NANYANG TECHNOLOGICAL UNIVERSITY SINGAPORE

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Investigating effects of viewing angle and stimulus interferences on Covert SSVEP

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Background:

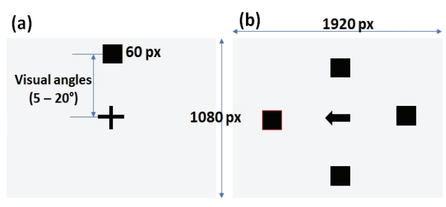
Traditional BCIs are not widely used due to limitations such as usability and practicality

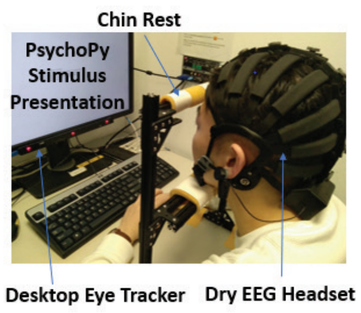
Research gap of traditional SSVEP

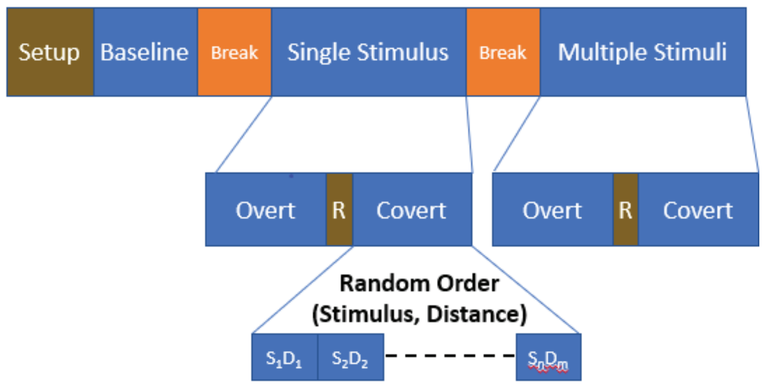
- Research done on multi-tasking of SSVEP did not include covert attention in the experiments hence results only applicable when all tasks are in overt attention which are unlikely in real world situations
- Peripheral view attention is more practical than overt attention but significantly less research done

Experiment Design:

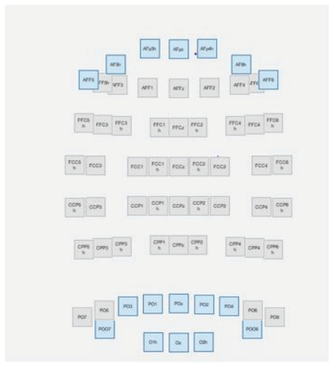
- SSVEP interface stimulus frequency
  - 5,10,15, 20-degree view angles
  - Overt, Covert with/without distractions
  - Stimulus frequencies in 6.67 8.57 , 12 & 15 Hz
- Synchronized EEG and eye tracker recordings and chin rest to keep distance constant





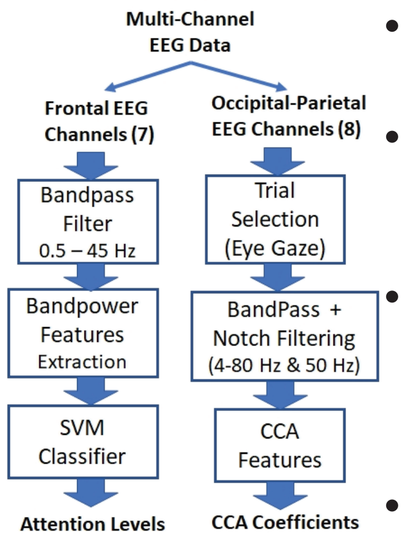


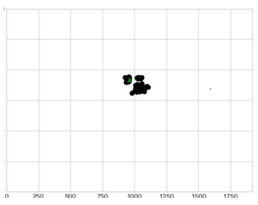
Electrode Positions (Frontal at the top, Occipital at the bottom, blue – active, grey - inactive)



- Sequence of experiments
  - Calibration > Overt single stimulus > Covert single stimulus > Overt Multiple stimulus > Covert multiple stimulus

Methodology & Analysis





- Channels are separated into frontal and occipital channels
- SVM classifiers used to get attention levels from frontal channel input and CCA for occipital channels
- Pre-processing of EEG signals by normalizing (mean zero & unit variance), notch (50Hz) and band-pass (4-40 Hz) filtering
- Eye tracker data to determine quality of data of each trial, data is evaluated manually
- Trials where users gaze are centered at intended target are accepted

Research Goal:

Original Hypothesis

- Covert SSVEP will perform worst the larger the viewing angle
- Non target distractions cause worst performance
- Overt SSVEP and Covert SSVEP reaction to stimulus distractions

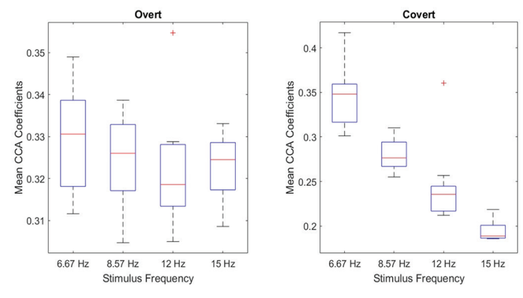
Objectives

- To find out and evaluate the relationship between viewing angle and non-target stimuli distractions in covert SSVEP

Results & Discussion:

CCA Analysis

We compared the CCA coefficients between overt and covert SSVEP



- Overt SSVEP performs the same at every frequency regardless of distraction and view angle
- Covert SSVEP performs better at lower frequencies
- Shorter data segment length achieve reliable SSVEP responses in peripheral visual attention

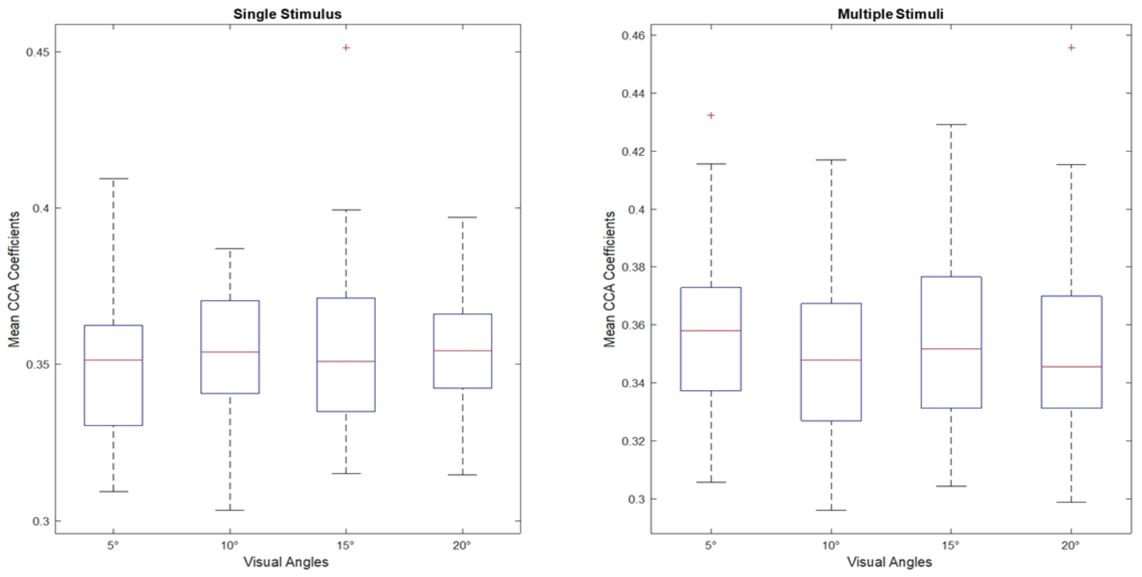


TABLE I

COMPARISON OF DIFFERENT EXPERIMENT SCENARIOS ACROSS VISUAL ANGLES USING CCA COEFFICIENTS [** INDICATES SIGNIFICANT DIFFERENCE AT $p < 0.001$ LEVEL AND * AT $p < 0.05$]

visual angles	5°	10°	15°	20°
Single-stimulus(C vs O)	**	**	**	**
Multi-stimuli(C vs O)	0.32	*(0.03)	0.06	0.21
Single Vs Multi (O)	**	**	**	**
Single Vs Multi (C)	0.16	0.33	0.86	0.55

- Performance in covert attention not affected by viewing angle in our study
- Conversely, overt attention single stimuli are affected by viewing angle as shown in the table