Is model fitting necessary for model-based fMRI?

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Summary

Is model fitting necessary?

Nope!*

*depending on: number of trials, signal-to-noise ratio, task dynamics, the model under consideration

So: model-based fMRI is robust but it is also insensitive

What is model based fMRI?

1. Fit a model (e.g. Q-learning) to human behavior
2. Estimate trial-by-trial values of variables (e.g. Q-values)
3. Look for correlates of these signals in the brain

Theory

Simple example with binary rewards

Subject computes $V_{true}$ with learning rate $\alpha_{true}$ (e.g. 0.1)

$V_{true}$ is the signal in the brain

Experimenter computes $V_{fit}$ with learning rate $\alpha_{fit}$ (e.g. 0.5)

$V_s$ is the regressor

Regression coefficient, $\beta_{fit}$

Depends on true signal, $\beta_{true}$, and correlation between $V_{true}$ and $V_{fit}$

$t$-statistic

Depends on correlation, number of trials, $T$, and signal-to-noise ratio, $SNR = \beta_{true} / \sigma_{reg}$

$t_{fit} = \rho(V_{true}, V_{fit})SNR \sqrt{\frac{T - 2}{1 + SNR^2(1 - \rho(V_{true}, V_{fit})^2)}}$

Experimental results* (nucleus accumbens ROI)


Effect of learning rate on correlations* and regression coefficients

Prediction error

Strong signals improve sensitivity

More trials improve sensitivity

Sensitivity to parameter fit can be tuned experimentally

Drifting reward probability

3. Look for correlates of these signals in the brain

Regressions coefficient, $\beta$

Effects of learning rate on correlations*

Experimental results* (nucleus accumbens ROI)

Prediction error

Frequently Asked Questions

What does this mean for my model?

Not all models will be as insensitive. Sensitivity can be tested with simulation

Can I be lazy and not fit my model?

No. If you can fit you should, but if parameter estimates are bad, it might be OK

What does this mean for my experiment?

Sensitivity to parameters can be tuned by changing the experiment

Can I join your new lab at the University of Arizona?

Why yes! Ask me now or visit u.arizona.edu/~bob

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