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Title: Detrimental effect of head motion covariates on GLM and multivoxel classification analysis of FMRI data
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Abstract: Head movements correlated with the stimulus time course can be a severe problem in FMRI analyses, yielding artefactual activations. To reduce this problem, the first step of data preprocessing is spatial alignment of the collected brain volumes over time, and the voxel wise removal of time signal components correlated with the six rigid body head motion parameters obtained from this motion correction step. This can be problematic for general linear model analyses when the head motion regressors are correlated with the stimulus time courses, as desired signal will be removed along with artifact, but the benefit of removing nuisance variance to statistical detection is considered to outweigh this loss of sensitivity. Less is known about the influence of the removal of correlated head motion on multivariate analysis classification methods, e.g. support vector machines. We investigated the influence of linear regression on GLM and support vector machine analyses by creating simulated data sets and removing nuisance regressor of varying correlation with the stimulus time course. We report that for both types of analysis, false positive and false negative rates increase with increasing similarity between regressor and stimulus. Additionally, crossvalidated classification performance becomes strongly biased toward sub chance performance levels as the correlation between nuisance regressor and stimulus increases, down to a performance level of 0%, where every instance is misclassified in crossvalidation. This bias becomes stronger with an increase in the number of voxels in the dataset, a decrease of the number of time points, and an increase of N for 1-in-N crossvalidation. An opposite classification performance bias is introduced for small numbers of time points, when the regressor is uncorrelated with the stimulus. We also show that obtaining a new null distribution cannot remove these introduced biases, as performance level correlation across simulated datasets before and after regression decreases along with the mean performance. Overall, these results highlight the very problematic nature of stimulus correlated head motion in FMRI experiments, especially in the context of multivoxel analyses which are both highly sensitive to motion induced artifacts and biases introduced by their attempted removal.