Visual Orientation and Directional Selectivity through Thalamic Synchrony

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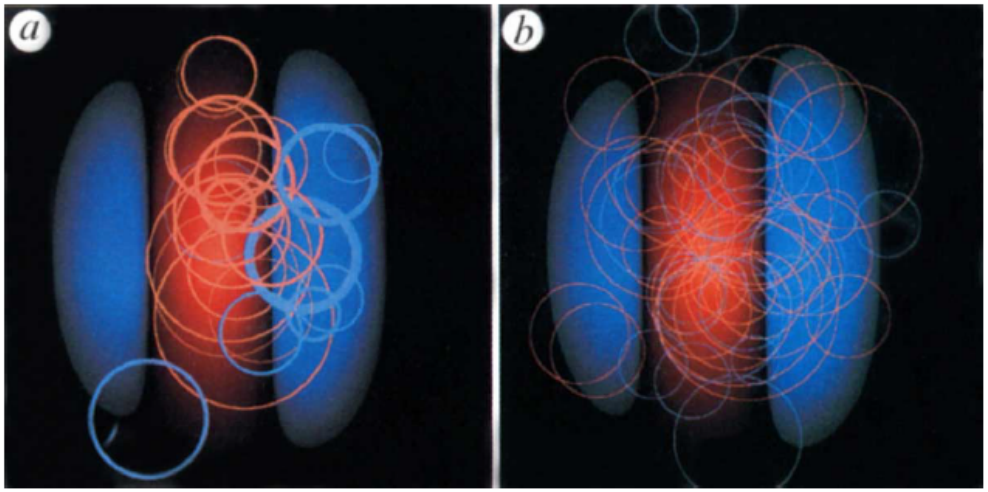
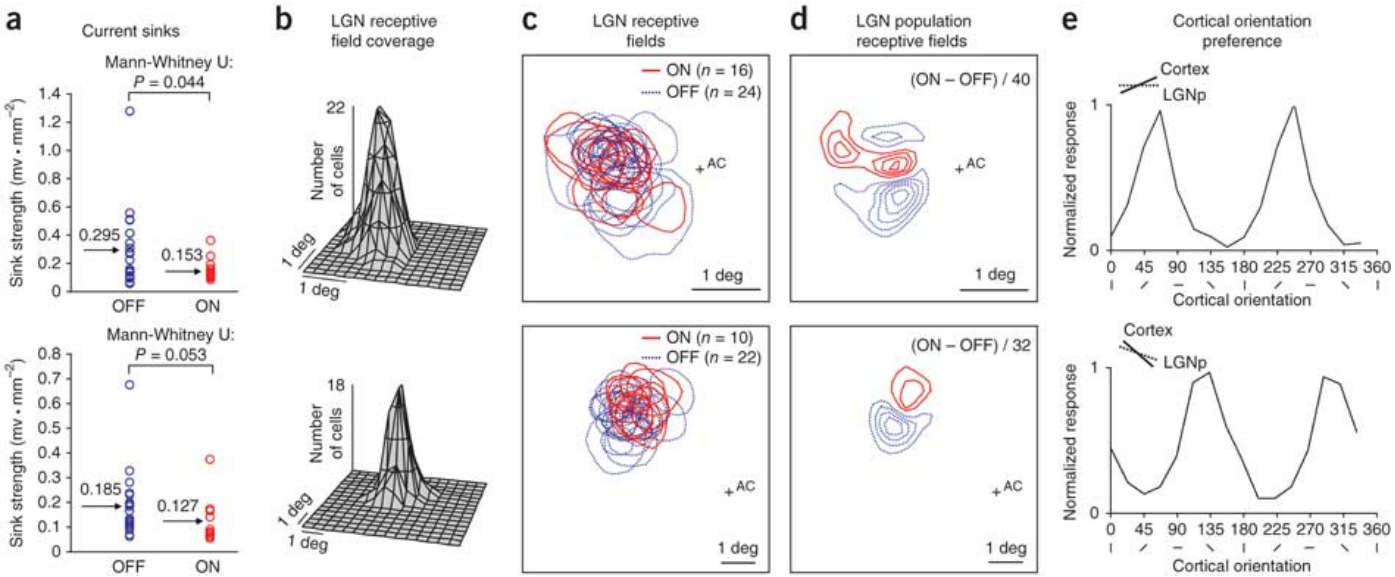
LGN inputs to simple cells (Reid and Alonso, 1995)

- simultaneous recordings, one LGN and one V1 simple cell
- ON/OFF LGN cells align to simple cell ON/OFF receptive field



LGN inputs to cortical column (Jin et al, 2011)

- simultaneous recordings, one V1 column and many LGN cells
- LGN OFF and ON inputs to same V1 column are highly overlapping
- average RF (ON-OFF) still highly correlated to column preferred orientation.



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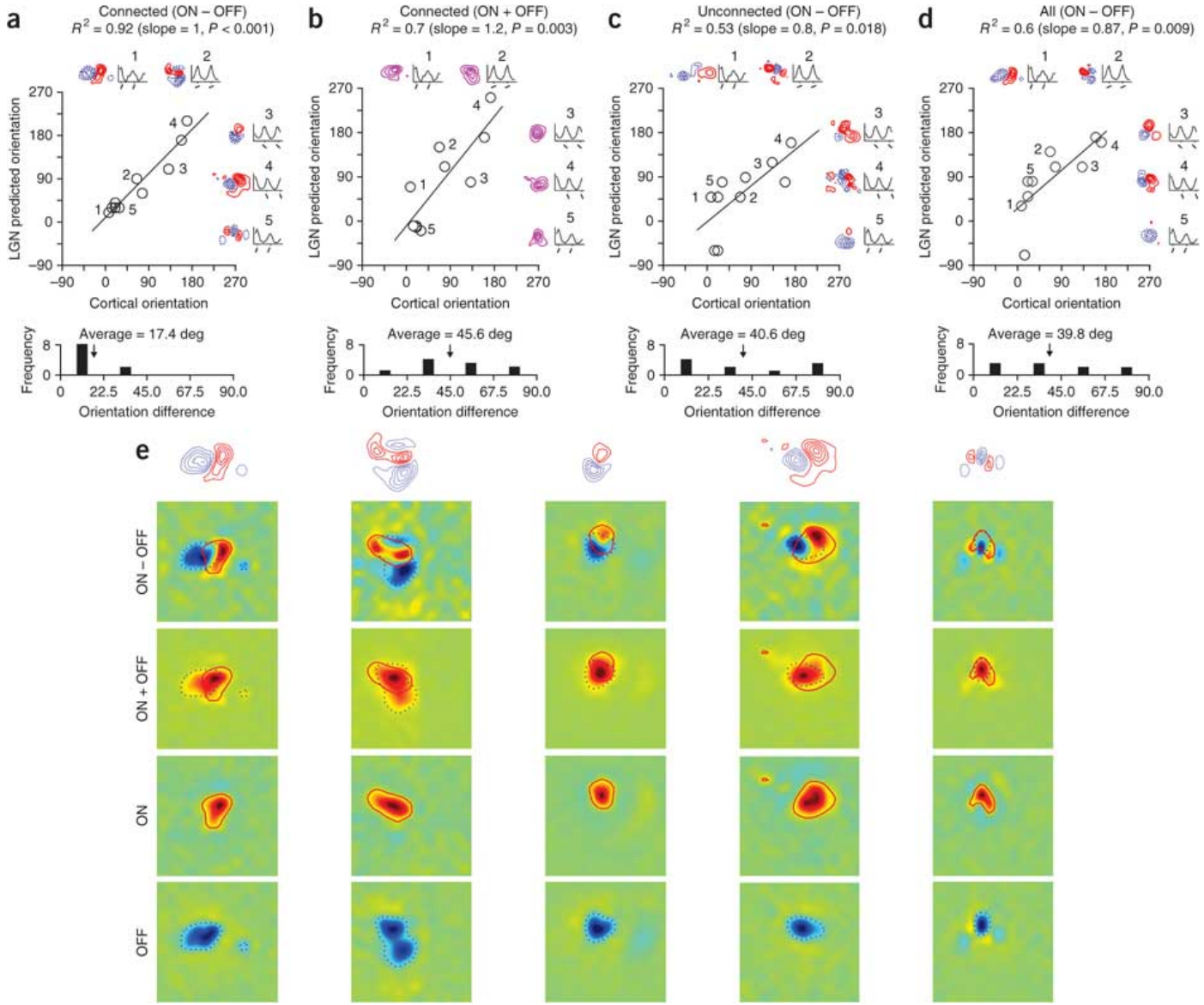
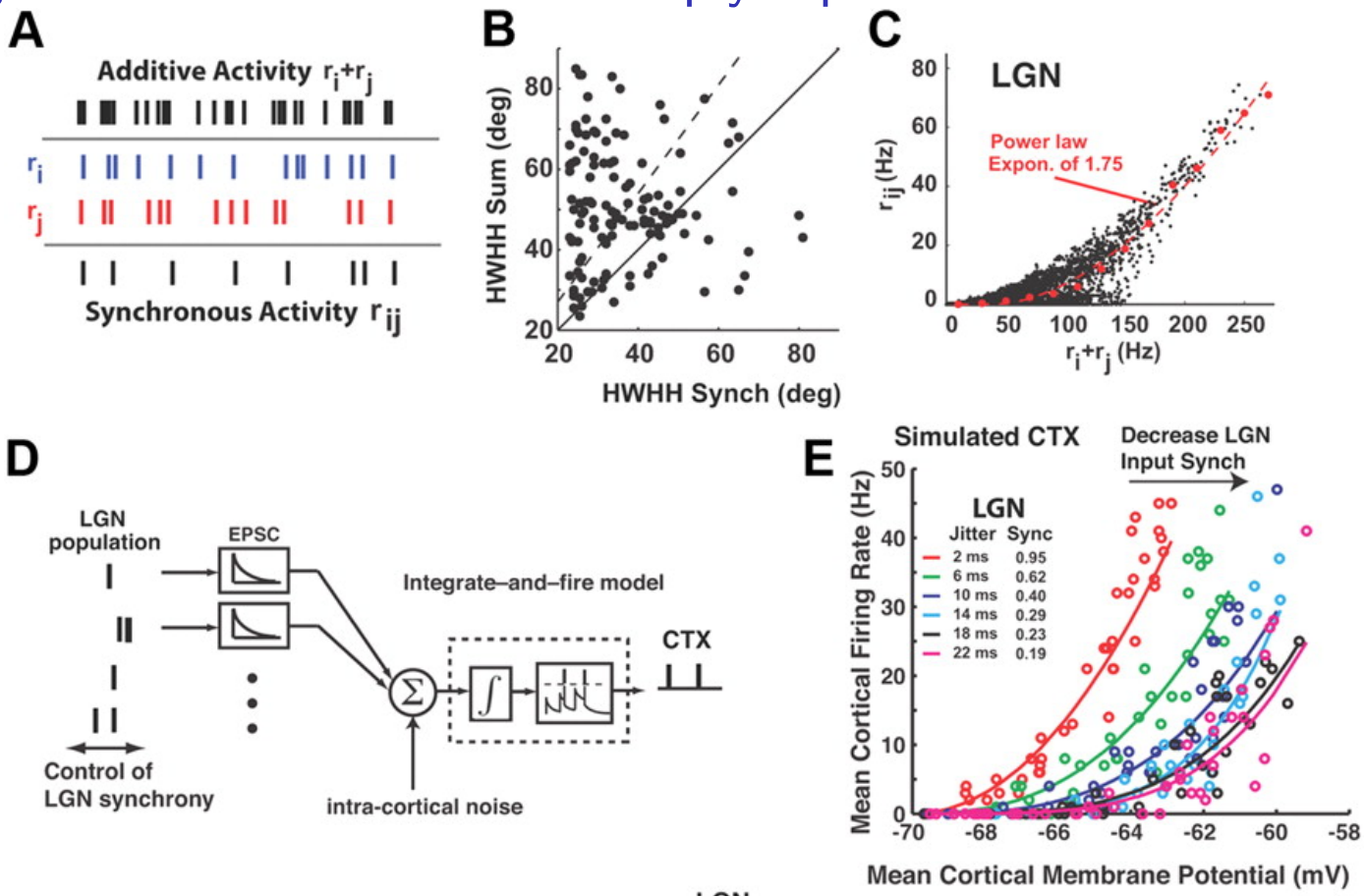
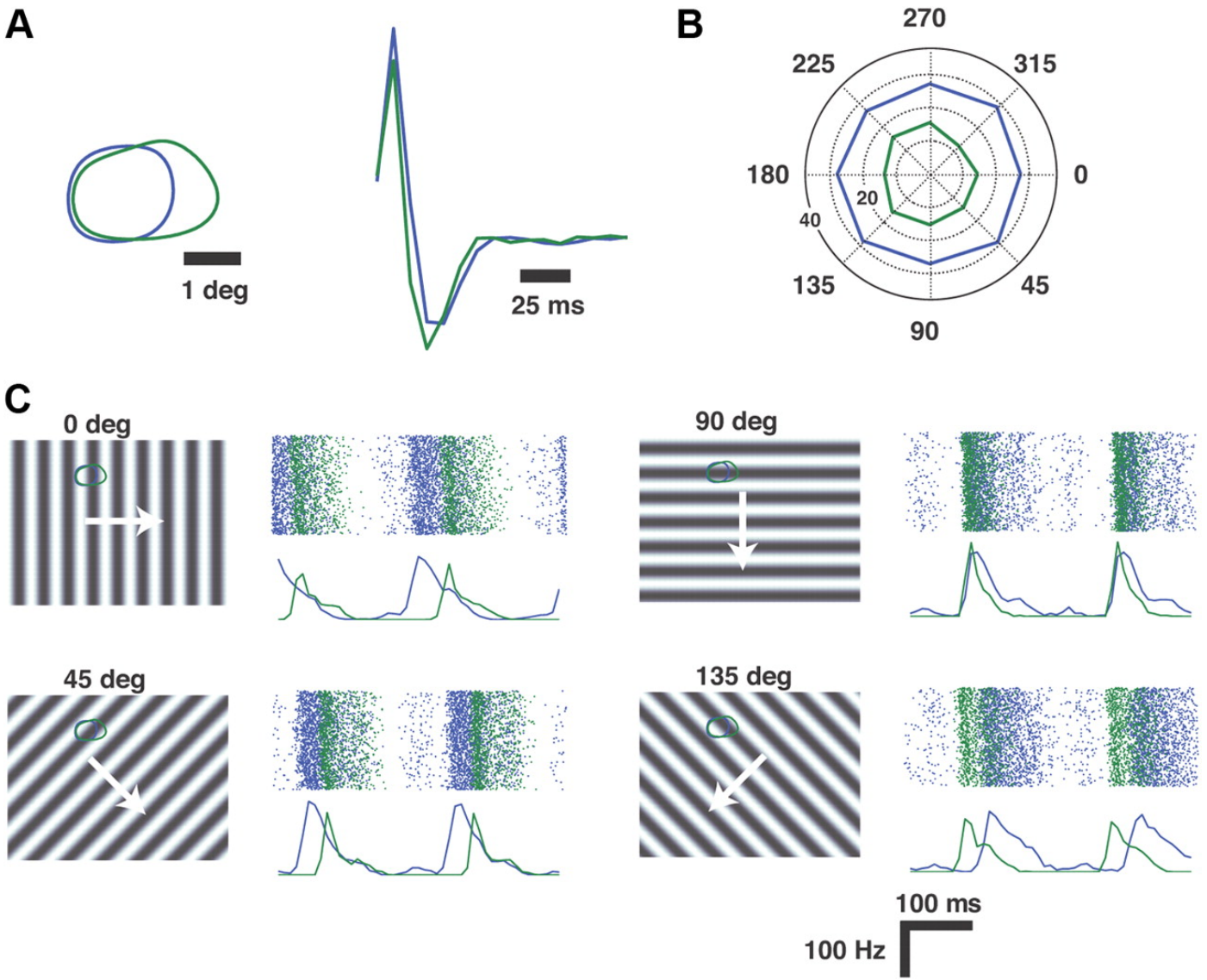


Single neurons can add or multiply inputs

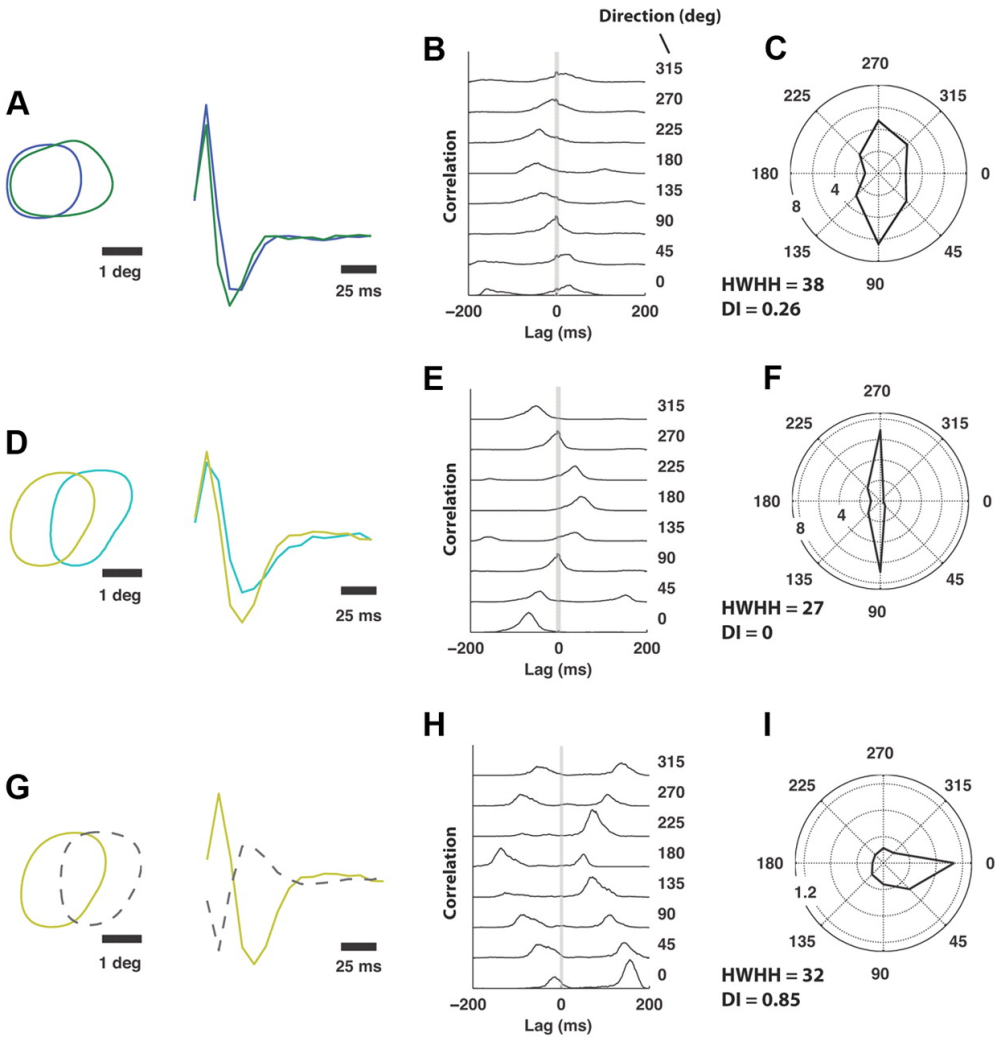


Orientation selectivity from synchronous (well aligned) inputs

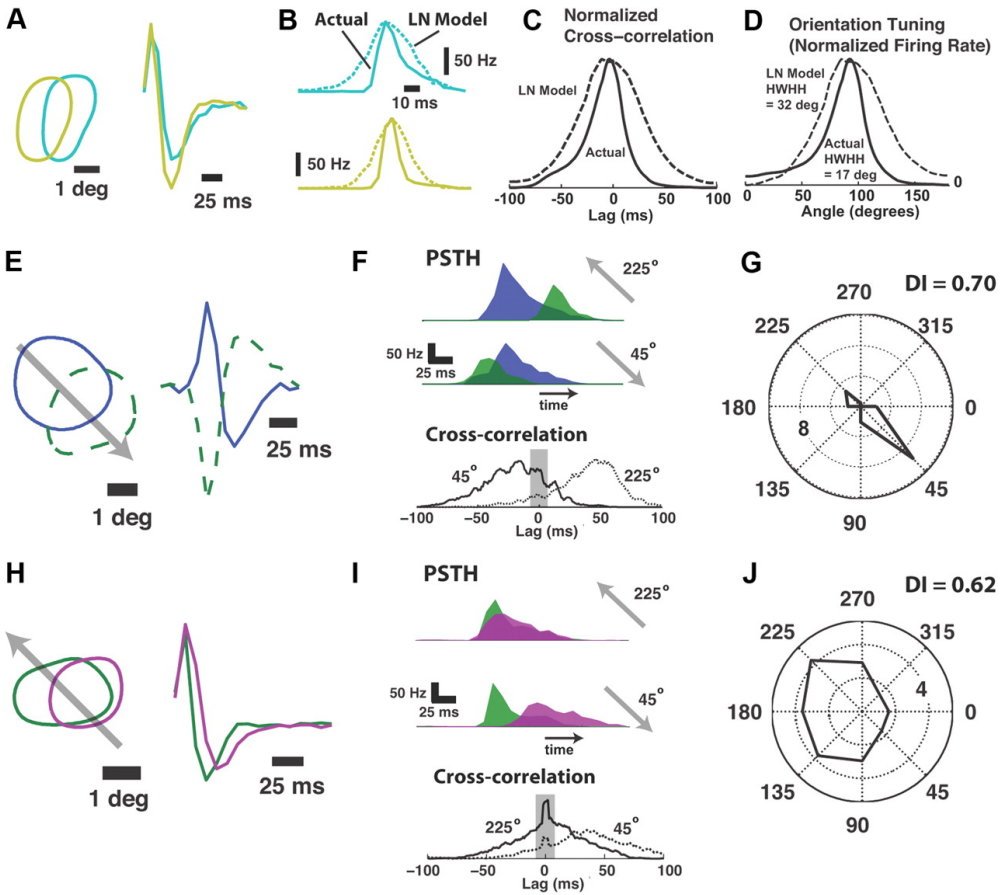
- simultaneous LGN recordings - but all results depend on PSTHs

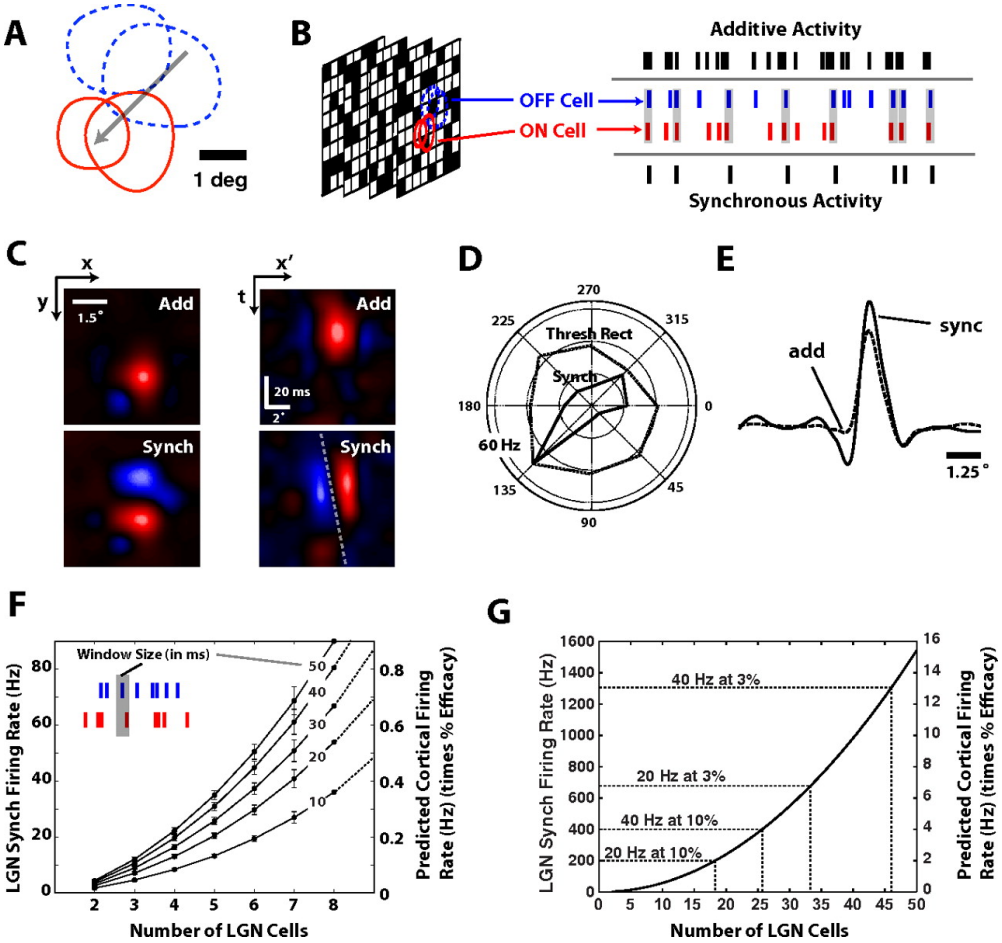


Orientation selectivity from synchronous (well aligned) inputs



Direction selectivity from synchronous inputs




A
1 deg
B
Additive Activity
OFF Cell
ON Cell
Synchronous Activity
C
x
y
1.5°
Add
Synch
x′
t
20 ms
2°
Add
Synch
D
270
225
315
Thresh Rect
Synch
180
0
60 Hz
135
45
90
E
add
sync
1.25°
F
Window Size (in ms)
50
40
30
20
10
LGN Synch Firing Rate (Hz)
Predicted Cortical Firing Rate (Hz) (times % Efficacy)
Number of LGN Cells
G
40 Hz at 3%
20 Hz at 3%
40 Hz at 10%
20 Hz at 10%
LGN Synch Firing Rate (Hz)
Predicted Cortical Firing Rate (Hz) (times % Efficacy)
Number of LGN Cells

Conclusions

- LGN ON and OFF inputs to a cortical column are highly spatially overlapping.
- Small latency differences in the responses of overlapping LGN cells can be used to compute orientation (even from ON-ON pairs).
- Latency differences vary with direction of motion, can be used to build direction detectors.