

Simultaneous encoding of speed, distance, and direction in discrete reaching: an EEG study

Associated Publication

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Experimental Paradigm

Twenty participants were recruited for this study. They performed directional discrete hand movements according to the visual on the screen with varying degrees of speed and distance. A trial consisted of the center-out (CO) movement in the first half and the center-in (CI) movement in the opposite direction in the second half. A 5 x 5 grid was presented on the screen with a white dot at the center of the grid. The dot then moves in one direction (up, right, down, left) with one type of distance (near or far) and one type of speed (slow or quick). The dot then stopped at one of the targets on the screen. Participants were instructed to follow the dot while it moved with their eyes and then fixate their gaze on the dot. They were then instructed to wait approximately 1 second before initiating the same movement as the dot. The color of the dot changed according to their movement, if they performed the correct movement (in this case, only the direction of the movement was checked) then the dot turned green and then the second half of the experiment was initiated with the same sequence of event but with CI movement of the opposite direction such that the participants moved their hand back to the initial position at the start of the trial when the trial ended. On the other hands, the dot turned red if the participant performed incorrect movement or if no movement was detected within 10 second and the trial was terminated. In this case, participants moved their hand back at the center position, waiting for the start of the next trial.

In the Eye blocks, participant blinked, moved their eye horizontally and vertically according to the visual cue on the screen. The goal of this measurement was to use this part of the data to train the eye artifact correction model that was applied to the trial blocks as well.

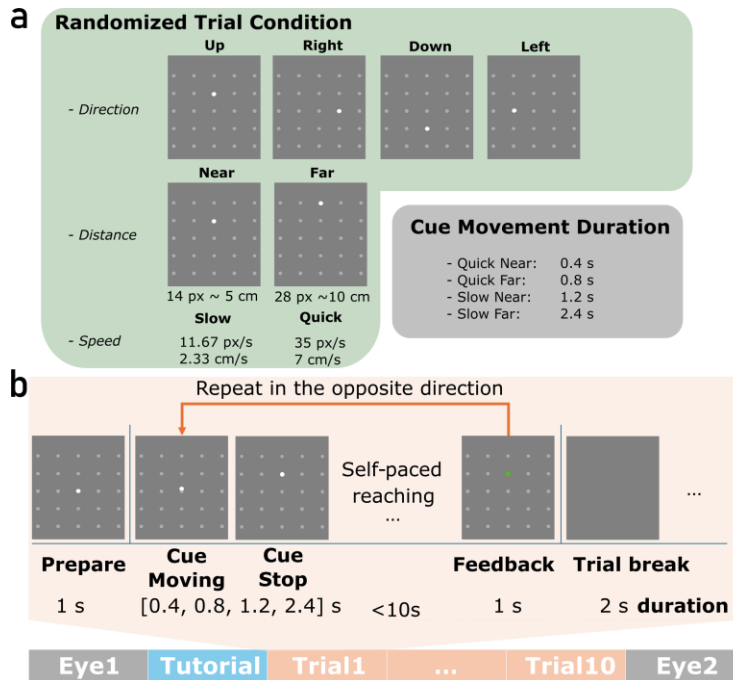


Figure 1: Overview of the experimental design

Data Acquisition

The participants were mounted with 4 EOG channels (EOGL1, EOGL2, EOGL3, EOGR1) and 60 EEG channels (AF7, AF3, AFz, AF4, AF8, F7, F5, F3, F1, Fz, F2, F4, F6, F8, FT7, FC5, FC3, FC1, FCz, FC2, FC4, FC6, FT8, T7, C5, C3, C1, Cz, C2, C4, C6, T8, TP7, CP5, CP3, CP1, CPz, CP2, CP4, CP6, TP8, P7, P5, P3, P1, Pz, P2, P4, P6, P8, PPO1h, PPO2h, PO7, PO3, POz, PO4, PO8, O1, Oz, O2). The sampling rate is 500 Hz. The reference electrode was placed on the right mastoid, and the ground electrode was placed at the FPz using the standard EEG layout. EOGL1, EOGL2, EOGL3 were placed on the left side, above, and below the left eye, and EOGR1 was placed on the right side of the right eye.

Hand kinematics were also measured with a custom-made motion caption system during the trial blocks. A camera pointed downward measured the position of the marker taped on the participant's index finger. The kinematics are the position (x, y) and the velocity (vx, vy) in 2 dimensions. The velocity was computed by linear approximation of the position. The validity of the measurement was also included, which can be either 0 when no marker is detected or 1 when the marker is detected. The kinematics was measured at 30 Hz but upsampled to 500 Hz to match the sampling rate of EEG data.

Dataset

There is a zip file per participant, which contains 2 types of files: *.set and *.fdt, which each correspond to one EEGLAB dataset. The filenames are named {participant code} - {block type}, containing all runs of the corresponding block type concatenated into one continuous dataset.

In the Trial blocks, there are in total 71 channels with extra 7 channels: x, y, vx, vy, validity (from the motion capture system) and targetPosX, targetPosY (the actual position of the dot on the screen).

The timing of the event was also provided with the following event code:

Event Code	Meaning
8000	Start of run
1000	Start of Trial block
1100	Start of Trial (CO)
1200	Target move (CO)
1300	Target stop (CO)
1400	Hand detected (CO)
1900	Time out (CI)
2100	Start of Trial (CI)
2200	Target move (CI)
2300	Target stop (CI)
2400	Hand detected (CI)
2900	Time out (CI)
1999	Trial break
1	Up
2	Right
3	Down
4	Left
10	Near
20	Far
100	Slow
200	Quick
10000	Correct direction detected
-10000	Incorrect direction detected

The condition of the current trial is presented with 3-digit encoding at the same time as the Target move event (“1200” or “2200”). For example, “124” means Slow, Far, up movement. The direction of the actual movement is coded with the same convention at the same time as the hand-detection event (“10000” and “-10000”). **To summarize, the 3-digit event code signifies the condition (Speed, distance, direction) of the cue in the current trial, while the 1-digit event code signifies the detected direction of movement from the participant.**

In the Eye blocks, there were only 64 channels of EOG and EEG with the event code:

Event Code	Meaning
1000	Start of trial
-1000	End of trial
1	Rest
2	Horizontal
3	Vertical
4	Blink

Please refer to [1] and [2] for more details on data processing and model training of the eye artifact correction algorithm.

References

[1] R. J. Kobler, A. I. Sburlea, C. Lopes-Dias, A. Schwarz, M. Hirata, and G. R. Muller-Putz, "Corneo-retinal-dipole and eyelid-related eye artifacts can be corrected offline and online in electroencephalographic and magnetoencephalographic signals," *NeuroImage*, vol. 218, p. 117 000, Sep. 2020, ISSN: 10538119. DOI: [10.1016/j.neuroimage.2020.117000](https://doi.org/10.1016/j.neuroimage.2020.117000)

[2] <https://github.com/rkobler/eyeartifactcorrection>