Predictable brain: Using machine learning to predict brain signals of subjects during social interaction

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INTRODUCTION

Brain synchronization is fundamental to successful communication between dyads in social interactions, such as teacher-student (Liu et al., 2017). Hyperscanning is a neuroimaging acquisition approach that consists of simultaneously measuring the brain activity of two or more individuals interacting (Wang et al., 2018). Combining that possibility with the fact that interbrain synchronizations (IBS) are present in social interactions lead us to an ambitious question. In a situation of teacher-student interaction, would it be possible to predict brain signals of a student using the brain signals of a teacher as predictors? To address this question, we propose this proof-of-concept study where we performed an fNIRS hyperscanning to collect brain signals from the prefrontal cortex and temporoparietal junction of pairs of teacher-student under a social interaction task

THE EXPERIMENT

Participants

Four adults (two males), age betwe21 to 28 years; Eight children (four boys) aged between 3 and 5. Total of eight healthy pairs of teacher-student.

Experimental design

The pairs performed a naturalistic protocol proposed by Brockington et al. 2018 to investigate the brain during a teacher-student interaction. In this task, the teacher and student played a space race game. The teacher certified that the child was able to count from 1 to 12, then instructed the student in how to add two natural numbers using matchsticks. They began the race by throwing two dice of six faces, the player who got the highest result of the addition of the outcomes from the two dice started the game. They continued the race by walking the steps according to the sum of the dice numbers. The experiment lasted 15 minutes and was recorded entirely.

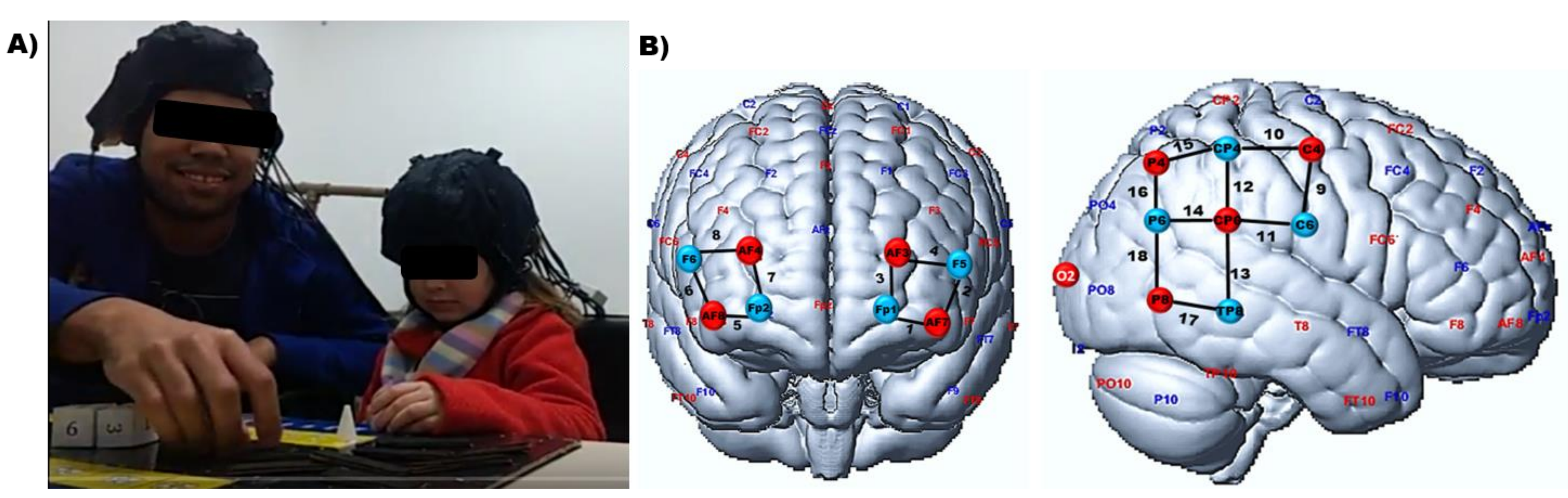

Figure1A. Participants during the experiment and fNIRS. **Figure 1B.** fNIRS montage. Red and blue circles represent light sources and detectors, respectively. The black numbers outside the circles are the fNIRS channels. The black numbers inside the circles represent the EEG 10 – 10 international system positions

fNIRS acquisition

We used a NIRScout (NIRx Medical Technologies) sampling rate of 7.81 Hz device, with 16 sources and 16 detectors to simultaneously collect the cortical data of teachers and students. Optodes were positioned in the prefrontal cortex (PFC) (channels from 1 to 8) and the tempo-parietal junction (TPJ) (channels from 9 to 17). The first was chosen because it is involved with executive functions related to counting and simple mathematical operations (Artemenko et al. 2018). The second is related to social functions such as empathy and memorization (Brockington et al., 2018).

fNIRS preprocessing steps

1. Visual inspection to detect signals irregularities that could be related to artifacts.
2. Bandpass filter (0.01Hz < freq. < 0.2Hz) on the raw data to remove low frequencies systemic artifacts, cardiac and respiratory cycles.
3. Calculation of the oxyhemoglobin variations by using the modified Beer-Lambert law with the whole time series as a baseline and differential path lengths (DPF) of 7.25 and 6.38 for the wavelengths of 760nm and 850nm, respectively.

DATA ANALYSIS

The predictive Model

Machine Learning Algorith (ML): Support vector regression (SVR) with a linear kernel.

Training data: 50% of the Oxyhemoglobin (HbO) related to the first half of the task period

Testing data: 50% of the Oxyhemoglobin (HbO) related to the second half of the task period

Predictors: 50% of the Oxyhemoglobin (HbO) related to the first half of the task period of all channels from the teacher's head (18 independent variables).

Response variables: signals from each channel of the student head

Total of 18 models, one for each channel.

Evaluation of Prediction Performance: Correlation between tested data and original data

RESULTS

SVR – Kernel Linear

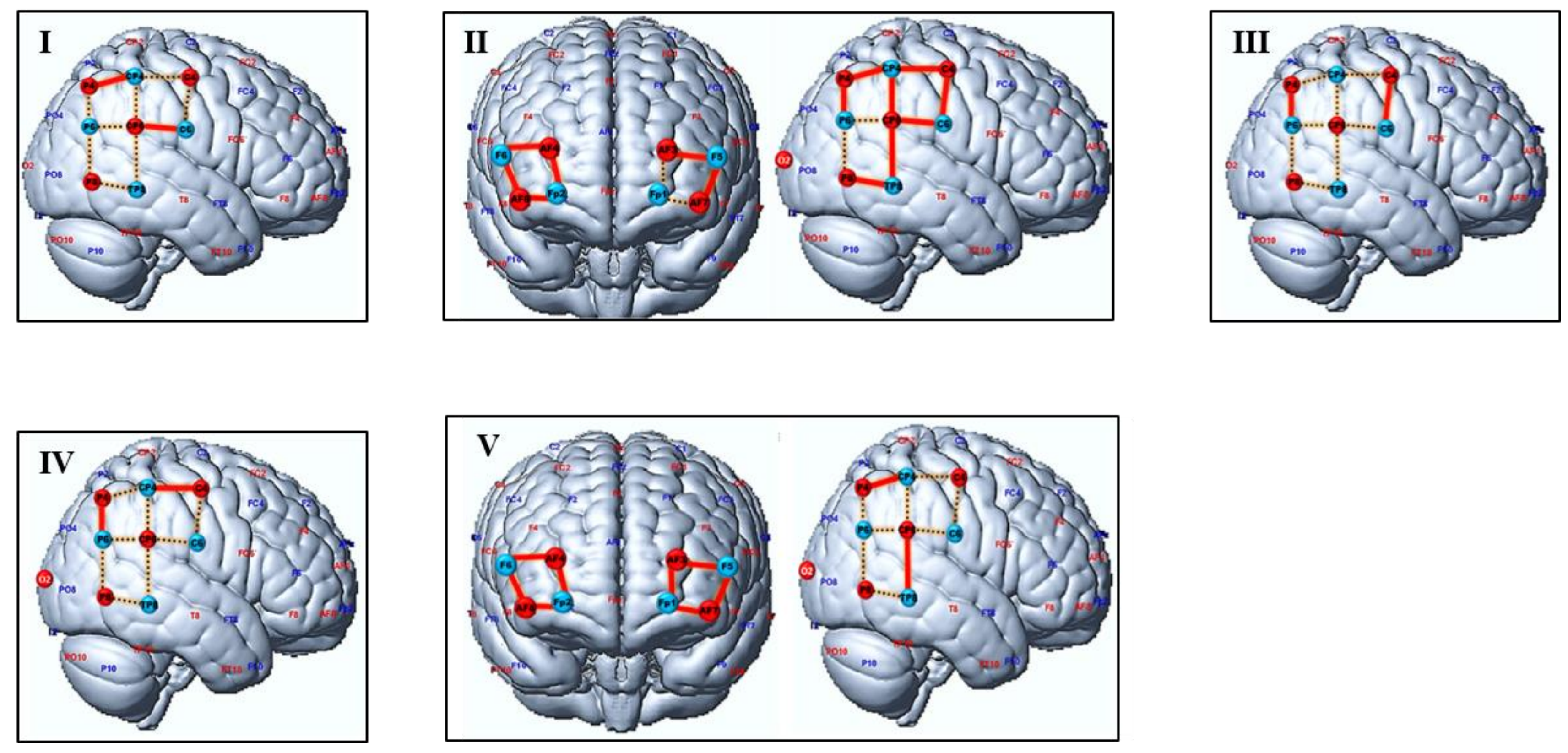

Figure2 Channels with significant correlation between the data test and data predicted by the SVR. Numbers from I to V represent each pair of student-teacher.

Channel	Pair I	Pair II	Pair III	Pair IV	Pair V
1					0.25**
2		0.26**			0.23 *
3					0.29 **
4		0.26**			0.18*
5		0.31**			0.36 **
6		0.18*			0.21 *
7		0.17*			0.33 **
8		0.24**			0.19 *
9		0.29**	0.15*	0.17*	
10		0.31**		0.22*	
11	0.17*	0.30**			
12		0.23**			
13		0.23**			0.10 *
15	0.15*				0.21 *
			0.16*		
16		0.28**			
17		0.30**			

Table1. Correlation values for SVR. Spearman coefficients of correlations between the signals predicted and test data. ** p-value =<0.001; * p-value =<0.01.

CONCLUSIONS

- The algorithm was able to predict the student's brain based on the teacher's brain for all five pairs of subjects.
- All dyads had at least two predicted signals from the TPJ.
- Two pairs of subjects had predictions of signals from the prefrontal.
- The pair II had signals from almost all channels (9,10,11,12,13,14,16,17 and 18) of the TPJ associated with the predicted data; the only exception was channel 15.

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