

Appendix D

Human performance in space telerobotic manipulation

Participant information

The experiment you are about to participate in is investigating the performance of humans operating robots at remote locations via telecommunications links. In particular, it will investigate the effects of varying certain aspects of the human-robot interface on the speed and accuracy in performing manipulation tasks.

You will be instructed in the use of a virtual reality headset and hand controllers and will be trained for approximately 15 minutes to control a robot arm to perform simple manipulation tasks. Should you successfully complete the training, following a break you will be required to perform another series of manipulation tasks, requiring approximately 20 to 30 minutes.

Important: Use of a virtual reality simulator can induce symptoms similar to motion sickness. This syndrome of effects, known as simulator sickness, can include general discomfort, fatigue, headache, eyestrain, nausea, blurred vision and dizziness. It does not affect everyone, and varies with the situation simulated. When it does occur, it usually ceases within a minute or so once exposure to the simulation is stopped. If you experience physical discomfort while in the simulator such that you do not feel you can continue, please advise the experimenter immediately and the simulation will cease. If you experience mild physical discomfort but feel you can continue, please also advise the experimenter of this.

All information and data collected in this study are kept private and confidential to the experimenter and the experimenter's supervisor. Individual participants will not be identifiable in results or publications. Your participation in this study is optional and you may withdraw your participation at any time, including the withdrawal of any information you have provided. However, by signing the consent form attached, it is understood that you have consented to participate in this experiment and to publication of the results, with the understanding that anonymity will be preserved.

If you have questions related to the study itself or the results obtained from your participation, please feel free to contact Philip Lamb, Department of Psychology, University of Canterbury, in Room 605, by phone at 364-2987 ext 7173, or by email at prl24@student.canterbury.ac.nz.

This research has been reviewed and approved by the University of Canterbury Human Ethics Committee.

Please take this sheet with you when you leave.

Human performance in space telerobotic manipulation

General demographics

Please circle the appropriate answer or fill in the spaces provided:

1. Sex: M / F
2. Age: _____
3. Handedness: Left / Right
4. Simulator experience:

“Simulator” includes full-motion simulators, head-slaved virtual reality equipment, and 3D first-person perspective computer games including flight simulators, “Quake” and “Tomb Raider” style games, and “Descent” style space flight simulations.

- None.
- Less than 5 hours.
- 5 – 50 hours
- 50 – 500 hours
- More than 500 hours

Participant consent

- I have read the participant information sheet provided and understand the description of the above-named experiment.
- On this basis, I agree to participate as a subject in the experiment, and I consent to publication of the results, with the understanding that anonymity will be preserved.
- I understand that I may withdraw my participation at any time, including the withdrawal of any information I have provided.

Name:

Signed: Date:

Student ID:

Pre-experiment simulator sickness questionnaire

In order to ensure your physical well-being following exposure to the simulator, it is necessary to enquire as to your present state of health. A similar questionnaire will be given to you following the experiment.

Please indicate the degree to which you are experiencing the following symptoms *right now*.

General discomfort	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Fatigue	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Headache	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Eyestrain	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Difficulty focusing	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Increased salivation	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Sweating	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Nausea	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Difficulty concentrating	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Fullness of head ¹	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Blurred vision	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Dizzy (eyes open)	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Dizzy (eyes closed)	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Vertigo ²	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Stomach awareness	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Burping	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>

¹ Fullness of head refers to an awareness of pressure in the head.

² Vertigo refers to a loss of orientation with respect to vertical or upright.

Are you currently experiencing any ailment or other condition outside your normal state of health that might account for any of these symptoms?

Yes

No

If yes, please indicate briefly the nature of the condition or ailment:

Thank you for your participation and cooperation.

Philip Lamb.

<i>Participant code</i>	<i>Date</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>
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Post-experiment simulator sickness questionnaire

In order to ensure your physical well-being following exposure to the simulator, please complete the following questionnaire now.

Please indicate the degree to which you are experiencing the following symptoms *right now*.

General discomfort	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Fatigue	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Headache	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Eyestrain	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Difficulty focusing	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Increased salivation	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Sweating	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Nausea	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Difficulty concentrating	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Fullness of head ¹	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Blurred vision	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Dizzy (eyes open)	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Dizzy (eyes closed)	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Vertigo ²	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Stomach awareness	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Burping	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>

¹ Fullness of head refers to an awareness of pressure in the head.

² Vertigo refers to a loss of orientation with respect to vertical or upright.

Thank you for your participation and cooperation.

Philip Lamb.

<i>Participant code</i>	<i>Date</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>

Take-home simulator sickness questionnaire

In order to ensure your physical well-being following exposure to the simulator, please complete the following questionnaire in 3 to 12 hours time, and return it to the Department of Psychology Office on Level 2 or alternately fold, seal and return it freepost by standard mail.

Please indicate the degree to which you are experiencing the following symptoms *right now*.

General discomfort	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Fatigue	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Headache	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Eyestrain	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Difficulty focusing	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Increased salivation	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Sweating	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Nausea	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Difficulty concentrating	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Fullness of head ¹	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Blurred vision	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Dizzy (eyes open)	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Dizzy (eyes closed)	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Vertigo ²	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Stomach awareness	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>
Burping	<i>None</i>	<i>Slight</i>	<i>Moderate</i>	<i>Severe</i>

¹ Fullness of head refers to an awareness of pressure in the head.

² Vertigo refers to a loss of orientation with respect to vertical or upright.

Have you participated in any activity since participating in the experiment that might account for any of these symptoms – e.g. exercise, public speaking, video games etc.?

Yes

No

If yes, please indicate briefly the nature of the activity:

Thank you for your participation and cooperation.

Philip Lamb.

<i>Participant code</i>	<i>Date</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>
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Appendix E

Detail of selected statistical analyses

Table 4. ANOVA for Task Completion Rate (§3.2.2, p35)

Source	SS	d.f.	MS	F	p
Task 1					
Between participants					
Intercept	0.297826	1	0.297826	509.8	.000**
Error	0.021615	37	0.000584		
Within participants					
VIEWFOR	0.000048	1	0.000048	0.306	.583
Error	0.005782	37	0.000156		
CTRLFOR	0.001650	1	0.001650	9.352	.0041**
Error	0.006529	37	0.000176		
VIEWFOR*CTRLFOR	0.000574	1	0.000574	3.641	.0642†
Error	0.005837	37	0.000158		
Task 2					
Between participants					
Intercept	0.091523	1	0.091523	419.8	.000**
Error	0.008066	37	0.000218		
Within participants					
VIEWFOR	0.003222	1	0.003222	55.71	.000**
Error	0.002140	37	0.000058		
CTRLFOR	0.000547	1	0.000547	12.43	.0011**
Error	0.001628	37	0.000044		
VIEWFOR*CTRLFOR	0.001237	1	0.001237	21.95	.000**
Error	0.002085	37	0.000056		
Task 3					
Between participants					
Intercept	0.045921	1	0.045921	273.5	.000**
Error	0.006211	37	0.000168		
Within participants					
VIEWFOR	0.002047	1	0.002047	36.51	.000**
Error	0.002074	37	0.000056		
CTRLFOR	0.000604	1	0.000604	10.21	.0029**
Error	0.002189	37	0.000059		
VIEWFOR*CTRLFOR	0.000091	1	0.000091	1.676	.204
Error	0.002013	37	0.000054		

Note: ** p < .01, * p < .05, † p < .10.

Table 5. ANOVA for ratio of Completion Rate pre-latch to post latch (§3.2.4, p40).

Source	SS	d.f.	MS	F	p
Task 1					
Between participants					
Intercept	275.7289	1	275.7289	351.5	.000**
Error	28.2365	36	0.7843		
Within participants					
VIEWFOR	1.2436	1	1.2436	4.52	.040*
Error	9.8950	36	0.2749		
CTRLFOR	1.0997	1	1.0997	2.69	.110
Error	14.7257	36	0.4090		
VIEWFOR*CTRLFOR	0.8910	1	0.8910	2.93	.095†
Error	10.9384	36	0.3038		
Task 2					
Between participants					
Intercept	369.9266	1	369.9266	293.4	.000**
Error	37.8199	30	1.2607		
Within participants					
VIEWFOR	0.0037	1	0.0037	0.0058	.940
Error	19.4108	30	0.6470		
CTRLFOR	5.9393	1	5.9393	5.66	.024*
Error	31.4795	30	1.0493		
VIEWFOR*CTRLFOR	15.0115	1	15.0115	19.79	.000**
Error	22.7563	30	0.7585		
Task 3					
Between participants					
Intercept	209.5697	1	209.5697	157.8	.000**
Error	27.8979	21	1.3285		
Within participants					
VIEWFOR	13.2957	1	13.2957	10.62	.004**
Error	26.2986	21	1.2523		
CTRLFOR	0.1027	1	0.1027	0.099	.757
Error	21.8894	21	1.0424		
VIEWFOR*CTRLFOR	1.2259	1	1.2259	1.10	.306
Error	23.4294	21	1.1157		

Note: ** p < .01, * p < .05, † p < .10.

Table 6. ANOVA for log_e of total head movement (§3.5, p50).

	SS	d.f.	MS	F	p
Between participants					
Intercept	529.2	1	529.2	458.1903	.000**
Error	42.7	37	1.16		
Within participants					
TASK	147.4	2	73.7	303.0549	.000**
Error	18.00	74	0.243		
VIEWFOR	116.0	1	116.0	851.0701	.000**
Error	5.04	37	0.1363		
CTRLFOR	0.485	1	0.4850	2.4902	0.123
Error	7.21	37	0.1948		
TASK*VIEWFOR	2.32	2	1.1608	6.0423	.0037**
Error	14.22	74	0.1921		
TASK*CTRLFOR	0.0865	2	0.0433	0.2413	.786
Error	13.26	74	0.1792		
VIEWFOR*CTRLFOR	0.0496	1	0.0496	0.3547	.555
Error	5.18	37	0.1400		
TASK*VIEWFOR*CTRLFOR	0.174	2	0.0868	0.6954	.502
Error	9.24	74	0.1248		

Note: ** $p < .01$, * $p < .05$, † $p < .10$.

Table 7. ANOVA for total hand controller work (§3.6, p52).

Source	SS	d.f.	MS	F	p
Between participants					
Intercept	805739.	1	805739	771.4829	.000**
Error	38643	37	1044		
Within participants					
TASK	73226	2	3661	152.2809	.000**
Error	17792	74	240.4		
VIEWFOR	3100	1	3100	20.7550	.000**
Error	5527	37	149.4		
CTRLFOR	712	1	713	5.6981	.022*
Error	4628	37	125.1		
TASK*VIEWFOR	1810	2	905	7.3447	.0012**
Error	9121	74	123.3		
TASK*CTRLFOR	106.9	2	53.5	0.5597	.574
Error	7068	74	95.5		
VIEWFOR*CTRLFOR	18.6	1	18.6	0.2129	.647
Error	3224	37	87.1		
TASK*VIEWFOR*CTRLFOR	1208	2	604	5.1820	.0078
Error	8631	74	116.6		

Note: ** p < .01, * p < .05, † p < .10.