CEREBELLAR PURKINJE CELL ACTIVITY RELATED TO CONDITIONING WITH MIXED INTERSTIMULUS INTERVALS.

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INTRODUCTION

Berthier and Moore (Experimental Brain Research, 63, 341-350, 1986) reported that Purkinje cells in cerebellar lobule HVI and neighboring lobules fire in relation to conditioned responses (CRs) when rabbits were trained using a simple delay conditioning paradigm with an ISI of 350 msec. Berthier and Moore (Experimental Brain Research, 83, 44-54, 1990) also reported that neurons in nucleus interpositus also fire in relation to CRs trained in simple delay conditioning. Choi (dissertation, 1999) trained rabbits with mixed ISIs of 300 msec and 700 msec and reported that neurons in nucleus interpositus fire in relation to bimodal CRs.

We used Choi=s procedure to train rabbits and investigate whether Purkinje cells in HVI and neighboring lobules fire in a way to represent both amplitude peaks. Recordings showed that Purkinje cells fire in anticipation of both amplitude peaks of bimodal CRs, as shown in the figure in which the trace is the average response for trials of the PSTH. This suggesting that cerebellar Purkinje cells can express integration of learning involving mixed ISIs of 300 msec and 700 msec.

METHOD

Rabbits were trained using a mixture of two CS-US intervals. Trial Type 1 consisted of a CS-US interval of 300 ms. Trial Type 2 consisted of a CS-US interval of 700 ms. The CS was a 300 ms tone of 1000 Hz and the US was periorbital electrostimulation of 1-2 ms duration. Training consisted of 80 trials per session with intertrial intervals averaging 25 seconds. Eyelid response was monitored with a micro torque potentiometer connected to the right eyelid.

During recordings eyeblink position and neural activity were amplified and recorded on a modified VCR tape for later analysis.

Marking lesions were made to determine the area of the brain recorded from. After the last recording session, the animal was sacrificed and the brain was removed. The brain was sliced in 60 micron sections, mounted and stained with thionin for verification of electrode placement.

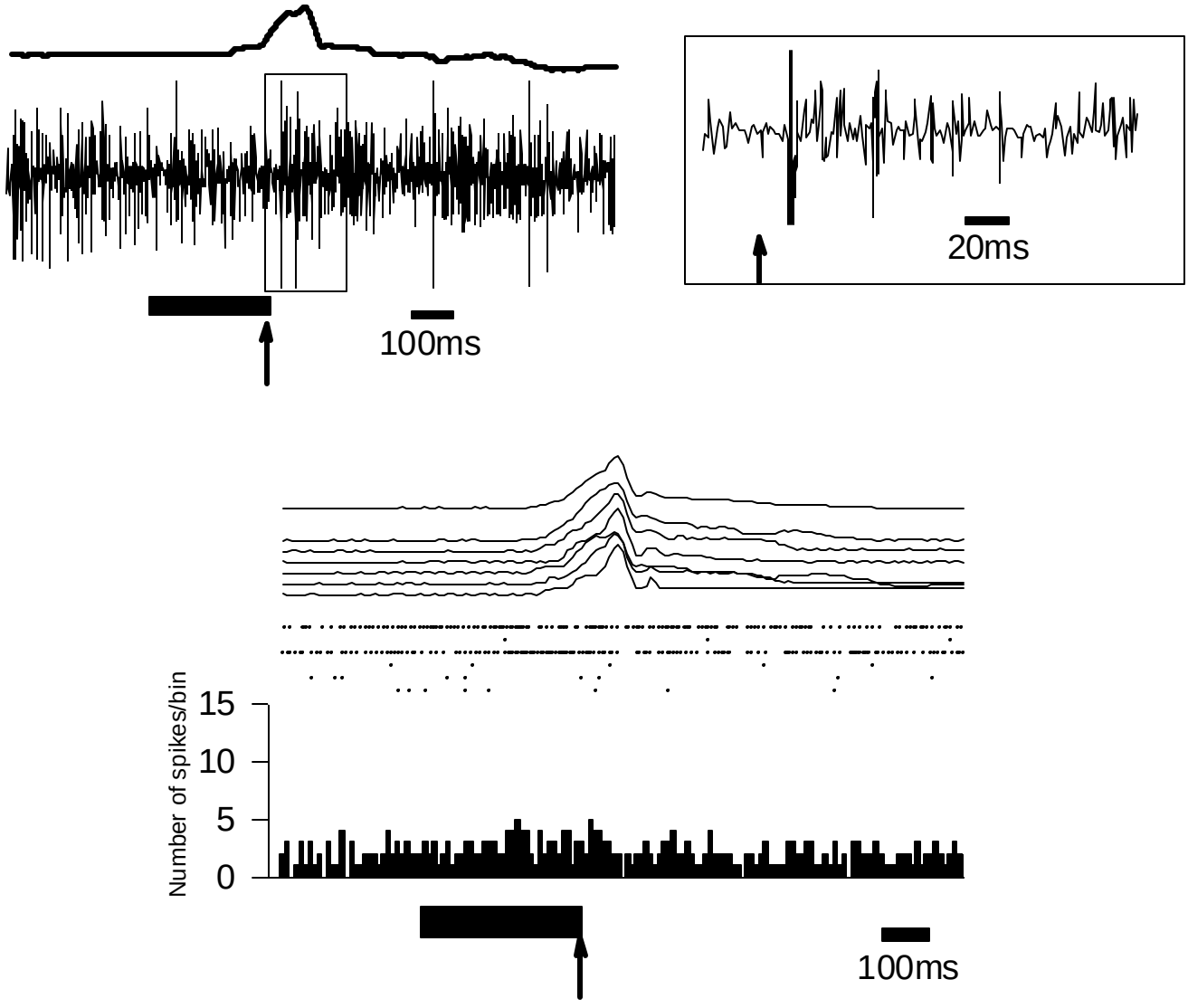
For each unit, response traces, raster plots, and histograms were made of each trial type. To assess if the activity of the unit preceded the CR or if the CR preceded the activity, cross-correlations were performed, using the Pearsons product-moment correlation coefficient to determine the relationship between the unit activity and the CR. Raster plots were summed together to produce peri-stimulus time histograms (PSTH) that were made for each unit from digitalized spike counts, with a 10 ms bin size.

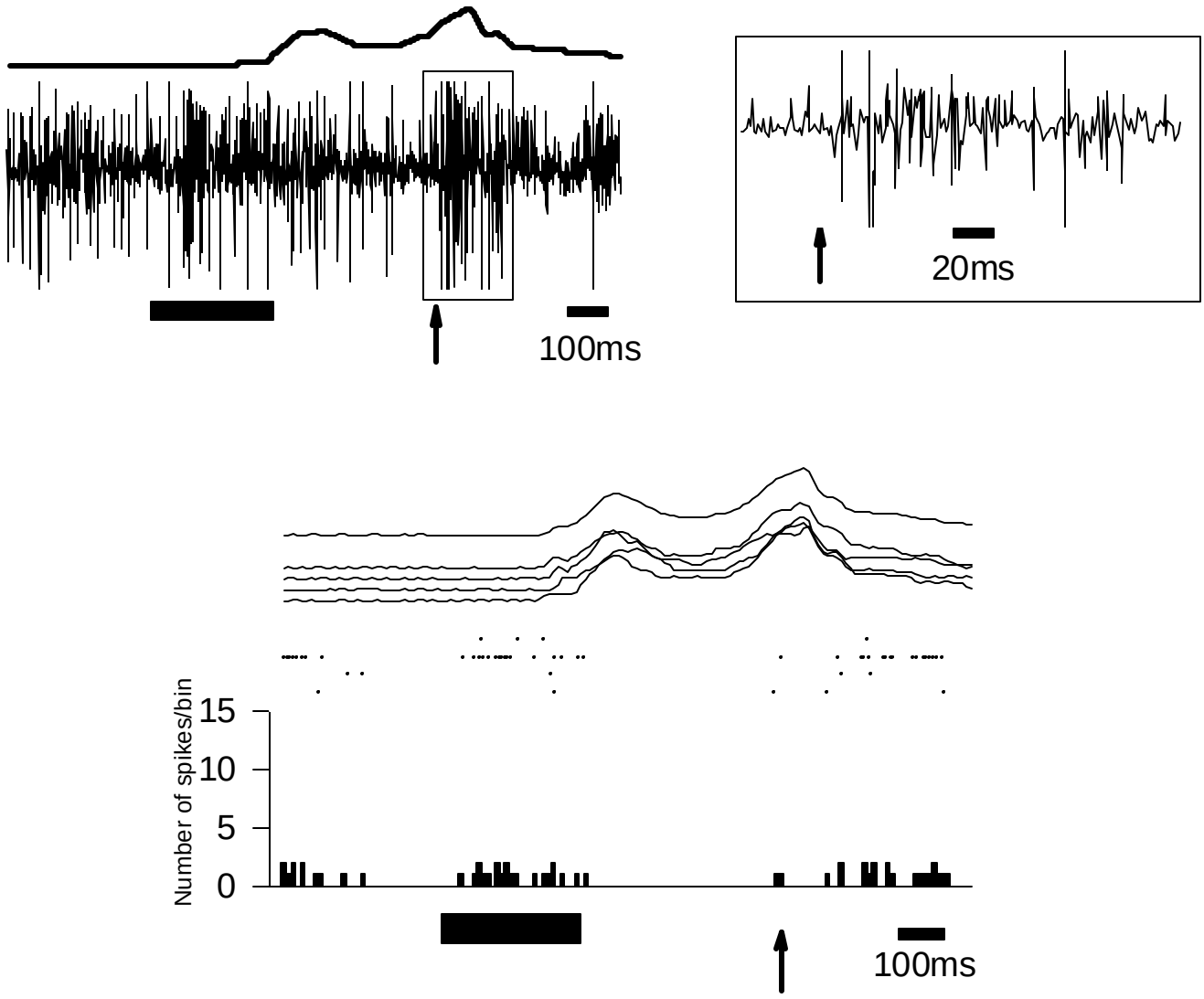
FIGURES

Each column represents a recording from a single unit during one session. The first figures in each column show short-ISI trials (300 ms). The next figure down shows long-ISI trials (700 ms) and the third one shows CS-alone probe trials. The last figure shows the correlagram for that unit.

In each of the first three figures of each column, eyeblink response traces are shown first, underneath which are raster plots, followed by peri-stimulus time histograms. The large dark bar indicates the 300 ms CS and arrow indicates the US. The correlogram has a time base of 10 ms. Zero t0 300 ms represents time proceeding the CR, the lead time, while 0 to -300 represents time following the CR, the lag time. Time zero is the initiation of the CR.

Unit 1

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Number of spikes/bin
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10
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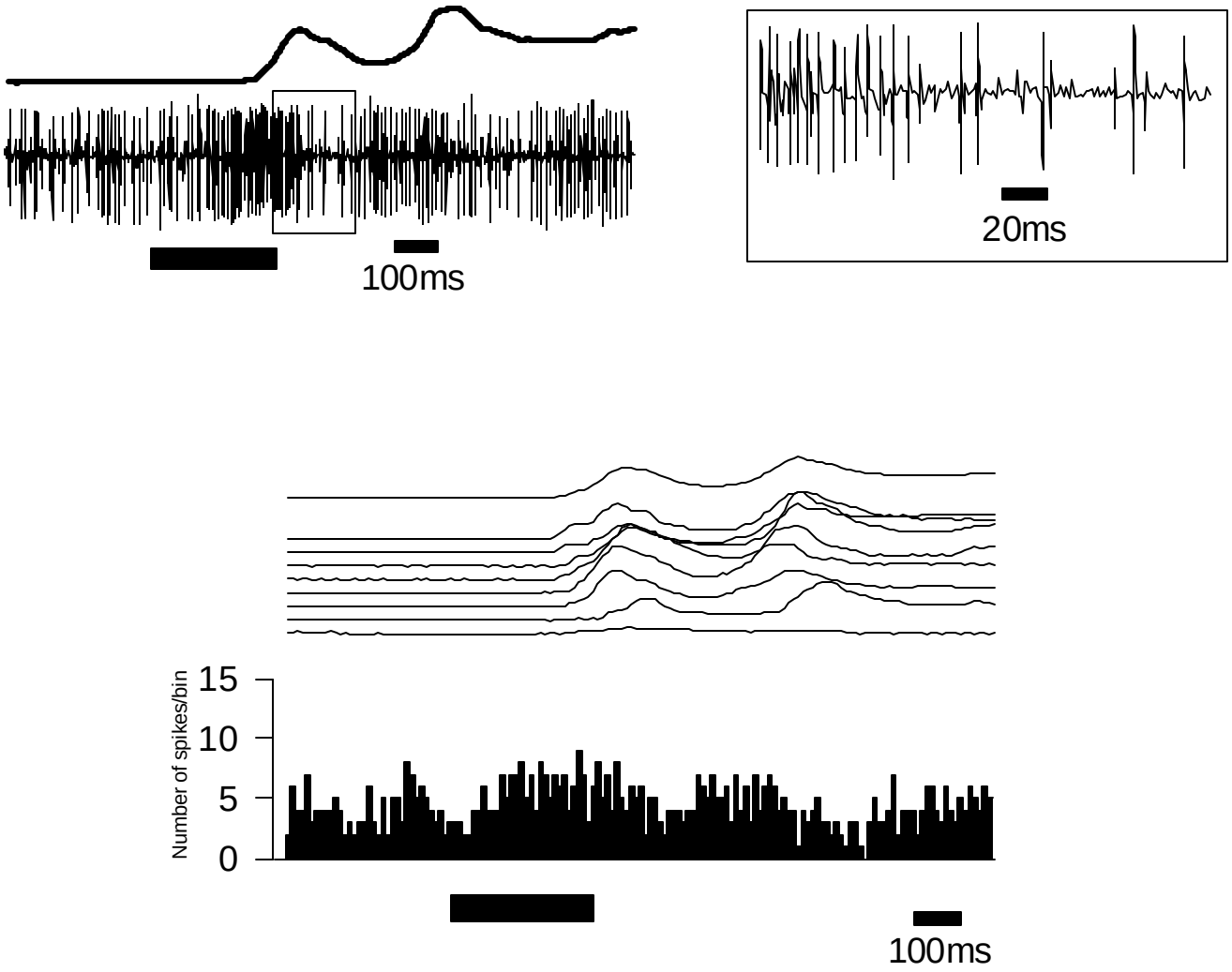
0
100ms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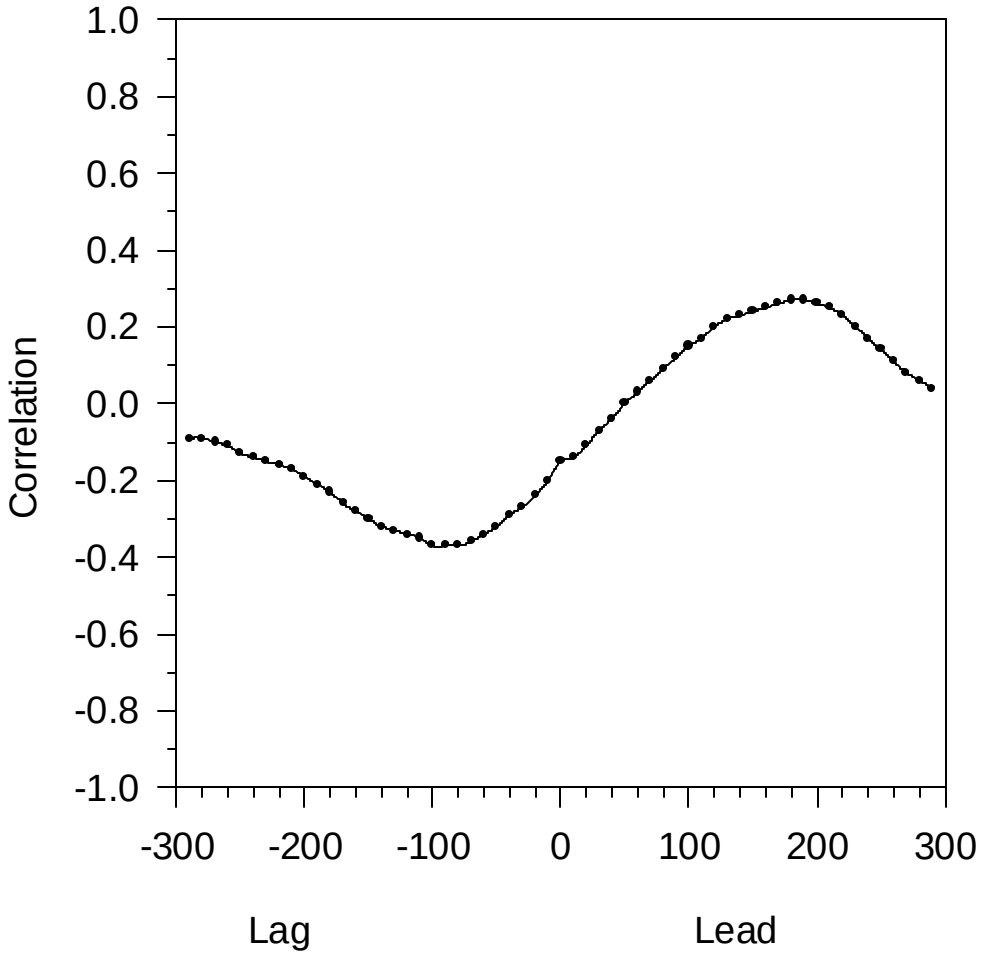
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Correlation
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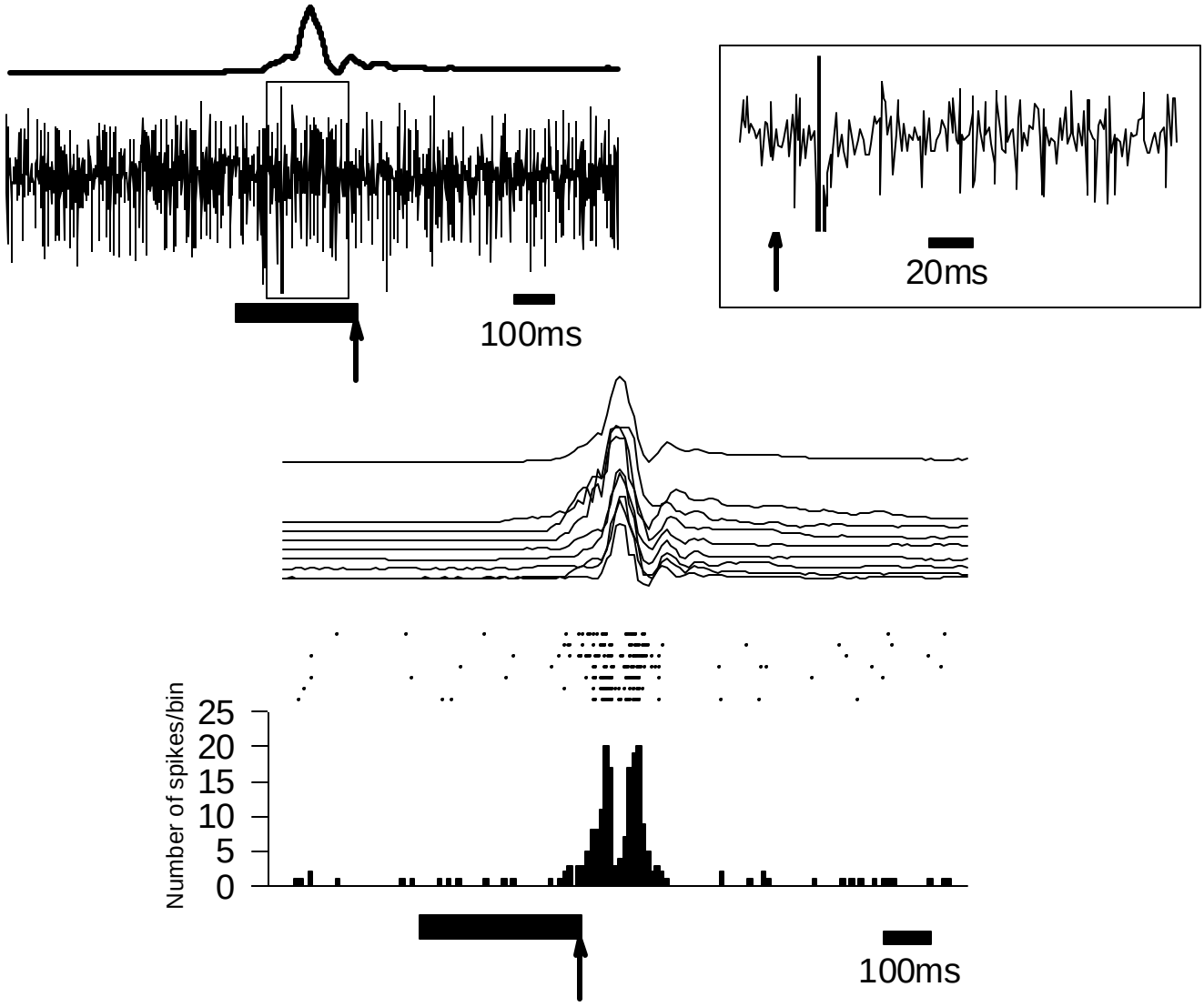
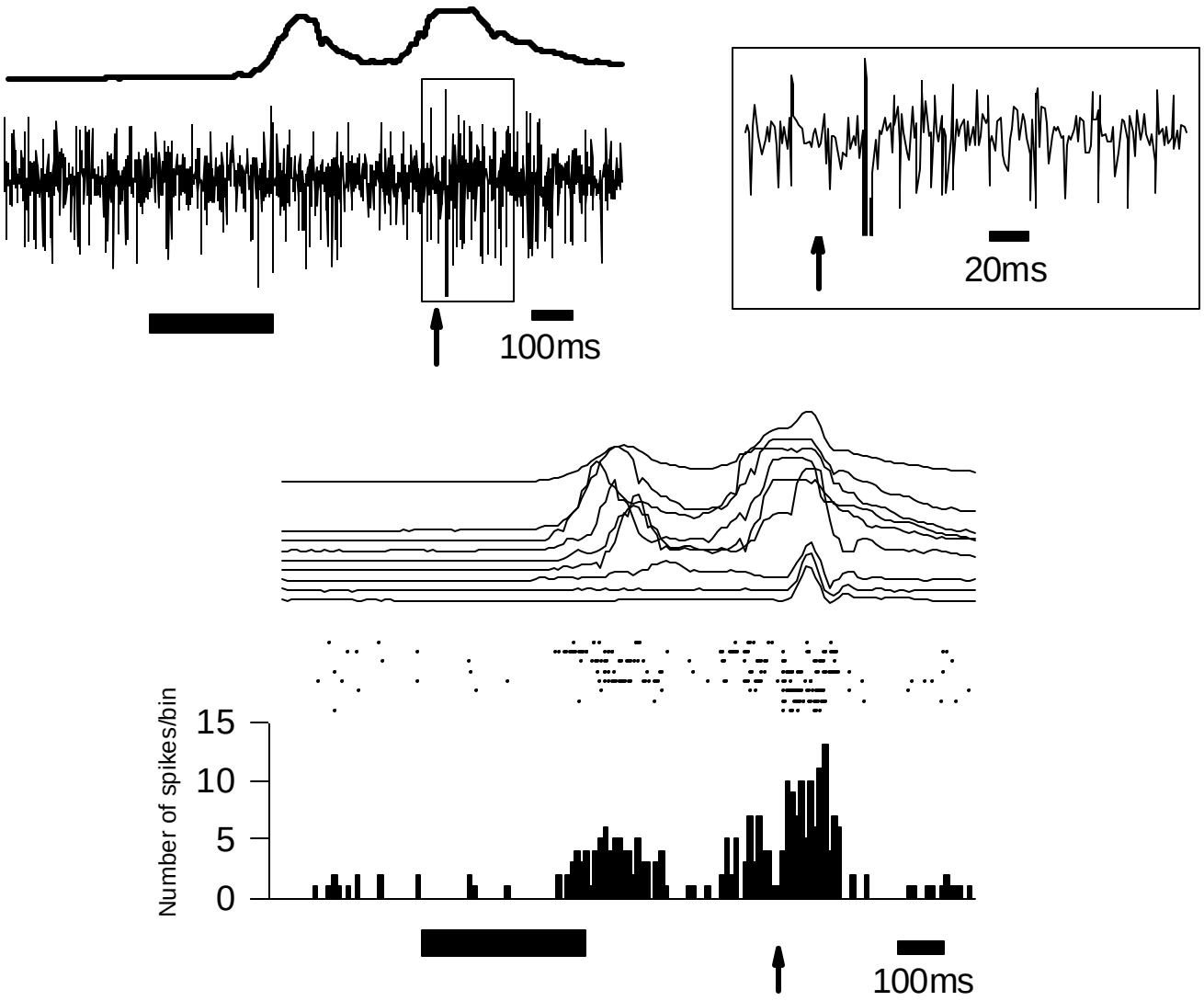
-200
-100
0
100
200
300
Lag
Lead

Unit 2

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Number of spikes/bin
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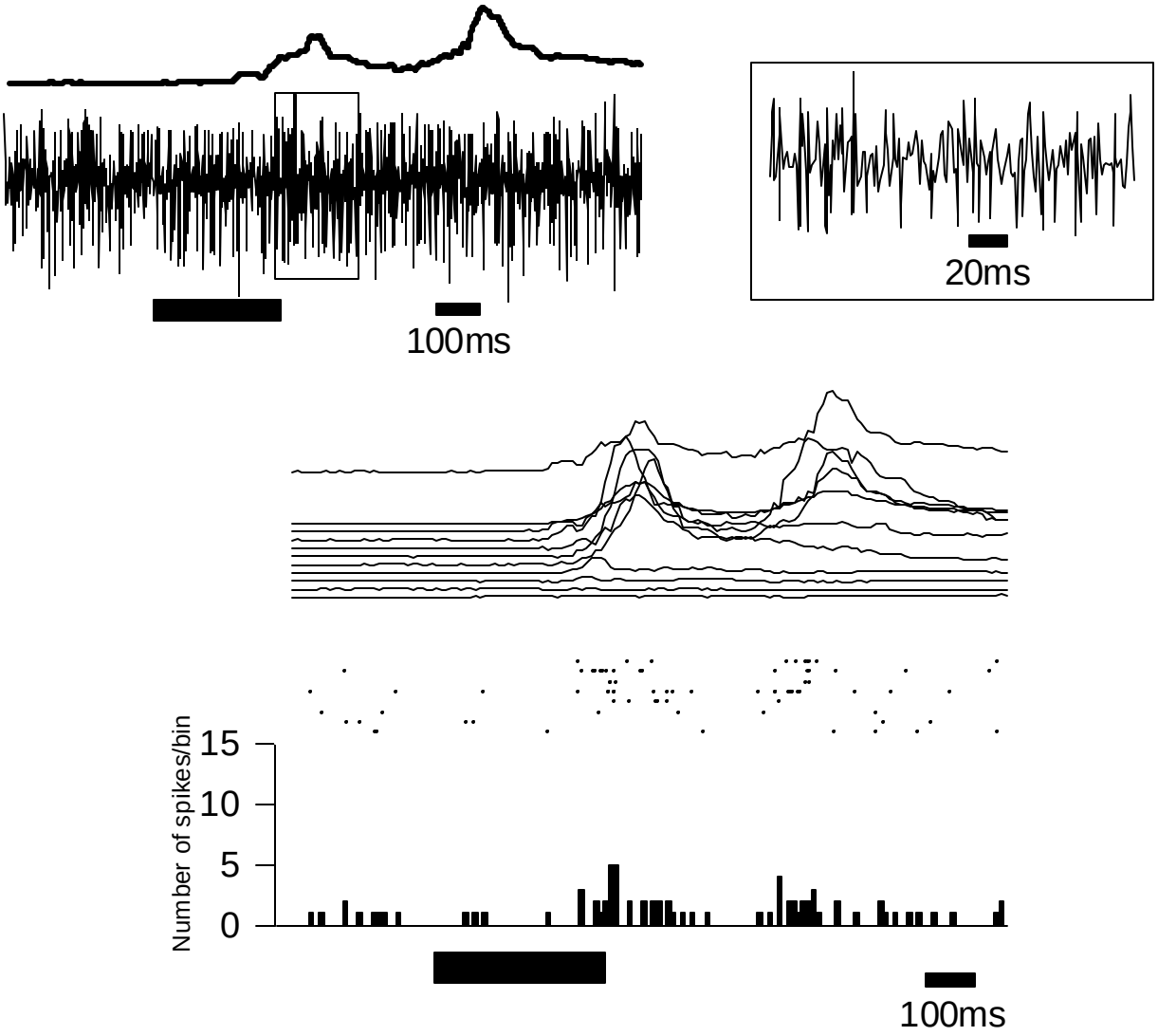
100ms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100ms
Number of spikes/bin
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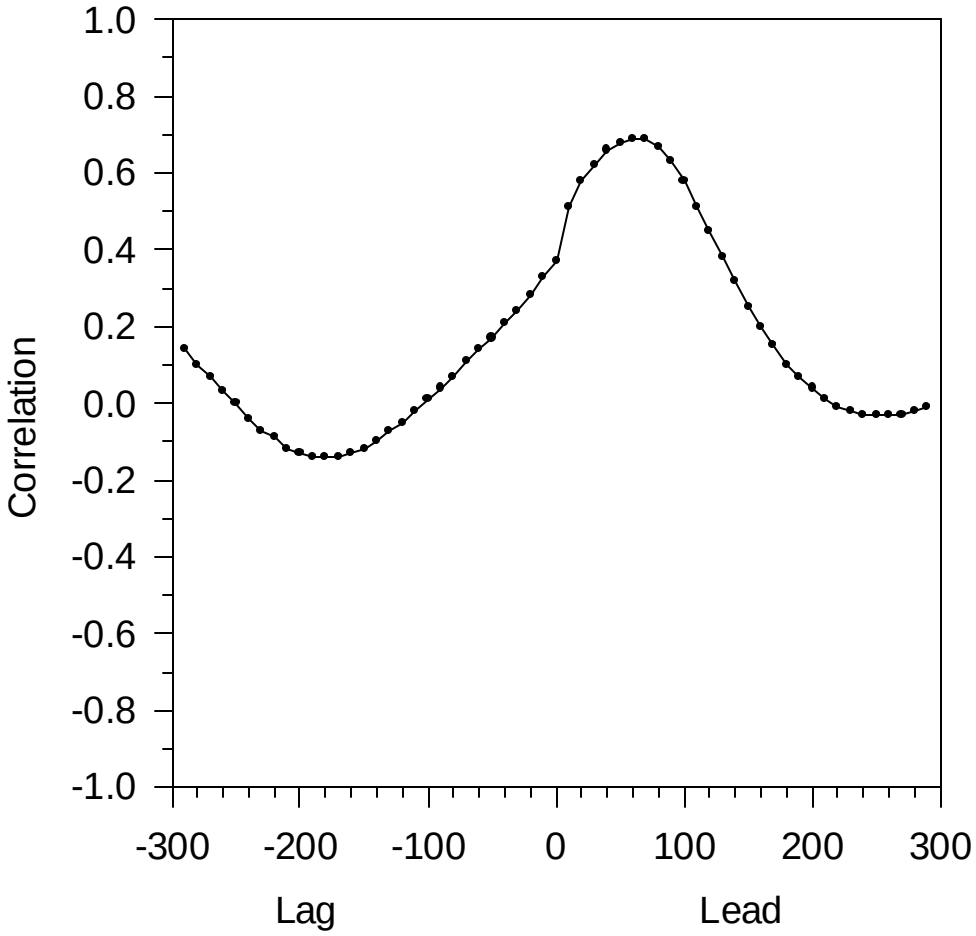
100ms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0.2
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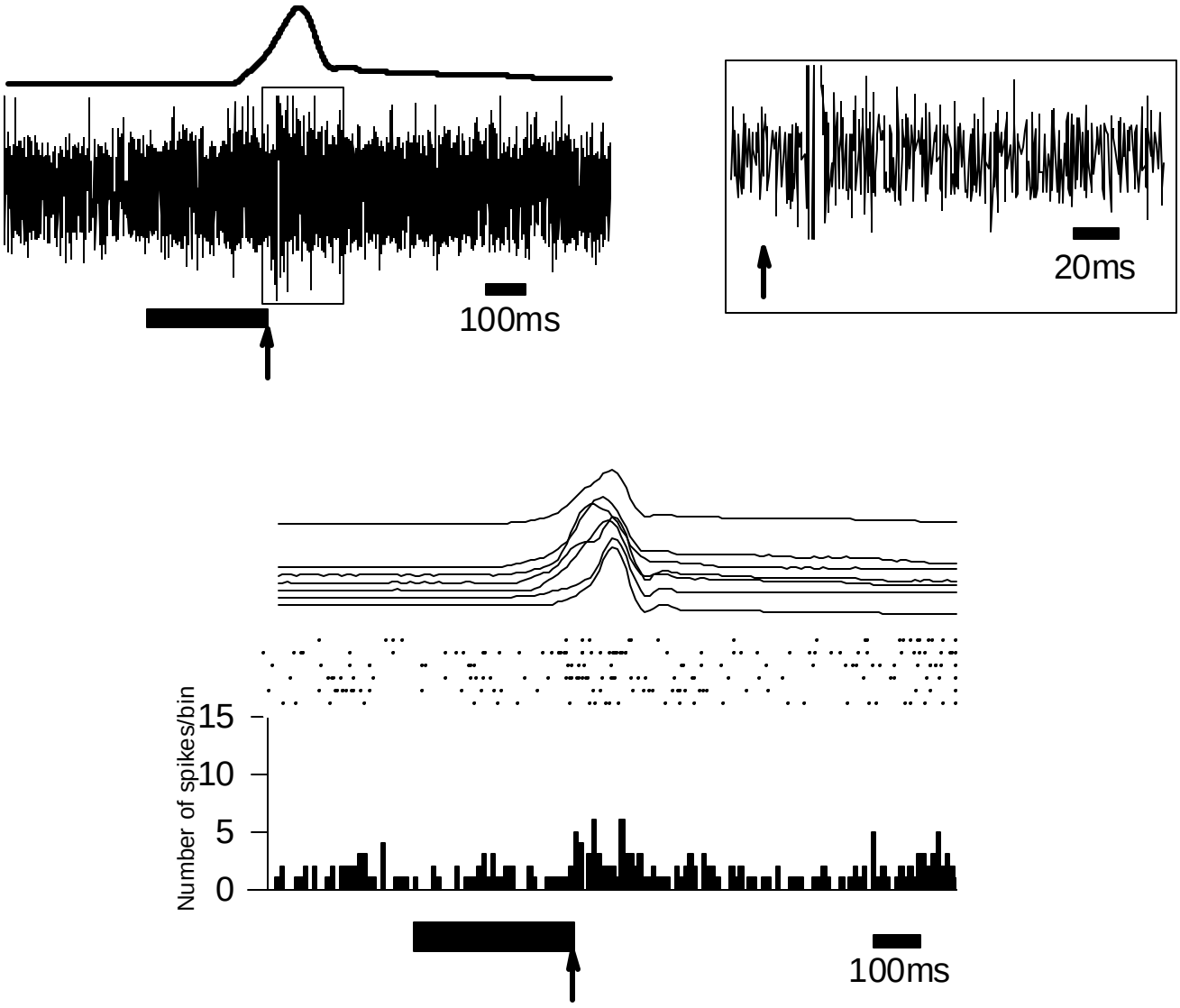
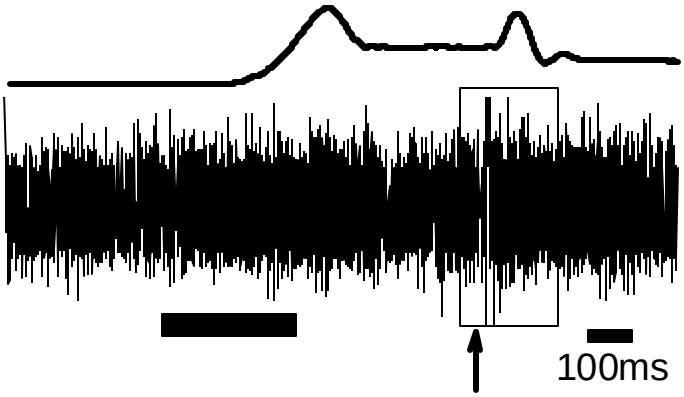
Correlation
-300
-200
-100
0
100
200
300
Lag
Lead

Unit 3

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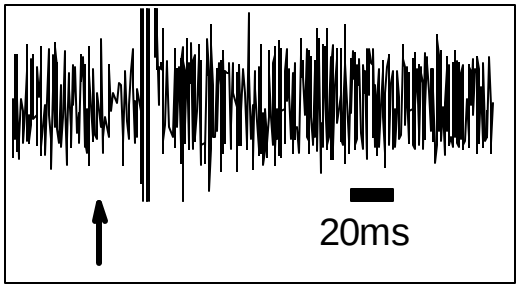
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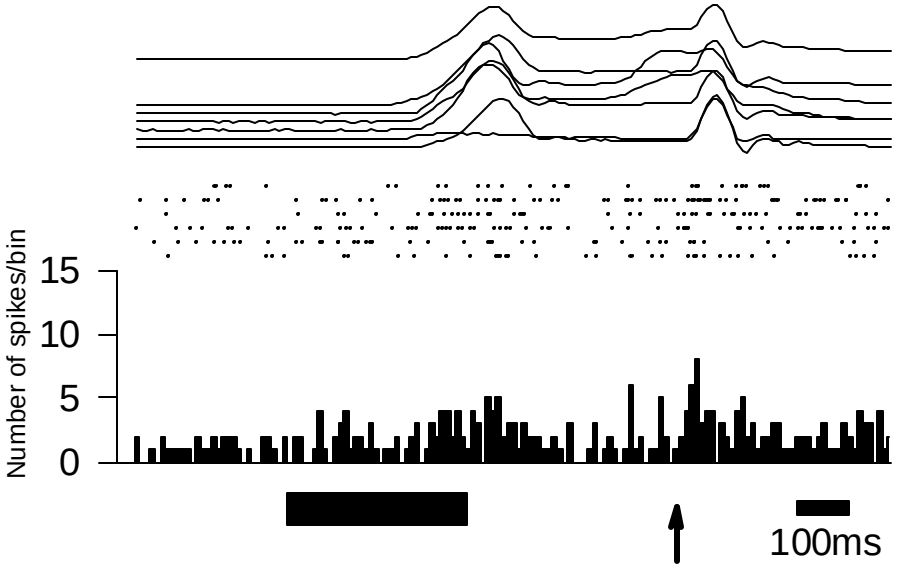
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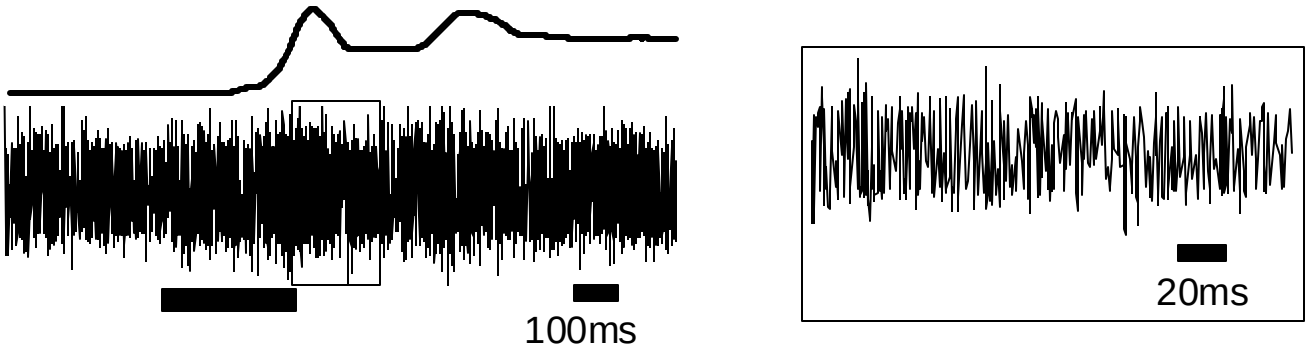
100ms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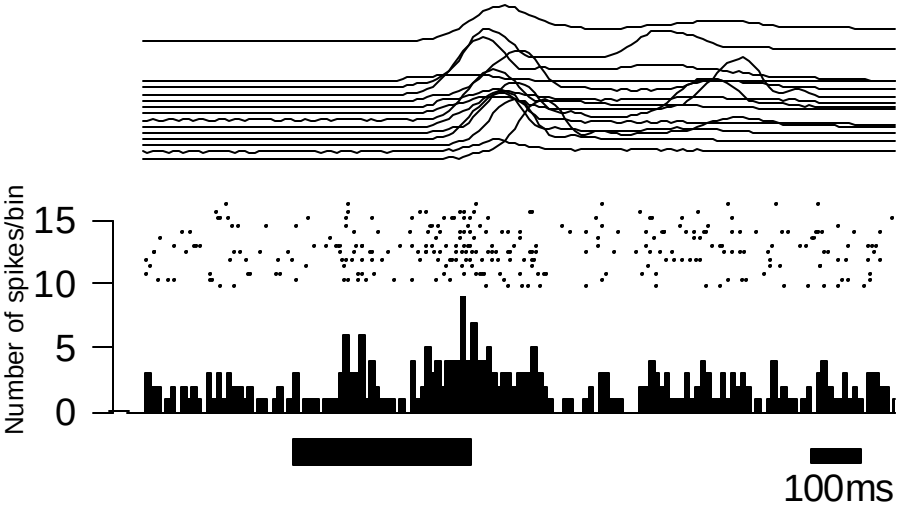
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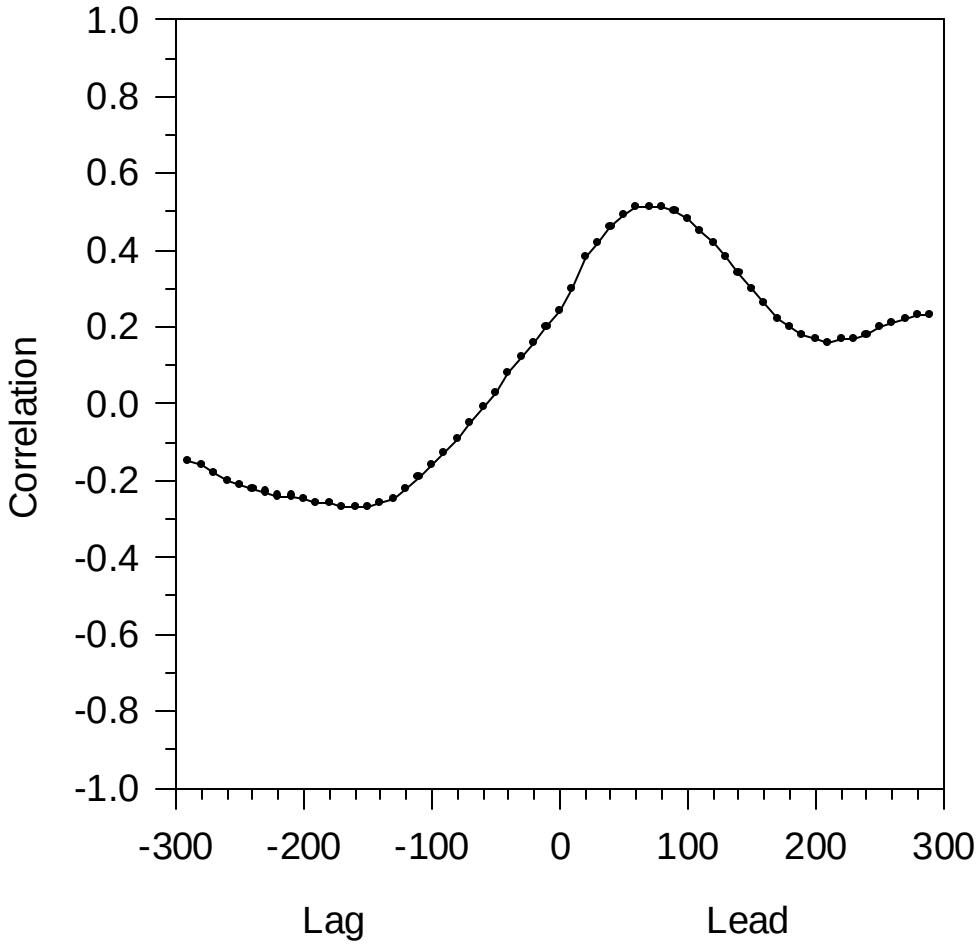
100ms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0.8
0.6
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0.0
-0.2
-0.4
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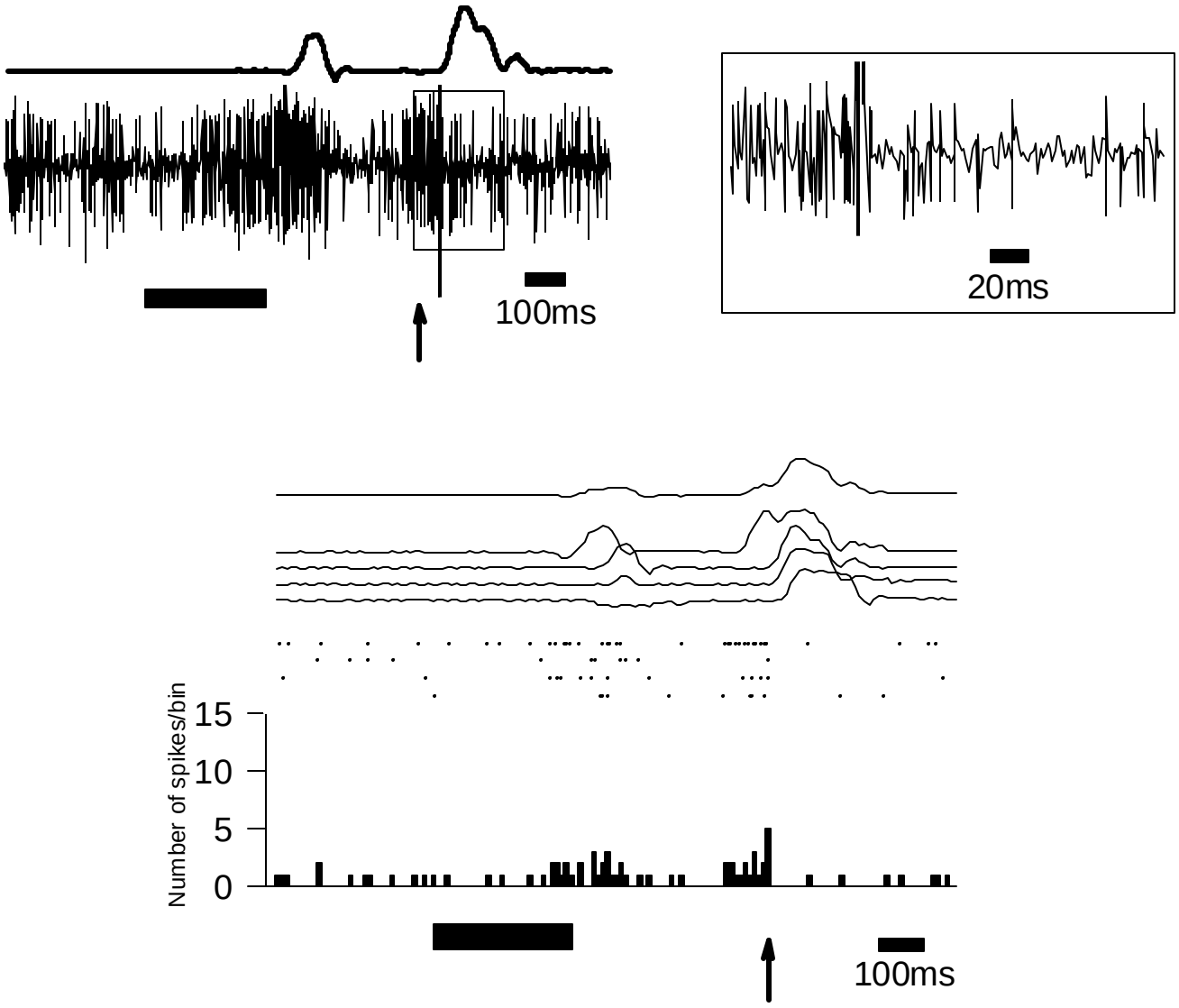
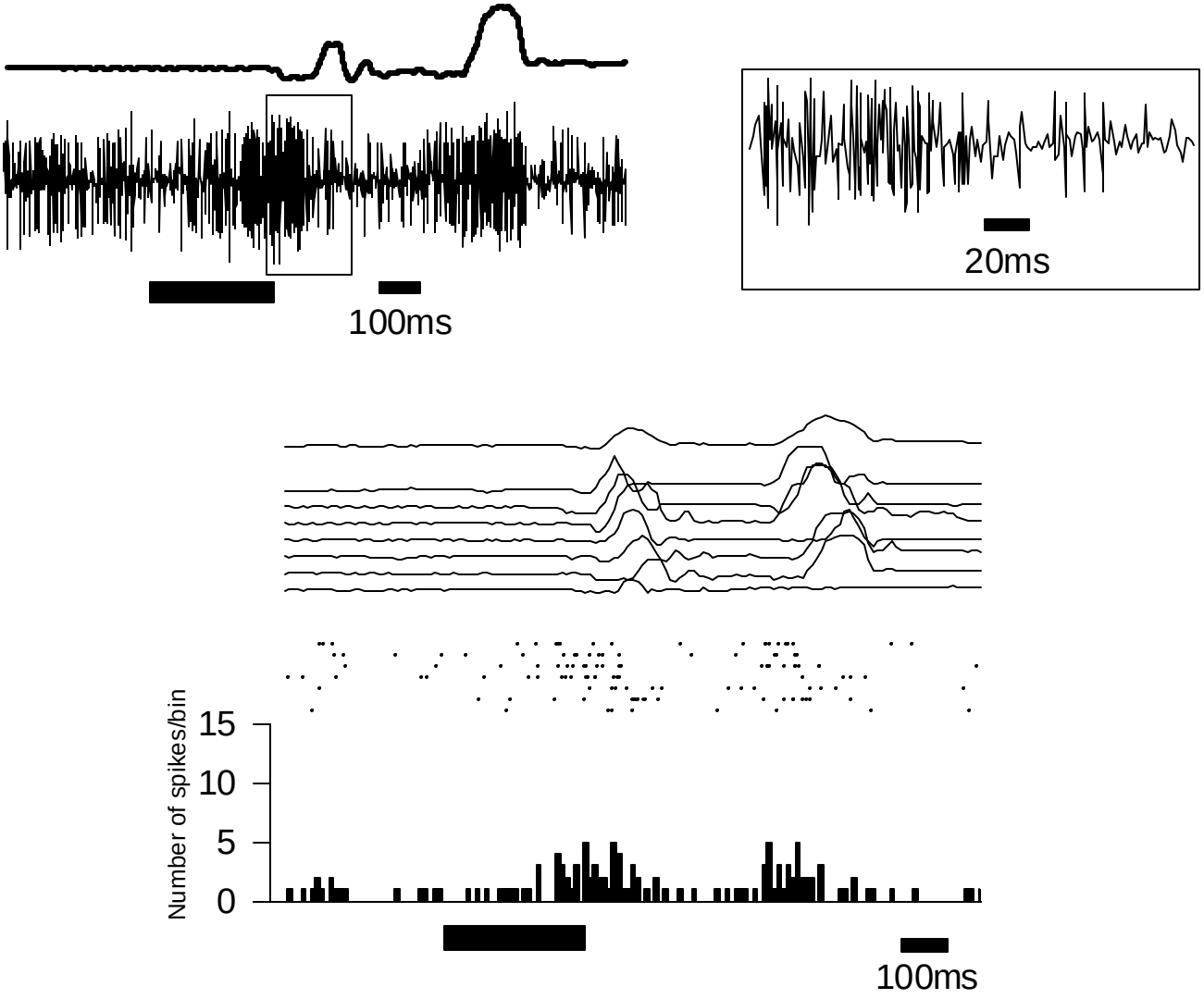
Correlation
-300
-200
-100
0
100
200
300
Lag
Lead

Unit 4

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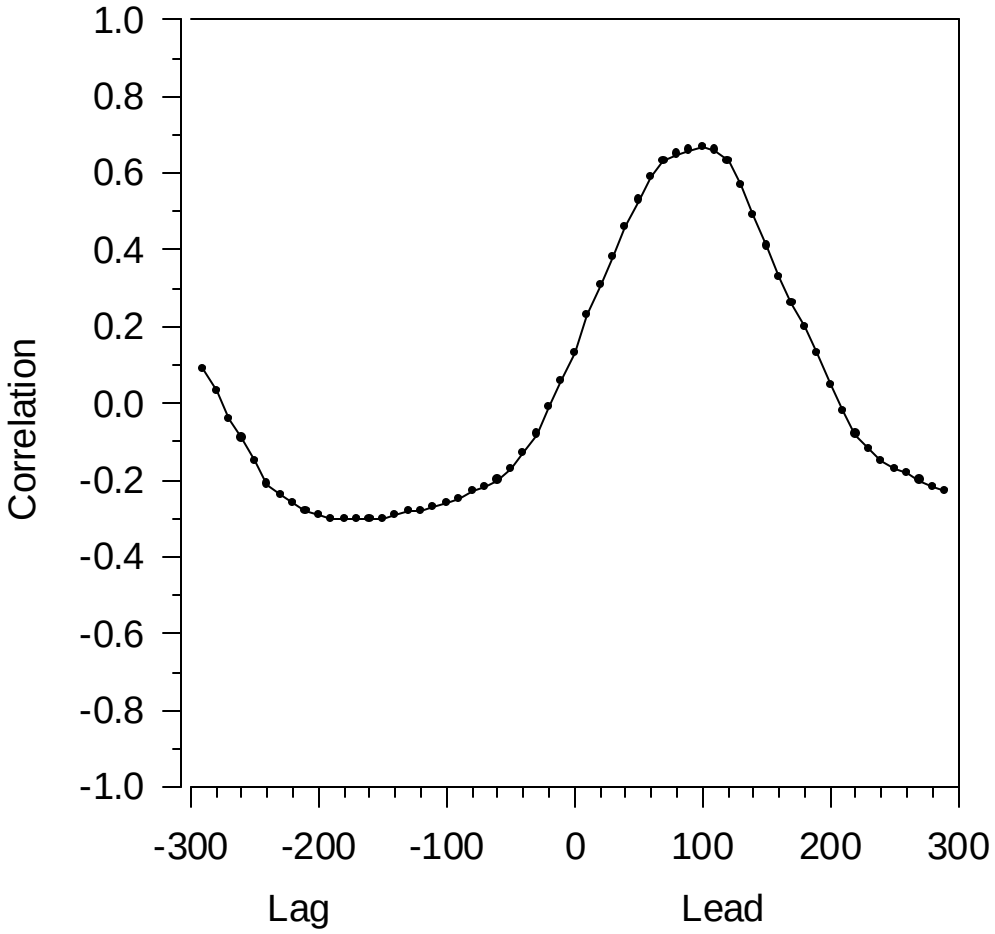
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Correlation
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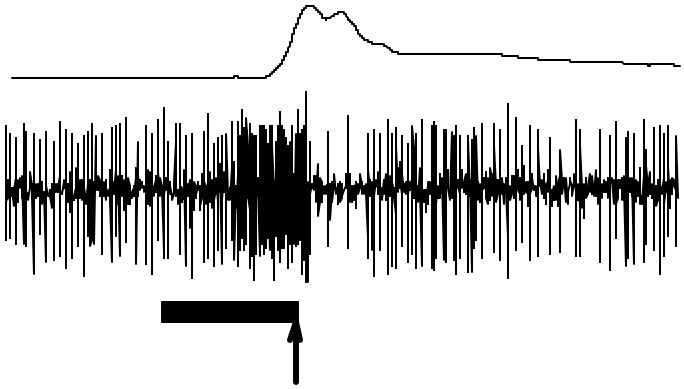
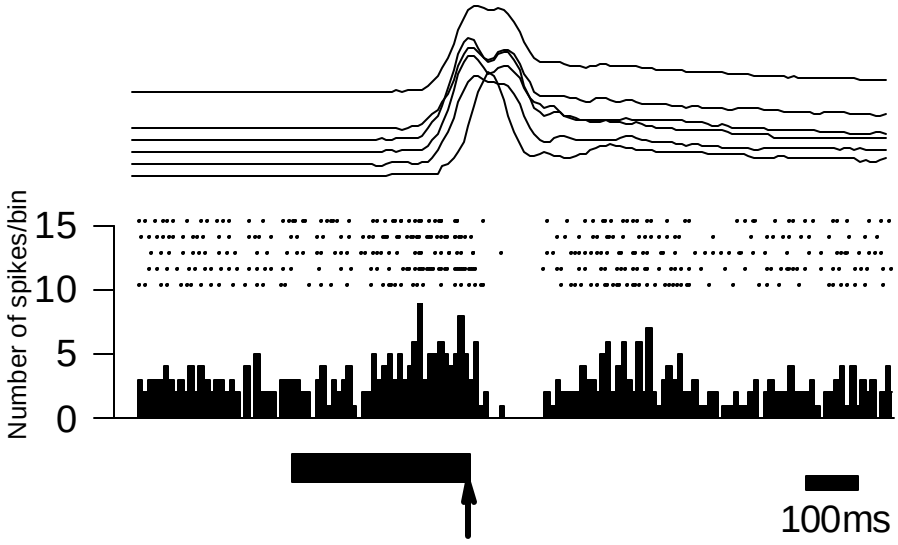
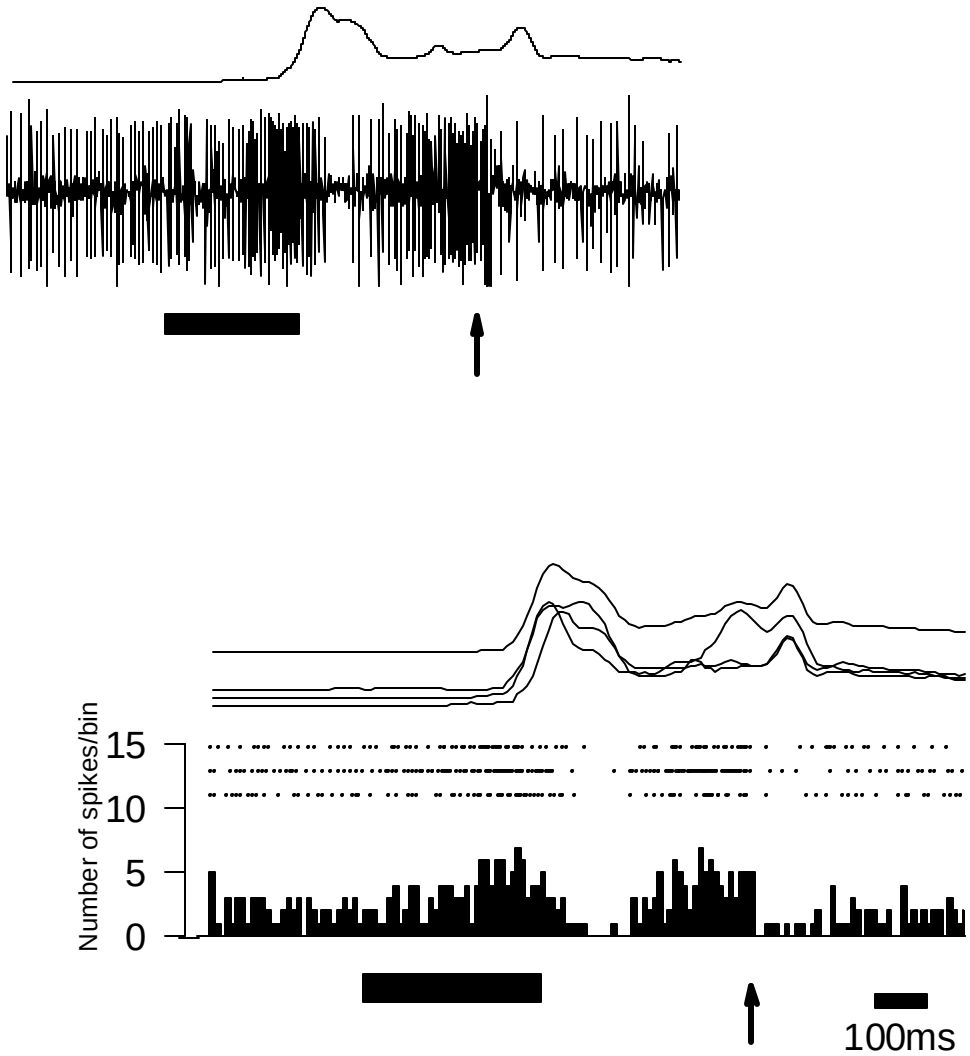
-200
-100
0
100
200
300
Lag
Lead

Unit 5






Number of spikes/bin
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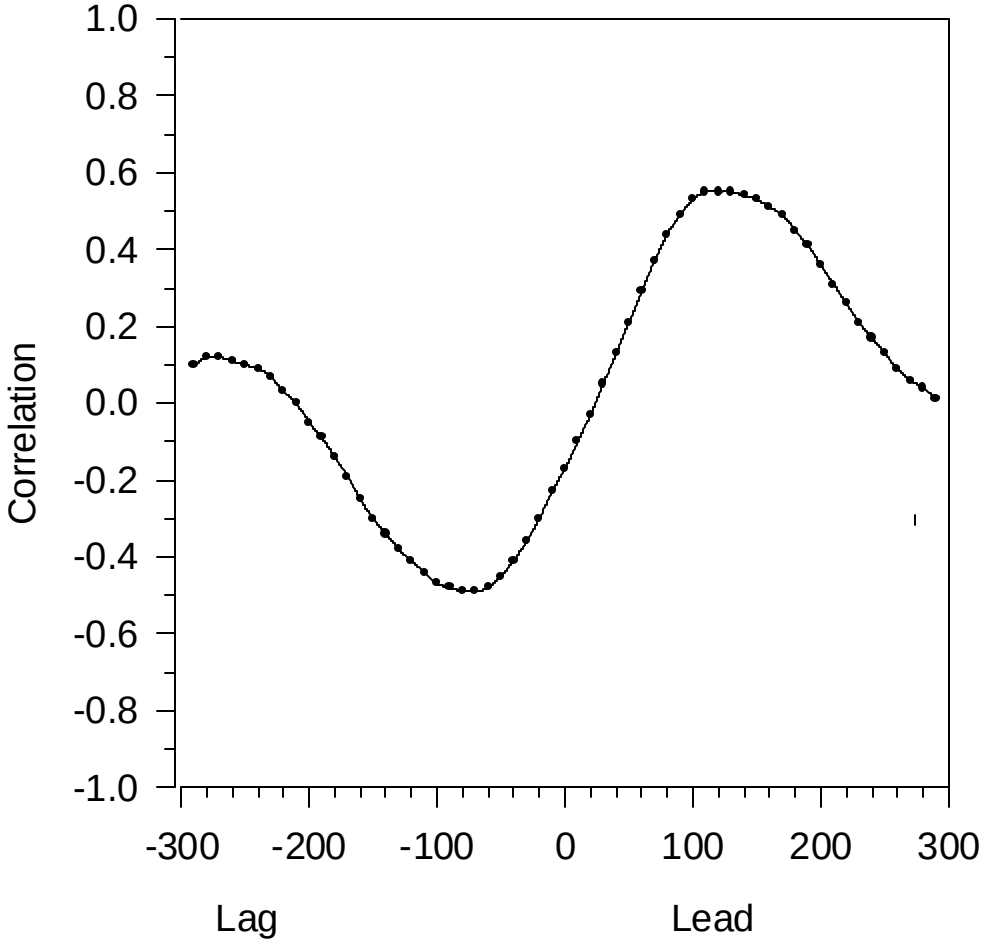
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Correlation
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-200
-100
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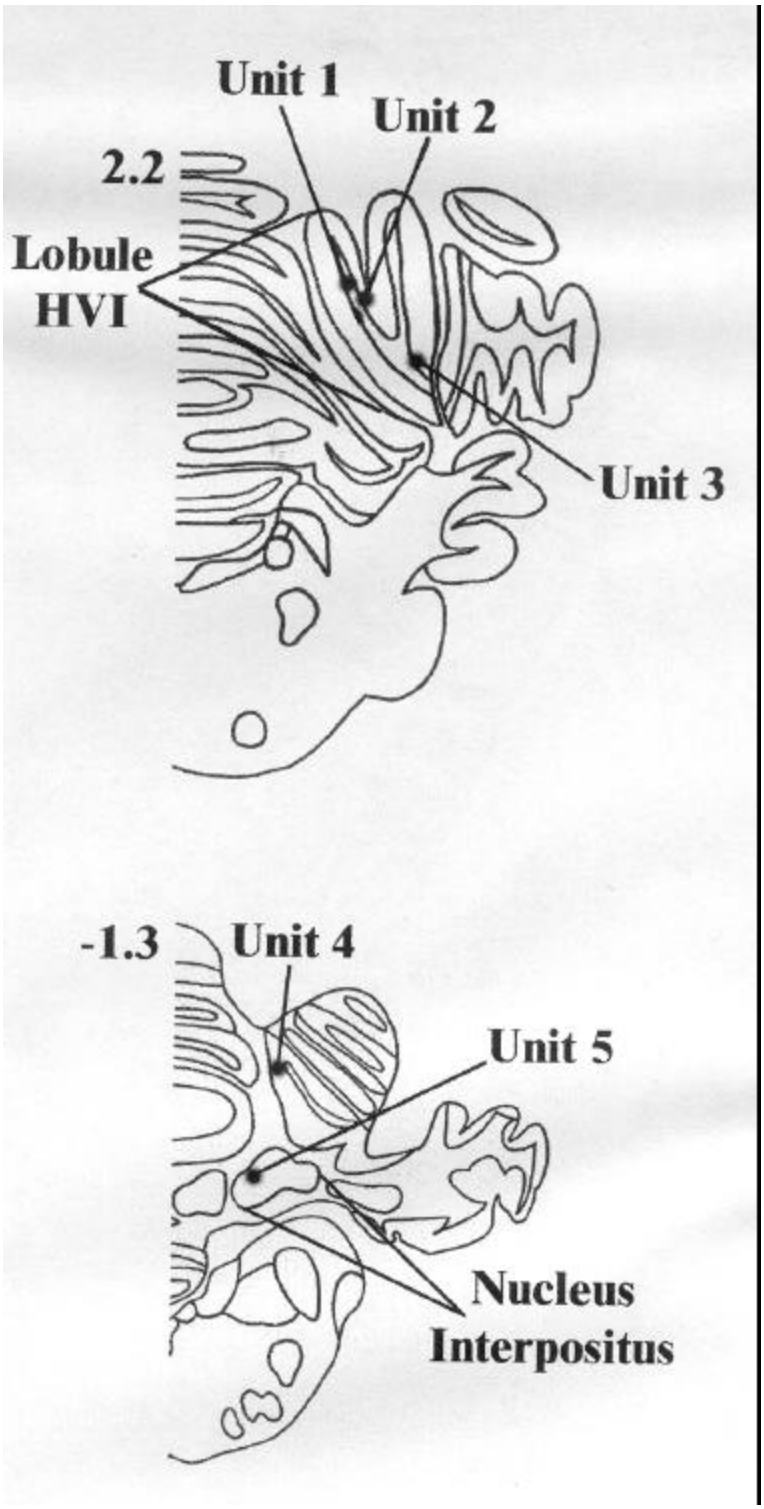
100
200
300
Lag
Lead


Unit 1
Unit 2
2.2
Lobule
HVI
Unit 3
-1.3
Unit 4
Unit 5
Nucleus
Interpositus

CONCLUSIONS

- Purkinje cells fire in anticipation of both amplitude peaks of bimodal CRs.

- Integration of learning involving mixed ISIs of 300 msec and 700 msec can be expressed by individual Purkinje cells.

- On short-ISI reinforced trials, both the neural response and the behavioral response to the second peak was suppressed. This suggests that the US becomes a conditioned inhibitor.

REFERENCES

Berthier, N.E. & Moore, J.W. (1986). Cerebellar Purkinje cell activity related to the classically conditioned nictitating membrane response. Experimental Brain Research, 63, 341-350.

Berthier, N.E. & Moore, J.W. (1990). Activity of deep cerebellar nuclear cells during classical conditioning of nictitating membrane extension in rabbits. Experimental Brain Research, 83, 44-54.

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ACKNOWLEDGEMENT

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WEBSITE

http://moorelab.sbs.umass.edu