Brain State Classification in a Social Hierarchy Game

Andrew Fischer¹,², Brooks King-Casas³, Stephen LaConte⁴
¹ Rice University
² Computational Psychiatry Unit, Department of Neuroscience, Baylor College of Medicine

abstract

Support vector machine (SVM) analysis was used to classify the cognitive states of subjects who played a two-person hierarchy/social exchange game using functional magnetic resonance imaging (fMRI) data. Forty-four participants (22 pairs) played 30 rounds of the game while being scanned in two 3T Siemens Trio scanners. During the game one player at a time played the role of the dominant player (α) or the other, the submissive player (β). Several different events could happen during the game play such as the α or β player earning a high or low amount of points to the β or α player or the β player challenging the α player to try to reverse the roles. The goal of this study was to examine the feasibility of predicting game-related events using classification models of the fMRI data. In addition to classification, general linear modeling was utilized to examine the neural correlates of the game-related events. Results from classifying the α player earning high vs. low levels suggest that combining data across subjects leads to higher classification compared to predicting within individual subjects. General linear modeling showed BOLD response to receiving a high or low reward in the bilateral insular cortex. Activity in the caudate was only observed in response to a high rewards.

methods

Fourty-four participant, played a social hierarchy game, outlined in figures (A) and (B). At the beginning of the first round, one subject was assigned the role α (α) and the other, the role β (β). Each was initially given 50 monetary units (MU). In total, 10 MU were allotted per player, per round. α was given the opportunity at the beginning of each round to endow β with MU. For this version of the game, endowments were restricted between 0-4 MU. Endowment values were revealed to β, and β was allowed to challenge for the α role in the next round. If β decided not to challenge, the roles were kept the same, and α retained his role for the next round. If β decided to challenge, β selected a challenge amount (1-10 MU), and α selected a defense amount (1-5 MU). Challenge and defense amounts were revealed together after the respective decisions of α and β. If β challenged α, defense became the α for the next round and made the initial endowment. If defense passed the challenge, the roles were kept the same and α remained as the α for the next round. At the end of each round, the MU totals were recalculated, and revealed to participants. Participants were paid $25 and $50 USD, based on the number of MU accumulated over the course of 30 rounds.

The support vector machine (SVM) algorithms within ANFI, 3tums, was used for multi-class classification of whole brain volumes (LaConte, 2006). Label files containing 1s and 0s corresponding to two classification states were created for a challenge or not challenging, α endorsing a high or low amount, β receiving a high or low reward, and β challenging with a high or low amount. Label files were created to model the hemodynamic response, 1.2 second leg time at the onset of the stimulus, and duration of 6-8 seconds. Significance time points before and after each of the events were identified and used to create a time locked schedule for training and testing of the models. The label files were split into 1/4ths, and models were built on 3/4ths of the data and tested on the remaining 1/4ths. Models were built and tested on each of the 4 possible 3/4ths/1/4ths splits for each subject for every event. Total correct classification scores were summed for each of the 4 splits for each subject per event and a final prediction accuracy was obtained. Large volume data sets were concatenated from multiple subjects to test the prediction of accuracy of models across multiple time points. Subjects with little variance concerning the event were not included in the analysis, e.g. Subject 001-1 always endores high when α. Separate general linear models (GLM) were specified and estimated for each of 25 subjects. All visual stimuli and motor responses were entered as separate regressors, which were constructed by covining punctuate events at the onset of each stimulus or motor response with the fed hemodynamic response function (HRF). Fixef effects associated with individual rounds were pooled across behaviorally defined categories and compared using a t-test.

results

Successful classification of whole brain states implementing the SVM algorithm allowed for an increased prediction accuracy for α endorsing a high (H) or low (L) amount (t-test, p<0.05) and β challenging or not challenging (t-test, p<0.05) to the keypress, when the decision is logged. Also, there was successful classification for β receiving a high or low amount (t-test, p<0.05) and on one time-series for β challenging with a high (H) or low (L) amount (t-test, p<0.05). For α endowments (D), modeling implemented 1-4TRs following the onset of the endowment increase (1627 time points) and 2TRs following the increase of the keypressed (1484 time points) showing relatively constant classification on an intra-subject basis. A concatenated data set for the same keypress endowment (1456 time points) showed improved improvement in the subject models implemented for β challenging (β) showed increased classification accuracy from 1-4TRs following the endowment increase (2350 time points) and following the evaluation screen (2534 time points), through 2TRs prior to and following the keypressed (3457 time points). A model built on the endowment evaluation, common keypress, and keypress time-series showed constant classification for β receiving a high or low endowment (1) on 1336, 1336, and 1288 time points, respectively. Models built on concatenated data for the endowment keypress (both 388 time points) had higher classification accuracies. A model built on the evaluation time-series of β challenging high or low or (732 time points) showed slightly significant classification accuracy.

summary

Support vector machine (SVM) algorithms were implemented to build models on fMRI data collected from subjects playing a social hierarchy game. These models were used to successfully classify whole brain states in the time course of the decision within each of the game β challenging or not challenging in response to a endowment (D), α endorsing a high or low amount to β (E), receiving a high or low amount (F), and β challenging with a high or low amount (G). Models built from combined data set generated higher classification accuracies than separate sub-models, as more time points are included in the concatenated data set models. Also, in general, time series closer to the event in question have higher classification accuracies. General linear modeling revealed BOLD activity in the bilateral insular cortex in response to both high and low endowments being revealed (H). High endowments also elicited activity in the left and right caudate (H).

Further studies will include implementation and analysis on model building with concatenated data sets, as the classification is more accurate. These results will be used in conjunction with activation maps elicited from the GLM to assist regions of interest (ROI) masks in hopes to optimize the SVM algorithm.

This work was partially supported by NSF REU Grant CNS-0752594.

references


