Dataset documentation: A feasibility study for validating robot actions using EEG-based error-related potentials

Manuscript:	A feasibility study for validating robot actions using EEG-based error-related potentials
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Introduction

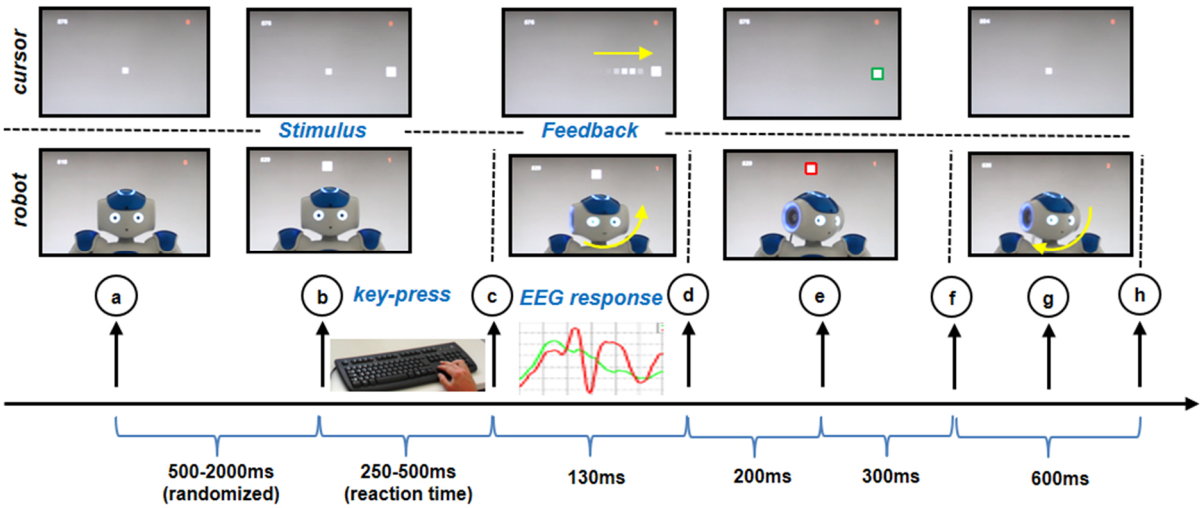
The purpose of the experiment was the investigation of perceived machine error in human-robot interaction. As the specific shape of such error-potentials (ErrPs) is different in different interaction scenarios (human-human, human-computer or human-robot) and only little work has been done to investigate error-potentials in human-robot interactions, this dataset investigates exactly this case. If ErrPs can be reliably classified from the EEG recording of the robot's operator they provide an intuitive way to evaluate the robot's actions in an unwitting and non-interrupting way. Furthermore, they can also be used to improve the system performance by detecting wrong robot behavior.

Scenarios

The experiment consisted of two scenarios which implemented different human interaction scenarios. In the first scenario (cursor scenario), the participants were involved in a human-computer interaction, where the computer exhibited randomized erroneous responses to the participants commands with a certain probability (pErr). In the second scenario (robot scenario), the participant had control over a humanoid robot and hence participated in a human-robot interaction. Besides the representation of the interaction and the feedback (moving square on screen versus head-movement of the robot) all other parameters such as the EEG hardware and EEG setup or the recording environment were the same in both scenarios.

Trial structure

a	Trial start
b	target stimulus presentation (in this case up)
c	participant response in form of arrow key press, start robot head movement
d	end robot head movement
e	target border feedback presentation (correct: green; incorrect: red)
f	disappearance target and start robot head turning back
g	ongoing robot head turning back
h	end of robot head turning back, updating average reaction time and error count



Study protocol

Number of subjects	12 (age: 30.3±7.3, 5 females, 8 males)
Number of scenarios	2 (cursor, robot)
Number of sessions	2 (one per scenario, conducted on after the other)
Number of blocks per session	10 (duration ~2.5 min)
Number of trials per block	50
Total number of trials	500 per subject and session
Total duration	~60 min
Number of error trials	~175 per subject and session
Number of non-error trials	~325 per subject and session
Error probabilities	$pErr_1$ = 20% and $pErr_2$ = 50% (pseudo-randomized and equally distributed)

Hardware

EEG amplifier and electrodes	Brain Products actiChamp amplifier; 32 active electrodes
Sampling rate	Recorded with 1000 Hz; downsampled to 256 Hz
Electrodes and placement	FP1, FP2, F3, F4, F7, F8, FC1, FC2, FC5, FC6, C3, C4, T7, T8, CP5, CP6, P3, P4, P7, P8, TP9, TP10, O1, O2, Fz, Cz, Pz, EOG1, EOG2, EOG3 (placement according to 10-20 system)
EOG channels	Central forehead (EOG3), left (EOG1) and right (EOG2) outer canthi
Referencing	Average of TP9 and TP10 (average mastoids referencing); same reference for both for EEG and EOG channels
Robot (in scenario 2 'robot')	Softbank Robotics NAO, 58cm tall humanoid robot with 21-25 degrees of freedom
Temporal data-linking	LED + photodiode at the back of robot's head

Trigger/Marker information in EEG data:

S1	Presentation of stimulus – left
S2	Presentation of stimulus – up
S3	Presentation of stimulus – right
R1	Response arrow key – left
R2	Response arrow key – up
R3	Response arrow key – right
S4	Feedback no error
S5	Feedback human error
S6	Feedback machine error
FB1	Feedback left
FB2	Feedback up
FB3	Feedback right
S7	Appearance of feedback (color-frame)
S8	Start robot head moving back
S9	End of trial

Dataset organization:

Filename	Description
s02_cursor.set/.fdt	Subject s02, cursor-scenario
s03_cursor.set/.fdt	Subject s03, cursor-scenario
s04_cursor.set/.fdt	Subject s04, cursor-scenario
s05_cursor.set/.fdt	Subject s05, cursor-scenario
s06_cursor.set/.fdt	Subject s06, cursor-scenario
s07_cursor.set/.fdt	Subject s07, cursor-scenario
s08_cursor.set/.fdt	Subject s08, cursor-scenario
s09_cursor.set/.fdt	Subject s09, cursor-scenario
s10_cursor.set/.fdt	Subject s10, cursor-scenario
s11_cursor.set/.fdt	Subject s11, cursor-scenario
s12_cursor.set/.fdt	Subject s12, cursor-scenario
s13_cursor.set/.fdt	Subject s13, cursor-scenario
s02_robot.set/.fdt	Subject s02, robot-scenario
s03_robot.set/.fdt	Subject s03, robot-scenario
s04_robot.set/.fdt	Subject s04, robot-scenario
s05_robot.set/.fdt	Subject s05, robot-scenario
s06_robot.set/.fdt	Subject s06, robot-scenario
s07_robot.set/.fdt	Subject s07, robot-scenario
s08_robot.set/.fdt	Subject s08, robot-scenario
s09_robot.set/.fdt	Subject s09, robot-scenario
s10_robot.set/.fdt	Subject s10, robot-scenario
s11_robot.set/.fdt	Subject s11, robot-scenario
s12_robot.set/.fdt	Subject s12, robot-scenario
s13_robot.set/.fdt	Subject s13, robot-scenario