Dissecting sources of neuronal noise that are reduced by attention in macaque area V4

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(sample data & code)
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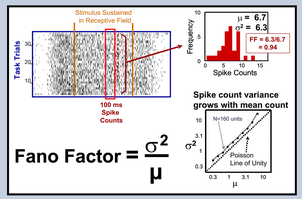
Introduction

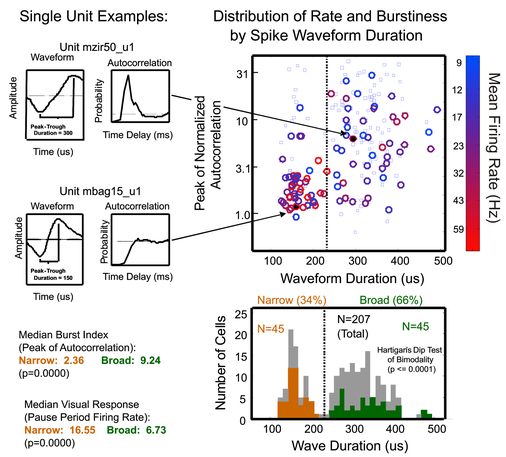
1) Neuronal responses exhibit trial-to-trial variability that places limits on discrimination/perception.
2) Previously we found attention reduces variability which may enhance perception (Mitchell et al, 2007)
3) There are a number of sources that may underlie the variability in neuronal responses.
4) Here we examine two sources of noise: low rate frequency fluctuations and bursts of spikes.

Fano Factor (Normalized Variance)



$$\text{Fano Factor} = \frac{\sigma^2}{\mu}$$

Narrow and Broad Spiking Cells

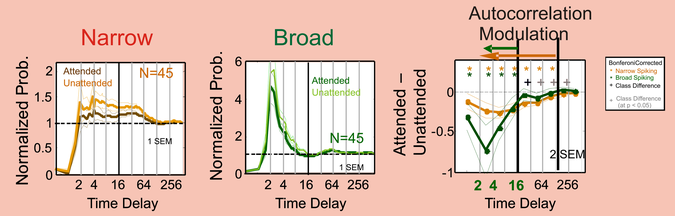


Classes Differ in Mean Rate and Burst Firing

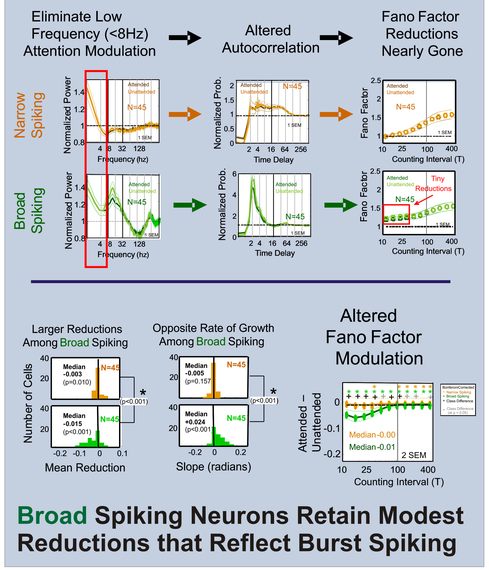
Median Burst Index (Peak of Autocorrelation):
Narrow: 2.36 **Broad: 9.24**
(p=0.0000)

Median Visual Response (Pause Period Firing Rate):
Narrow: 16.55 **Broad: 6.73**
(p=0.0000)

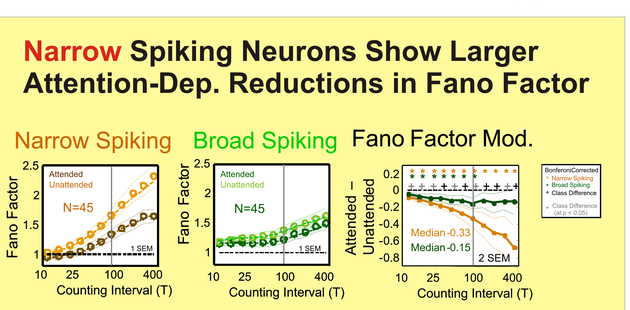
Broad Spiking Neurons Show Reductions in Short Timescale (<16ms) Autocorrelation, Narrow Spiking Show Reductions on Long Scales



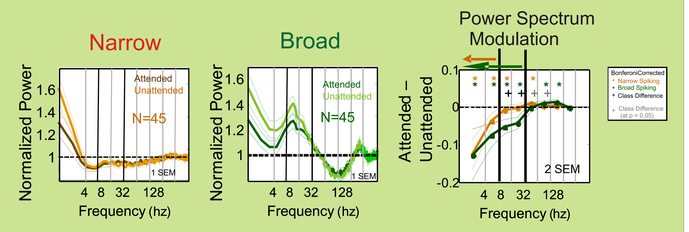
Low Frequency Fluctuations Account For Nearly All Fano Factor Reductions



Narrow Spiking Neurons Show Larger Attention-Dep. Reductions in Fano Factor



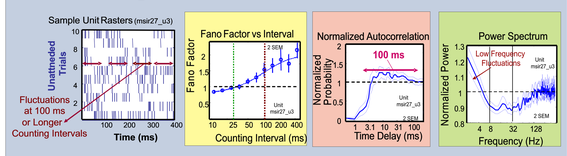
Both Narrow and Broad Spiking Neurons Show Reductions in Low Frequency (<8Hz) Fluctuations



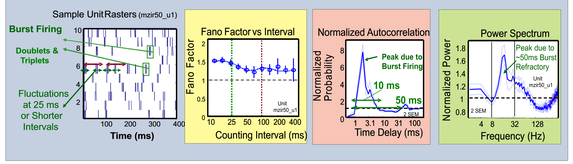
... But Only Broad Spiking Neurons Show Reductions at Higher (15-25 Hz) Frequencies

Timescales of Variability

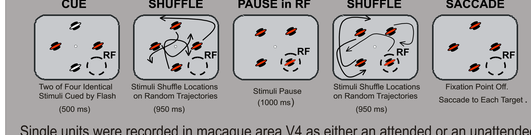
Long Timescale Fluctuations



Short Timescale Fluctuations

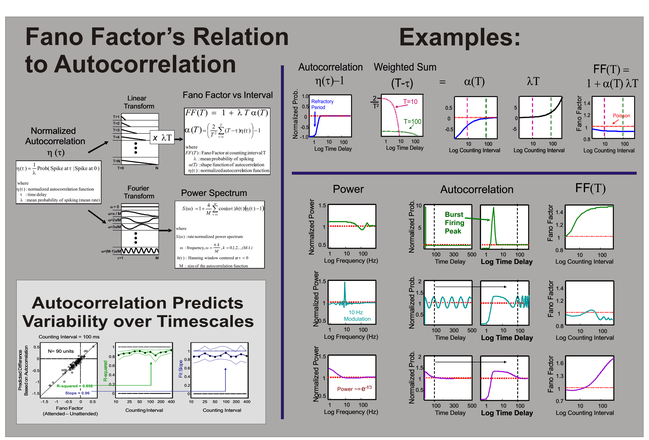


Multi Object-Tracking Task:



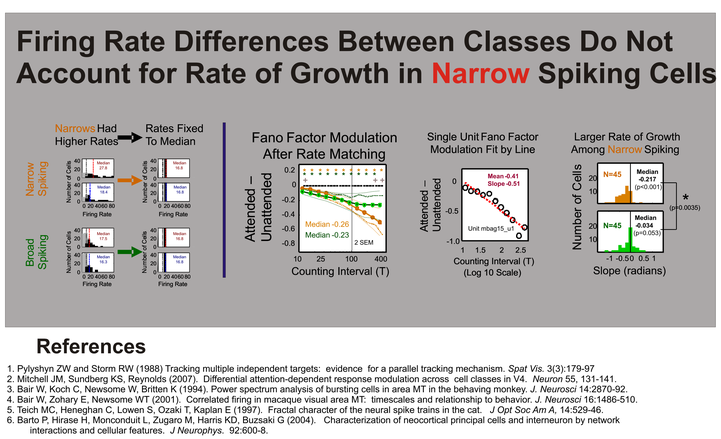
Single units were recorded in macaque area V4 as either an attended or an unattended stimulus entered and paused in the RF. We analyzed the sustained response during this period. Accurate estimation of the autocorrelation and power spectra requires many spikes. We restricted our analysis to the subset of units with higher firing rates (> 7.5 Hz).

Fano Factor's Relation to Autocorrelation



Examples:

Firing Rate Differences Between Classes Do Not Account for Rate of Growth in Narrow Spiking Cells



Summary

1) **Narrow** spiking cells exhibit larger attention-dependent reductions in Fano Factor than **broad** spiking cells.

2) Reductions in both classes are mainly due to low frequency (<8Hz) fluctuations.

3) **Broad** spiking neurons also exhibit reductions at higher frequencies (~20Hz) that reflect reductions in burst firing.

4) By reducing the low frequency noise fluctuations in cortex, attention may improve perception/read-out.

References

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Acknowledgments

Thanks to Etienne Hughes for the insight that it should be possible to analytically derive the relation between Fano Factor and Autocorrelation Functions.

Funding provided by NEI Grant R01EY13802.