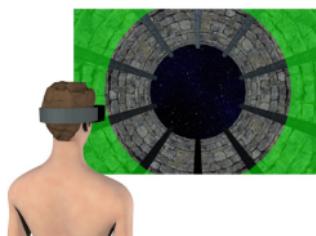
- If your head is laterally tilted with respect to the trunk, the halo will be red:



- Look straight ahead so that the virtual laser pointer falls on the central target, then slowly straighten your head on your shoulders. This will make the halo turn progressively from red to green:

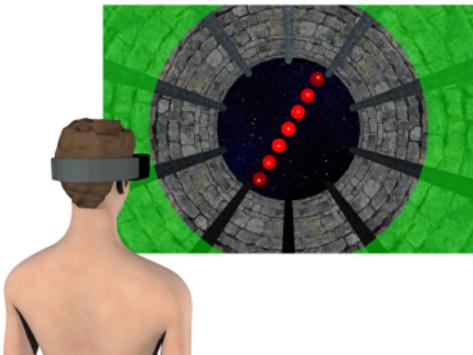


- When the halo pops to bright green, hold this position.



## *Step 2: Acquire the Target Orientation*

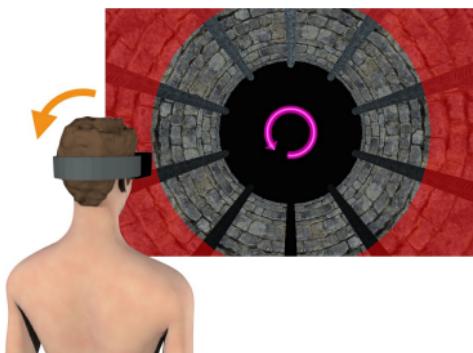
- Once your head is aligned with your body (i.e. when the halo is bright green), a line of balls will appear at the end of the tunnel, representing the target orientation.



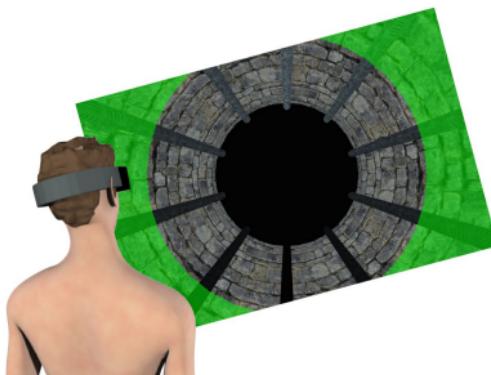
- Memorise the target orientation.

### ***Step 3: Tilt the Head***

- If the halo turns red, you must tilt your head to a new orientation. The arrow tells you which way to rotate the head.



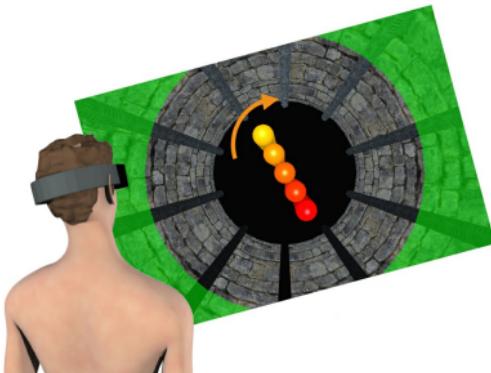
- Roll your head from side to side until the halo turns bright green and hold this position.



## ***Step 4: Align to Remembered Target***

- With the left hand use the ***VR Headset Remote*** to align the virtual tool to the memorised target.

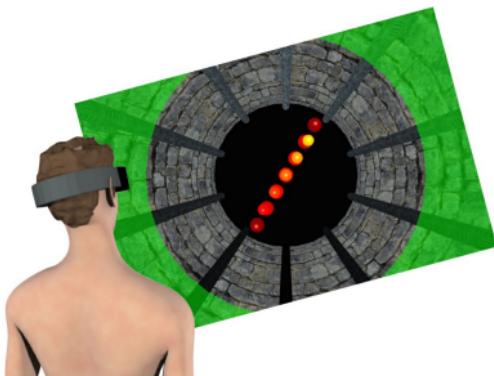
**Note:** Press and hold the right and left arrows on the ***VR Headset Remote*** to rotate the virtual tool clockwise and counter-clockwise, respectively.



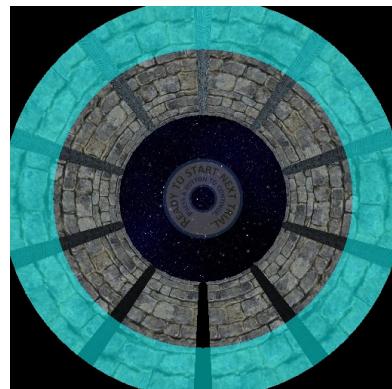
- Press the Center Button on the ***VR Headset Remote*** to validate your response once you think that the virtual tool is aligned with the memorised target.

## ***Step 5: Check Response***

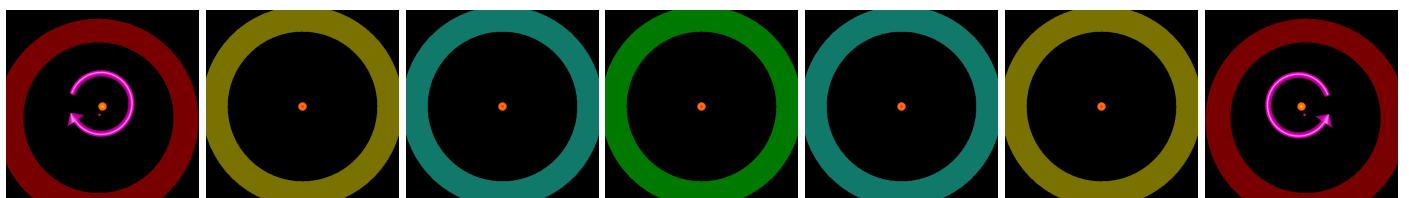
- In some of the trials a line of target balls will be projected from your hand towards the targets, allowing you to verify whether or not you correctly aligned your hand.



The Visual-Visual task starts with a welcome screen that prompts the subject to press a button in order to start a block of trials:

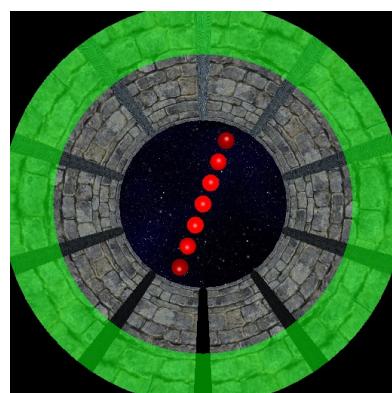


He or she is then guided to look straight ahead and bring the head to an upright position with respect to the shoulders. A 'laser pointer' (red dot) indicates the direction of gaze, which must be made to fall on the orange central target through pitch and yaw movements of the head. Simultaneously, the halo around the subject's viewpoint into the virtual world changes color, from red when the head is tilted far from the upright position through yellow and cyan until it turns suddenly bright green to indicate that the head is at the proper orientation. A circular arrow may appear when the head is far from the desired posture, giving the subject an indication of which way to tilt the head:

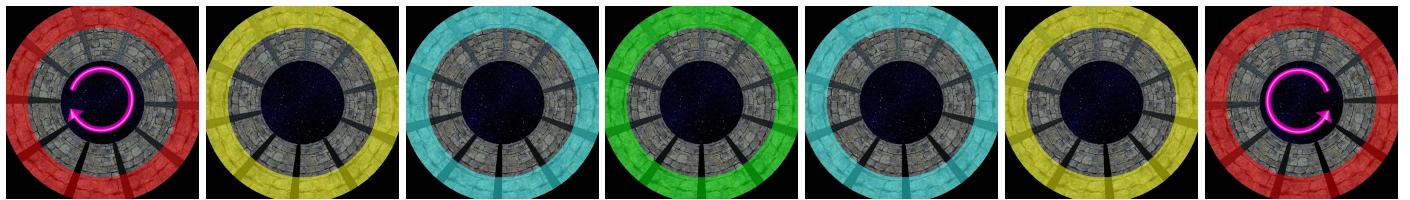


Tilted to the Left ----- Correct Orientation ----- Tilted to the Right

A target orientation is then presented to the subject in the form of a line of balls presented at the end of the tunnel:

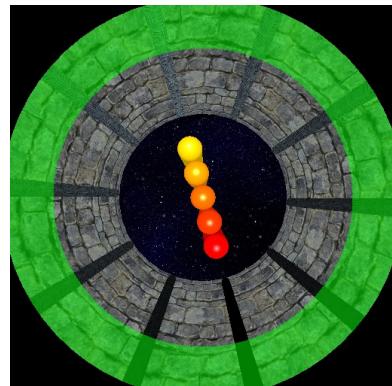


The target disappears and the subject is prompted to tilt the head to a new orientation through the same system of halo colors and direction arrows as described previously:

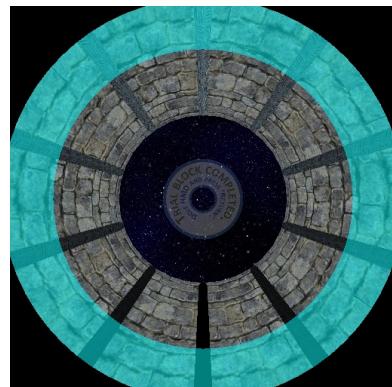


Tilted to the Left ----- Correct Orientation ----- Tilted to the Right

The subject then reproduces the remembered target orientation by turning the virtual tool using the Remote Control. The subject presses the right and left arrows of the Navigation Ring on the Remote Control to turn the virtual tool clockwise or counter-clockwise, respectively.

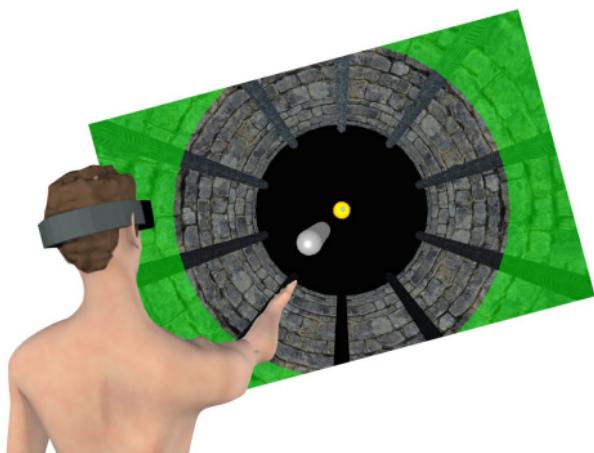
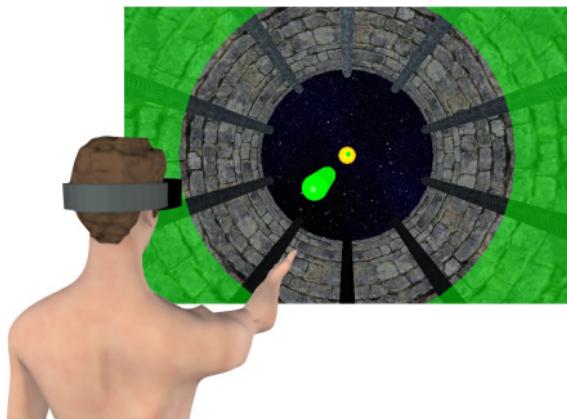


The subject presses the Center Button on the Remote Control to validate the trial and move on to the next. If the block of trials is completed, a message is displayed to let the subject know:



Note that other circular prompt with text instructions may appear at different times in response to different conditions or actions by the subject. For instance, a message will be generated if the subject does not maintain the head in the specified tilted position. All possible messages are shown in a separate section to this document.

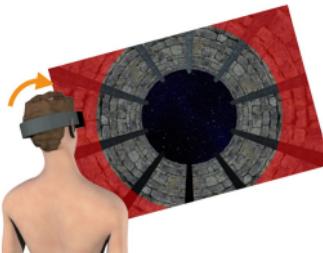
## Manual-Manual



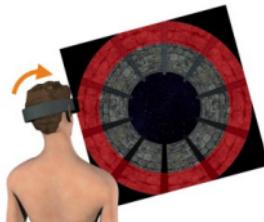
Press '**Next**' to continue.

## ***Step 1: Straighten Head***

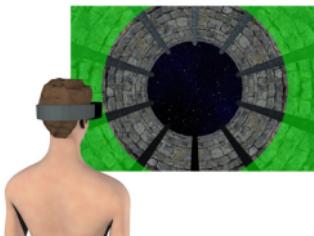
- If your head is laterally tilted with respect to the trunk, the halo will be red:



- Look straight ahead so that the virtual laser pointer falls on the central target, then slowly straighten your head on your shoulders. This will make the halo turn progressively from red to green:

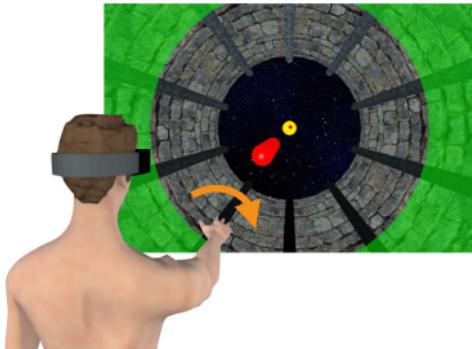


- When the halo pops to bright green, hold this position.

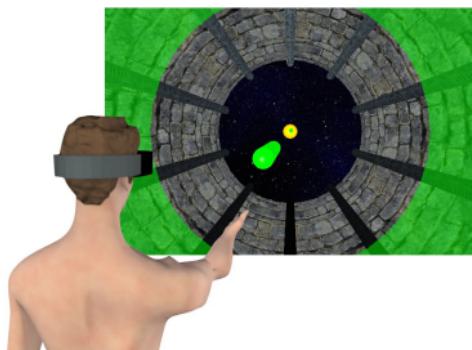


## *Step 2: Acquire the Target Orientation*

- Once your head is aligned with your body (i.e. when the halo is bright green), a yellow spherical target will appear. Raise your arm and point your hand such that the virtual laser-pointer falls on the target.



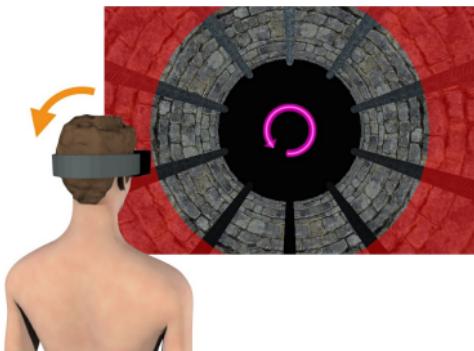
- Rotate your hand in a rolling motion around the axis of your arm until the virtual pointer and tool turn bright green. Memorise the hand orientation.



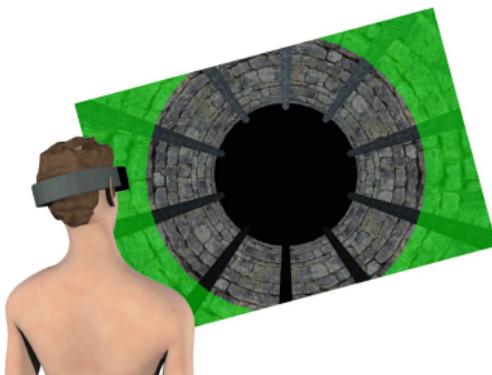
- When the target disappears, lower your arm to your side.

### ***Step 3: Tilt the Head***

- If the halo turns red, you must tilt your head to a new orientation. The arrow tells you which way to rotate the head.



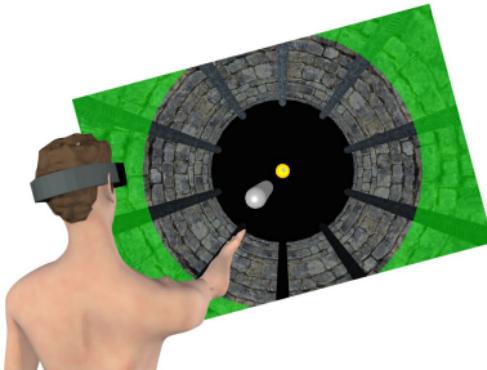
- Roll your head from side to side until the halo turns bright green and hold this position.



## ***Step 4: Align to Target***

- When the orange disk reappears, raise your arm and aim with the hand until the virtual laser pointer falls on the disk.
- Rotate your hand in a rolling motion around the axis of your arm to the remembered target orientation.

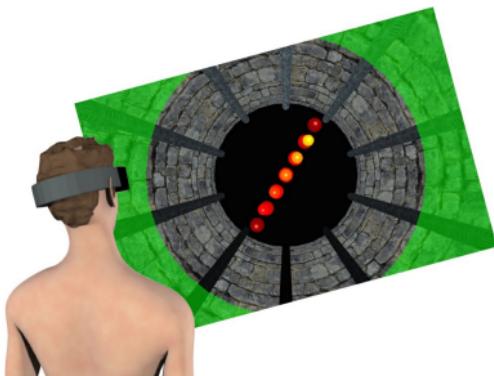
**Note:** In this phase the virtual tool gives no indication about the orientation of the hand around the roll axis. You must rotate the hand to the **remembered** orientation while pointing to the target in azimuth and elevation.



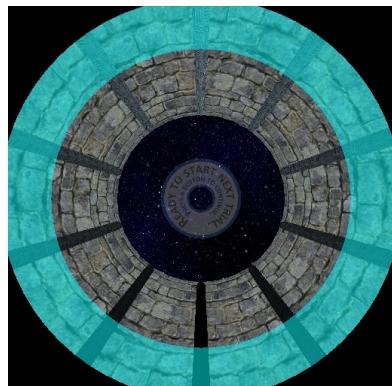
- With your left hand, press the Center Button on the ***VR Headset Remote*** to validate your response once you think your hand is aligned with the memorised target.

## ***Step 5: Check Response***

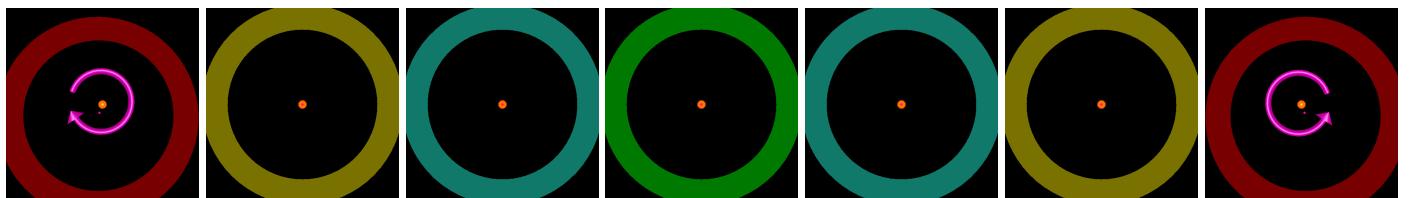
- In some of the trials a line of target balls will be projected from your hand towards the targets, allowing you to verify whether or not you correctly aligned your hand.



The Manual-Manual task starts with a welcome screen that prompts the subject to press a button in order to start a block of trials:

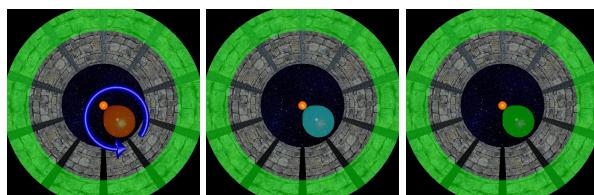


He or she is then guided to look straight ahead and bring the head to an upright position with respect to the shoulders. A 'laser pointer' (red dot) indicates the direction of gaze, which must be made to fall on the orange central target through pitch and yaw movements of the head. Simultaneously, the halo around the subject's viewpoint into the virtual world changes color, from red when the head is tilted far from the upright position through yellow and cyan until it turns suddenly bright green to indicate that the head is at the proper orientation. A circular arrow may appear when the head is far from the desired posture, giving the subject an indication of which way to tilt the head:

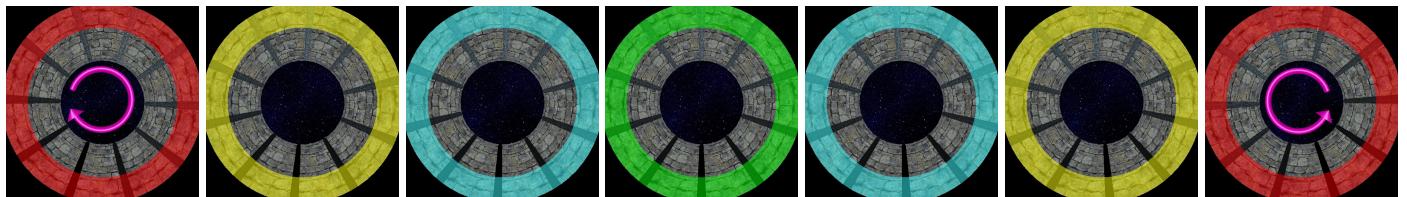


Tilted to the Left ----- Correct Orientation ----- Tilted to the Right

The subject is then guided to place the hand at the target orientation. The subject sees a) an orange spherical target at the end of the tunnel, b) a virtual representation of a tool in the visual scene (a cylinder) that moves with the hand in 3D visual space and c) a 'laser pointer' that projects from the tool along the axis of the fingers. The virtual tool changes color according to the roll orientation of the hand (pronation/supination). The subject must raise the arm in front of the body, aim the tool by moving the arm in azimuth and elevation until the laser pointer falls on the spherical target and then rotate the hand until the tool turns green. If the orientation of the hand is far from the target orientation, an arrow appears around the virtual tool showing which way to rotate the hand.

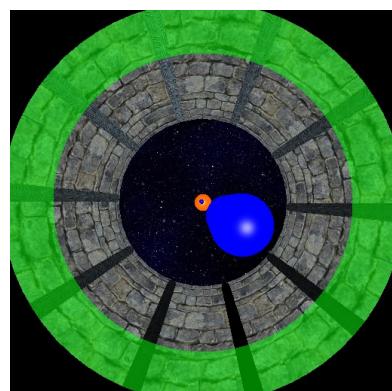


Once the target orientation has been achieved and held for 1 second, the tool and laser pointer disappear. The subject must lower the arm and is then prompted to tilt the head to a new orientation through the same system of halo colors and direction arrows as described previously:

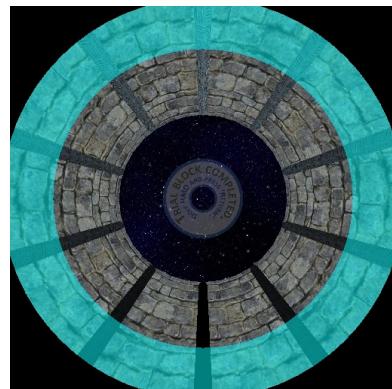


Tilted to the Left ----- Correct Orientation ----- Tilted to the Right

Finally subject then reproduces the remembered target orientation with the hand. The virtual tool, laser pointer and spherical target reappear, but this time the tool and laser pointer are constantly blue. The subject must raise the hand and aim with the laser pointer at the spherical target but then rotate the hand to the remembered orientation without any further visual cues:

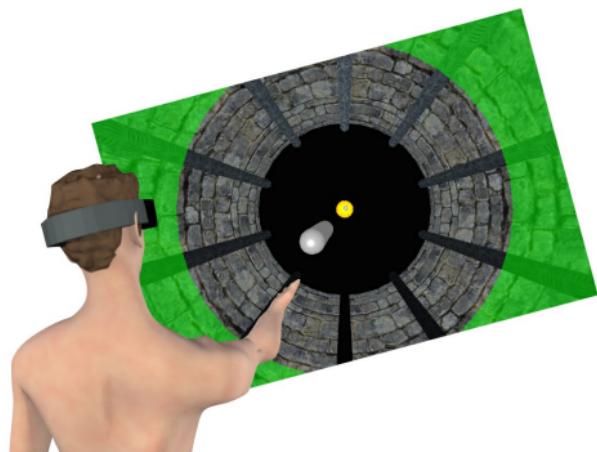
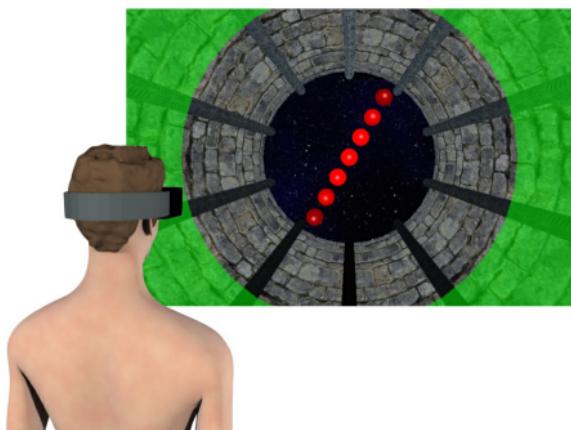


The subject presses the Center Button on the Remote Control to validate the trial and move on to the next. If the block of trials is completed, a message is displayed to let the subject know:



Note that other circular prompt with text instructions may appear at different times in response to different conditions or actions by the subject. For instance, a message will be generated if the subject does not maintain the head in the specified tilted position. All possible messages are shown in a separate section of this document.

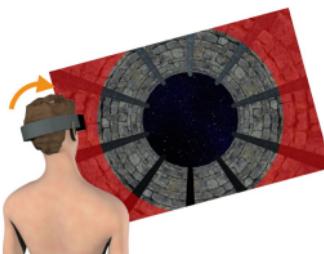
## Visual-Manual



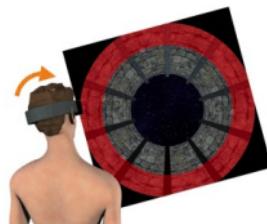
Press '**Next**' to begin.

## ***Step 1: Straighten Head***

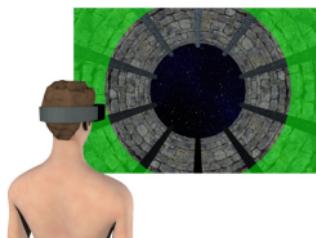
- If your head is laterally tilted with respect to the trunk, the halo will be red:



- Look straight ahead so that the virtual laser pointer falls on the central target, then slowly straighten your head on your shoulders. This will make the halo turn progressively from red to green:

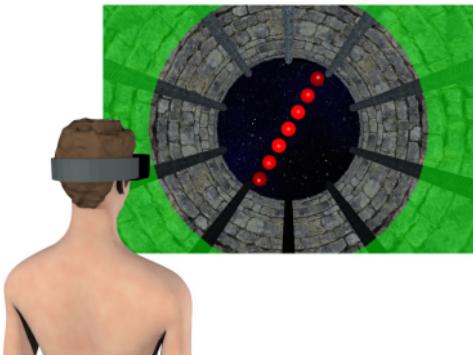


- When the halo pops to bright green, hold this position.



## *Step 2: Acquire the Target Orientation*

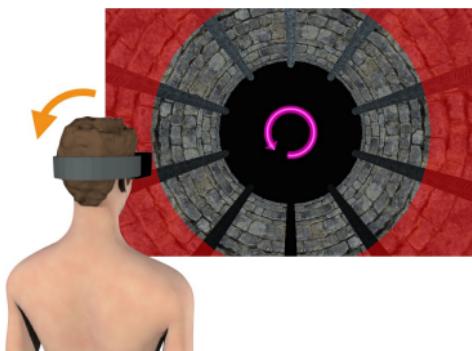
- Once your head is aligned with your body (i.e. when the halo is bright green), a line of balls will appear at the end of the tunnel, representing the target orientation.



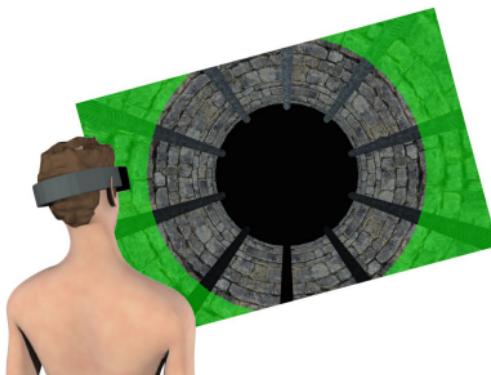
- Memorise the target orientation.

### ***Step 3: Tilt the Head***

- If the halo turns red, you must tilt your head to a new orientation. The arrow tells you which way to rotate the head.



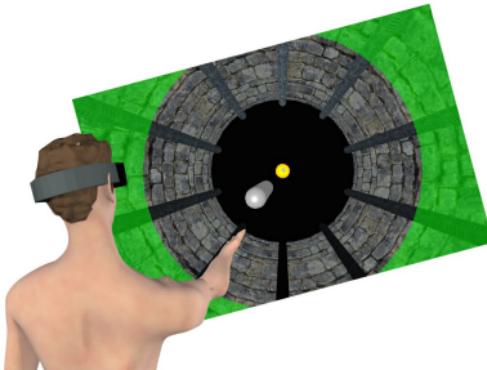
- Roll your head from side to side until the halo turns bright green and hold this position.



## ***Step 4: Align to Target***

- When the orange disk reappears, raise your arm and aim with the hand until the virtual laser pointer falls on the disk.
- Rotate your hand in a rolling motion around the axis of your arm to the remembered target orientation.

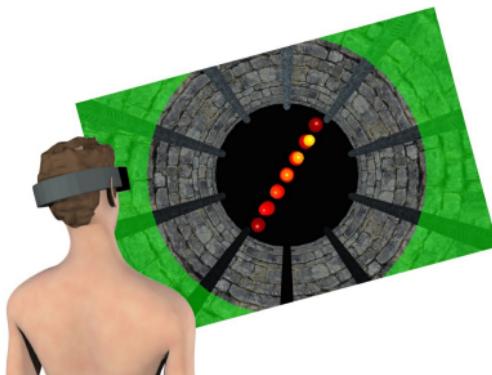
**Note:** In this phase the virtual tool gives no indication about the orientation of the hand around the roll axis. You must rotate the hand to the **remembered** orientation while pointing to the target in azimuth and elevation.



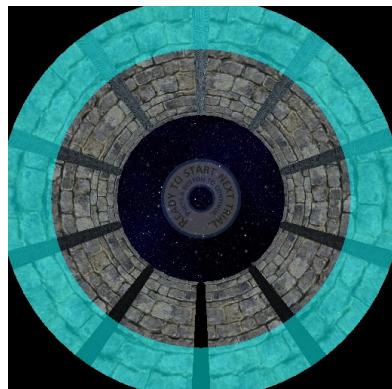
- With your left hand, press the Center Button on the ***VR Headset Remote*** to validate your response once you think your hand is aligned with the memorised target.

## ***Step 5: Check Response***

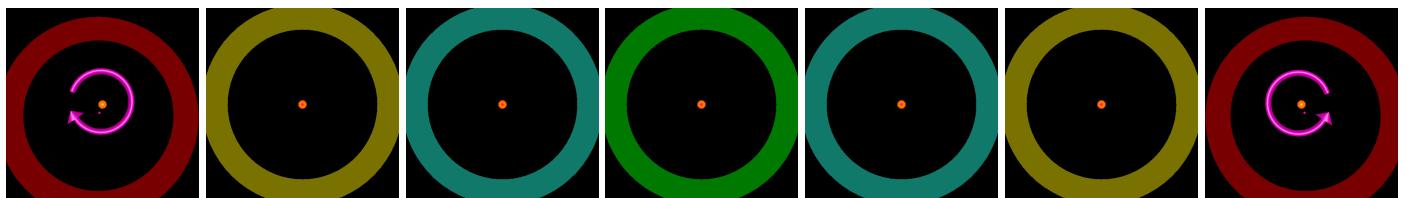
- In some of the trials a line of target balls will be projected from your hand towards the targets, allowing you to verify whether or not you correctly aligned your hand.



The Visual-Manual task starts with a welcome screen that prompts the subject to press a button in order to start a block of trials:

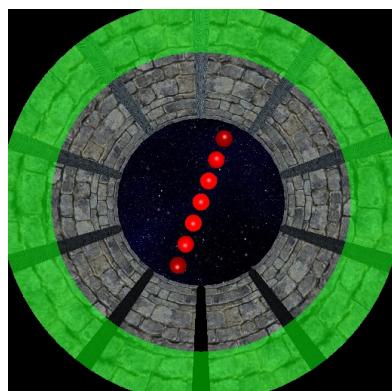


He or she is then guided to look straight ahead and bring the head to an upright position with respect to the shoulders. A 'laser pointer' (red dot) indicates the direction of gaze, which must be made to fall on the orange central target through pitch and yaw movements of the head. Simultaneously, the halo around the subject's viewpoint into the virtual world changes color, from red when the head is tilted far from the upright position through yellow and cyan until it turns suddenly bright green to indicate that the head is at the proper orientation. A circular arrow may appear when the head is far from the desired posture, giving the subject an indication of which way to tilt the head:

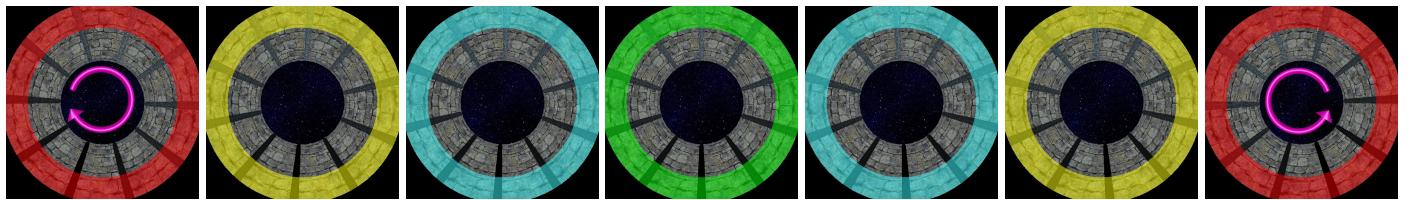


Tilted to the Left ----- Correct Orientation ----- Tilted to the Right

A target orientation is then presented to the subject in the form of a line of balls presented at the end of the tunnel:

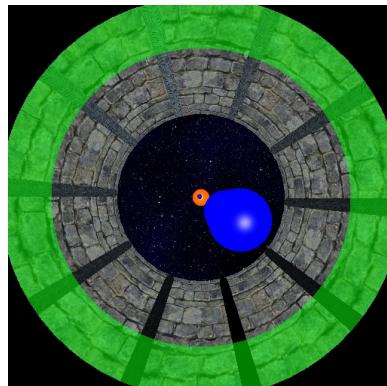


The target disappears and the subject is prompted to tilt the head to a new orientation through the same system of halo colors and direction arrows as described previously:

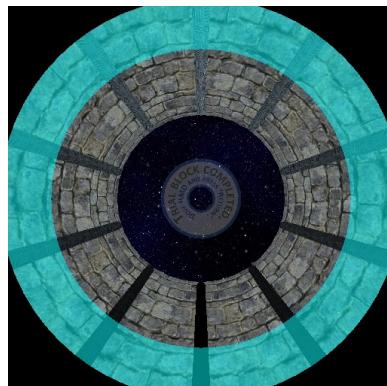


Tilted to the Left ----- Correct Orientation ----- Tilted to the Right

The subject then reproduces the remembered target orientation with the hand. The subject sees a) an orange spherical target at the end of the tunnel, b) a virtual representation of a tool in the visual scene (a cylinder) that moves with the hand in 3D visual space and c) a 'laser pointer' that projects from the tool along the axis of the fingers. The subject must raise the arm in front of the body, aim the tool by moving the arm in azimuth and elevation until the laser pointer falls on the spherical target and then rotate the palm of the hand to align with the remembered orientation of the visual target.



The subject presses the Center Button on the Remote Control to validate the trial and move on to the next. If the block of trials is completed, a message is displayed to let the subject know:



Note that other circular prompt with text instructions may appear at different times in response to different conditions or actions by the subject. For instance, a message will be generated if the subject does not maintain the head in the specified tilted position. All possible messages are shown in a separate section of this document.



BlockCompleted



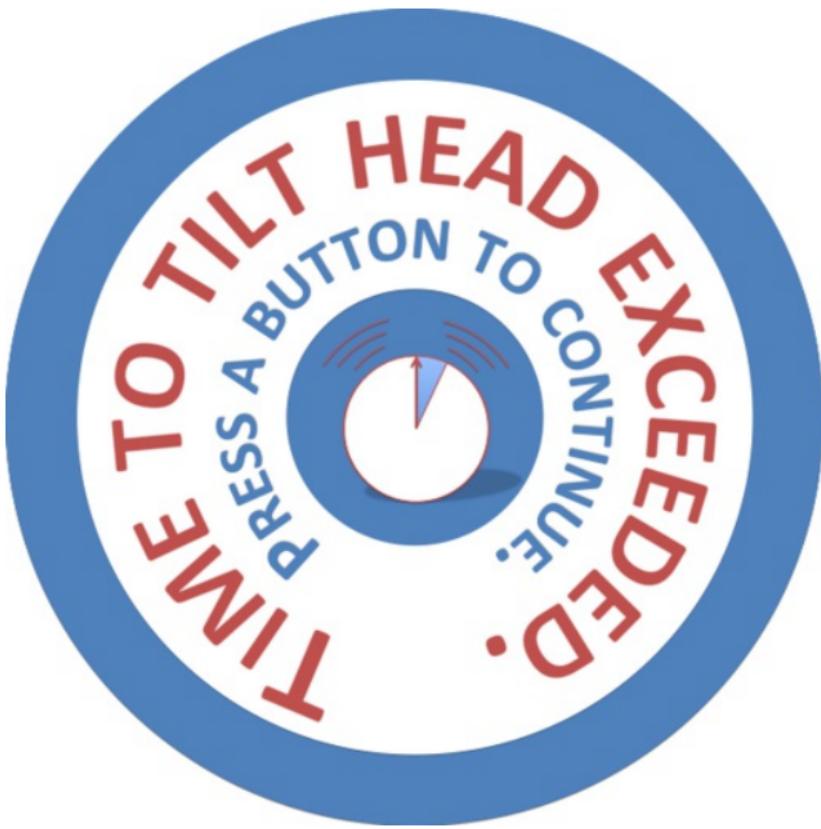
HandRotateTimeout



HandShouldNot



HandTooSoon



HeadAlignmentTimeout



HeadMisalignment



LowerArm



LowerArmTimeout



RaiseArm



RaiseArmTimeout



ReadyToStart



ResponseTimeout



TimeLimit



BlockCompleted



HandRotateTimeout



HandShouldNot



HandTooSoon



HeadAlignmentTimeout



HeadMisalignment



LowerArm



LowerArmTimeout



RaiseArm



RaiseArmTimeout



ReadyToStart



ResponseTimeout



TimeLimit