

Experiment Script:

In this study, you will be seated in our wheelchair and you will use two different interfaces to control the robotic arm. The first is a joystick that you control with your hand. The second are switches embedded within the wheelchair headrest, which you control using your head.

The session will last approximately 2 hours. If you agree to participate in this study, you can read and sign this consent form.

----- OPERATION -----

Let me first explain how you control the robot using the interface.

The 'hand' of the robot is able to move in left-right, front-back and up-down directions. [demonstrate] It is also able to rotate left-right, up-down and twisting left-right. [demonstrate]

For either control interface, you can't control all of directions at the same time. Instead you have to switch between different control modes, which you just saw me do. The light display tells you which motion directions are active in the current control mode.

With the joystick you can control 2 directions at a time, which will be shown as 2 lights on the display. Each pair of directions is 1 control mode. The joystick has a total of 4 control modes. Buttons on the joystick are used to switch between the modes. In mode number 1, you can control the motion in the left-right directions and the front-back directions. In mode 2, you can control the motions in the left-right directions and the up-down directions. In mode 3, the wrist can be controlled in two directions, rotating left and right as well as angling up and down. In mode 4, you can bent the wrist left and right. Mode 5 is used to open and close the gripper. (Demonstrate as I speak)

With the head array you can control 1 direction at a time, which will be shown as 1 light on the display. Each single direction is a control mode. The head array has a total of 6 control modes. Tapping the back of the headrest is used to switch between the modes. Tapping to the left and right moves the robot within the selected mode.

----- SAFETY -----

When controlling the robot, please be mindful that the arm has motion limitations.

Be careful not to have the arm hit itself, especially in situations like this. [demonstrate close to the base]

Try not to hit the table or other hard surfaces, especially with the fingers.

If you have any questions, just ask.

----- TASKS -----

In order for you to get familiar with the control interfaces and robot, first we will go through a training period. You will operate the arm using both interfaces. I will explain more about this in a moment.

After that we will perform the experiment. There will be two different task setups, that involve reaching objects and moving objects. You again will use both interfaces. I will explain more about this after training.

----- TRAINING -----

To begin, practice reaching this plate, as if you are going to pick it up, using the ____ (joystick or head-array). Try one more time, now from a different starting position.

This system also has the option for the robot to help you out during the motion. Try reaching for the plate again – this time the help will be on.

This type of help will always be on during the experiments.

Now we are going to introduce multiple objects. When there are multiple objects, the robot can't step in and help until it has a good idea of which object you are trying to reach.

Sometimes how quickly the robot is able to figure out which object is influenced by the control mode you are moving in.

The robot has a way to pick control modes that it thinks will help **it** figure out where **you** are trying to go.

By pressing this button [show], you can tell the robot to go ahead and pick that control mode. The lights on the display will tell you which control mode it picked.

Sometimes nothing will happen when you press that button. This just means that you are already in the control mode that the robot would have picked.

You can try this out now. Reach for one of the objects, and press the button once you are about halfway there. [They do it.]

Now try reaching for the other object, but this time press the button earlier. [They do it.]

During the experiment you can actually press the button more than once – as often as you like. Would you like to try it again? [Max 1 more.]

Let's try this again for a different set of objects. Feel free to experiment with pressing the button at any point during the motion.

[Max 2 executions.]

Now let's do the same thing with the ____ (head array or joystick) interface.

That's it for the training. I'm now going to setup the first experimental task.

----- TESTING -----

Reaching Task:

This task has 5 different objects, labeled as A, B, C, D and E.

At the start of each trial, I will tell you which object to reach for, with a specific robot hand orientation.

For example, if the target was this [demonstrate an object-gripper orientation combo with the robot hand], I would say "B" and then show you the target orientation with my own hand [demonstrate with your hand].

IF FIRST TASK: I will also tell you whether the option that we just practiced, where you press the button and the robot picks the control mode, is active.

For some trials this option will be active, and for others it won't be.

When it is active, you can press the button as many times as you like. You must press the button at least once.

IF SECOND TASK: I will also tell you whether the option, where you press the button and the robot picks the control mode, is active.

Like in the first task, for some trials this option will be active, and for others it won't be.

When it is active, you again can press the button as many times as you like and must press it at least once.

IF FIRST TASK: The robot's starting position and starting control mode will be automatically varied for each trial. The robot will move on its own to the start position, before the trial starts.

You will first use the ____ interface. We are going to perform 8 trials with this interface.

[perform trials]

We will now switch to the ____ interface. We are going to perform 8 more trials with this interface.

Two-step Task:

In this task, the robot starts with a cup in its hand. The task is to pour the cup contents into one of two bowls (A or B), and then place the cup down in one of two locations (C or D).

At the start of each trial, I will tell you which bowl to pour into.

I also will tell you where to put down the cup after pouring. The cup should be put down with a specific orientation. I will have a second cup off to the side here that shows the target orientation.

For example, if the target location was here [point] with this orientation [place 1st cup, then immediately remove], I would say “C” and orient the cup off to the side like this [orient].

To open the gripper, _____ **add text for each interface***

IF FIRST TASK: I will also tell you whether the option that we just practiced, where you press the button and the robot picks the control mode, is active.

For some trials this option will be active, and for others it won't be.

When it is active, you can press the button as many times as you like. You must press the button at least once.

IF SECOND TASK: I will also tell you whether the option, where you press the button and the robot picks the control mode, is active.

Like in the first task, for some trials this option will be active, and for others it won't be.

When it is active, you again can press the button as many times as you like and must press it at least once.

IF FIRST TASK: The robot's starting position and starting control mode will be automatically varied for each trial. The robot will move on its own to the start position, before the trial starts.

You will first use the ____ interface. We are going to perform 8 trials with this interface.

[perform trials]

We will now switch to the ____ interface. We are going to perform 8 more trials with this interface.