Information Jitter Derivative Method: A Novel Approach to the Analysis of Multiplexed Neural Codes

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Problem

- Studies that **investigate the presence of information multiplexed at several time scales** across the neural response rely on specific ad hoc assumptions [1].
- We still lack a simple method that can easily **individuate all temporal scales carrying unique information within a spike train**.

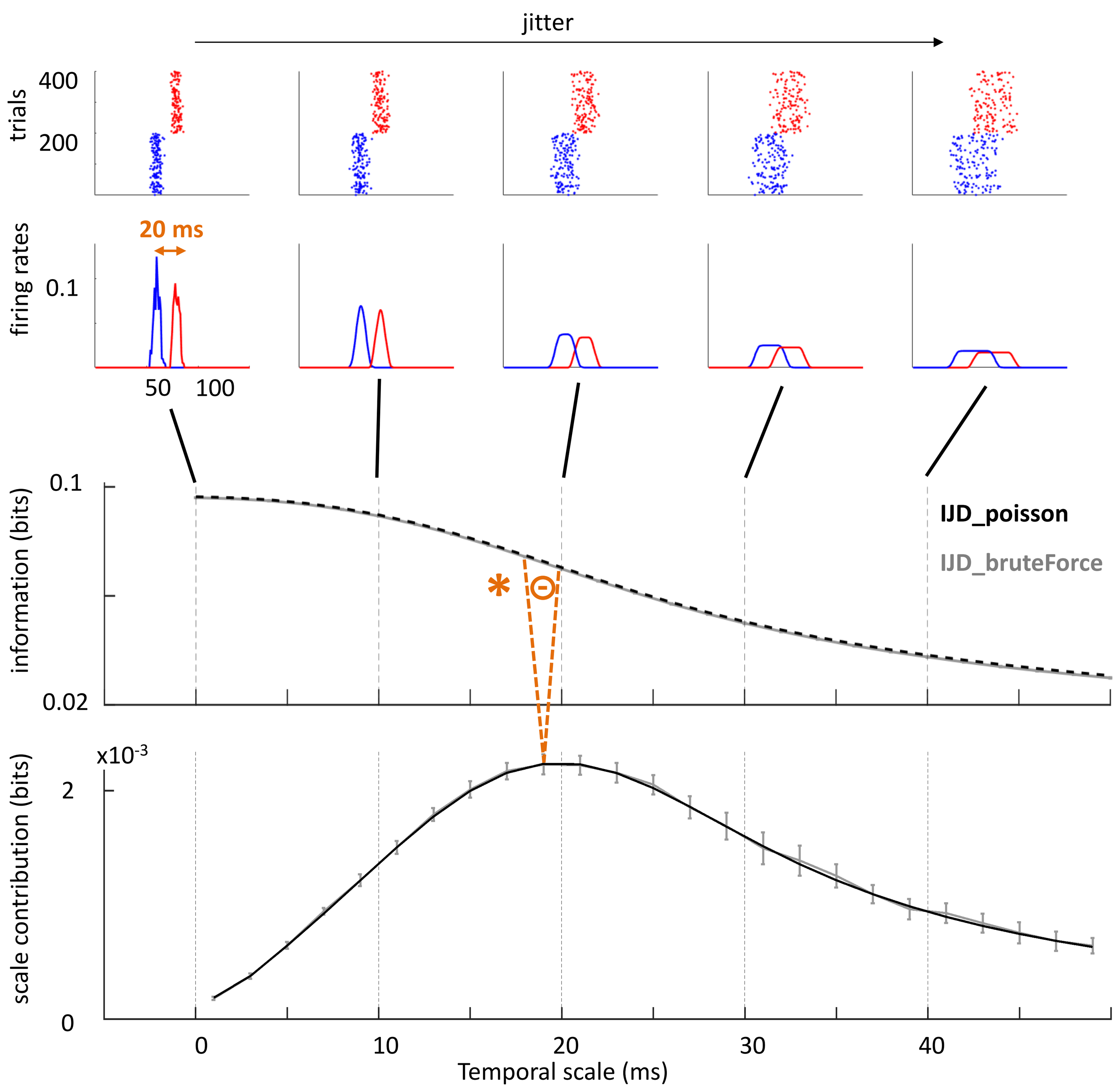
Approach

- The **Information Jitter Derivative Method (IJD)** computes the **derivative of the information with respect to the precision** with which the neural response is measured. It uses **a jitter approach to modify such precision**.
- We analyzed data recorded from the **retinal ganglion cells (RGCs)** of the axolotl salamander and the **trigeminal ganglion cells (TGCs)** in the rat somatosensory system.

Conclusions

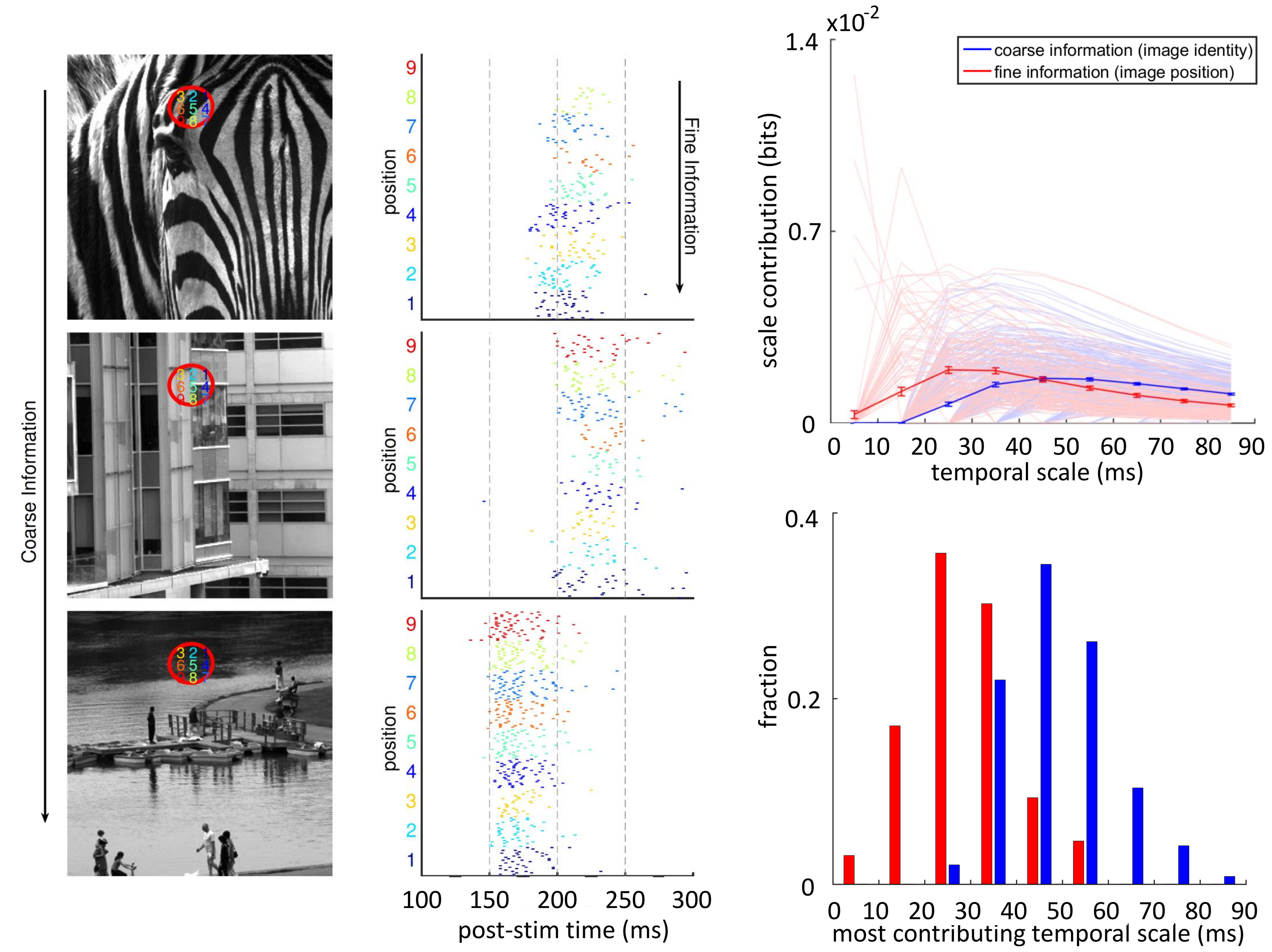
- The IJD method provides a straightforward procedure to infer the **unique contribution** that each temporal scale makes to the sensory information contained in the neural response.
- **RGCs and TGCs** use **coarse and fine temporal scales to encode the information about coarse and fine spatial features**, respectively.

Method



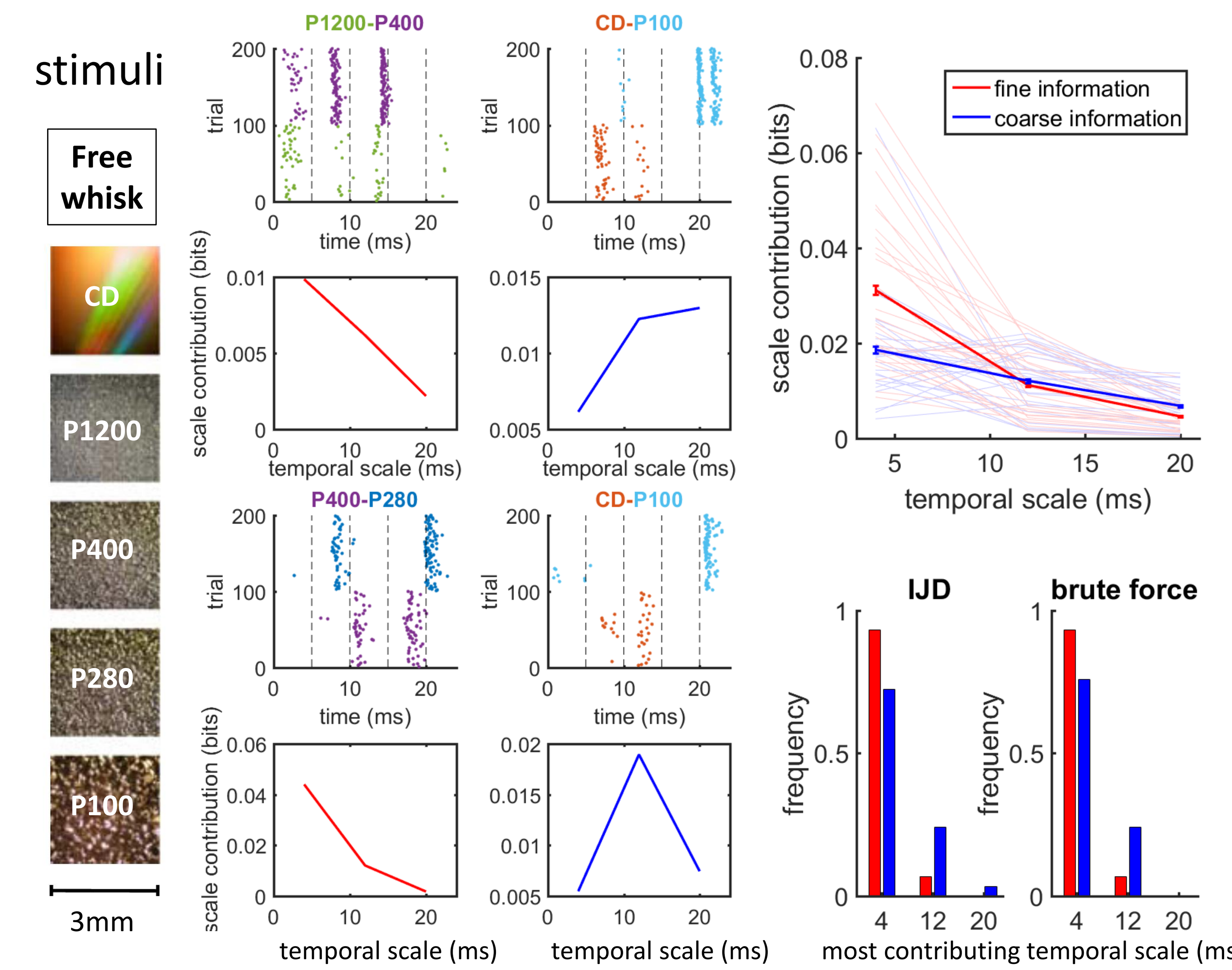
Analysis of RGCs responses

How do RGCs in the axolotl salamander's retina [2] encode information about different features of a visual scene?



Analysis of trigeminal cells responses

How do TGCs in the rat's somatosensory system [3] encode information about different textures?



Implementation details

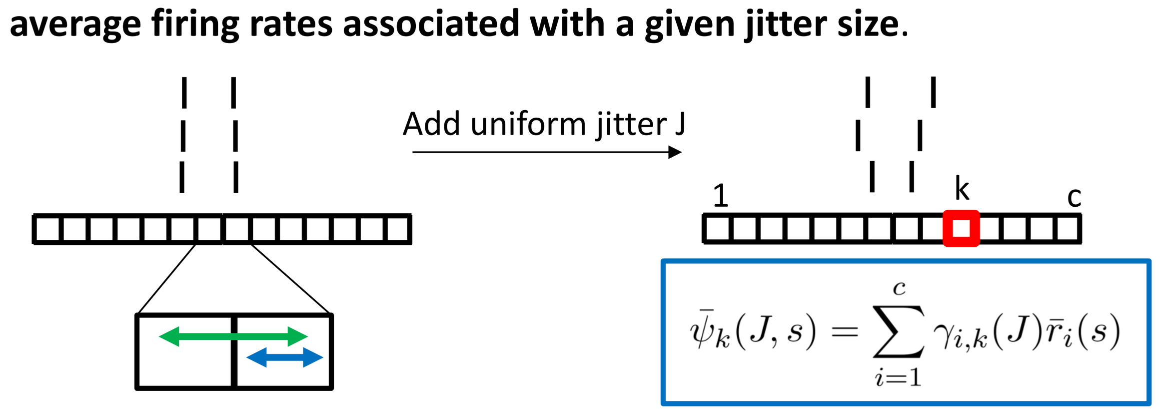
Two alternative implementations:

- **IJD_bruteForce**, which uses a standard procedure to compute information.
- **IJD_poisson**, to be applied when the number of trials per stimulus is low and the standard information calculation is affected by a large bias. More in details:

1. Analytically derive the average firing rates associated with a given jitter size.

Assumptions:

1. Poisson spiking process in each bin.
2. Independence among different bins.



$$\bar{\psi}_k(J,s)=\sum_{i=1}^{c}\gamma_{i,k}(J)\bar{r}_i(s)$$

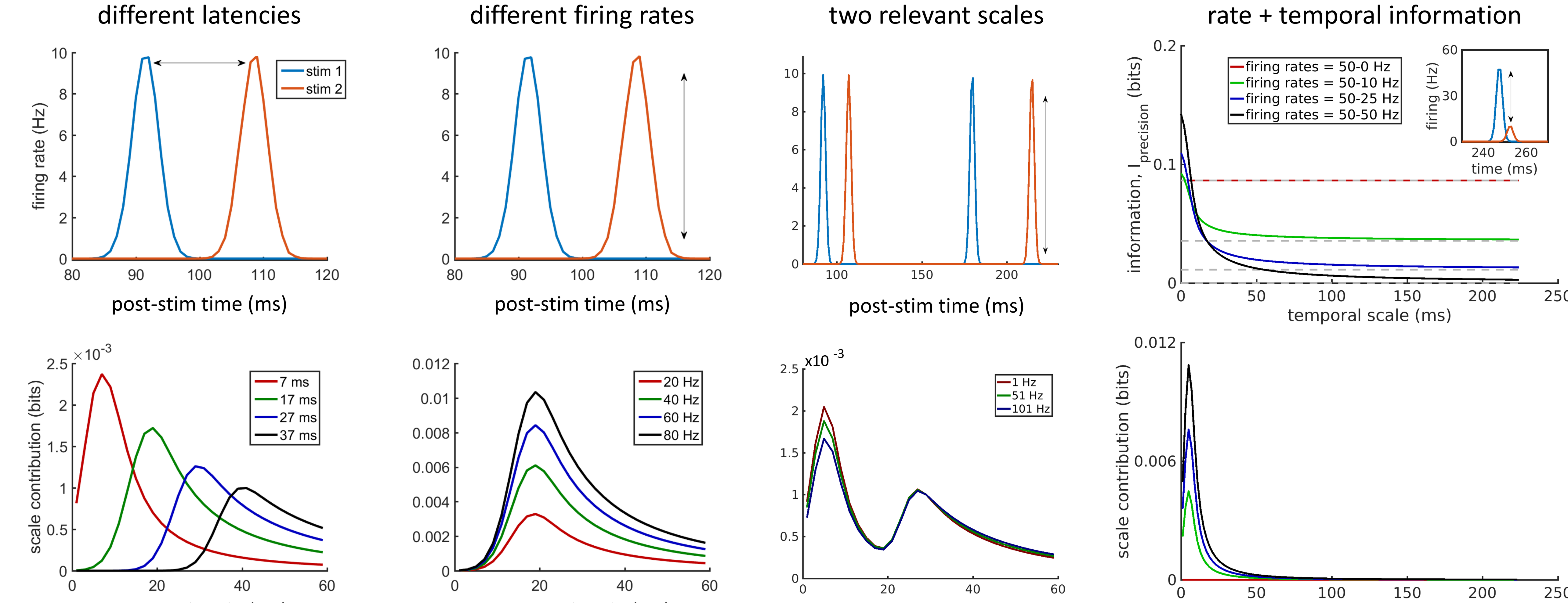
2. Compute the information contained in the jittered neural response.

$$I(S;R)=-\sum_r p(r)\log_2(p(r))+\sum_s p(s)\sum_r p(r|s)\log_2(p(r|s))$$

$$\prod_i^n p(r_i|s)=\prod_i^n Pois(r_i;t\bar{\psi}_i(J,s))$$

3. Calculate the contribution of each temporal scale by performing a finite difference (see the figure above ✱) on the information values obtained in the previous point.

Simulations



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