A Functional Near Infrared Spectroscopy Study of Verbal Fluency

J. Lengenfelder[1,2] G.T. Voelbel[1,2], G. Wylie[1,2], R. L. Barbour[3,4], Y. Pei[3], N. Nadkani[1], A. Smith[1], & J. DeLuca[1,2]

[1] Kessler Medical Rehabilitation Research & Education Corp, West Orange, NJ [2]University of Medicine and Dentistry of New Jersey

3NIRx Medical Technologies 4SUNY Downstate Medical Center

ABSTRACT

Objective: To investigate the pattern of cerebral activation in the frontal lobes of healthy adults with functional Near Infrared Spectroscopy (fNIRS), during a verbal fluency task.

Participants and Methods: Participants were 9 right-handed, healthy adults (6 females) between the ages of 20 and 51 without any history of neurological disease or psychiatric disorders. Participants were seated comfortably and 30 fNIRS source/ detector optodes were placed on their foreheads. Following a 5 minute baseline period, participants produced words starting with F, A, and S with a 1 minute time limit for each letter.

Results: Across the 9 participants there was significantly elevated oxyhemoglobin (Oxy-Hb) detected in the left inferior frontal gyrus (Broadman Areas 45 & 46), between the left dorsal and ventral lateral prefrontal cortex, during the FAS verbal fluency task when compared to the baseline period.

Conclusions: This study demonstrates that fNIRS, a new functional neuroimaging technique, can be used to detect changes in Oxy-Hb within the frontal lobe during a verbal fluency task in healthy adults. The increase in the left inferior frontal gyrus is consistent with prior functional imaging studies of verbal fluency tasks.

Introduction

- The ability of near infrared light to penetrate through the cranium and detect blood flow changes has prompted the utility of near infrared methods. (Fig 1)
- We examined the pattern of cerebral activation during a verbal fluency task, FAS, with a functional near infrared spectroscopy system (Fig 2).

Figure 1.

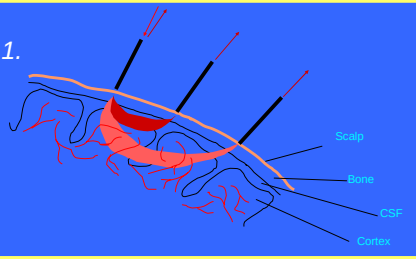

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Figure 2. Multi-channel Continuous Wave Near Infrared Imager

METHODS

Participants

- 9 Right-Handed Healthy Adults
- Age: 30.7 (11.3) years
- Education: 15.9 (2.7) years
- Free of substance abuse and major psychiatric disorders
- No history of neurological disease or trauma

Behavioral Task

- *5 minute baseline*
- *FAS:* Produce as many words beginning with F, A, and S in 1 minute

Procedures

Equipment

- Multi-channel continuous wave near infrared imager (NIRx Medical Technologies; see Fig 1)
- 30 source and 30 detector optodes (900 channels)
- Dual wavelength of near infrared light (760 and 830nm) see Fig 3
- Optodes placed on forehead 10% above nasion in a 10 cm by 3 cm rectangle configuration, Fig 4.

Figure 3. Wavelength of near-infrared light

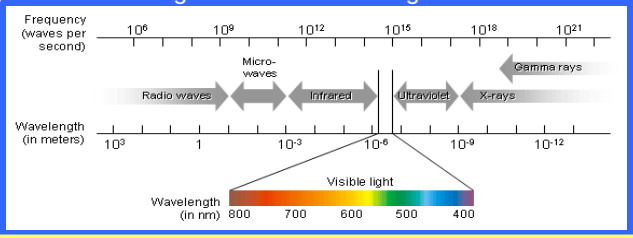
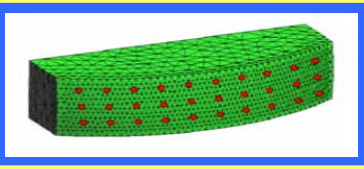


Figure 4. Three dimensional model of source-detector pairs.



METHODS cont'd

Data Preprocessing and Analysis

Preprocessing

- Near Infrared Analysis, Visualization and Imaging (NAVI) software (NIRx Medical Technologies, LLC)
- Low-band pass filter (.15 Hz)
- 15% mean Coefficients of Variation threshold
- Oxy-Hb concentration was modeled with a modified Lambert-Beer analysis for each time point in each voxel of modeled space (Fig 4).
- Data converted to Analyze format

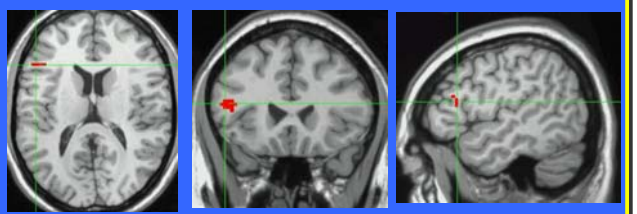
Data Analysis

- AFNI image analysis software
- Time-series deconvolved for each N-back Condition
- T-test to compare N-Back conditions across participants (random effects analysis).
- Voxel-level probability threshold .05.
- Cluster-level threshold 31 contiguous voxels
- Statistical maps overlaid on high-resolution MRI

Results

- Significantly elevated oxyhemoglobin (Oxy-Hb) detected in the left inferior frontal gyrus (Broadman Areas 45 & 46), between the left dorsal and ventral lateral prefrontal cortex, during the FAS verbal fluency task when compared to the baseline period. (Fig 5)

Figure 5 . Activation during FAS



Conclusions

- Functional Near Infrared Spectroscopy (fNIRS) is able to detect increases in Oxy-Hb during a verbal fluency task in healthy individuals.
- Pattern of activation is consistent with prior functional imaging studies
- fNIRS has the potential to allow for experimental paradigms that are highly impractical or infeasible with other functional imaging modalities due to restricted patient access and limited freedom of patient movement.