User-Exoskeleton Interaction Observation Questionnaire

-

EXPERIMENTER GUIDE

User Exoskeleton Interaction Observation Protocol

This protocol aims to measure some behavioural indicators of user-machine interaction. It describes the quality of the interaction occurring between the wearer and the lower-limb exoskeleton.

<table>
<tr><td rowspan="2" style="background:#4472C4;color:white;"></td><td colspan="3" style="background:#70AD47;">Instruction</td></tr>
<tr><td style="background:#4472C4;color:white;">Step</td><td style="background:#4472C4;color:white;">Description</td><td style="background:#4472C4;color:white;">Complementary information</td></tr>
</table>

	Step	Description	Complementary information
Protocol description	1 - Instruction	The experimenter provides instructions to the participant.	The instruction will be: "We ask you to go up and down the stairs wearing the exoskeleton. While you perform the task, a video camera will record the execution of the task."
	2 - Activate Video Recording	Start camera recording	
	3 - Start data collection	The experimenter compile the checklist items	The checklist encompasses the following item: Time required to donning and doffing the exoskeleton; Number of steps climbed and down; Number of times the user stumble when ascending or descending the stairs; Is the crutch used during the test; Is the torso bent forward (provoke high load of upper limbs when crutches are used) to avoid falling backward; During the Anterolateral shifting of body center of gravity, is the swing leg adequately relieved to initiate the stride correctly; Number of error messages by the HMI (Human Machin-Interface); Number of times the safe mode has been activated (the system switched off) when the situation requires it and did not require it.
	4 - Participant starts the task	The participant wears the exoskeleton and positions him/herself in front of the stairs.	
	5 - Participant Preparation	The participant complete ascending and descending the stairs.	
	6 - Stop video recording	Stop camera recording.	
	7 - Check for data missing	The experimenter watches the recorded video, adjusting the checklist if data was missing or the observation was not appropriated. Delete the video recorded at the end.	

1.1.1 User-Exoskeleton Interaction (UEI) Questionnaire

The experimenter will perform an observational analysis of the participant wearing the lower-limb exoskeleton (LLE) while both ascending and descending the staircase-based testbed.

The observational analysis will be performed by means of a quantitative checklist, which items reflect the quality of the interaction occurring between the wearer and the LLE.

The run will be video recorded should the experimenter be distracted or make any mistake while observing.

In the observational checklist, "stair level" refers to the "step" as a component or part of the staircase-based testbed, whereas "steps walked" refers to the steps physically moved by the legs of the user. Also, "HMI" means "Human-Machine Interface" and refers to the user interface with which the LLE may be equipped. "Number of error messages" refers to the possible occurrence of malfunctions of the LLE which the HMI would report. "Safe mode" refers to the LLE stopping due to the occurrence of malfunctions.

1.1. Time required to donning the exoskeleton.	0 – 1 min.	5 – 10 min.	> 10 min.	N/A
	1	2	3	
	High	Medium	Low	
1.2. Time required to doffing the exoskeleton.	0 – 1 min.	5 – 10 min.	> 10 min.	N/A
	1	2	3	
	High	Medium	Low	
1.3. Number of stair levels climbed up.	4 – 6	2 – 4	0 – 1	N/A
	1	2	3	
	High	Medium	Low	
1.4. Number of stair levels climbed down.	4 – 6	2 – 4	0 – 1	N/A
	1	2	3	
	High	Medium	Low	
1.5. Number of steps walked up.	6	7-8	9-12	N/A
	1	2	3	
	High	Medium	Low	
1.6. Number of steps walked down.	6	7-8	9-12	N/A
	1	2	3	
	High	Medium	Low	
1.7. Number of times the user stumbled while ascending the stairs.	0 – 1	2 – 5	> 5	N/A
	1	2	3	
	High	Medium	Low	
1.8. Number of times the user stumbled while descending the stairs.	0 – 1	2 – 5	> 5	N/A
	1	2	3	
	High	Medium	Low	
1.9. Is the crutch used during the test?	No		Yes	N/A
	1		3	
	High		Low	
1.10. In general, is the torso bent forward (*provoke high load of upper limbs when crutches are used*) to avoid falling backwards?	No		Yes	N/A
	1		3	
	High		Low	
1.11. During the Anterolateral shifting of body centre of gravity, is the swing leg adequately relieved to correctly initiate the stride?	Yes		No	N/A
	1		3	
	High		Low	
1.12. Number of error messages sent by the HMI (*Human-Machine Interface*).	0 – 1	2 – 3	> 3	N/A
	1	2	3	
	High	Medium	Low	
1.13. Number of times the safe mode has been activated (*the system switched off*) when the situation did not require it?	0 – 1	2 – 3	> 3	N/A
	1	2	3	
	High	Medium	Low	
1.14. Has the safe mode not been activated (*the system did not switch off*) when the situation did require it?	No		Yes	N/A
	1		3	
	High		Low	

UEI Observational Checklist Scoring Algorithm

(1.1. + 1.2. + 1.3. + 1.4. + 1.5. + 1.6. + 1.7. + 1.8. + 1.9. + 1.10. + 1.11. + 1.12. + 1.13. + 1.4.) / 14

UEI benchmarking thresholds

Min. score = 1
Max. score = 3
1 < high UEI quality < 1.5
1.6 < medium UEI quality < 2
2.1 < low UEI quality < 3