EasyChair Preprint

№ 6521

Hemodynamic Brain Responses During Working Memory Load Processing in Aphasia

Bijoyaa Mohapatra

EasyChair preprints are intended for rapid dissemination of research results and are integrated with the rest of EasyChair.

September 1, 2021

Hemodynamic Brain Responses during Working Memory Load Processing in Aphasia

Bijoyaa Mohapatra[1]*

[1] Department of Communication Sciences and Disorders, Louisiana State University, Baton Rouge, Louisiana, USA

***Bijoyaa Mohapatra, bmohap@lsu.edu**

Introduction

Functional near-infrared spectroscopy (fNIRS) is a noninvasive optical brain imaging technique used to measure hemodynamic activation within the brain in response to stimulation and workload (Mehagnoul-Schipper et al., 2002). Workload induced by different conditions result in varying hemodynamic responses (Sun et al., 2019). The hemodynamic responses are recorded as relative changes in concentration of oxygenated hemoglobin (HbO) and deoxygenated hemoglobin (HbR) in different regions of the brain.

Several neuroimaging technologies have been used with post-stroke individuals with aphasia (IWA) to understand their neurobehavioral performance and neurological markers associated with language and cognitive difficulties. Very few studies have used fNIRS technology to understand brain activations and hemodynamic markers of behavior in aphasia (example, Sakatani et al., 1998). Therefore, the aim of this study is to assess the feasibility of a fNIRS system in measuring hemodynamic responses in IWA on cognitive tasks of varying mental workload.

Methods

Four IWA with a history of unilateral stroke and no other associated neurologic or psychologic disorders have participated to date. All participants completed the Western Aphasia Battery-Revised, Beck's Anxiety Inventory, and Geriatric Depression Scale prior to the fNIRS experimentation (participant characteristics in Table 1). A computer-delivered working memory (n-back) task varying across two workload conditions:1- back (low load) and 2-back (high load) was used for the experiment. Prefrontal cortical activity was measured using the 18-channel optode band from the fNIR 203C system (Biopac Systems, Inc.). The COBI studio software was utilized to record the hemodynamic neural activity and the fNIRSoft software was used for data processing. Prior to analyses, raw light intensity measures were filtered using a low pass filter of 0.1Hz followed by the ambient light removal. Relative changes in oxygen concentration during task in comparison to the initial rest period was calculated using the modified Beer-Lambert Law. The HbO and HbR are the variables of interest and were recorded across both tasks. The concentration levels for each variable were averaged across all channels and for all four participants.

Results

Hemodynamic responses due to workload induced by n-back tasks were discriminated from the resting state. The HbO and HbR activation patterns on 1-back and 2-back are

presented in figure 1. Several interesting findings were noted: 1) differential pattern of oxygen consumption in the brain were observed between 1- and 2-back tasks, 2) oxygenated hemoglobin concentration was high for the 2-back (high) load condition than the 1-back (low) load condition); $HbO_{high} > HbO_{low}$ i.e., mental workload induced by 2-back condition was more, 3) deoxygenated hemoglobin concentration was more for the 1-back (low) load condition than the 2- back (high) load condition; $HbR_{high} < HbR_{low}$ (Figure 1). Three IWA (75%) showed elevated HbO in unilateral hemisphere in conjunction with slight increase in HbR on low load task (Kim et al., 2018). Subjective ratings of workload were higher for 2-back (Table 1).

Conclusions

Overall, our data support the feasibility of fNIRS to detect mental workload in IWA. With the inclusion of more participant data, robust information can be obtained regarding the potential of fNIRS as a brain computer interface for IWA.

References

Kim, I. S., Millin, N. J., Hwang, J., Kim, I. S., Millin, N. J., & Hwang, J. (2018). Word retrieval by verbal fluency tasks for young and old people: an fNIR study. *Clinical Archives of Communication Disorders*, *3*(1), 52-58.

Mehagnoul-Schipper, D. J., van der Kallen, B. F., Colier, W. N., van der Sluijs, M. C., van Erning, L. J. T. O., Thijssen, H. O., ... & Jansen, R. W. (2002). Simultaneous measurements of cerebral oxygenation changes during brain activation by near-infrared spectroscopy and functional magnetic resonance imaging in healthy young and elderly subjects. *Human brain mapping*, *16*(1), 14-23.

Sakatani, K., Xie, Y., Lichty, W., Li, S., & Zuo, H. (1998). Language-activated cerebral blood oxygenation and hemodynamic changes of the left prefrontal cortex in poststroke aphasic patients: a near-infrared spectroscopy study. *Stroke*, *29*(7), 1299-1304.

Sun, Z., Huang, Z., Duan, F., & Liu, Y. (2020). A Novel Multimodal Approach for Hybrid Brain–Computer Interface. *IEEE Access*, *8*, 89909-89918.

Acknowledgment

The authors would like to extend their gratitude to all individuals with aphasia who participated in this research.

Figure 1. Average data (from four IWA) for oxygenated (HbO) and deoxygenated (HbR) blood flow obtained from 18-channel prefrontal optode band during performance on low-load (1-back) and high-load (2-back) tasks

Table 1. Participant characteristics and perceived rating of workload on 1- and 2-back

No.	Age (in yrs)	Sex	WAB-R AQ	Aphasia Severity	BAI	GDS	1-back SR	2- back SR
1	66	F	78.3	mild	12	3	2	3
2	72	M	55.6	moderate	3	4	3	5
3	58	F	88.3	mild	2	4	4	5
4	68	M	82.6	mild	3	2	4	5

Note. WAB-R- Western Aphasia Battery-Revised (Aphasia Quotient AQ <93.8 diagnosis of aphasia); BAI- Beck's Anxiety Inventory (scores: 0-21 low anxiety, 22-35 moderate anxiety, >36 cause for concern; GDS- Geriatric Depression Scale, scores > 5 points suggestive of depression, ≥ 10 points almost always indicative of depression, > 5 points should warrant a follow-up comprehensive assessment); SR- Subjective rating of induced mental workload (1- minimum, 5- maximum)