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NEAR-INFRARED SPECTROSCOPY AND THE SWALLOWING EVENT

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Abstract: In this work, we applied near infrared spectroscopy (NIRS) to observe brain hemodynamics in the frontal lobes during the swallowing event.

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1. Introduction

NIRS has been a paradigm of new technology and medicine for more than 20 years, covering many fields of study. However, this promising technology has not been used before in the speech language pathology field to study the important event of swallowing.

The swallowing hemodynamic response was correlated with the two major swallowing events that occur during the oral transport phase: submental muscle group activity and breathing. Important to the swallowing event are the simultaneous measurement of the breathing rate and air volume. The interplay of these two events with the swallowing apnea was the core result of this investigation. Data analysis and interpretation were based on cross and time correlations due to the physiology of the swallowing. Since swallowing is a process in which the synchronization and synergy among structures is necessary to successful and healthy deglutition, the correlation concept captures many important features relevant to clinical studies. The results were based on observations in a healthy population and served as a guide for future research in disordered deglutition or dysphagia.

2. **Methods:** The NIR response to the swallowing event was measured using the frequency-domain dual-channel ISS oximeter (Champaign, IL). At the same time, a nasal cannula measured the air inspiration during swallowing, a SEMG probe measured the sub-mental activity and a breathing belt the movement of the diaphragm. All signals were recorded simultaneously using the BoxyRead program developed at the University of Illinois. Six participants ranging from 19 to 42 years of age served as subjects. All experiments were performed with the participant seated comfortably in an upright position. The same pool of participants was used throughout in order to have reproducible experimental conditions and follow up, regardless of the changes in protocol during its development.

Figure 1. Schematic of the setup used to study the swallowing event.

Goal 1 was to distinguish between activation and deactivation phases. The two periods described in the protocol provided the two different physiological conditions that distinguished between activation-deactivation phases along with their respective hemodynamic responses. The first protocol consisted of a

baseline period of 1-minute duration followed by a period of 10 continuous swallows using a graded cup. The sequence was repeated ten times.

Goal 2 was to observe the differences in the hemodynamic behavior between single and continuous swallowing tasks. In an effort to determine if single swallow tasks could show a clearer signal in terms of hemodynamic behavior and breathing patterns. The participants were asked to perform the act of one swallow. It was hypothesized that one swallow was likely to give a more defined muscular activity than if the subjects were to execute a rapid series of swallows. The protocol was modified to 1-minute of baseline time followed by one single bolus of 15 ml. This sequence was repeated five times. These series continued with the first protocol in which 1-minute baseline was followed by 10 continuous swallows, which were also repeated 5 times. Therefore, the entire protocol consisted of ten minutes of baseline and approximately 14 minutes of swallowing.

Goal 3 was to determine how long the brain hemodynamics takes to react to the swallow. In an effort to correlate direction of respiration with the frontal lobes hemodynamic changes, 10 continuous swallows followed 1-minute of baseline. This was based on the findings of the obstructive sleep apnea project done in our laboratory (Safonova et al., 2003). According to this premise, an increase in oxy-hemoglobin [O_2Hb] and a decrease in deoxy-hemoglobin [HHb] contents during the swallowing apnea was anticipated. This protocol was used to determine for how long the two concentrations, [O_2Hb] and [HHb], were uncorrelated or negatively correlated as well as correlated or positively correlated. In other words, how long the hemodynamic response in the frontal lobes takes to react to the swallow.

3. Results and Discussion

Figure 2 shows the changes in oxygenation in the left frontal lobe before, during and after the swallowing protocol described in goal 1. After swallowing there is an increase in the oxygenation value. We determined that this increase is due to the lack of breathing that occurs during swallowing.

Figure 2: Changes in oxygenation in the left frontal lobe during swallowing. Light blue is the time preceding deglutition. During the pink part, there is a rapid succession of 10 swallowing followed then by rest.

Figure 3 show the changes in oxygenation due to swallowing in the right frontal lobe following the two different protocols. From 1-5 the protocol required successive independent swallows. From 6 to 10, the protocol required a single event of rapid succession of swallows.

Figure 3. Difference in % change in oxygenation in the right frontal lobe for two different protocols of swallowing. 1-5, independent events. 6-10, rapid succession of swallows.

Figure 4 shows the correlation between decrease of breathing during swallowing and the increase in frontal lobe oxygenation. This response is the normal vasoreactivity of the brain that responds to the lack of arterial oxygen by increasing the cerebral blood flow.

Figure 4. Correlation between changes in breathing rate and oxy and deoxy-hemoglobin in the frontal lobes.

In conclusion, the swallowing process causes relatively large changes in brain oxygenation mainly due to changes in the breathing pattern during deglutition.

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References

Safonova, L. P., Michalos, A., Wolf, U., Choi, J. H., Wolf, M., & Mantulin, W. (2003). Diminished cerebral circulatory autoregulation in obstructive sleep apnea investigated by near - infrared spectroscopy. *Sleep Research Online*, 5 (4), 123-132