Correlation at the neuron and population levels

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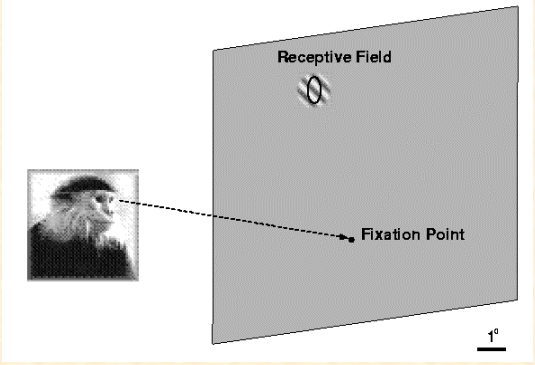
Brown: N. Hatsopoulos, J. Donaghue

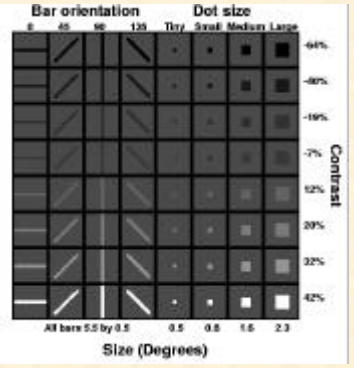
Correlation at the neuron and population levels

- Correlation in responses of single neurones
  - Fine temporal structure
    - Repeating triplets / quadruplets
    - Response latency
- Correlation in populations of neurones
  - Pairs of neurones and synchrony
  - Simulations of pairs of neurones
  - Simulations of populations of neurones

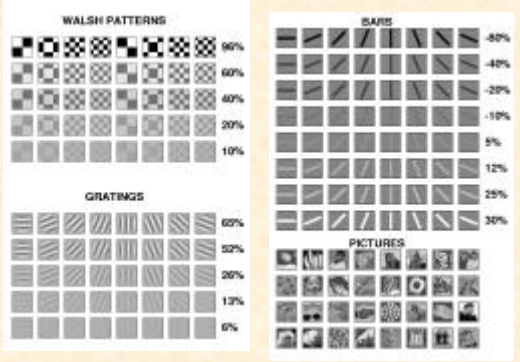
Recording from LGN/V1



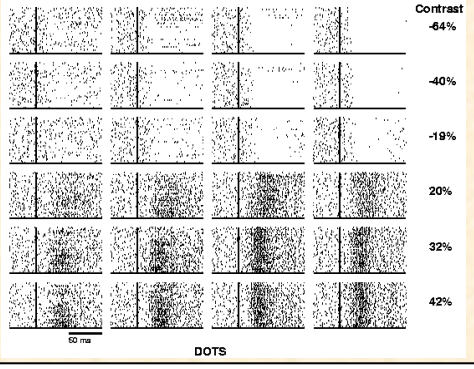
LGN Stimuli



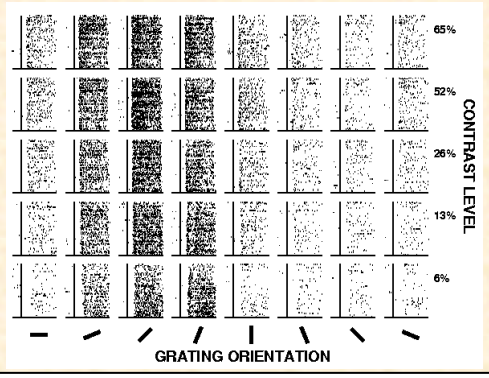
Example V1 Stimuli



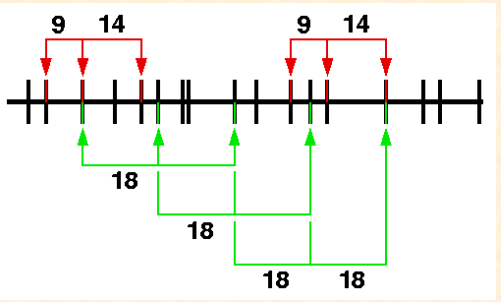
Example LGN responses



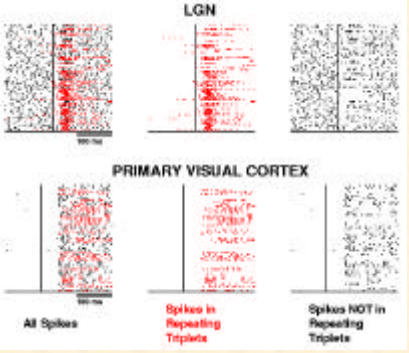
Example V1 responses



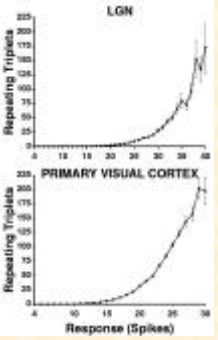
Detecting repeating triplets



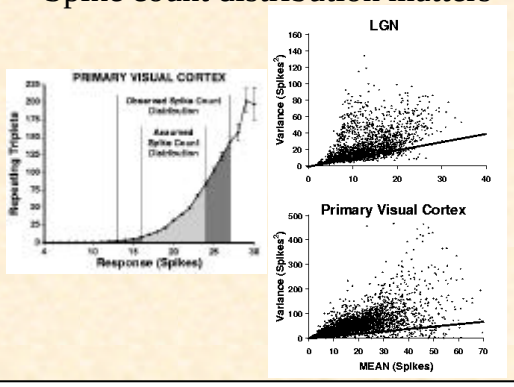
Repeating triplets in responses



Repeating triplets and spike count



Spike count distribution matters



Spike count matched model

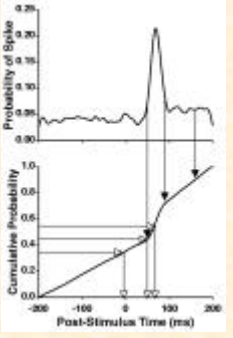
SCM Model

Generate the cumulative SDF

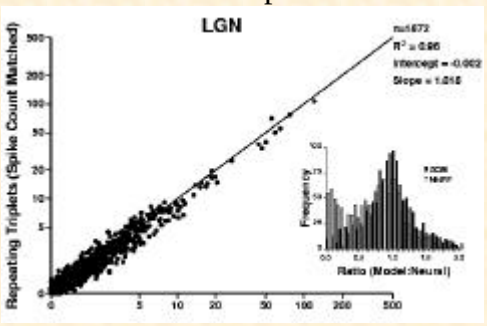
Take each observed spike count (e.g. 3)

Simulate a spike train using random numbers (0-1)

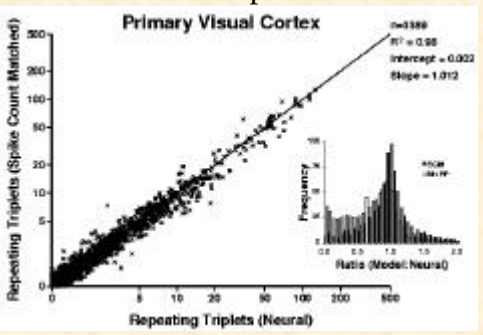
Adjust to match ISI



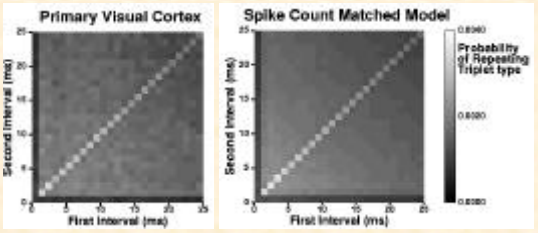
Predicting fine temporal structure of LGN responses



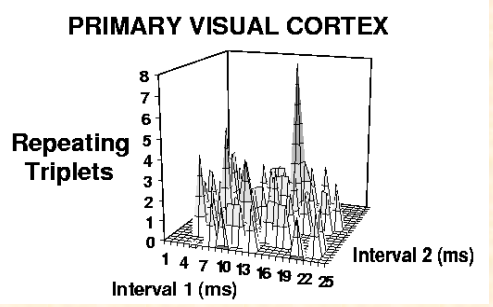
Predicting fine temporal structure of V1 responses



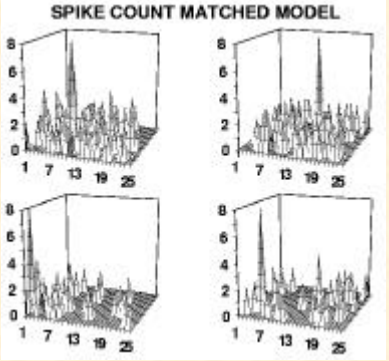
Predicting type of repeating triplets



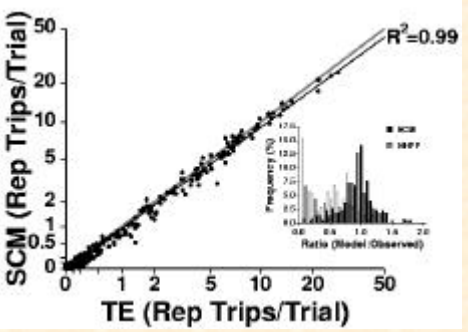
LGN/V1 sticks out like a sore thumb



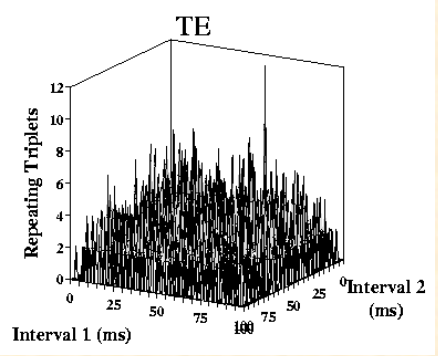
SCM sticks out like a sore thumb



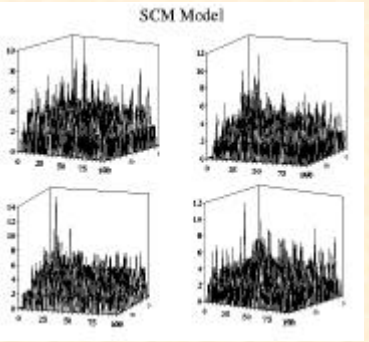
Inferior temporal cortex



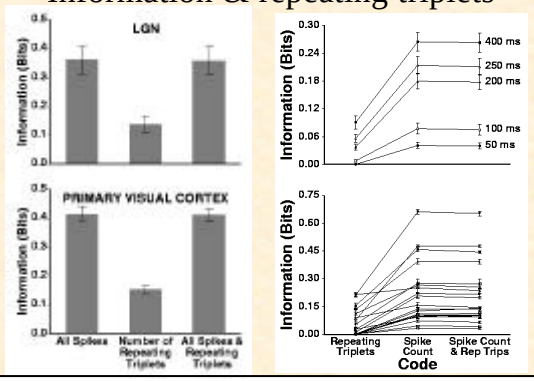
IT & the sore thumb



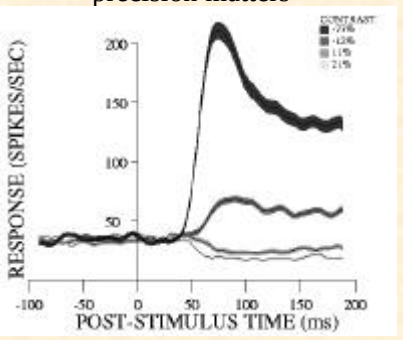
SCM model of IT & sore thumbs



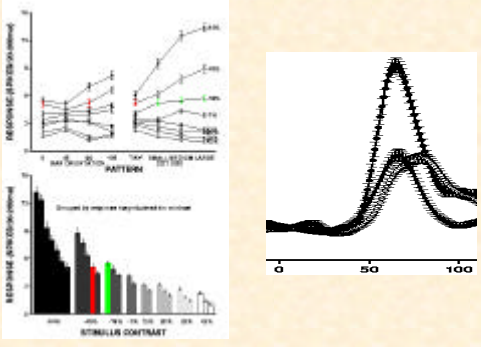
Information & repeating triplets



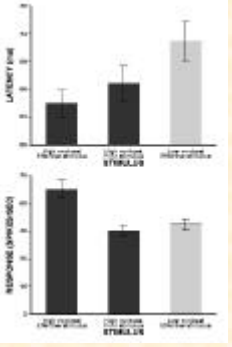
Response latency: when temporal precision matters



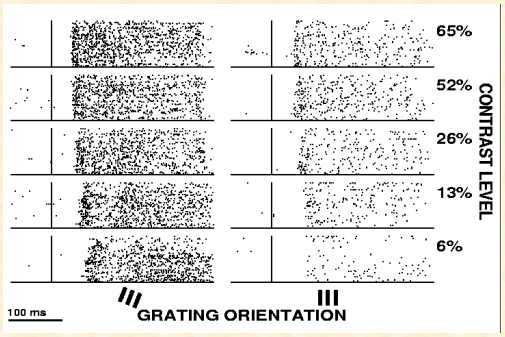
LGN latency & response magnitide



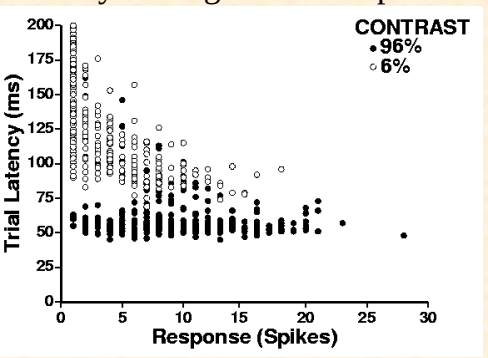
LGN response latency & magnitude



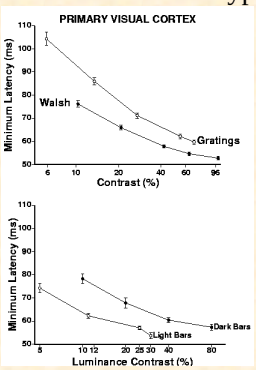
V1



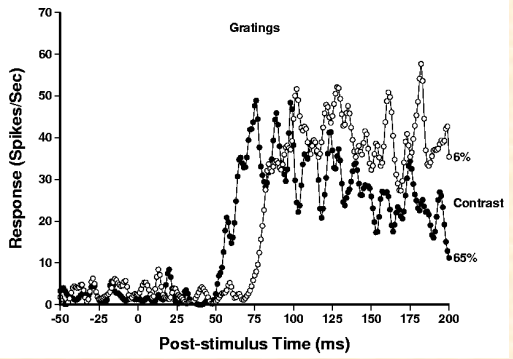
Latency & magnitude independent



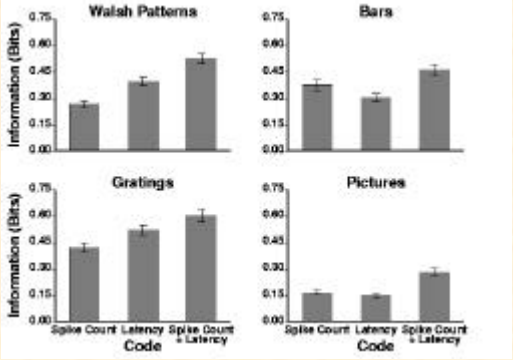
V1 latency related to stimulus type & contrast



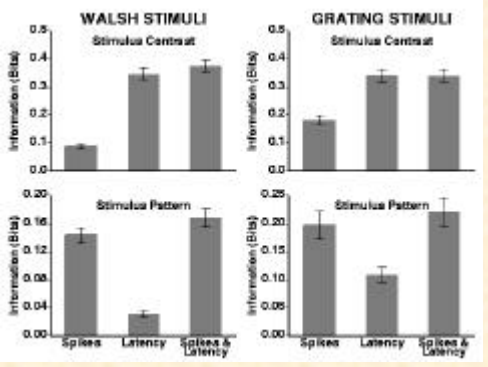
V1 population response



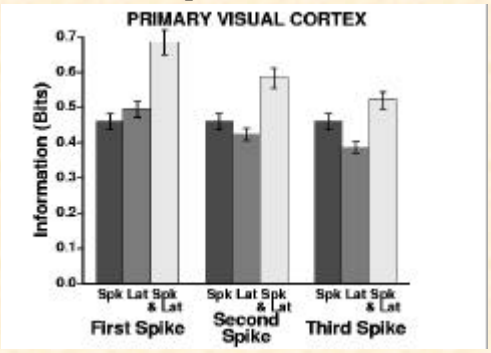
Independence of information



Latency = contrast, count = ID



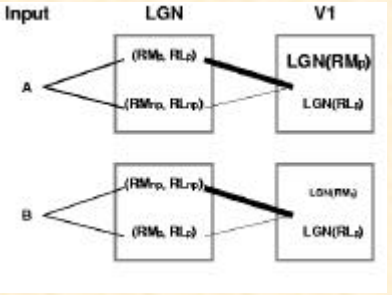
1st spike matters



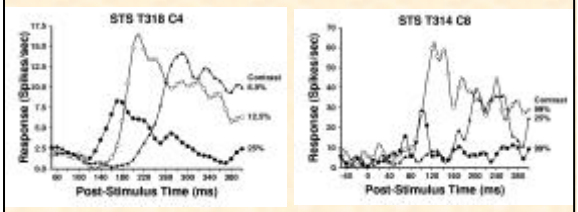
Moving from LGN to V1

LGN: latency is related to spike count.

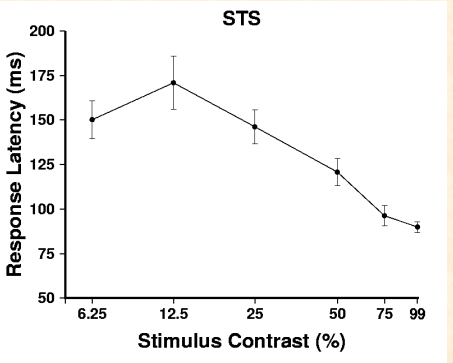
V1: latency almost independent of spike count.



STS - contrast & latency



STS - Latency & contrast



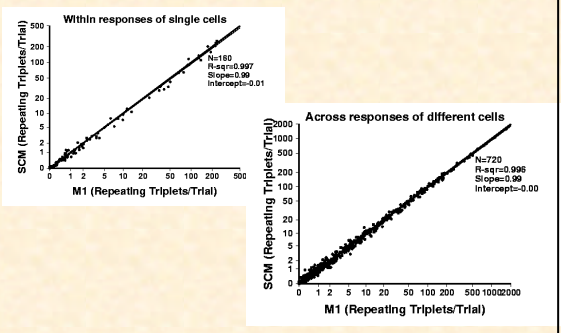
Summary of single cell codes

- Spike count distribution induces correlation
- Fine temporal structure at chance level
  - Need to include correlation for spike count
- Response latency (1st Spike)
  - Latency carries information about contrast
  - Spike count carries information about ID
- To describe responses of single cells
  - Spike count distribution
  - Spike density function (response envelope)
  - Do we need a different SDF for each contrast?

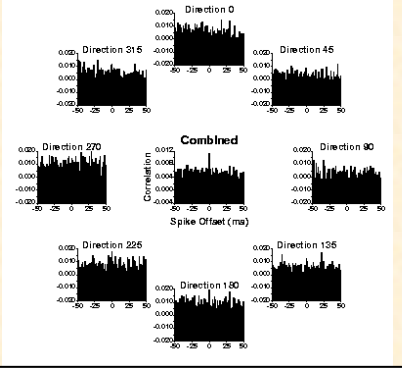
Pairs of neurones & synchrony

- Recordings from single neurones in M1
  - Nicho Hatsopoulos (Brown University)
- Recorded using Utah array
- Total of 96 pairs
- Monkey making arm movements to move manipulandum to a target light
- Examined responses for triplets & synchronous spikes

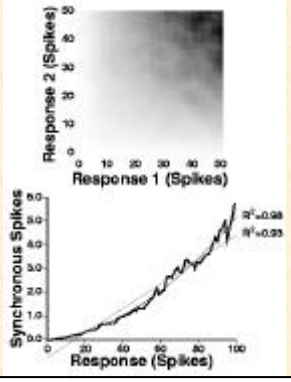
SCM model predicts triplets



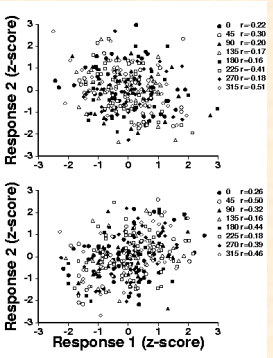
Synchrony in M1 neural responses



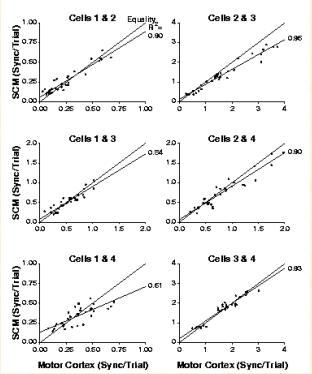
Synchrony & spike counts



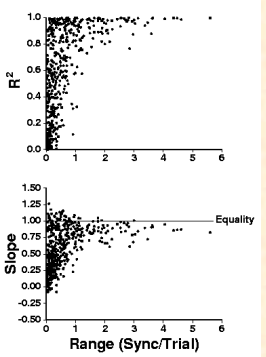
Coarse correlation



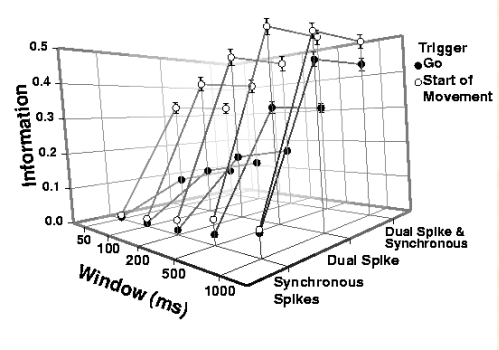
SCM model underestimates synchrony



SCM model explains variability in synchrony



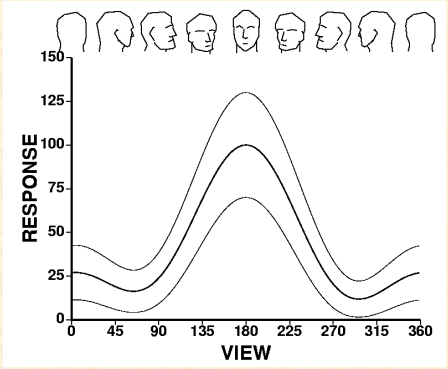
Sync spikes don't carry unique information



Summary of pairs of neurones

- Synchronous spikes related to product of spike counts
  - Independent of variability (assuming Gaussian)
  - Dependent on coarse temporal correlation of spike counts
- When synchrony exceeds chance levels
  - Ensure that no relationship between spike counts and number of synchronous spikes
  - A scaling between predicted & observed implies no useful/unique signal
  - Use several experimental conditions

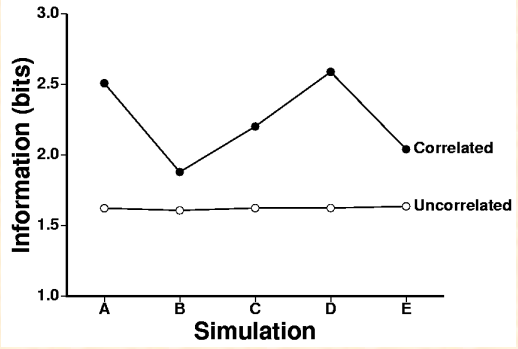
Tuning curves



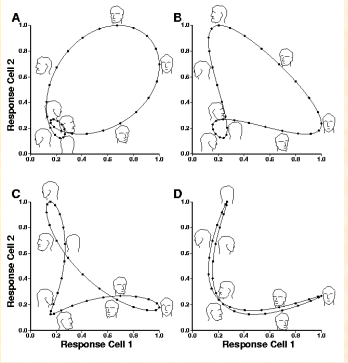
The effect of coarse temporal correlation

- Used simulations of small populations
  - Truncated Gaussian to model spike count distribution
- Examined details using a simulated pair of neurones
  - Varied mean~variance relationship (Fano)
  - Varied correlation of response variabilty

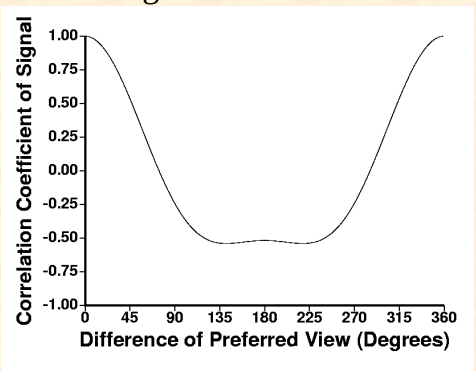
Coarse correlation and population information



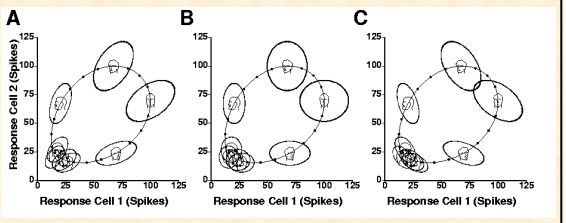
Offset of tuning curves



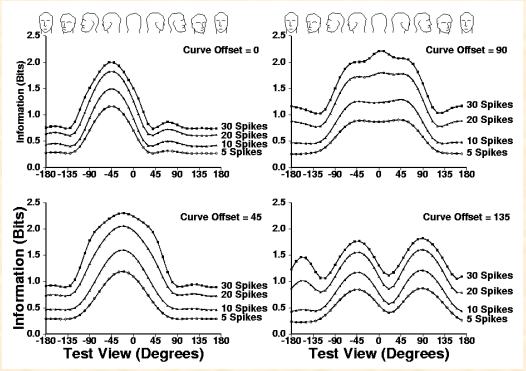
Signal correlation



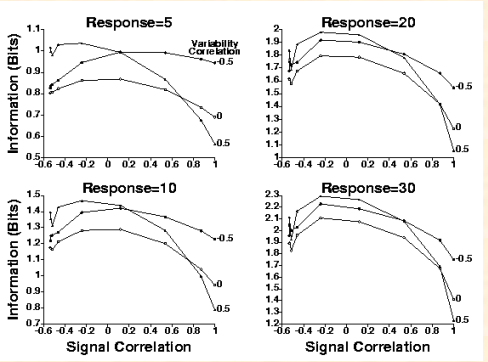
Noise correlation



Effect of spike count range



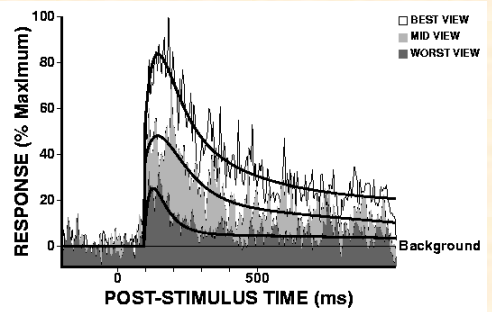
Signal & noise correlation



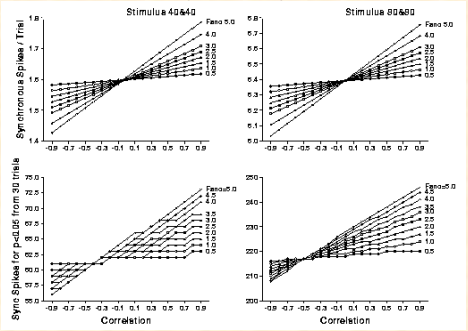
Simulations of synchrony

- Used SCM model with average spike density function of STS neurones
- Measured distribution of synchronous spikes from 10,000 “trials” at each spike count pair (1..100,1..100)
- Calculated synchronous spike distribution to different stimuli
  - Defined stimuli by mean and variance (truncated Gaussian distribution)
  - Used range of fano factor & correlation

Simulated spike density function



Effect of variability and correlation on synchrony



Summary

- Correlation of “noise” tends to increase the transmitted information
- The effect of the correlation of the response variability depends on
  - the distribution of the stimuli
  - the maximum response
  - suggests there is no generic answer
- Synchronous spikes is related to correlation of response variability
  - A possible code for signaling correlation on a trial by trial basis