README

Contact: Lewis Wheaton

Email: lewis.wheaton@ap.gatech.edu

Phone: (410) 207–9419

Methods: Electroencephalography, motion capture, signal analysis, statistical tests

Format: text and binary

Source code:

.m	MATLAB source code
.Rmd	R source code
.csv	Comma–separated variables
.xlsx	Excel data

Location where data collected: 575 14th ST NW, Atlanta, Ga 30318

Time period during which data were collected: 2017–01–23 to 2019–08–27

Uncertainty: electroencephalographic data were collected at 1000Hz, motion capture data were collected at 100Hz

Description of parameters/variables: see details below in File Information

Software: Matlab 2021b, RStudio 1.4.869, R 4.0.2, EEGLAB v2021.0, Excel 16.49

Code and data files are grouped by the figures or statistical results that they created.

aim2_settings.m path and global defines for other Matlab functions.

Fig. 3

(a) Time-normalized grasp aperture from movement begin to movement end

Left: bootstrap (n=2000) mean ± 95% bootstrap confidence in…

- aperture_cache.mat

  - Variables:

  - apr_profile: grasp aperture data. condition x movement x normalized time

  - apr_profile_cnt: counts of the valid elements for each condition

  - bs_apr_cis_nf: bootstrap confidence intervals for the nf condition

  - bs_apr_cis_vf: bootstrap confidence intervals for the vf condition

  - bs_apr_means_nf: bootstrap mean for the nf condition

  - bs_apr_means_vf: bootstrap mean for the vf condition

  - COND_NF: 1

  - COND_VF: 2 constant index definitions for the first dimension of the apr_profile matrix

- plot_nf_vf_cont_grasp_profile.m processes aperture_cache.mat and produces the plot

Right: bar plots of bootstrap means ±95 % CI in 10 % bins with differences of p<0.05 denoted by overbars.

- kine_apr_profiles.csv

    Aperture measurements during executing the task. Time–normalized to 200 units.

  - Columns:

  - subject: the subject (participant) number

  - condition: the condition, nf, vf

  - epoch: the epoch number

  - move: move number within the epoch

- apr_ndx: index (1–200) of the time–normalized movement

- apr_profile: aperture measurement

- extract_mean_apr_profiles.m reads kine_apr_profiles.csv, calculates the mean by bin, and produces kine_apr_mean_profiles.csv.

- kine_apr_mean_profiles.csv

    Aperture profile mean values calculated in 10% of the time–normalized movement increments

    - Columns:

    - subject: the subject (participant) number

    - condition: the condition, nf, vf

    - epoch: the epoch number

    - apr_ndx: index (1–200) of the time–normalized movement (10% increments)

    - apr_mean: aperture mean during this 10% of the movement

    - trimmed_mean: not used

    - se_trimmed_mean: not used

- aperture_sig_test.R

    - Reads `kine_apr_mean_profiles.csv`, runs statistical tests, and creates kine_apr_mean_profiles_nf_vf_p–values.csv.

- kine_apr_mean_profiles_nf_vf_p–values.csv

    Measures of statistical difference between the nf and to conditions.

    - Columns:

    - pct: percent of the time–normalized movement

    - pvalue: measure of statistical difference at the time interval

    - tvalue: as pvalue

    - df: degrees of freedom

- cilow:
- cihigh: low and high confidence invent values
- effsize: measure of effect size (Wilcox's Q)
- plot_nf_vf_grasp_bars.m creates the bar graph and marks significant differences.

(b) Peak grasp aperture during reach to grasp phase, by disc size and condition. Horizontal bars indicate mean values. Dots represent data points. Disc sizes denoted by dashed horizontal lines (sml=small (2.2cm), med=medium (3.7cm), lrg=large (5.0cm)). Conditions: nf = no vibrotactile feedback during transport phase, vf = with vibrotactile feedback during transport phase. No statistically significant difference between feedback conditions (p > 0.05)

- kinematics_nf_vf.csv
- Columns:
- group not used
- subject subject number
- condition nf or vf
- trial trial number (1–30)
- move_num move number within trial (1–6)
- move_begin_time button release time

- grasp_begin_time when aperture begins increasing

- trans_begin_time when prosthesis grasps disc

- trans_peak_vel peak velocity during transport

- trans_peak_vel_time when peak transport velocity occurs

- trans_end_time when the disc is released

- app_peak_time when the peak aperture occurs during reach to grasp

- app_peak_amount size of the aperture at peak grasp aperture

- app_peak_ratio not used

- app_overshoot_norm not used

- app_peak_vel not used

- app_move_peak_vel not used

- diameter_and_aperture_by_disc_nf_vf.R reads kinematics_nf_vf.csv and produces the pirate plot of peak apertures during reach to grasp.

- peak_aperture_by_disc_cond_p–values.txt statistical results of comparing peak grasp apertures between nf and vf conditions.

Peak Aperture Timing Statistics

- kinematics_nf_vf.csv See above for column description

- kine_aperture_timing.R statistical analyses of aperture peak time

- kine_aperture_timing.txt results of statistical analyses

Fig. 4

(a) Time-normalized movement velocity during the reach to grasp phase (from move begin to disc grasp), bootstrap (n=2000) mean ± bootstrap confidence interval. Velocity is above zero because the participant has released the button and is in motion at the beginning of the reach.

Left: plots of time-normalized bootstrap means ±95 % CI.

- velocity_cache.mat cached velocity data

  - Variables

  - BOOT_B number of bootstrap iterations

  - COND_NF constant to index arrays

  - COND_VF constant to index arrays

  - bs_rtg_cis_nf bootstrap reach to grasp confidence intervals for the nf condition

  - bs_rtg_cis_vf bootstrap reach to grasp confidence intervals for the vf condition

  - bs_rtg_means_nf bootstrap reach to grasp means for the nf condition

  - bs_rtg_means_vf bootstrap reach to grasp means for the vf condition

  - bs_trans_cis_nf bootstrap transport confidence intervals for the nf condition

  - bs_trans_cis_vf bootstrap transport confidence intervals for the vf condition

  - bs_trans_means_nf bootstrap transport means for nf conditions

  - bs_trans_means_vf bootstrap transport means for vf conditions

  - rtg_vel_profile_cnt number of profiles for each condition

  - rtg_vel_profiles velocity profiles for each condition

- subject_cnt number of subjects for each condition

- trans_vel_profile_cnt number of profiles for each condition

- trans_vel_profiles transport velocity profiles for each condition

- plot_nf_vf_cont_rtg_vel.m plot the continuous reach to grasp velocity profile for each condition

Right: bar plots of bootstrap means ±95 % CI in 10 % bins wit…

- kine_rtg_velocity.csv

  - Columns

  - subject subject number

  - condition nf or vf

  - epoch trial (epoch) number

  - move move number within the trial (1–6)

  - rtg_ndx bin of this sample (1–200)

  - rtg_vel mean velocity at sample bin

- extract_mean_rtg_vel.m calculates mean across moves for each subject

- kine_rtg_velocity_mean.csv

  - Columns

  - subject subject number

  - condition nf or vf

  - epoch trial (epoch) number

  - rtg_ndx bin of this sample (1–200)

  - rtg_vel mean velocity at sample bin

- rtg_vel_sig_test.R Performs statistical tests between conditions

- kine_rtg_velocity_mean_nf_vf_p–values.csv results of statistical tests

  - Columns

  - pct percent of time–normalized movement

  - pvalue the statistical difference between the two conditions

  - tvalue as the pvalue

  - df degrees of freedom for the comparison

  - cillow, cihigh the confidence interval

  - effsize the Wilcox's Q effect size

- Reach to grasp velocity statistics.xlsx Summarized statistics

- plot_nf_vf_rtg_vel_bars.m plot the bar graph plot of reach to grasp velocity with statistical significance marked

(b) Time-normalized movement velocity during the transport phase (from disc grasp to disc release), bootstrap (n=2000) mean ± bootstrap confidence interval

Left: plots of time-normalized bootstrap means ±95 % CI.

- velocity_cache.mat see above

- plot_nf_vf_cont_trans_vel.m plot the continuous transport velocity profile for each condition

Right: bar plots of bootstrap means ±95 % CI in 10 % bins with differences of p<0.05 denoted by overbars.

- kine_trans_velocity.csv

  - Columns

  - subject subject number

- condition nf or vf

- epoch trial (epoch) number

- trans_ndx bin of this sample (1–200)

- trans_vel mean velocity at sample bin

- extract_mean_trans_vel.m calculates mean across moves for each subject

- kine_trans_velocity_mean.csv

  - Columns

  - subject subject number

  - condition nf or vf

  - epoch trial (epoch) number

  - trans_ndx bin of this sample (1–200)

  - trans_vel mean velocity at sample bin

- trans_vel_sig_test.R Performs statistical tests between conditions

- kine_trans_velocity_mean_nf_vf_p–values.csv

  - Columns

  - pct percent of time–normalized movement

  - pvalue the statistical difference between the two conditions

  - tvalue as the pvalue

  - df degrees of freedom for the comparison

  - cillow, cihigh the confidence interval

  - effsize the Wilcox's Q effect size

- Transport velocity statistics.xlsx Summarized statistics

- plot_nf_vf_trans_vel_bars.m plot the bar graph plot of reach to grasp velocity with statistical significance marked

Error and Trial Time Statistics

kine_error_stats.m reads raw movement data files and summarizes number of errors

kine_stats.txt the summary

kine_error_stats.csv errors and trial times by subject, condition, trial, and vf status

- Columns

- subject the subject number

- first_condition whether the subject received nf or vf in the first half of the trials

- trial_num trial number (1–30)

- vf_status whether vf was on for this trial

- errors number of errors committed in this trial

- trial_time how long the trial took

kine_error_stats.R run statistical tests on the number of errors, sending output to kine_error_stats.txt

kine_error_stats.txt summary statistics

kine_trial_time_stats.R run statistical tests on the trial times, sending output to kine_trial_time_stats.txt

kine_trial_time_stats.txt summary statistics

Fig. 5 Mean spectral alpha (10–14 Hz) power ±95 % confidence interval for cortical regions of interest for prosthesis users (NF, VF). Regions with differences of p<0.05 denoted with

(a) grasp peak aperture.

fams_gpa_spec_out.csv

- Columns
- subject the subject number
- condition nf or vf
- which_half which set of trials, 1 or 2
- epoch epoch or trial number
- move move number
- channel EEG electrode
- frequency frequency in Hz
- app_overshoot_norm not used
- spec_power_db power in dB not used
- spec_power_abs power

(b) transport peak velocity

fams_tpv_spec_out.csv

- Columns
- subject the subject number
- condition nf or vf
- which_half which set of trials, 1 or 2
- epoch epoch or trial number
- move move number
- channel EEG electrode

- frequency frequency in Hz

- trans_peak_vel not used

- spec_power_db power in dB not used

- spec_power_abs spectral power

export_mean_abs_power_at_gpa_and_tpv_rois.m combine fams_gpa_spec_out.csv and fams_tpv_spec_out.csv by electrode montage and frequency range to produce abs_alpha_power_at_gpa_and_tpv_rois.csv

abs_alpha_power_at_gpa_and_tpv_rois.csv

- Columns

- montage electrode montage, Frontal, Left Parietal, or Left Motor

- freq_range low and high frequency limits for the spectral power measure

- channels channels included in the montage

- subject subject number

- condition nf or vf

- which_half 1 for first set of trials, 2 for the second half

- epoch epoch or trial number

- move move number (1–6)

- phase gpa (grasp peak aperture), or tpv (transport peak velocity)

- mean_power_abs mean spectral power

eeg_power_statistics.R perform statistics on the spectral power at gpa and tpv, writing eeg_power_statistics.txt

eeg_power_statistics.txt statistical results

eeg_power_statistics.xlsx spreadsheet used to create graphs