Application of Functional Near-Infrared Spectroscopy in Apraxia Studies in Alzheimer's Disease: A Proof of Concept Experiment

Apraxia refers to an impairment in performing consecutive movements and is among the early impairments in Alzheimer's disease (AD).[1] In investigating brain areas involved in apraxia, functional magnetic resonance imaging (fMRI), and electroencephalography (EEG) are the mostly used neuroimaging techniques.[2] This is while these are both highly sensitive to motion. An alternative to fMRI and EEG is functional near-infrared spectroscopy (fNIRS). fNIRS is less motion-sensitive which enables better data acquisition during motor tasks.[3] In addition, fNIRS has a better temporal resolution compared to fMRI and offers a more precise localization of activity compared to EEG.[4] However, despite these advantages, fNIRS has not yet been applied in the study of apraxia. Here, we present a proof of concept fNIRS experiment that offers some considerations for the design of an fNIRS study of apraxia in patients with neurodegenerative diseases.

In this experiment, we chose block design over an event-related task, because in this design, the stimuli are more predictable, making it easier for patients to maintain cognitive engagement.[5] Furthermore, the hemodynamic responses are linearly summed when the brain is activated repeatedly as in block design, compensating for disrupted neurovascular coupling in neurodegenerative diseases.[6] The task consists of two runs: (1) Observation, in which the subject should only observe the gestures and (2) imitation, in which the subject should imitate the gestures. Each run included three blocks of limb gestures and three blocks of oral gestures as these are the most common forms of apraxia in neurodegenerative diseases and have diagnostic value.[7] A jittered 19.2s to 32s resting interval separated the blocks. Each block included five random gestures shown for 6s with a 1s interval in between [Figure 1]. The gestures were extracted from Dementia Apraxia Test.[8] A 63-year-old AD patient and a 37-year-old healthy subject were recruited and informed consent was obtained. A continuous-wave OxyMon fNIRS system (Artinis Medical Systems, Netherlands) with 28 active channels and a 10 Hz sampling rate was used. Measured wavelengths were 762 and 845 nm. Based on previous findings, the middle and superior parts of the temporal lobe, inferior and superior parts of the parietal lobe, and superior, middle, and inferior parts of the frontal lobe were selected as regions of interest.[9-11] Location of optodes was determined using fNIRS Optodes' Location Decider[12] and the most similar template was selected [Figure 2]. Raw data were processed using Homer3 in MATLAB 2021a (MathWorks, Natick, MA, USA).[13] After the conversion of light intensity signals to an optical density (OD), a bandpass filter of 0.01–0.1 Hz was applied and targeted principle component analysis was performed.[14] Changes in OD were then converted to concentration changes using modified Beer–Lambert Law.[15] Concentration changes within a period of-2s before stimulus onset to 60s after stimulus onset (2s for baseline, 35s for five stimuli, and 23s for return to baseline) were averaged to obtain the hemodynamic response functions (HRF) during the task. Next, the HRF from channels within one region of interest (ROI) was averaged. Figures 3 and 4 demonstrate the HRF during the task. Overall, this experiment suggests that fNIRS can be used to study apraxia, especially in elderly patients with neurodegenerative diseases.

Statements

Statements section should be removed, because they are duplicated in Acknowledgement and Financial support sections.

Acknowledgment

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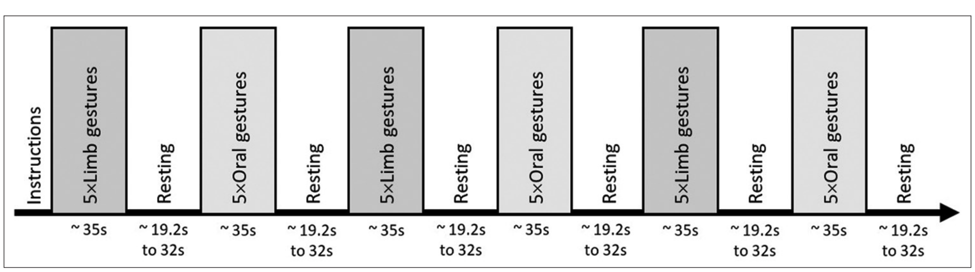

Figure 1: A single run of the task

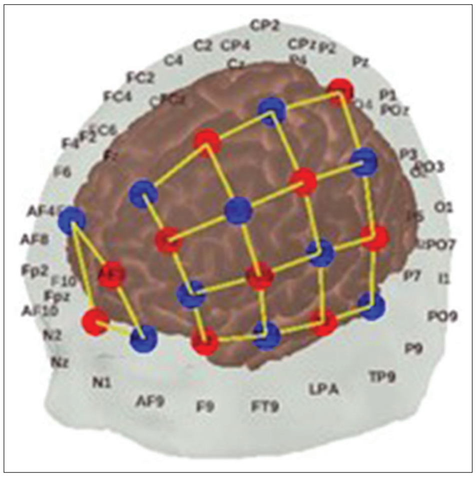

Figure 2: fNIRS optodes' template. fNIRS - Functional near-infrared spectroscopy

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

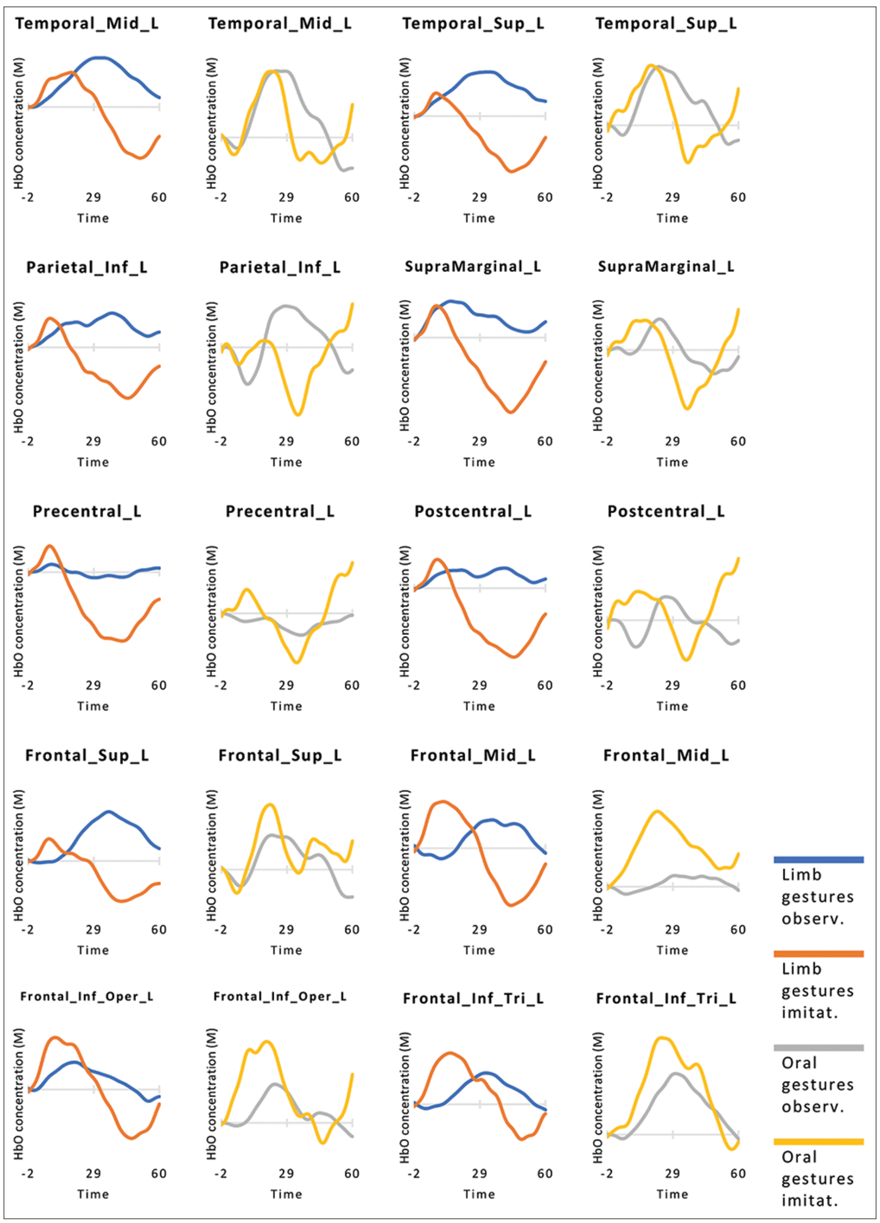

Figure 3: HRF during the task in an Alzheimer's patient. HRF - Hemodynamic response functions

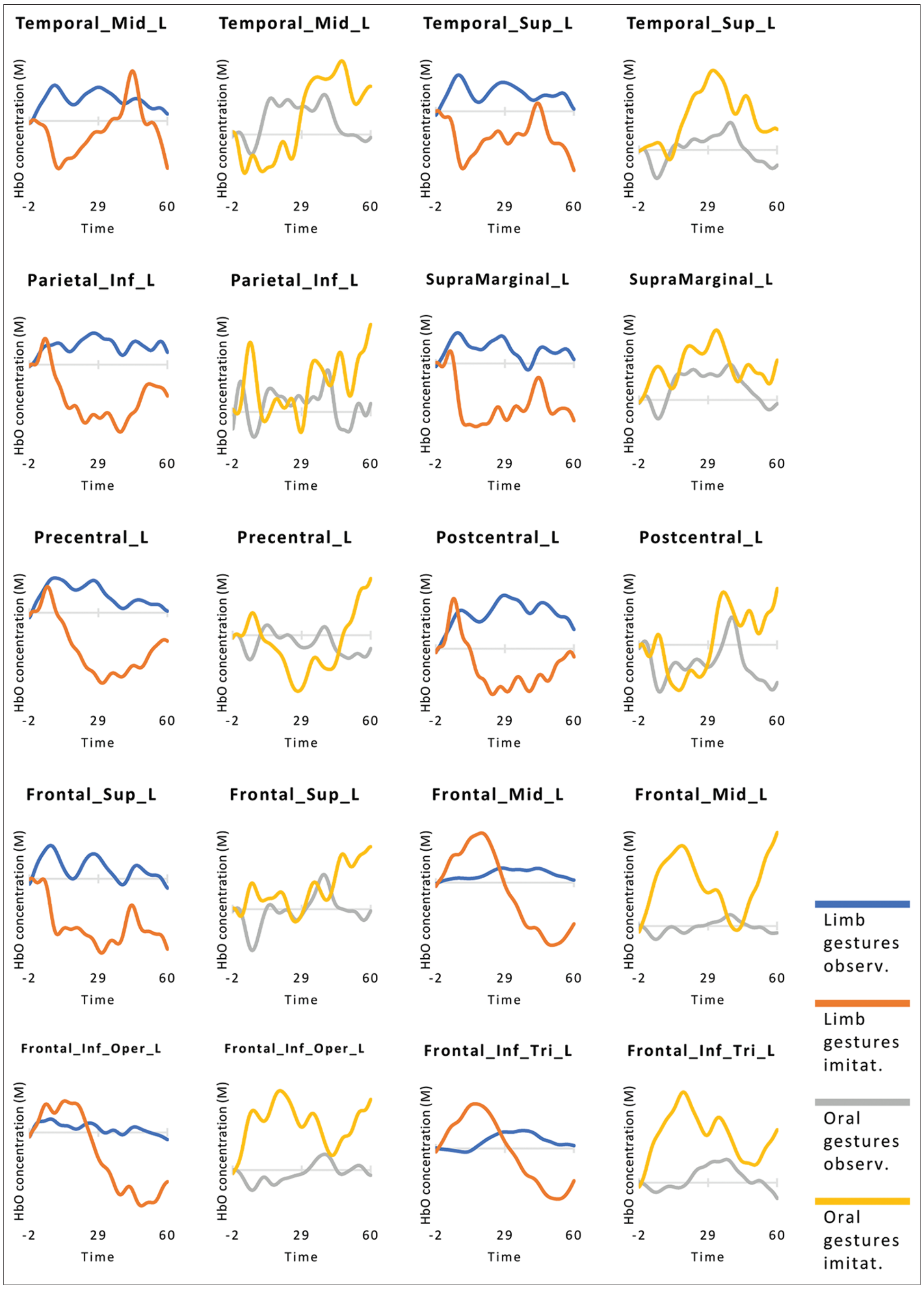

Figure 4: HRF during the task in a healthy subject. HRF - Hemodynamic response functions

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