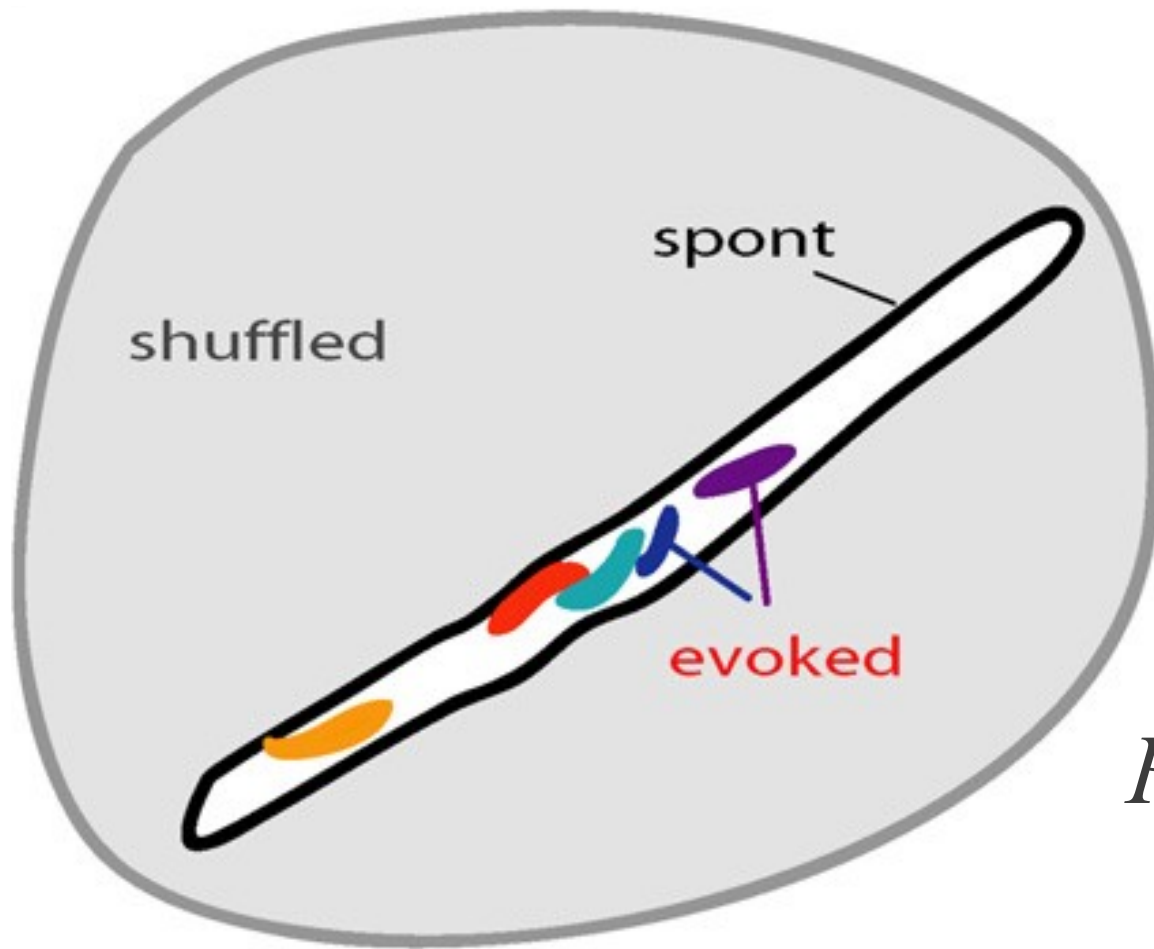


Spontaneous Events Outline the Realm of Possible Sensory Responses in Neocortical Populations

Artur Luczak, Peter Bartho, Kenneth D. Harris

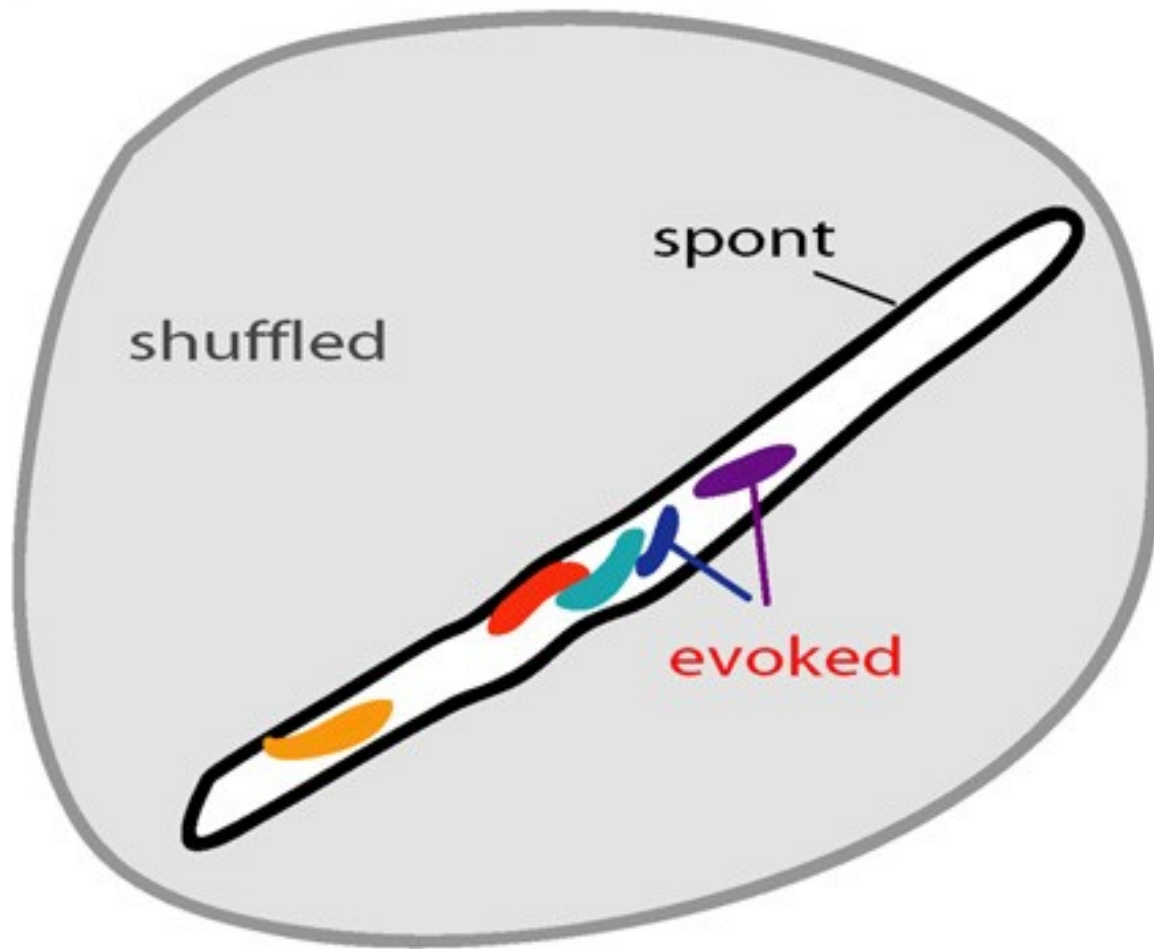
Set of Neuronal Responses



$N \times 100$
response matrix:

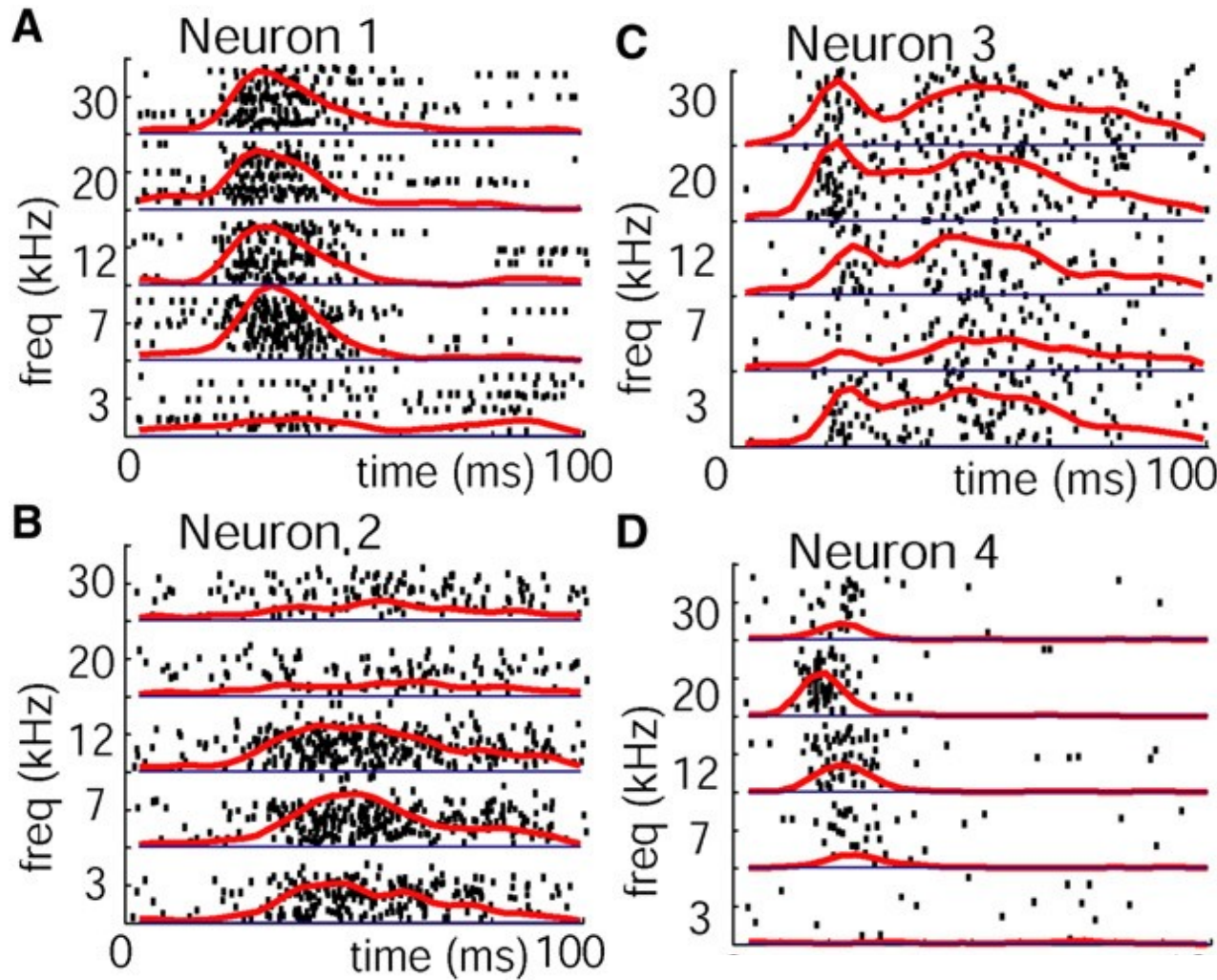
$$R = \begin{bmatrix} r_{1,1} & r_{1,2} & \dots & r_{1,100} \\ r_{2,1} & r_{2,2} & \dots & r_{2,100} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n,1} & r_{n,2} & \dots & r_{n,100} \end{bmatrix}$$

Set of Neuronal Responses



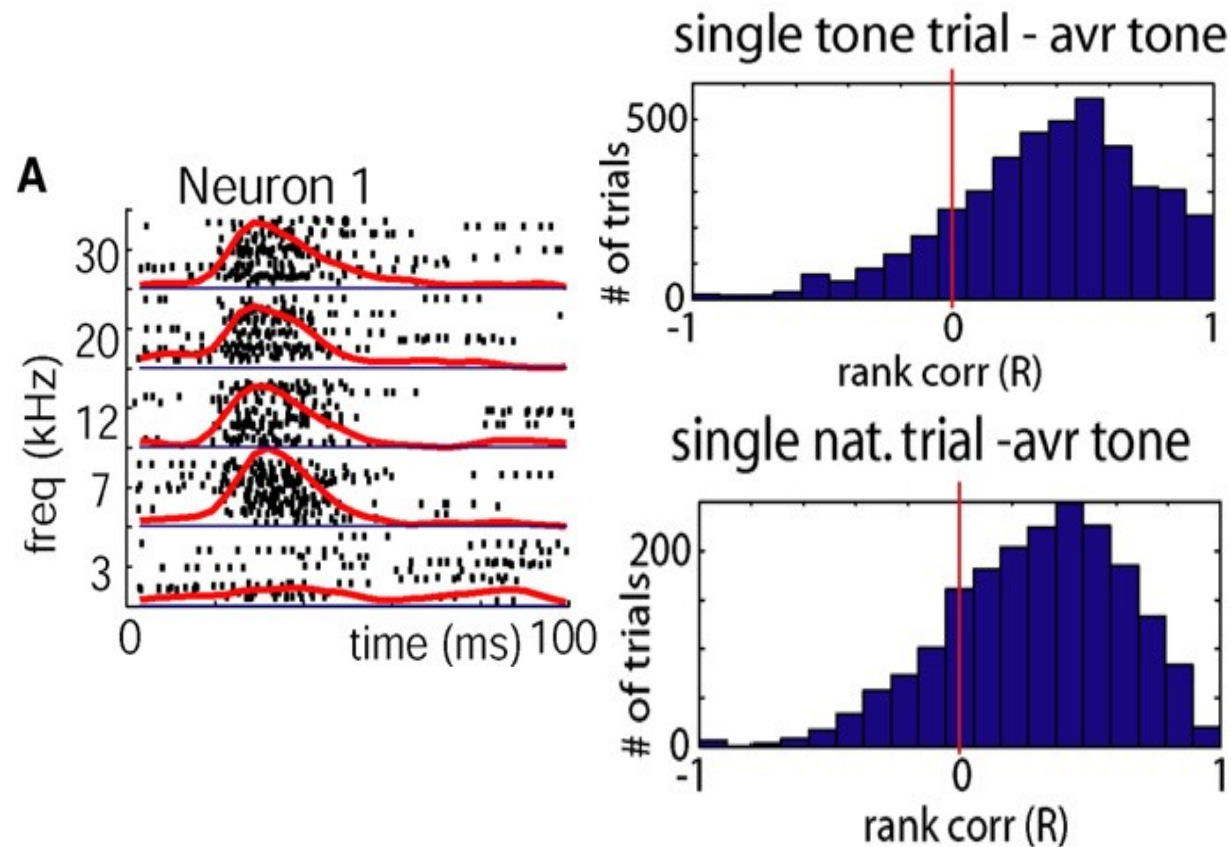
- Constrained vocabulary of spike patterns expressible by cortical circuit
- Spontaneous events widely sample this vocabulary

Consistent PSTH structure



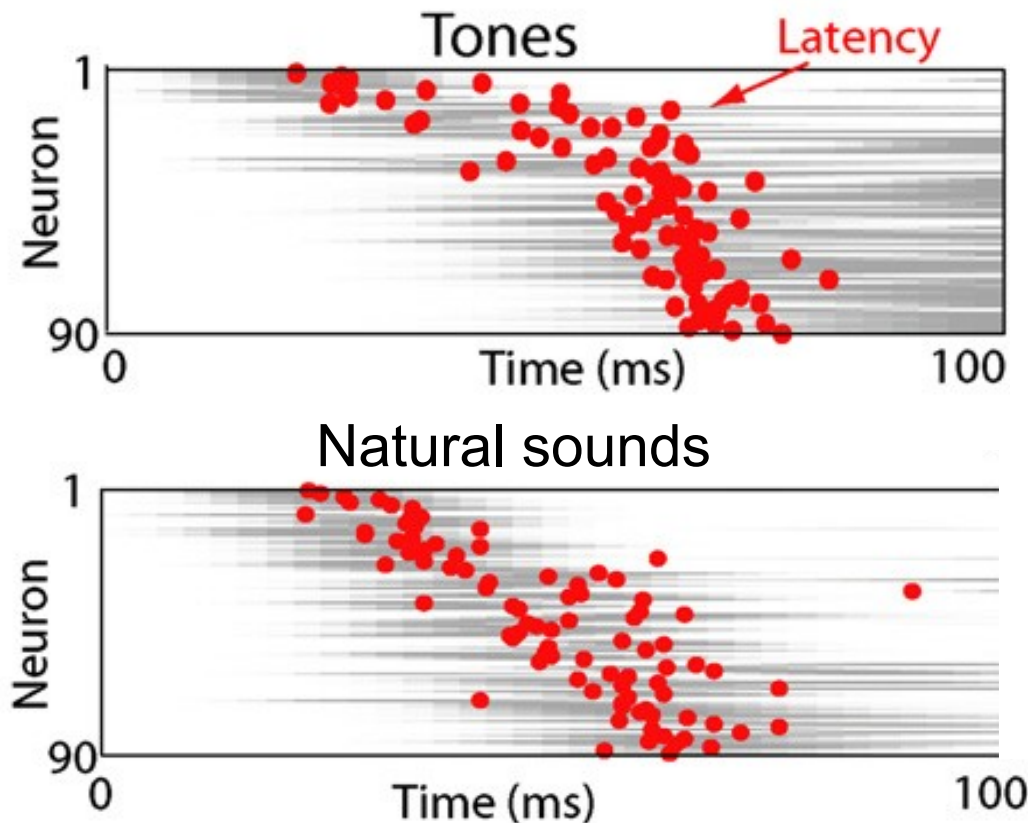
- temporal structure conserved across stimuli
- varied widely between neurons

Consistent PSTH structure



- High average correlation of PSTH with mean PSTH (0.72 ± 0.24)

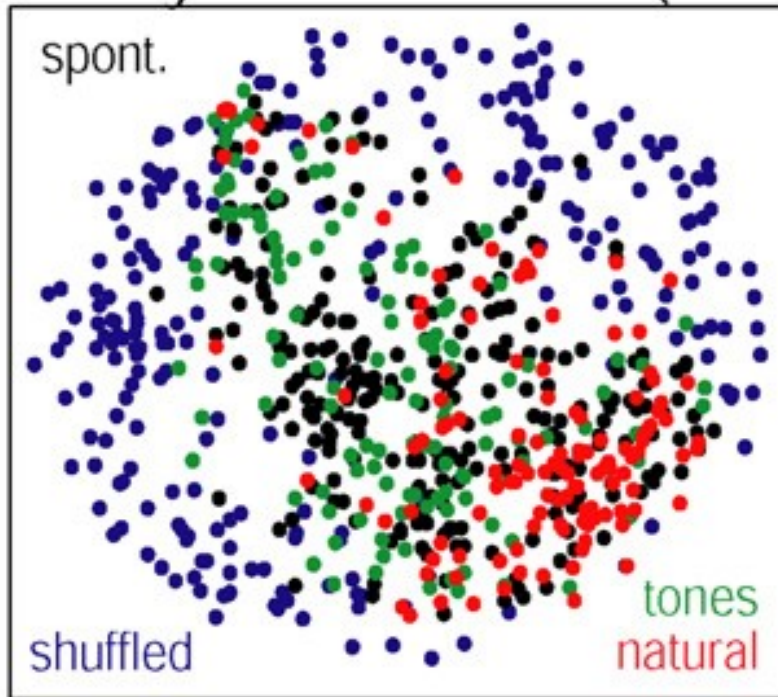
Population Level



Stereotyped spike latency translates into sequential population response

Visualizing Response Constraints

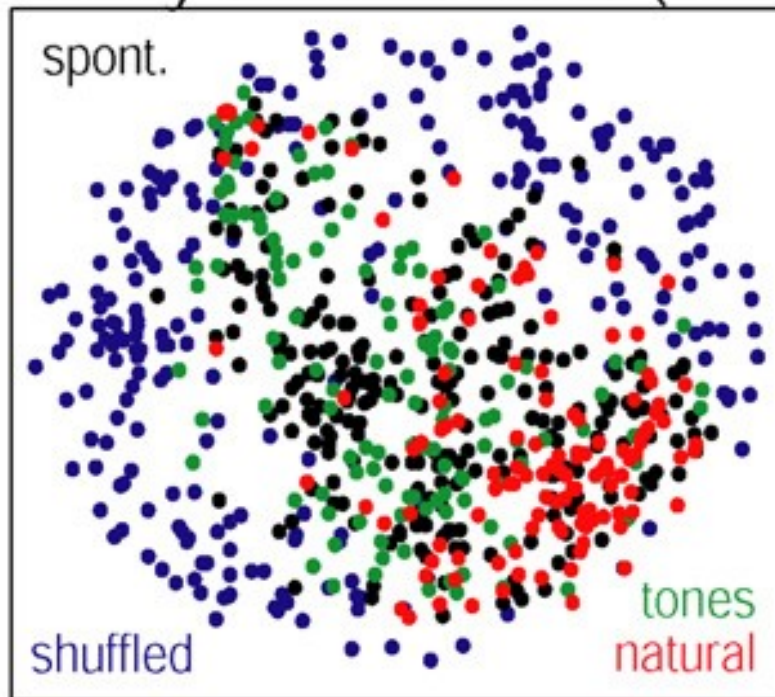
C Activity of 45 neurons (MDS)



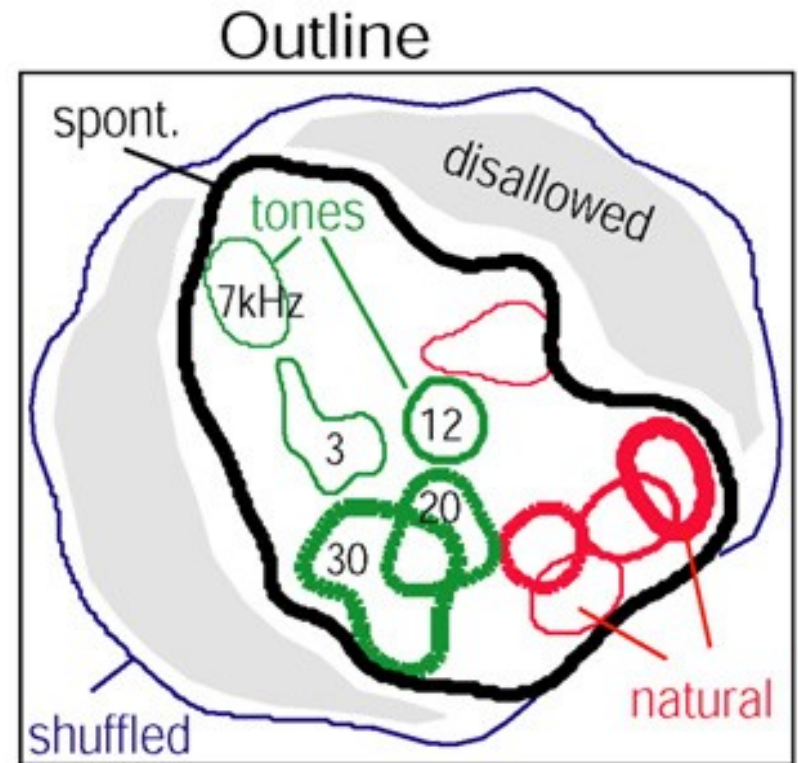
- Reduced dimensionality with multidimensional scaling (MDS)
- MDS is roughly isometric (w.r.t. Euclidean metric)

Visualizing Response Constraints

C Activity of 45 neurons (MDS)



D



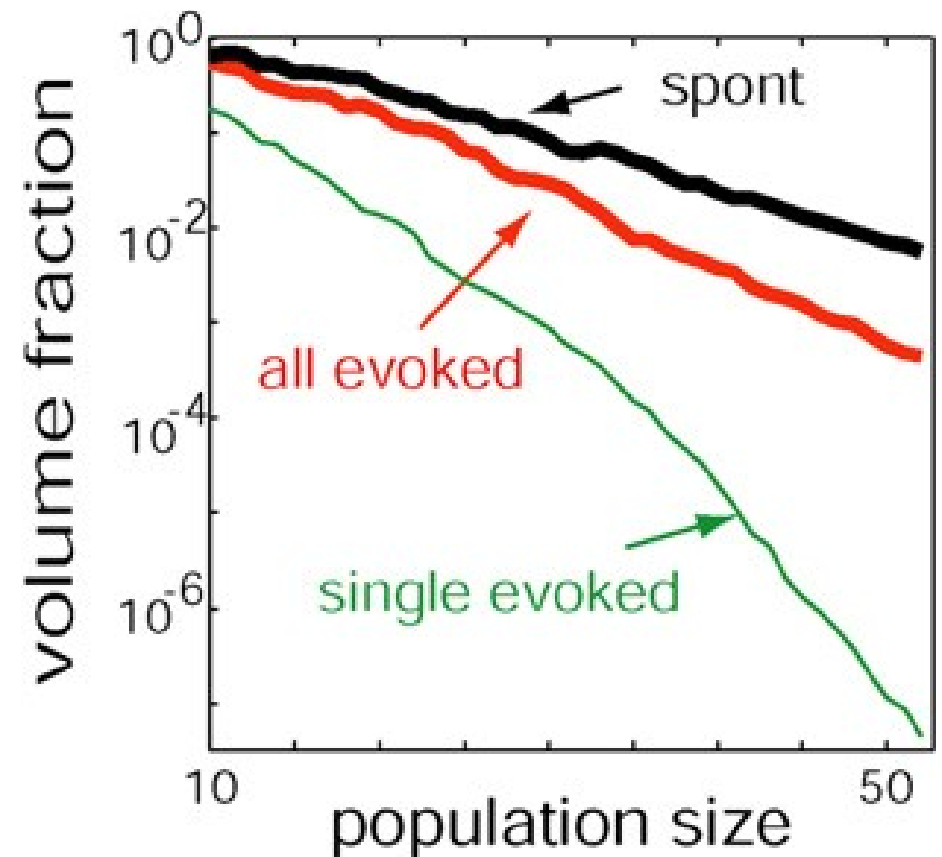
Quantifying Response Constraints

- Relative volume of region satisfying constraint was estimated as absolute value of determinant of cell-by-cell spike count covariance matrix
- Normalized by determinant shuffled covariance matrix
- Does this make sense? Shouldn't constraints reduce this volume? On the other hand, constraints increase covariances, which in turn increases this volume?

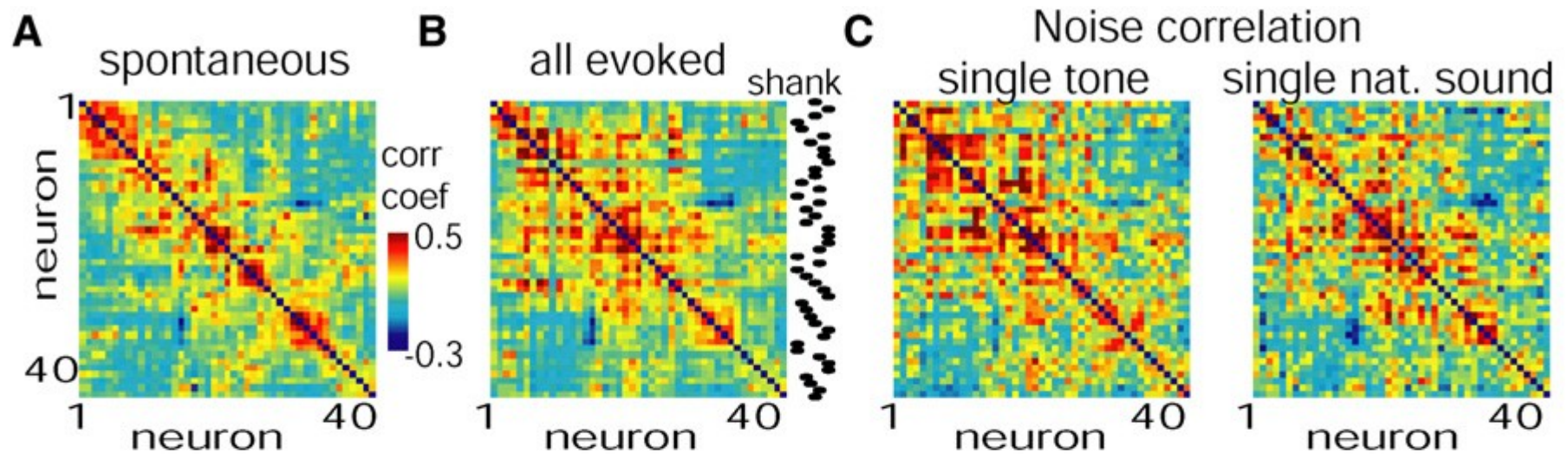
Quantifying Response Constraints

Paper claims that volume decreases monotonically with number of cells, and suggests this implies that each cell further constrains the population response.

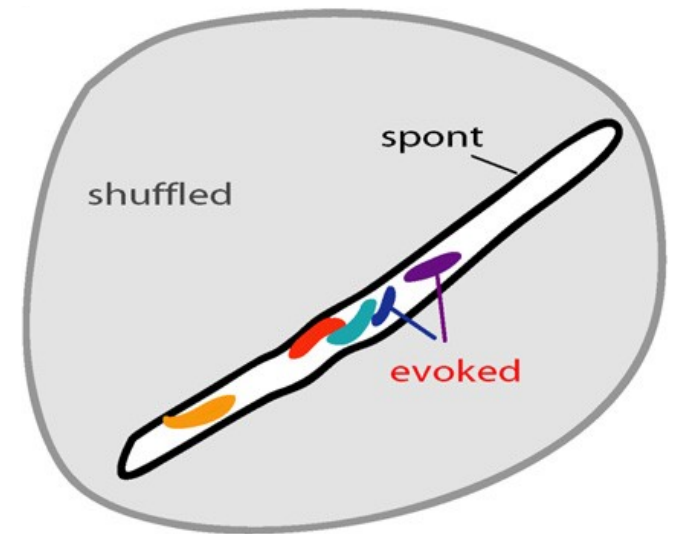
Shouldn't this occur when covariances are small, so that neurons don't constrain much?



Geometry of Response Constraints



Similarity of signal/noise correlation matrices to spontaneous correlation matrix suggests similar orientation in population response space



Possible mechanisms of constraint

- Temporal response profile of individual neurons partially determined by gated ion channel thresholds
- Strong reciprocal neuronal connectivity occurs more often than expected by chance
 - This constrains activation to subsets of neurons
- More likely, correlations just represent larger-scale network interactions (data not shown)

Relation to memory replay studies

- A number of studies have suggested that spontaneous activity in resting or sleep replays firing patterns seen during prior behavior.
- In this study, rat had never heard the tone stimuli presented prior to spontaneous activity recording
- Similarity in firing pattern may arise from constraints
- Also, firing rates may be as useful as temporal order/correlation in characterizing replay

Significance for Information Encoding

- Constraints reduce vocabulary of a neuronal ensemble
- Potentially inefficient
- Redundancy may increase neural code's robustness

Other curiosities...

- Paper claimed that each tetrode yielded 5-15 well-isolated units
 - So 1-4 units per electrode.
 - Likely some double-counting?
 - Correlation analysis dependent on sorting
- Upstate detected by transition from <1 spike per 30 ms to >15 spikes per 60 ms