% EEG data Preprocessing pipeline

%Influenced by Makoto's preprocessing pipeline from the EEGlab wiki <https://sccn.ucsd.edu/wiki/Makoto's_preprocessing_pipeline>

% Special thanks to assistance from Dr. Carl E. Stevens Jr., Dr. Eric Rawls, and Dr. Matt Judah for their support in developing this code

SubjectIDs = ([5000,5002:5025,5027:5063,5065:5085,5087:5100]);

%SubjectIDs = ([5065]);%:5085,5087:5100]);

numsubjects = length(SubjectIDs);

parentfolder = 'D:\JoshMP\_2020\JoshMP\_EEGData';

for i = 1:length(SubjectIDs)

subject = num2str(SubjectIDs(i));

subjectfolder = [parentfolder '/' 'P ' subject '/'];

%read in bdf file

EEG = pop\_biosig(['D:\JoshMP\_2020\JoshMP\_EEGData\TECH' subject '.bdf'], 'channels',[1:38] ,'importannot','off');

[ALLEEG EEG CURRENTSET] = pop\_newset(ALLEEG, EEG, 1,'overwrite','on','gui','off');

% down sample to 256 hz

EEG = pop\_resample( EEG, 256);

[ALLEEG EEG CURRENTSET] = pop\_newset(ALLEEG, EEG, 1,'overwrite','on','gui','off');

%high-pass filter at 1 Hz band edge

%EEG = pop\_eegfiltnew(EEG, [], 1, 16896, true, [], 0);

EEG = pop\_eegfiltnew(EEG, 'locutoff',1);

[ALLEEG EEG CURRENTSET] = pop\_newset(ALLEEG, EEG, 1,'overwrite','on','gui','off');

%import chanlocations

EEG = pop\_chanedit(EEG, 'lookup','C:\\Program Files\\MATLAB\\R2019b\\toolbox\\eeglab2019\_1\\functions\\supportfiles\\Standard-10-5-Cap385\_witheog.elp');

[ALLEEG EEG CURRENTSET] = pop\_newset(ALLEEG, EEG, 1,'overwrite','on','gui','off');

% Keep original EEG to use for interpolating removed channels

originalEEG = EEG;

% clean the line noise

EEG = pop\_cleanline(EEG, 'bandwidth',2,'chanlist',[1:38] ,'computepower',1,'linefreqs',60,'normSpectrum',0,'p',0.01,'pad',2,'plotfigures',0,'scanforlines',1,'sigtype','Channels','tau',100,'verb',1,'winsize',4,'winstep',4);

[ALLEEG EEG CURRENTSET] = pop\_newset(ALLEEG, EEG, 1,'overwrite','on','gui','off');

% Remove bad channels

EEG = pop\_clean\_rawdata( EEG,'FlatlineCriterion',5,'ChannelCriterion',0.8,...

'LineNoiseCriterion',4 );

[ALLEEG EEG CURRENTSET] = pop\_newset(ALLEEG, EEG, 1,'overwrite','on','gui','off');

% interpoalte missing channels from the original dataset

EEG = pop\_interp(EEG, originalEEG.chanlocs, 'spherical');

[ALLEEG EEG CURRENTSET] = pop\_newset(ALLEEG, EEG, 1,'overwrite','on','gui','off');

% compute the average reference

EEG = pop\_reref( EEG, []);

[ALLEEG EEG CURRENTSET] = pop\_newset(ALLEEG, EEG, 1,'overwrite','on','gui','off');

% Perform artifact subspace reconstruction (ASR)

EEG = clean\_artifacts(EEG, 'FlatlineCriterion','off','ChannelCriterion','off','LineNoiseCriterion','off','Highpass','off','BurstCriterion',20,'WindowCriterion','off','BurstRejection','on','Distance','Euclidian');

[ALLEEG EEG CURRENTSET] = pop\_newset(ALLEEG, EEG, 1,'overwrite','on','gui','off');

% Re-compute the average reference

EEG = pop\_reref( EEG, []);

[ALLEEG EEG CURRENTSET] = pop\_newset(ALLEEG, EEG, 1,'overwrite','on','gui','off');

% Run ICA

% EEG = pop\_runica(EEG,'icatype','binica', 'extended',1,'interupt','on');

EEG = pop\_runica(EEG, 'extended',1,'interupt','off');

[ALLEEG EEG CURRENTSET] = pop\_newset(ALLEEG, EEG, 1,'overwrite','on','gui','off');

% Save Dataset

EEG = pop\_saveset( EEG, 'filename',['TECH' num2str(SubjectIDs(i)) '\_256hz\_hpFilt1\_chanLoc\_clnLine60hz\_aveRef\_ASR\_ICA.set'],'filepath',['D:\\EEG Frequency Analysis\\3rd Year Project Analysis\\ICA\_ProcessedFiles\\']);

%low-pass filter at 100 Hz band edge

EEG = pop\_eegfiltnew(EEG, 'locutoff', 100);

[ALLEEG EEG CURRENTSET] = pop\_newset(ALLEEG, EEG, 1,'overwrite','on','gui','off');

%Add trial event code labels from text file

EEG = pop\_editeventlist( EEG , 'AlphanumericCleaning', 'on', 'BoundaryNumeric', { -99}, 'BoundaryString', { 'boundary' }, 'List', ...

'D:\JoshMP\_2020\Processing Scripts\subject\_bineqs\_MP\_LettersSounds.txt', 'SendEL2', 'Workspace&EEG', 'UpdateEEG', 'codelabel' ); % GUI: 29-May-2019 12:35:19

EEG = pop\_overwritevent( EEG, 'codelabel' ); % GUI: 29-May-2019 13:15:40

[ALLEEG EEG CURRENTSET] = pop\_newset(ALLEEG, EEG, 1,'overwrite','on','gui','off');

%Epoch to the added bins

EEG = pop\_epochbin( EEG , [-950.0 1550.0], 'pre'); % GUI: 29-May-2019 12:36:12

[ALLEEG EEG CURRENTSET] = pop\_newset(ALLEEG, EEG, 1,'overwrite','on','gui','off');

% Save Dataset

EEG = pop\_saveset( EEG, 'filename',['TECH' num2str(SubjectIDs(i)) '\_256hz\_hpFilt1\_chanLoc\_clnLine60hz\_aveRef\_ASR\_ICA\_lpFilt100hz\_evList\_bnEp\_ICA.set'],'filepath',['D:\\EEG Frequency Analysis\\3rd Year Project Analysis\\PreProcessedData\\']);

end

SubjectIDs = ([5000,5002:5025,5027:5063,5065:5085,5087:5100]);

numsubjects = length(SubjectIDs);

parentfolder = 'D:\EEG Frequency Analysis\3rd Year Project Analysis\PreProcessedData';

for i = 1:length(SubjectIDs)

subject = num2str(SubjectIDs(i));

%load ICA processed EEG dataset

EEG = pop\_loadset('filename',['TECH' subject '\_hpFilt1\_lpFilt100\_notchFilt60\_loc\_reRef\_elist\_be\_ICA.set'],'filepath',parentfolder);

%ICA component processing 1

EEG = pop\_iclabel(EEG, 'default');

%sum of all non-brain ics

EEG\_label\_art = sum(EEG.etc.ic\_classification.ICLabel.classifications(:,2:end)'>.90);

%find entries that are 1

art = find(EEG\_label\_art>0);

%put the outcome in EEG structure for referencing

EEG.etc.FIN\_art = art;

%remove bad ics

EEG = pop\_subcomp( EEG, art, 0);

EEG = pop\_saveset( EEG, 'filename',['TECH' subject '\_hpFilt1\_lpFilt100\_notchFilt60\_loc\_reRef\_elist\_be\_ICA\_ICsRm.set'],'filepath','D:\\EEG Frequency Analysis\\3rd Year Project Analysis\\ICA\_ProcessedFiles\\');

% artifact thesholding ICA corrected paricipants and saving artifact summaries

% Artifact Rejection one: Moving Window peak to peak, Channels: IO1/IO2

% Voltage Threshold = 75, Moving Window Width = 200, Window Step = 100, Flag 4,

EEG = pop\_artmwppth( EEG , 'Channel', [ 35 36], 'Flag', [ 1 4], 'Threshold', 75, 'Twindow', [ -199.2 798.8], 'Windowsize', 200, 'Windowstep',...

100 );

% Artifact Rejection two: Step like artifacts, Channels: LO1/LO2

% Voltage Threshold = 30, Moving Window Width = 400, Window Step = 10, Flag 3,

EEG = pop\_artstep( EEG , 'Channel', [ 33 34], 'Flag', [ 1 3], 'Threshold', 30, 'Twindow', [ -199.2 798.8], 'Windowsize', 400, 'Windowstep',...

10 );

% Artifact Rejection three: large artifacts, Channels: all

% Voltage Threshold = 200, Moving Window Width = 1000, Window Step = 100, Flag 2,

EEG = pop\_artmwppth( EEG , 'Channel', 1:36, 'Flag', [ 1 2], 'Threshold', 200, 'Twindow', [ -199.2 798.8], 'Windowsize', 100, 'Windowstep',...

100 );

% creating and saving artifact summary file to F:\Josh Navon\EEGlab Processing\Artifact Summaries\ICA\_ICLabel Removed AR Summaries

EEG = pop\_summary\_AR\_eeg\_detection(EEG, ['D:\EEG Frequency Analysis\3rd Year Project Analysis\Artifact Summaries/TECH' subject 'ICA\_AR\_summary.txt']);

% save eeg dataset with artifact detections

EEG = pop\_saveset( EEG, 'filename',['TECH' subject '\_hpFilt1\_lpFilt100\_notchFilt60\_loc\_reRef\_elist\_be\_ICA\_ICsRm\_AR3.set'],'filepath','D:\\EEG Frequency Analysis\\3rd Year Project Analysis\\ICA\_ProcessedFiles\\ArtifactDect\\');

end

SubjectIDs = ([5000,5002:5025,5027:5063,5065:5085,5087:5100]);

numsubjects = length(SubjectIDs);

parentfolder = 'D:\EEG Frequency Analysis\3rd Year Project Analysis\ICA\_ProcessedFiles\ArtifactDect';

ALLERP = buildERPstruct([]);

CURRENTERP = 0;

for i = 1:length(SubjectIDs)

subject = num2str(SubjectIDs(i));

%load ICA processed EEG dataset

EEG = pop\_loadset('filename',['TECH' subject '\_hpFilt1\_lpFilt100\_notchFilt60\_loc\_reRef\_elist\_be\_ICA\_ICsRm\_AR3.set'],'filepath',parentfolder);

fprintf('\n\n\n\*\*\* Processing subject %d (%s) \*\*\*\n\n\n', s, subject);

%EEG = pop\_loadset('filename',[subject '.set'],'filepath','C:\Users\mjudah\Documents\MAS\4 MAS ICA Cleaned'); %put file path in the quotation marks at the end of this line (e.g., 'C:\\Users\\mjudah\\Desktop\\RAM TF\\Epoched\\')

%EEG = pop\_rmdat( EEG, {'2560' '5120'},[0 60] ,0); %select data in 60 second epoch after trigger codes that mark eyes open and eyes closed conditions; inside the quotation marks put the trigger codes for eyes opeen and eyes closed blocks (e.g., '10 20')

%EEG = eeg\_regepochs(EEG, 'recurrence',1, 'eventtype','3','extractepochs','off'); %This will place a marker every 1 second, and the above example will call the event '3' which you'll set to whatever you want. Epochs will not be extracted as 'extractepochs' is set to off.

%EEG = pop\_epoch(EEG, {'3'}, [-1, 1]); %epoch the data around the eventtype (3) I specified using pop\_epoch:

%eeglab redraw

ChanNr = [4 27 31 40]; %use frontal electrodes F3/4 Fz FCz

[spectra,freqs] = spectopo(EEG.data(ChanNr,:,:), 0, EEG.srate);

% delta=1-4, theta=4-8, alpha=8-13, beta=13-30, gamma=30-80

deltaIdx = find(freqs>1 & freqs<4);

thetaIdx = find(freqs>4 & freqs<8);

alphaIdx = find(freqs>8 & freqs<13);

betaIdx = find(freqs>13 & freqs<30);

gammaIdx = find(freqs>30 & freqs<80);

% compute absolute power in dB

deltaPower = 10^(mean(spectra(deltaIdx))/10);

thetaPower = 10^(mean(spectra(thetaIdx))/10);

alphaPower = 10^(mean(spectra(alphaIdx))/10);

betaPower = 10^(mean(spectra(betaIdx))/10);

gammaPower = 10^(mean(spectra(gammaIdx))/10);

TBR = thetaPower/betaPower;

% compute relative power in dB

totalPower=deltaPower+thetaPower+alphaPower+betaPower;

relativeDelta=deltaPower/totalPower;

relativeAlpha=alphaPower/totalPower;

relativeBeta=betaPower/totalPower;

relativeTheta=thetaPower/totalPower;

EEG = pop\_saveset( EEG, 'filename',[subject 'preproc\_freqs.set'],'filepath','C:\Users\mjudah\Documents\MAS\Resting State');

end;