Stimulus induced decorrelation of neuronal activity in the visual system

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Introduction

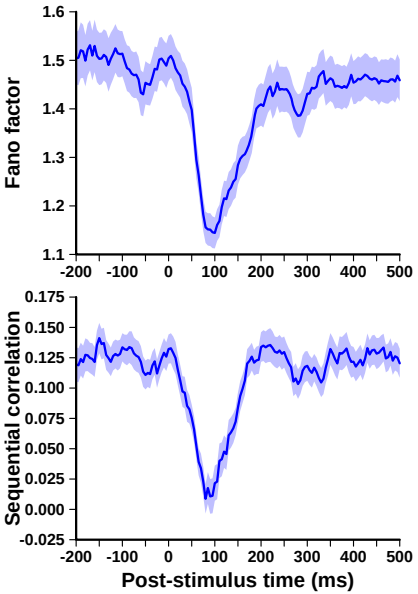
The capacity of single neurones to encode information, assuming a fixed range of signal strengths, is determined by the trial-by-trial variability of the response and the auto-correlation of the response. The amount of information carried by a population of neurones is influenced by the correlation structure between the neurones (as correlation increases, entropy decreases but the mutual information typically increases). While these limiting factors have been examined using a "fixed" analysis window, we wanted to see how these response statistics varied over time.

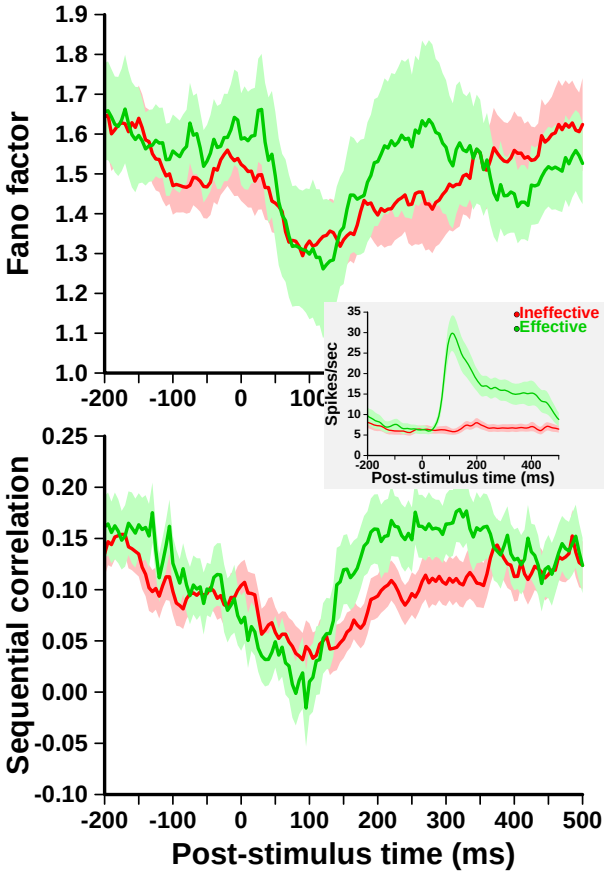
Methods

Responses elicited by a wide range of visual stimuli, including faces, bodies, hands, animals and abstract images from single and pairs of single neurones in the inferior temporal cortex and superior temporal sulcus of 2 macaque monkeys were collected. Recordings from 85 neurones were analysed, 51 of which were tested with effective (>70%) and ineffective (<30% of maximum response) stimuli. The 85 neurones allowed for 111 pairs of simultaneously recorded neurones to be examined. Analyses were performed using sliding 50ms windows.

Results

At response onset (~50 ms), the variability of the response (fano factor, σ^2/μ), and the auto correlation drops. Thus, the initial period of a visually evoked response is de-correlated from previous activity and less variable than expected given the magnitude of the response.





The decrease in response variability and the de-correlation at response onset were present even when there was almost no response (red lines).

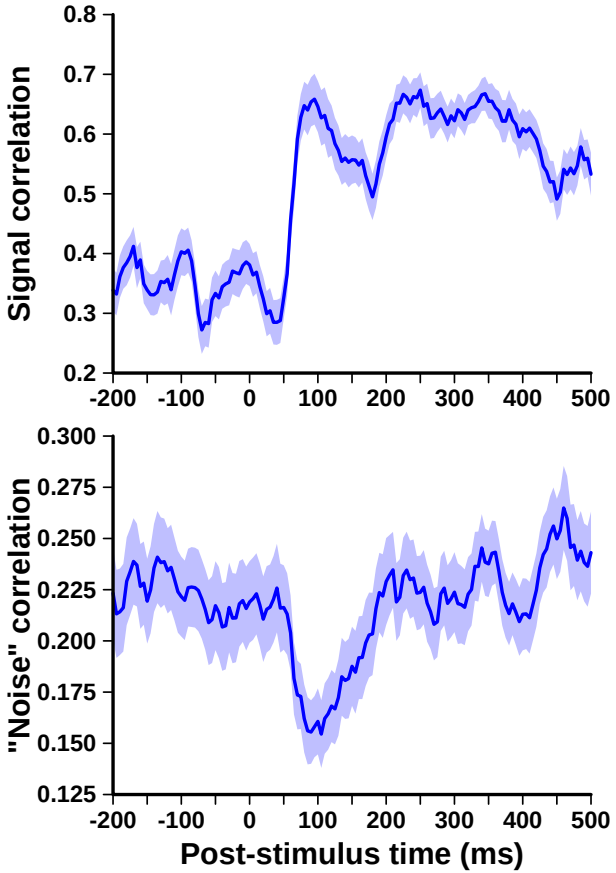
Conclusions

The widespread decrease in auto-correlation suggests that

- the initial transient is almost entirely feed-forward
- feed-forward connections contribute little to "spontaneous activity" but influence even "inactive" neurones

The return to correlated levels suggests that

- Lateral/feedback signals are important driving force after the transient response



Despite a marked increase in the signal correlation at response onset (upper) the trial-by-trial variability between neurones became less correlated for ~100ms.

Conclusions

The cross-correlation data suggests that

- feed-forward signals are independent of each other even when neurones seem to convey similar information
- The return to higher "noise" correlation and the simultaneous drop in signal correlation suggests that lateral connections de-correlate signals
- Combined with the positive auto-correlation, we suggest "soft-max" rather than mutual inhibition interactions occur