Cue- target fMRI Design Deconvolution Efficiency

(need a new name)

Here, we simulate different cue- target fMRI paradigm designs and assess their efficiency.

Efficiency is calculated based on two parameters:

i. Detection Efficiency (Fd): This is a parameter of how good the GLM is able to detect a brain activation.
ii. HRF Estimation Efficiency (Fe): This is a parameter of how good the HRF can be estimated in a continuous brain signal. In simple terms, this is a measure of how good the shape of the HRF is and how good is the deconvolution between the HRF for cue and target.

Please note: Do not compare the numbers for Fd and Fe, they are relative to themselves. For example, '20' for Fd and '20' for Fe do not mean the same thing. They have NOT been standardized yet, so they do not qualify for comparison. But '20' Fd is definitely greater than '12' Fd.

We are still looking for a way to find one estimation parameter that defines the overall design efficiency for this case, I am thinking about a weighted linear combination of Fd and Fe, but they need to be standardized with respect to something first.

I have not added the statistical models and algorithms used to compute these values, but the references are added.

Fd and Fe depend on the following parameters:

i. Stimulus Duration (How long is the cue or target on the screen)
ii. Lower Bound of ISI
iii. Upper Bound of ISI
iv. Ratio of activation for cue to that of the target
    Say activation_cue = 0.7* activation_target
v. Percentage of Cue only trials
vi. No. of trials total

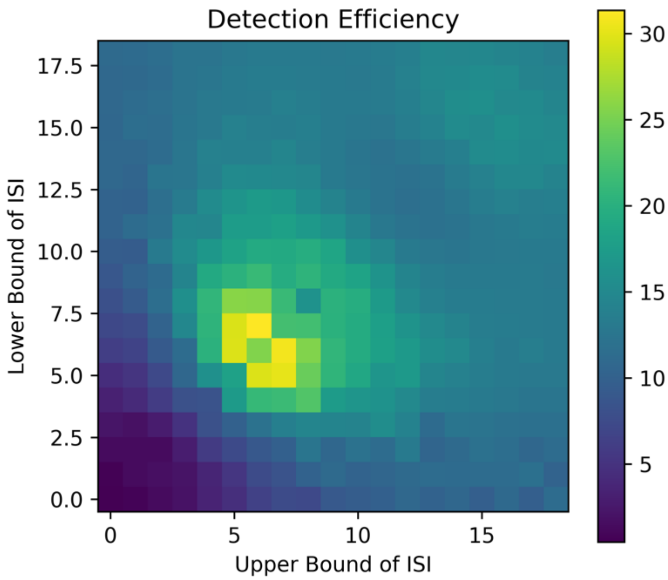
** The bold parameters play a significant role in efficiency.
In some simulations, there are no noise added so, **BRAIN = SIGNAL ONLY.**
In some simulations, noise is added to the model so, **BRAIN = SIGNAL + NOISE**

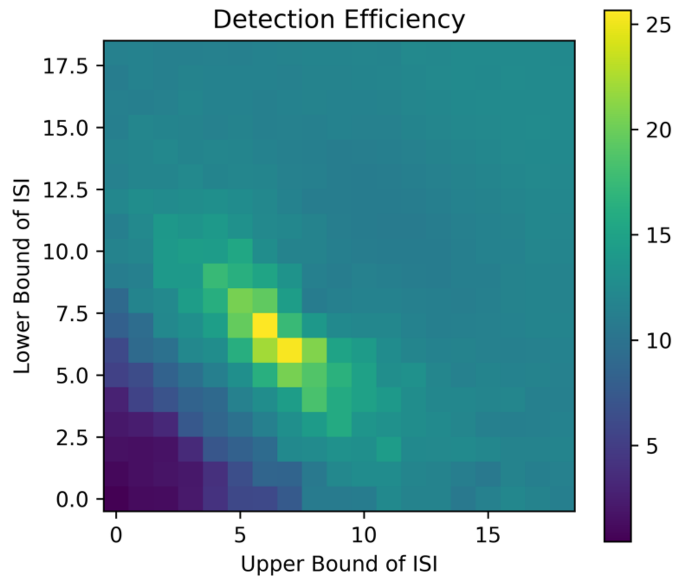
PTO

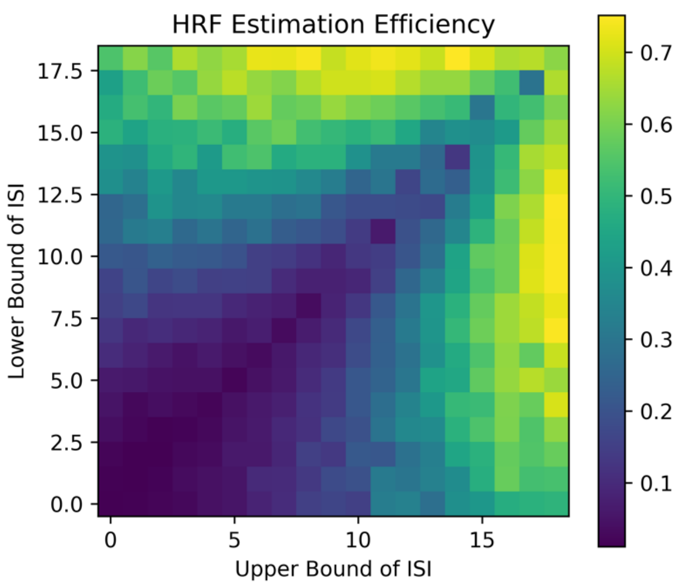
SIMULATION A:

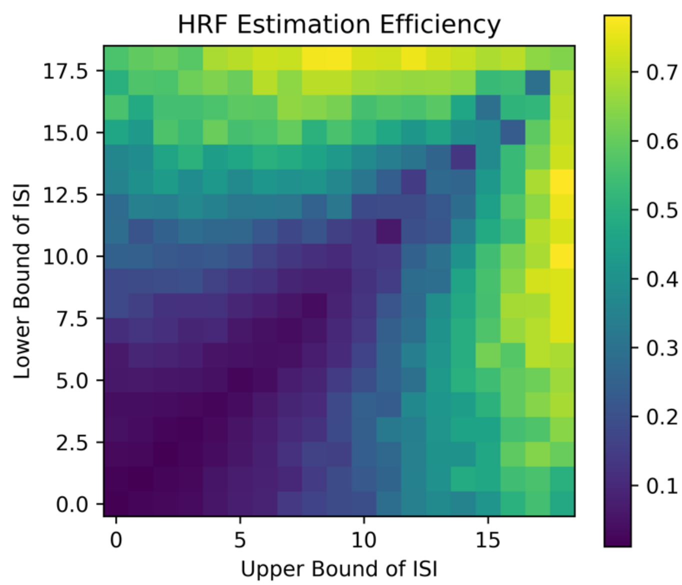
There are exactly 100 trials in each experiment. That means each pixel represents 100 trials spaced according to the respective bounds of jitters.
BRAIN = SIGNAL

100 trials	Ratio of Activation = 1	Event Dur: 0.1s	100 trials	Ratio of Activation = 0.1	Event Dur: 0.1s









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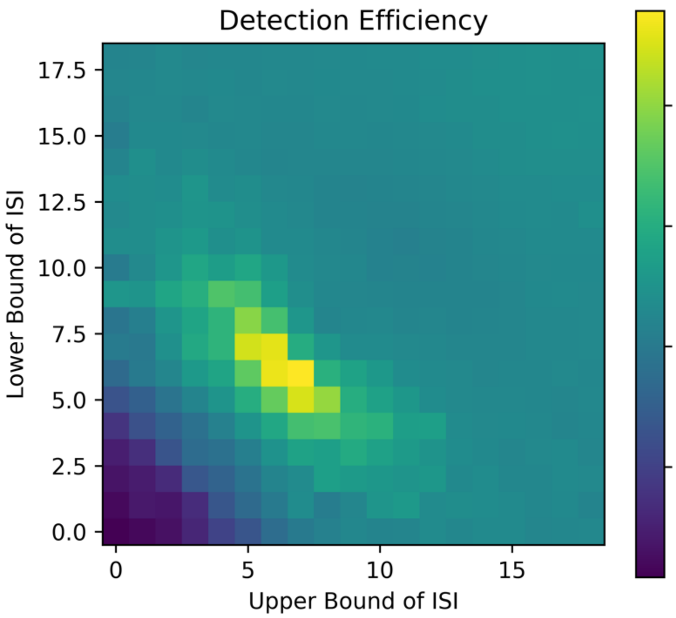
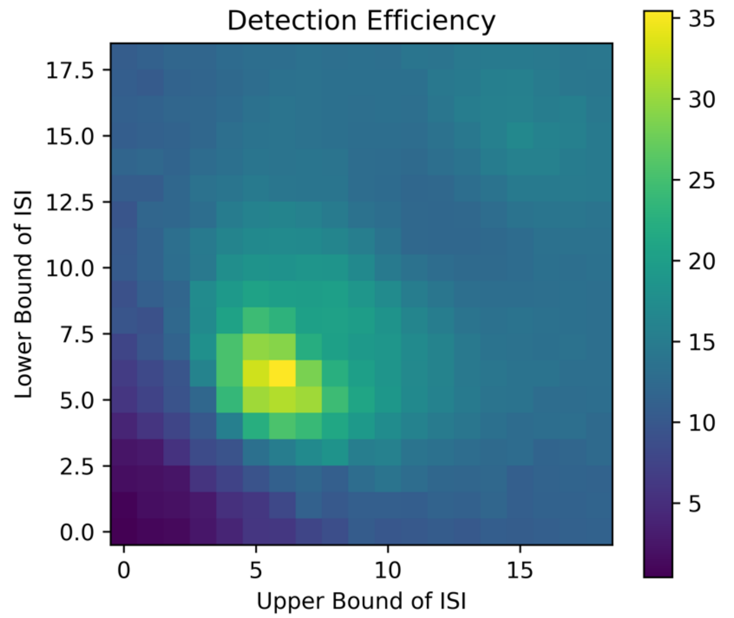
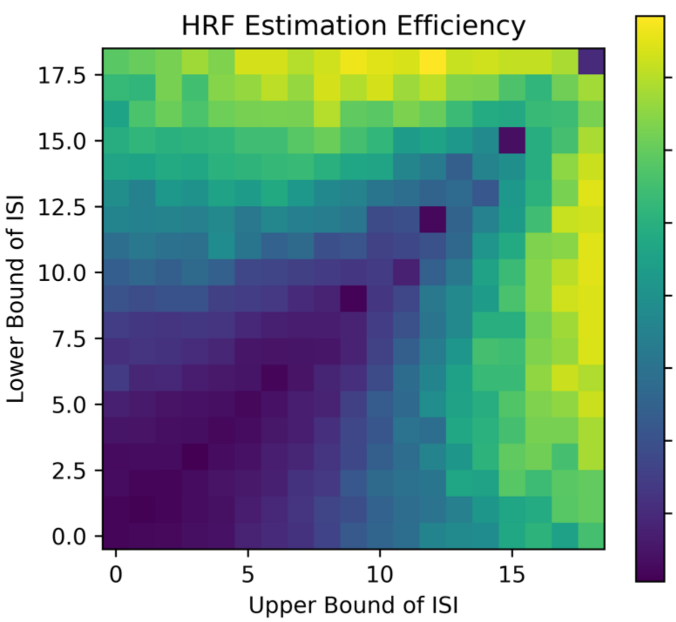
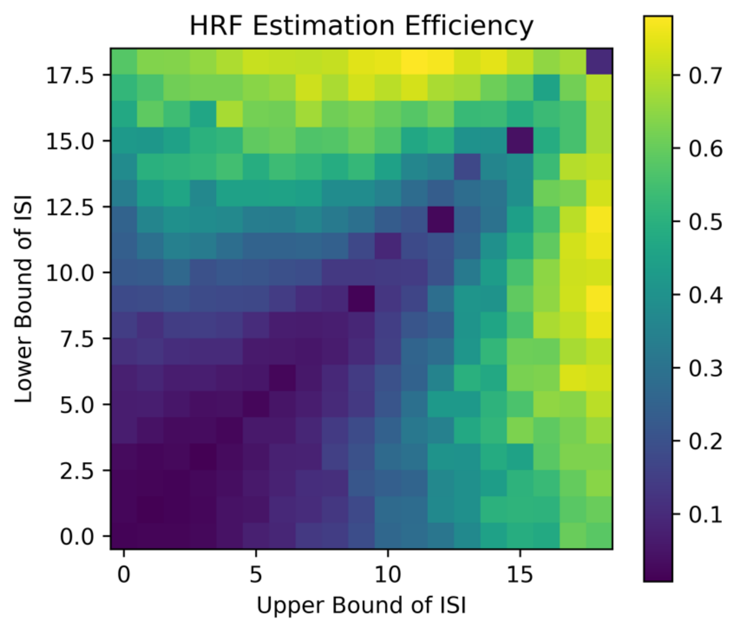
100 trials	Ratio of Activation = 0.1	Event Dur: 0.5s	100 trials	Ratio of Activation = 1	Event Dur: 0.5s



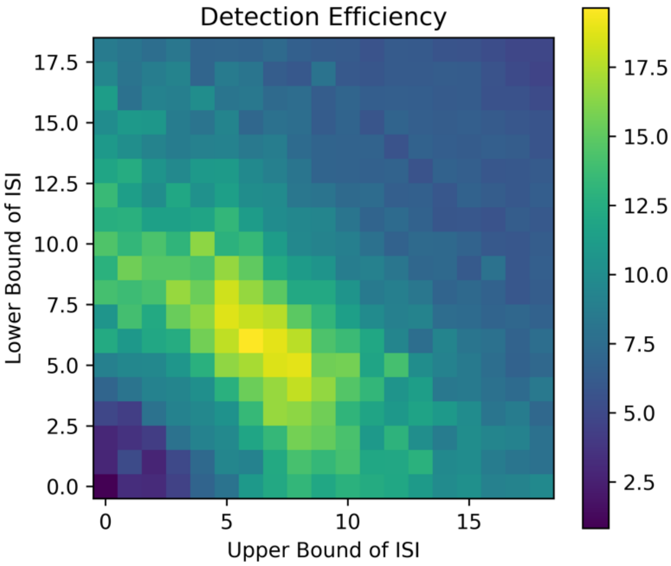


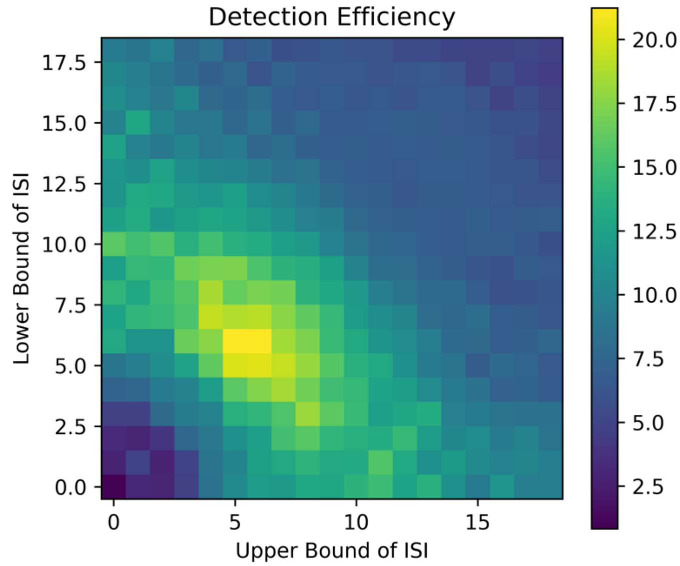


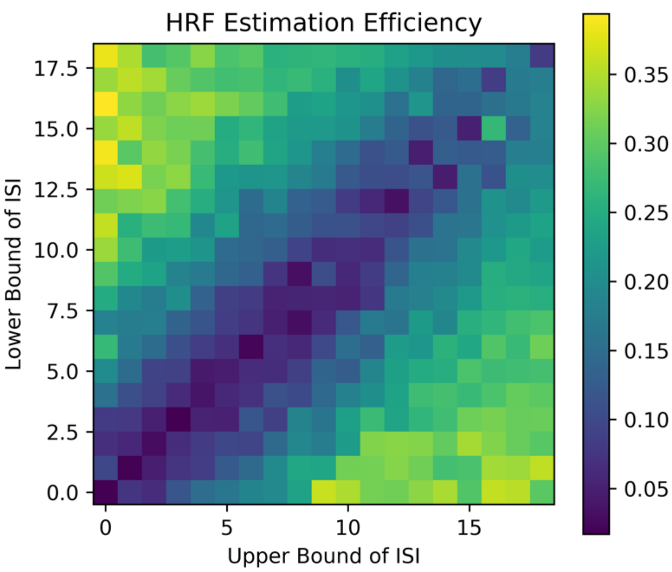


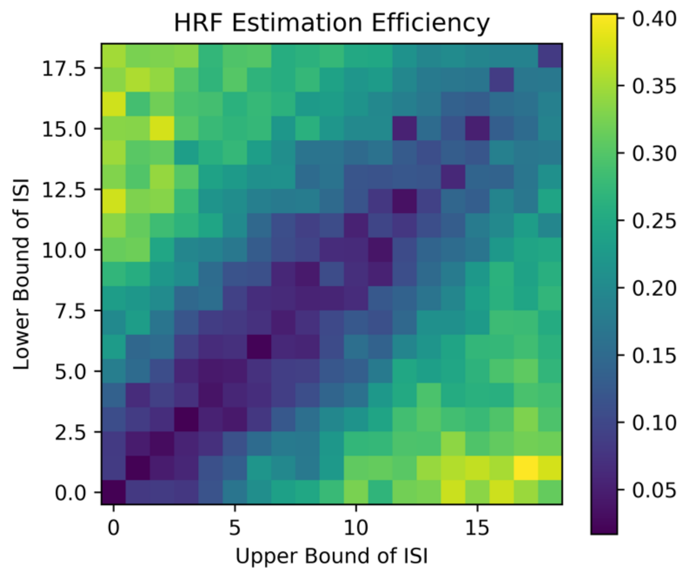
SIMULATION B: There are variable number of trials in each experiment, but the total time of the experiment is FIXED at 294 TRs. So, as the ISIs become longer, the number of trials reduce. So, coordinate (2,3) has higher number of trials than coordinate (12,13).
BRAIN = SIGNAL + NOISE

294 TRs (Fixed Time)	Ratio of Activation = 0.1	Event Dur: 0.5s	294 TRs (Fixed Time)	Ratio of Activation = 1	Event Dur: 0.5s

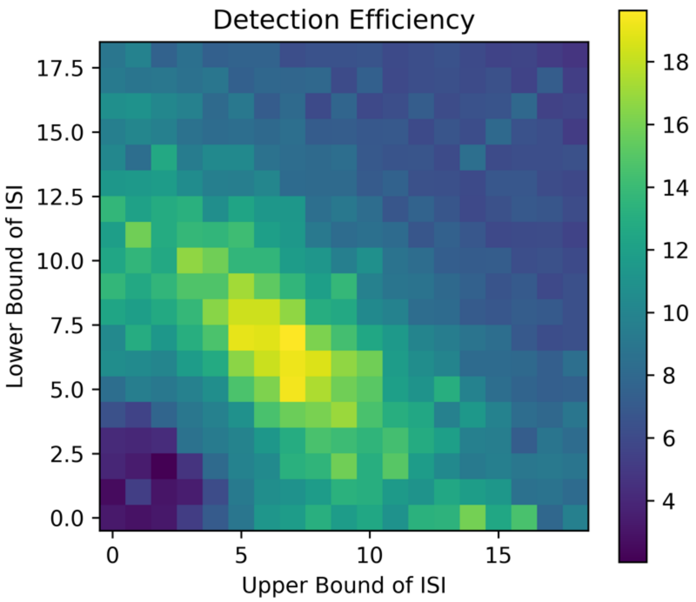


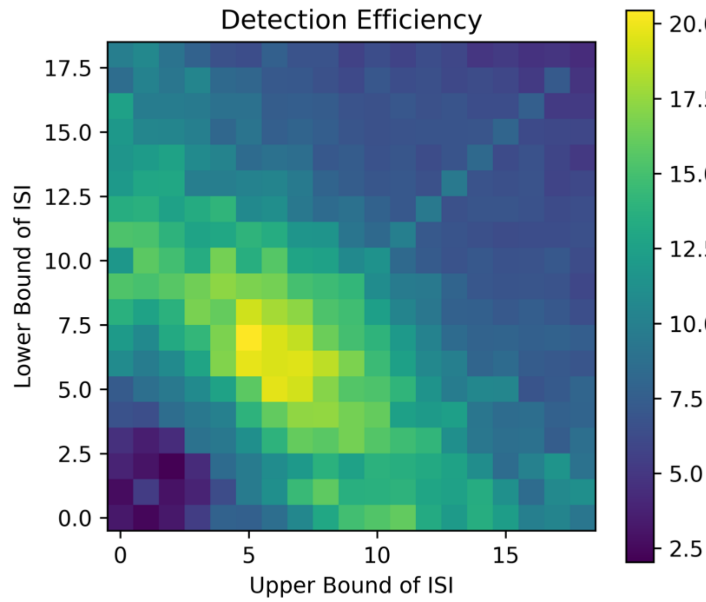


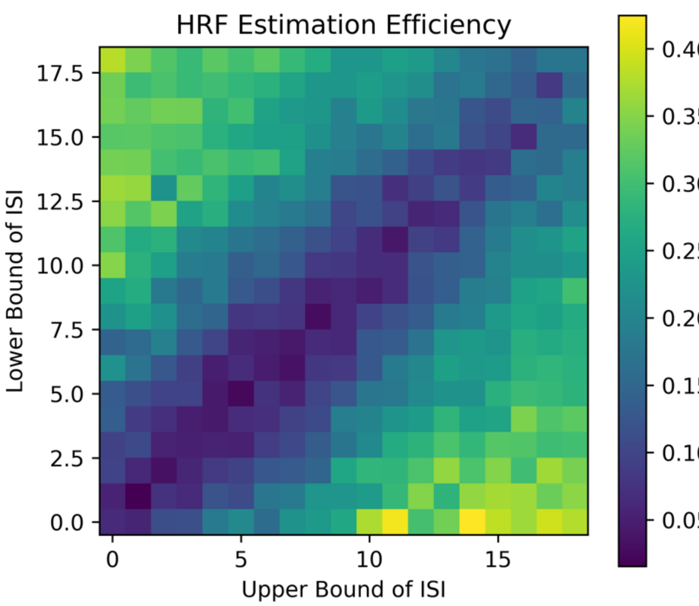


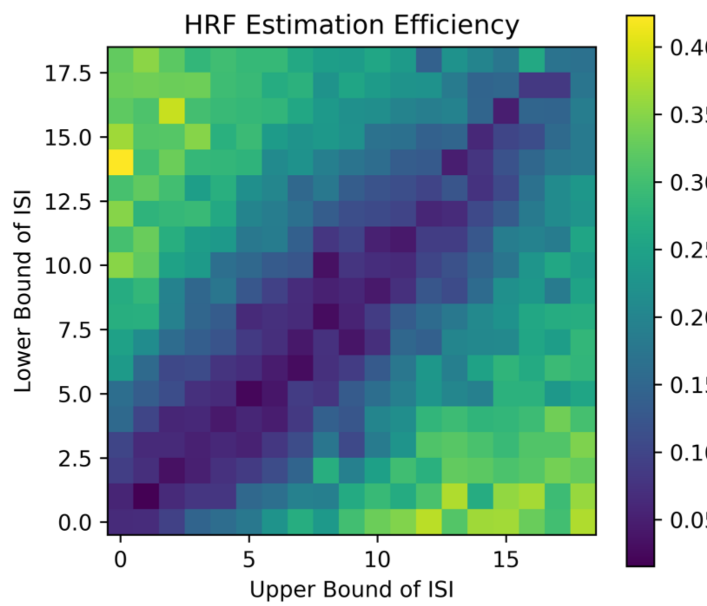


294 TRs (Fixed Time)	Ratio of Activation = 0.1	Event Dur: 0.1s	294 TRs (Fixed Time)	Ratio of Activation = 1	Event Dur: 0.1s





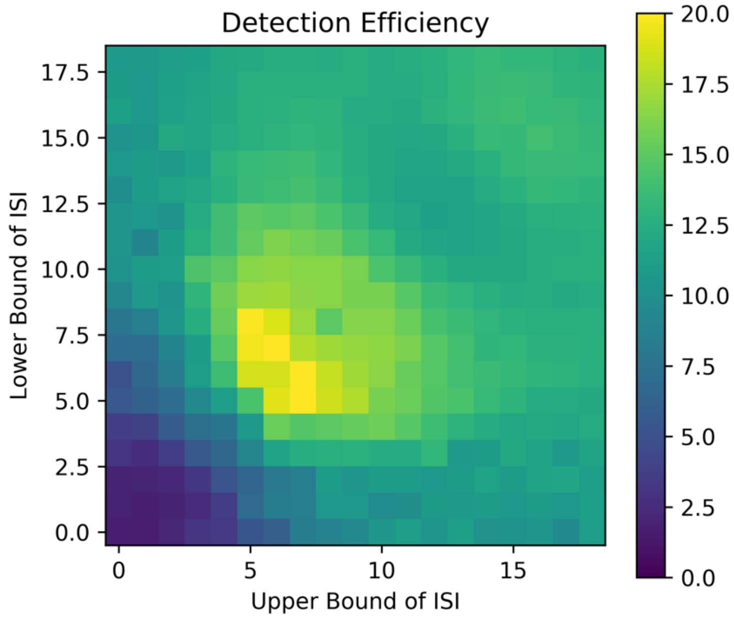


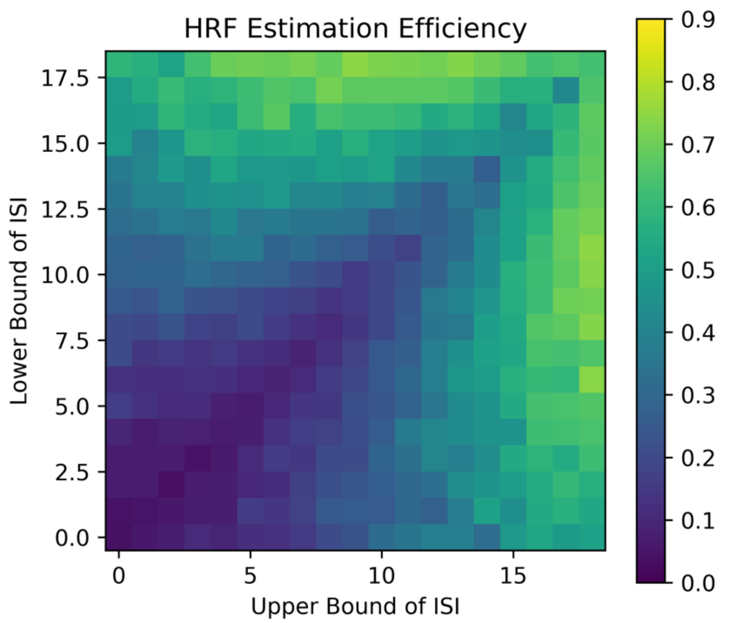


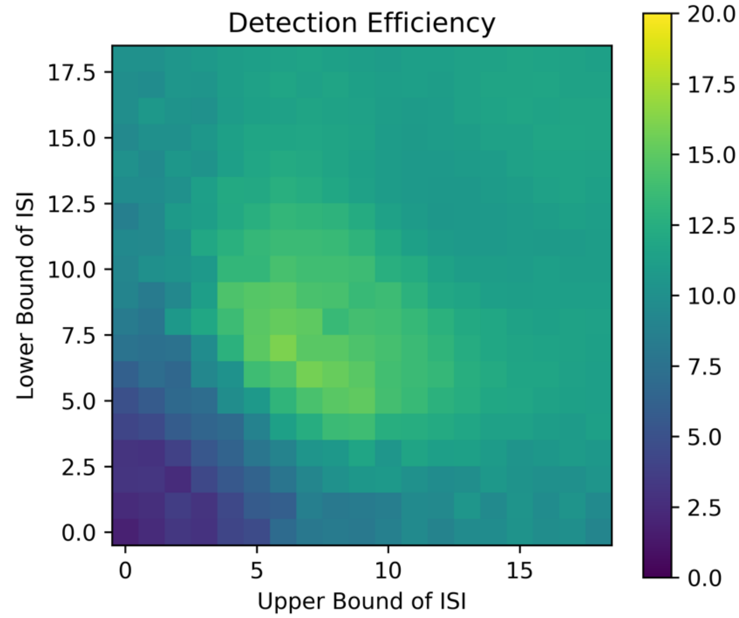
SIMULATION C: There are less than 100 trials in each experiment. That means each pixel represents 100 trials spaced according to the respective bounds of jitters.

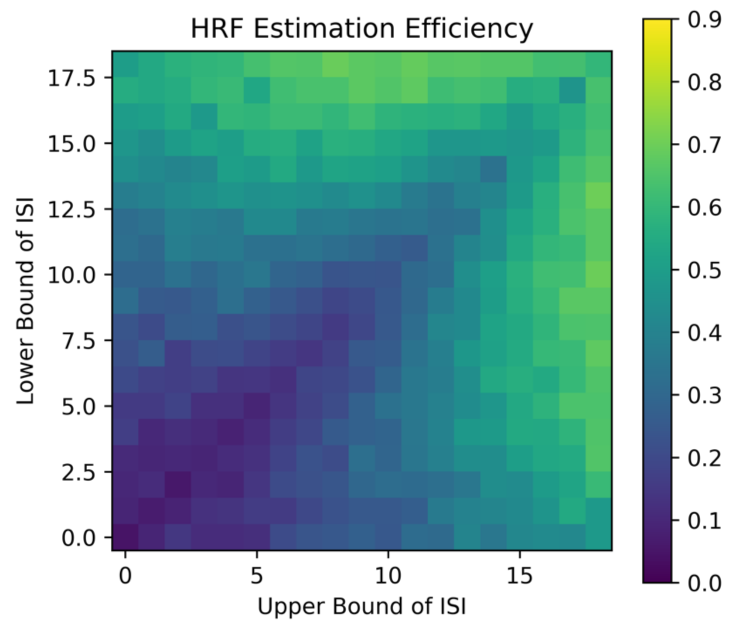
BRAIN = SIGNAL ONLY.
Here we vary the proportion of cue only trials. So, if proportion is 0.1, it means there are 10% cue only trials in the design.

90 Trials, Proportion = 0.1	Ratio of Activation = 1	Event Dur: 0.1s	80 Trials, Proportion = 0.2	Ratio of Activation = 1	Event Dur: 0.1s

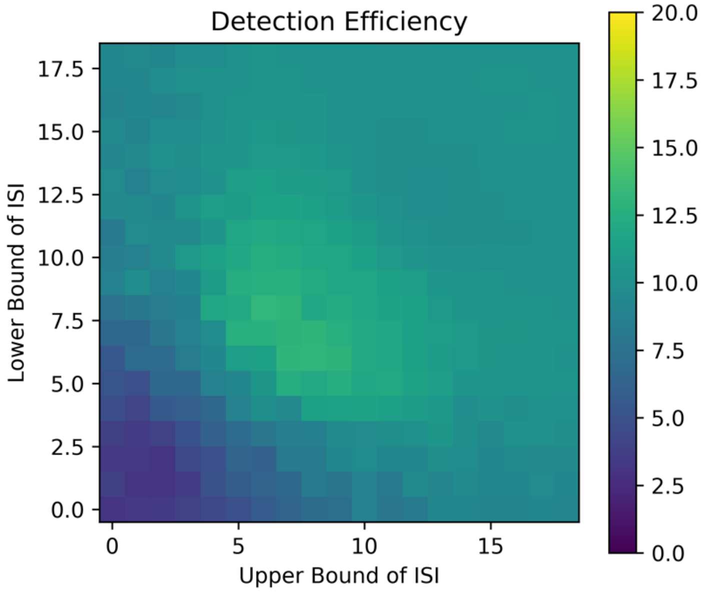


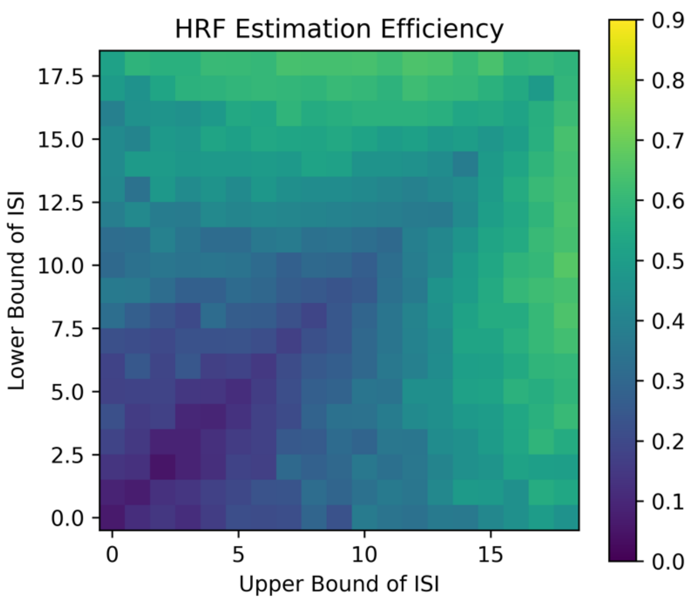


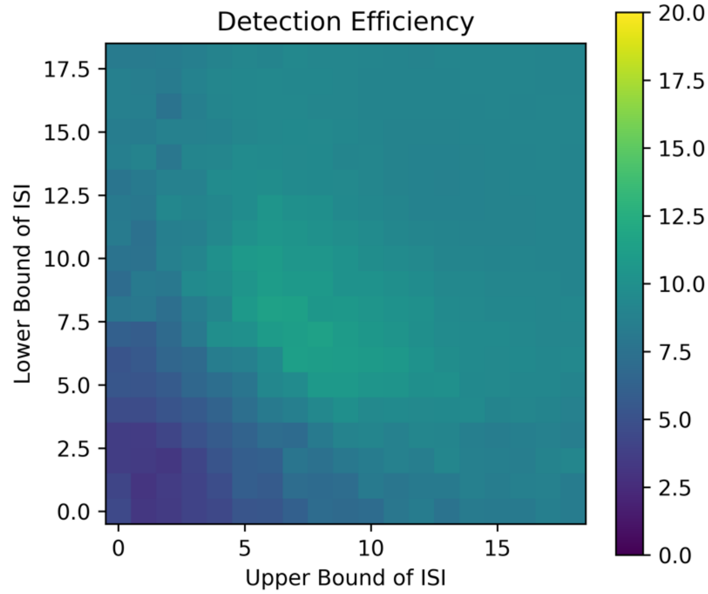


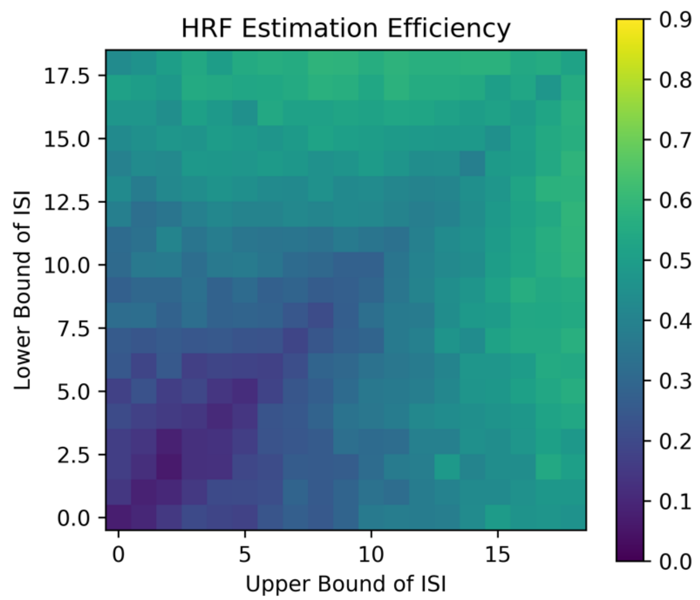


70 Trials, Proportion = 0.3	Ratio of Activation = 1	Event Dur: 0.1s	60 Trials, Proportion = 0.4	Ratio of Activation = 1	Event Dur: 0.1s



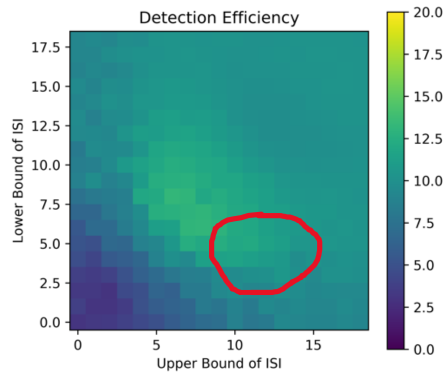


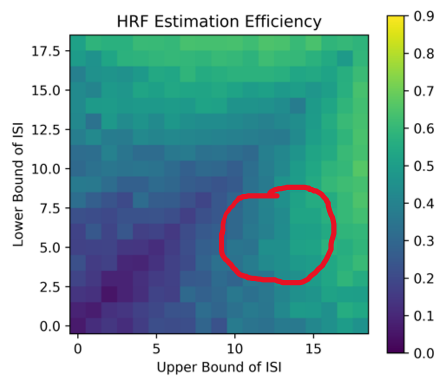




KEY FINDINGS:

1. **Cue only trials help in the detection efficiency**
2. **The best region of operation is mostly around 2-12 ISI as shown in the figure below as it employs the best of Fe and Fd:**





References:

Dale, A. M. (1999). Optimal experimental design for event-related fMRI. *Human Brain Mapping*, *8*(23), 109–114. https://doi.org/10.1002/(sici)1097-0193(1999)8:2/3<109::aid-hbm7>3.3.co;2-n

Wager, T. D., & Nichols, T. E. (2003). Optimization of experimental design in fMRI: A general framework using a genetic algorithm. NeuroImage, 18(2), 293–309. https://doi.org/10.1016/S1053-8119(02)00046-0

Kao, M., Mandal, A., Lazar, N., & Stufken, J. (2009). NeuroImage Multi-objective optimal experimental designs for event-related fMRI studies. *NeuroImage*, *44*(3), 849–856. https://doi.org/10.1016/j.neuroimage.2008.09.025