Decoding of semantic category information from single trial fMRI activation in response to word stimuli, using searchlight voxel selection

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Introduction It has been established that machine learning classifiers can be used to decode the semantic category of *picture* stimuli from a block of images acquired while the stimuli were being displayed to a subject. We show that it is possible to do this for *word* stimuli from images acquired during a 4 second interval. Moreover, we introduce a novel application of voxel searchlights as a voxel selection technique furthersing the ability to localize the information used by the classifier.

Dataset

Each trial of this event-related study had the subject see a word for three seconds and think of its properties while it was on the screen, after which the screen blanked for eight seconds. Each of 6 epochs consisted of the presentation of 7 exemplars of 2 categories,"tools" and "buildings", yielding a total of 84 trials. Images obtained in seconds 7-11 of each trial were averaged together to produce an example for classifier training.

Methods We trained a Gaussian Naive Bayes classifier in six-fold cross-validation, testing on each epoch and training on the remaining five. Inside the training set for each fold, we ran an additional cross-validation for scoring and selecting voxels to train the classifier on. We considered two accuracy selection criteria: the accuracy of GNB trained on 1)a *single voxel* and 2)using voxels inside a *searchlight* (a 3x3x3 voxel cube) centered on it. Both criteria yield one accuracy score per voxel.

Results and Conclusions

The table shows the classification results obtained in 3 subjects, selecting various numbers of voxels using each method.

Subject	Method	no. sig. voxels	number of voxels selected 20	50	100	200	300	400	600	800	1000	all
01481B	searchlight	317	0.77	0.81	0.81	0.81	0.82	0.82	0.81	0.81	0.79	0.65
	single voxel	1	0.77	0.82	0.81	0.80	0.79	0.75	0.74	0.71	0.73	0.65
01482B	searchlight	180	0.81	0.76	0.77	0.77	0.79	0.81	0.79	0.76	0.76	0.63
	single voxel	0	0.74	0.74	0.79	0.79	0.76	0.75	0.76	0.75	0.74	0.63
01897B	searchlight	449	0.74	0.75	0.81	0.82	0.81	0.81	0.81	0.82	0.81	0.69
	single voxel	3	0.81	0.80	0.80	0.81	0.80	0.80	0.80	0.77	0.77	0.69

The best results obtained with either method are similar, though it appears that, as the number of voxels selected increases, *searchlight* selected voxels are more accurate. Given that GNB adds information voxelwise to predict a label for an image, one can determine which voxels contributed information by looking at their individual prediction accuracies. We do so by converting the accuracy at each voxel into a p-value under the null hypothesis that the accuracy is 0.5, and thresholding the resulting p-value image using a false discovery rate procedure (0.01 nonparametric threshold). As evidenced by the table column "no. sig. voxels", the *searchlight* p-value images contained hundreds of significant voxels, while the *single voxel* p-value images contained almost none. This indicates that many voxels, together with their neighbors, can form a group where the majority decides more accurately than any individual.

Figure 3 show the voxels whose searchlight accuracies were deemed significant for three subjects (70We thus conclude that searchlight accuracy is a valid indicator of voxel contribution to decoding accuracy, and better than single voxel accuracy.

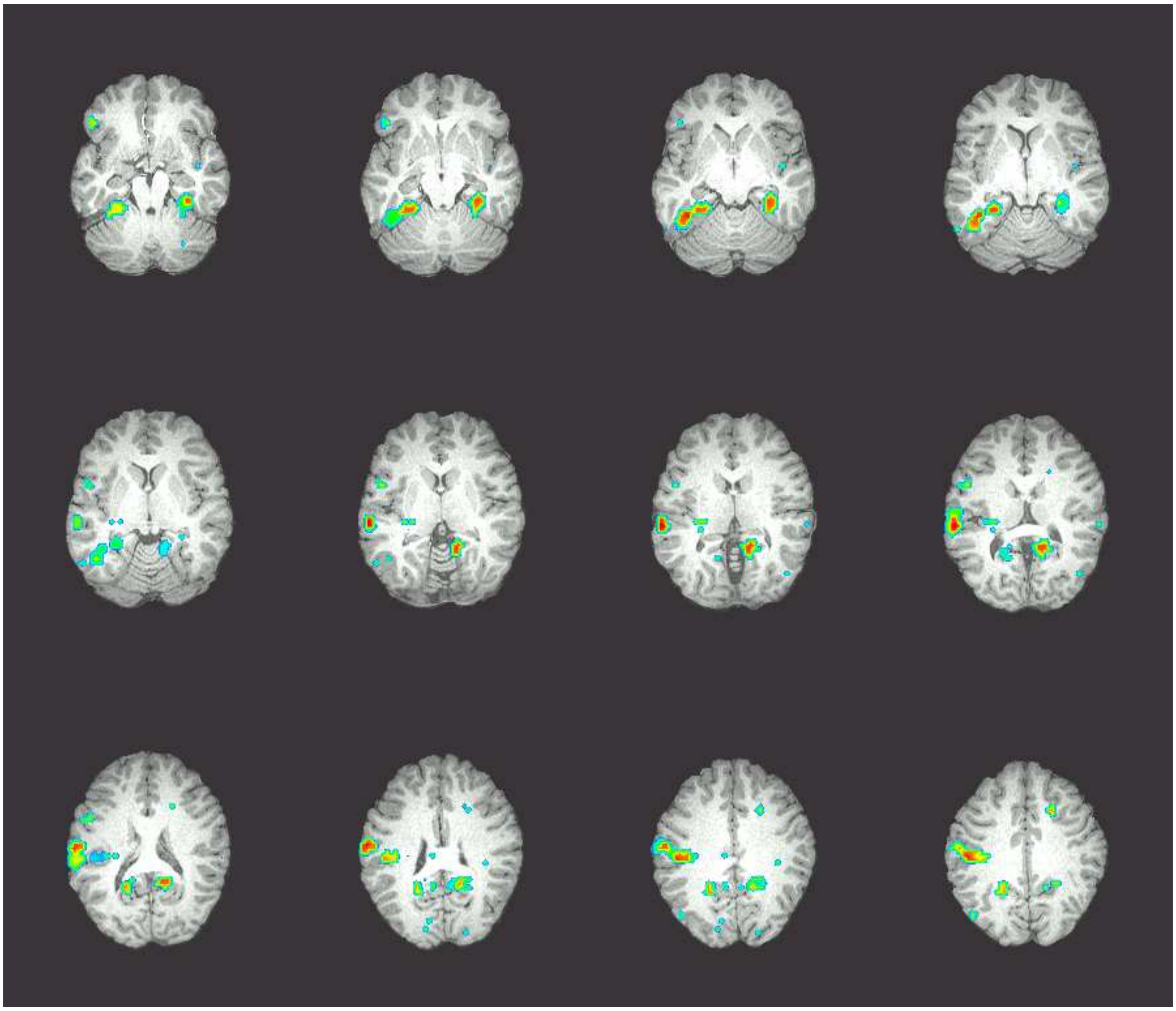

Figure 1: **Searchlight accuracy for voxels that have significant p-values, in subject 01481B**. The scale ranges from 70%(blue) to 80%(bright red).

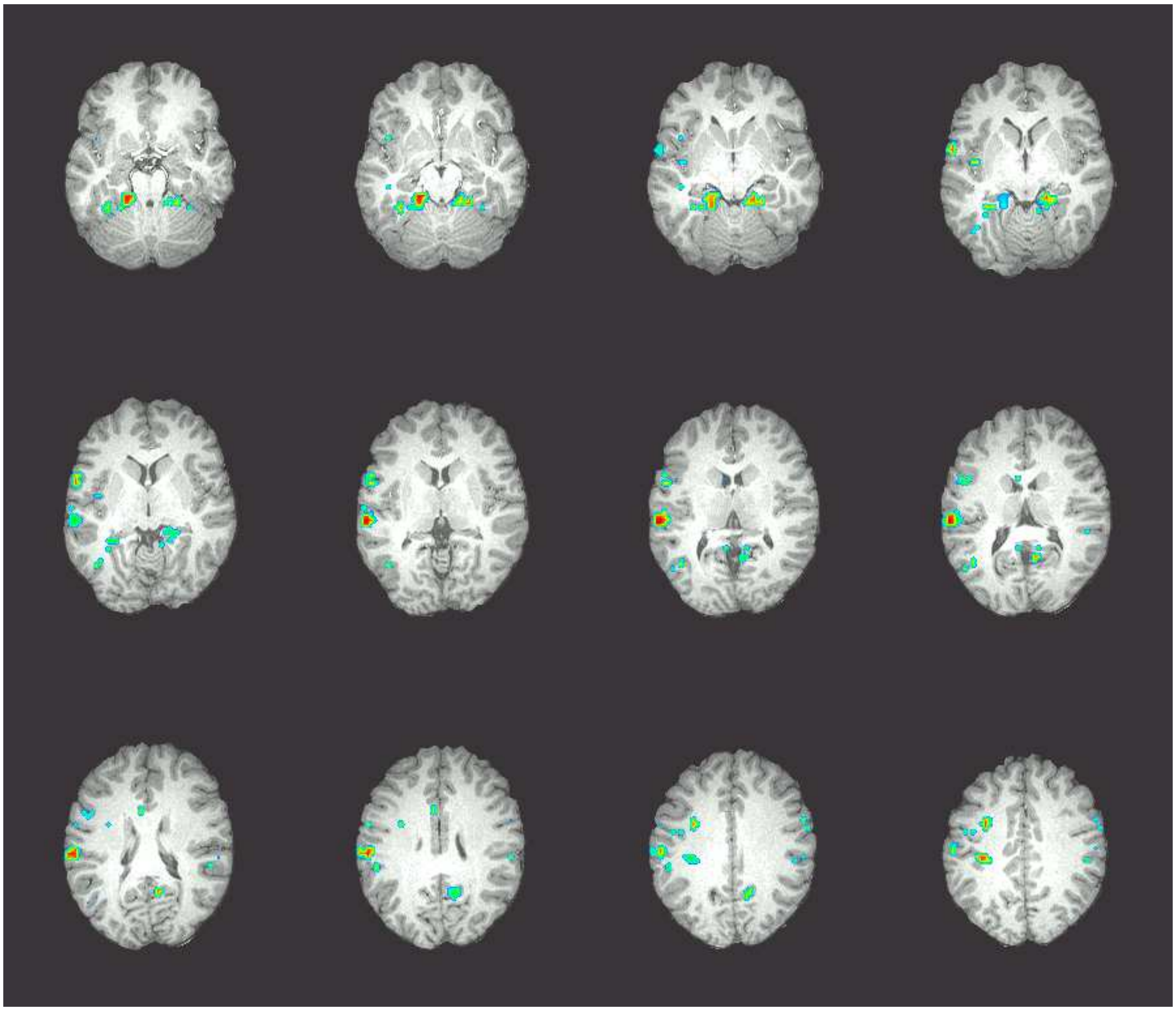

Figure 2: **Searchlight accuracy for voxels that have significant p-values, in subject 01482B**. The scale ranges from 70%(blue) to 80%(bright red).

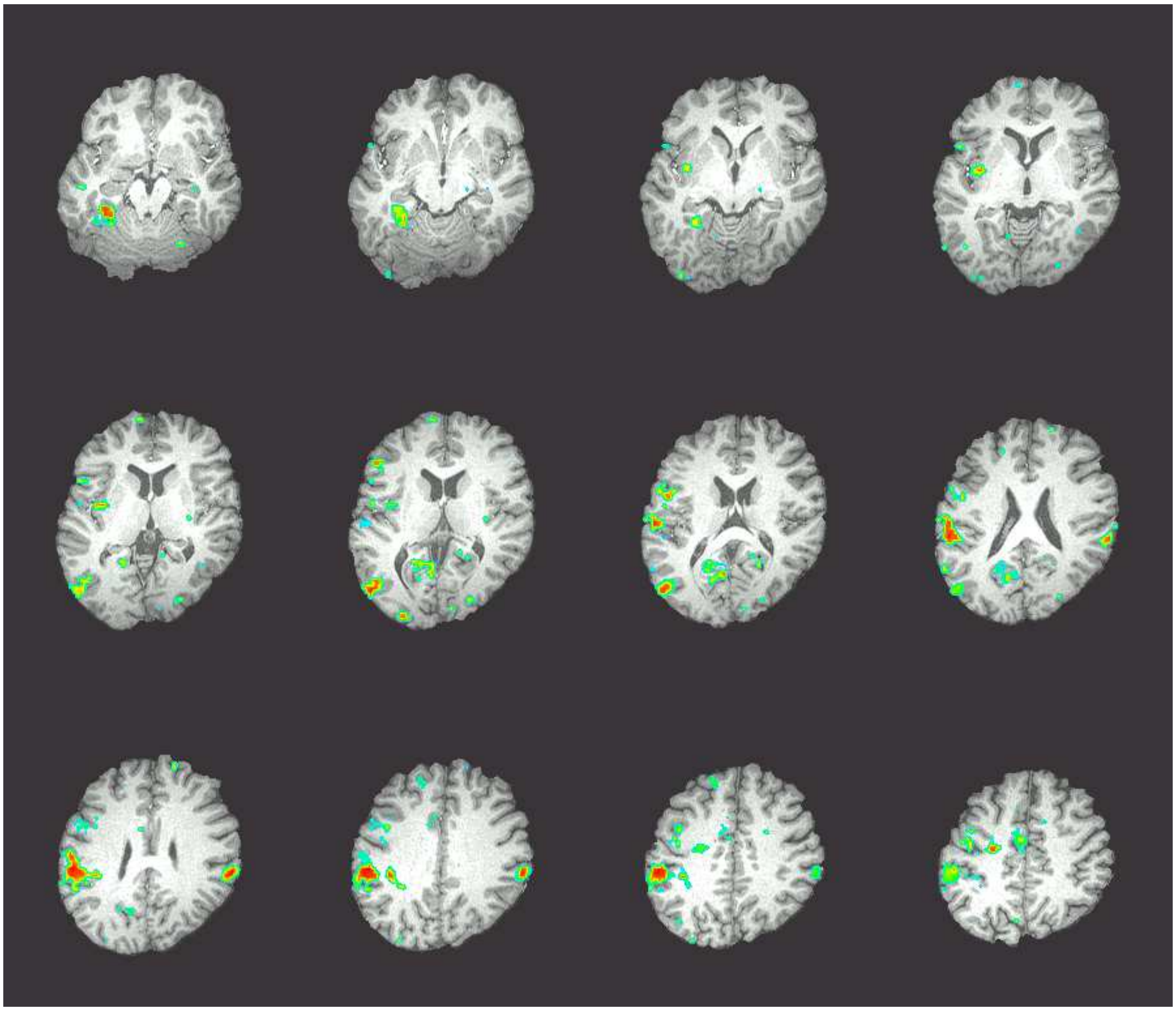

Figure 3: **Searchlight accuracy for voxels that have significant p-values, in subject 01897B**. The scale ranges from 70%(blue) to 80%(bright red).