Cerebral Vascular Responsivity and Cognitive Performance in Younger and Older Adults

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Background

Evoked neural and hemodynamic responses to external stimuli can be used to measure local cerebral responsiveness [1]. Auditory evoked response potential (AEP) components have been shown to increase in latency with normal aging [2]. Additionally, evoked hemodynamic responses decrease in amplitude in healthy aging adults [3,4]. Cognitive functions may decline with age [5,6]. We hypothesize that limitations in cerebral vascular respoinsivity due to normal aging may be correlated to reduced cognitive function. In order to investigate the relationship between evoked neural and hemodynamic responses with cognitive function and age, we will combine electrophysiological and optical imaging techniques with psychological test batteries. Furthermore, we will use machine learning algorithms to predict cognitive performance and age based on cerebral vascular responsiveness

Materials and Methods

- Participants will be
  - 12 healthy young subjects (18-25 years old)
  - 12 healthy older subjects (62-69 years old)
- We will conduct phone interviews to screen for
  - Cognitive & neuropsychological abnormalities (Tics score <30; history of neuropsychological disorders)
  - Sleep disorders
- Testing procedures
  - Hearing loss screening
  - Questionnaires
    - DEX; Prospective and Retrospective Memory Questionnaire; Pittsburgh Sleep Quality Index
  - Neuropsychological Test Battery
    - Shipley Vocabulary; Symbol Digit Modalities Test; Brief Visuospatial Memory Test; Trail A/B; Letter Number Sequencing Test
  - Auditory Task

Figure 1: Fiber-coupled light emitting diodes (LEDs, left side) emitting 740, 810, and 880 nm light illuminated the head and a fiber-coupled photodiode (right side) collected light scattered from the cortex. The fibers were encased in hyperdermic tubing which collected electroencephalographic signals from the cortex.

Electrical and Optical Brain Imaging

- We will instrument subjects with electrodes and optodes over the right auditory cortex (Figure 1)
- Light emitting diodes (LEDs) emitting 740, 810, and 880 nm light will illuminate the head
- Stimulate the right auditory cortex using 3 speaker clicks (2 ms, 3 Hz) delivered to the left ear
  - Delivered at random intervals between 8-22 s
  - 2 different intensities (50 dB and 65 dB)
  - Button press response to click
- Optical measurements will be used to calculate oxyhemoglobin (HbO2), deoxyhemoglobin (Hb), and total hemoglobin (HbT) concentration changes using the modified Beer-Lambert law [7]

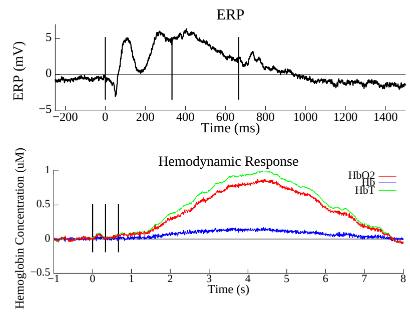

Figure 2: (Top Panel) Evoked response potentials (ERPs) from the right parietal lobe following auditory stimulation in the left ear using 3 speaker clicks delivered at random intervals between 8-22 seconds. (Bottom Panel) Evoked hemodynamic responses from the right parietal lobe following auditory stimulation in the left ear using 3 speaker clicks delivered at random intervals between 8-22 seconds. Changes in oxyhemoglobin (HbO2, red), deoxyhemoglobin (Hb, blue), and total hemoglobin (HbT, green) concentration are shown.

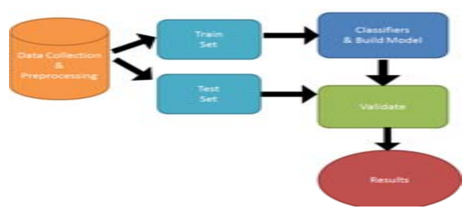

Figure 3: The machine learning process includes data collection of both physiological and psychological attributes, later is split into training set and test with 80% for training and rest testing. This is later used to build the model and test it to report the results.

Machine Learning

- Features/Attributes
  - AEP latency (ms)
  - AEP amplitude (mV)
  - Hemodynamic response amplitude (uM)
  - Hemodynamic response area (uM^2)
  - Reaction time (ms)
  - Dex questionnaire (assess depressive symptoms)
  - Prospective and Retrospective memory questionnair
  - Sleep index
  - Shipley vocabulary
  - Symbol digit modality test
  - BVMT (3 learning trials, delayed recall, copy trial, recognition test)
  - Trials A & B
  - Number letter sequencing
- Algorithms [8]
  - Decision Tree
  - Naïve Bayes
  - Support Vector Machines
- We propose to conduct multiple experiments evaluating as how algorithms perform on predicting both physiological and psychological signals over varying age groups.

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