Cortical Rhythms and Interneurons for Routing and Reading Working Memory

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GRS Neurobiology of Cognition

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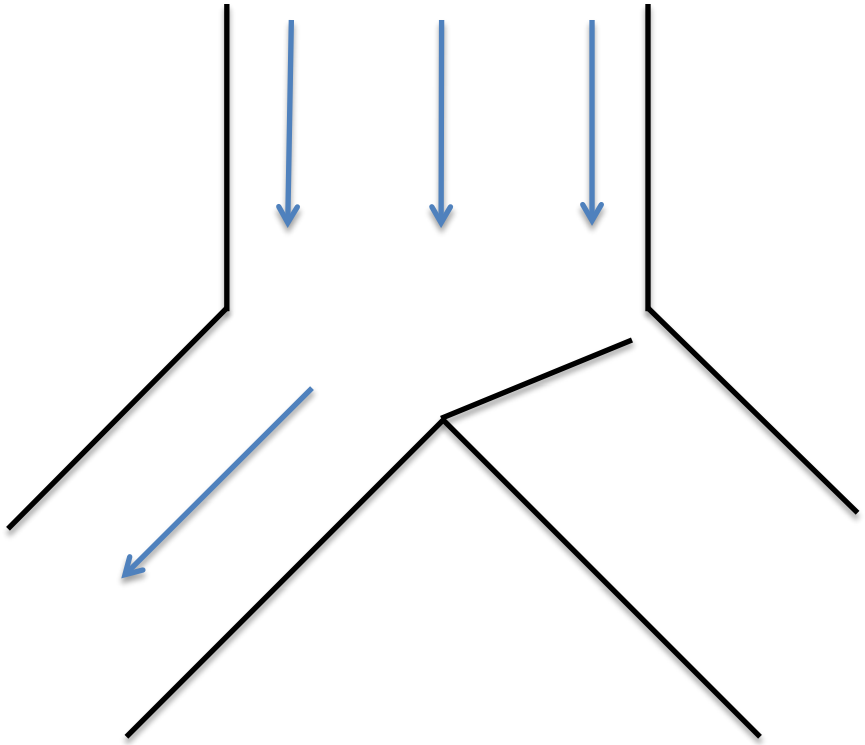
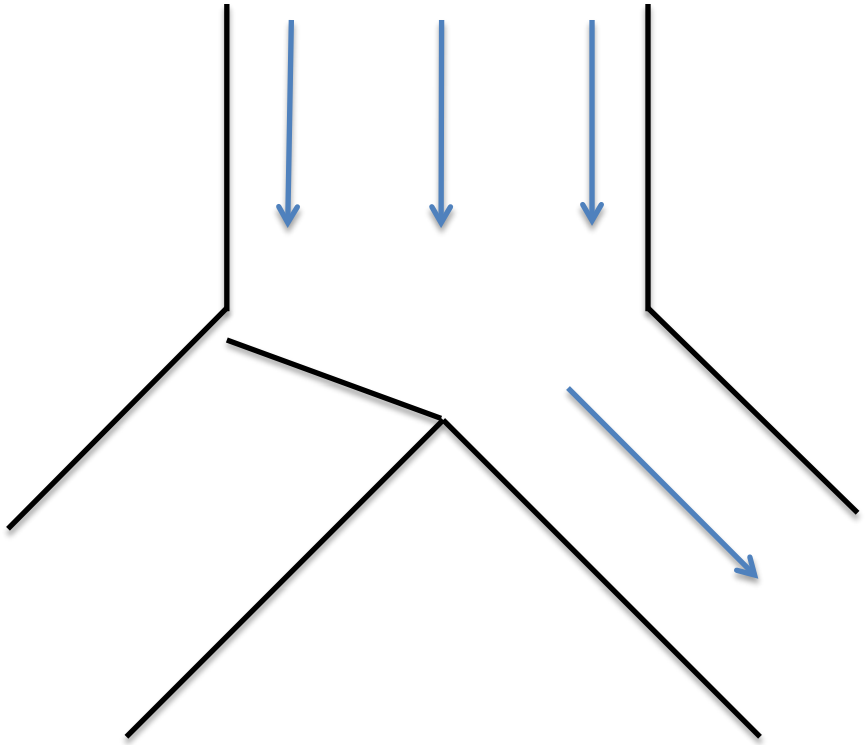
Routing



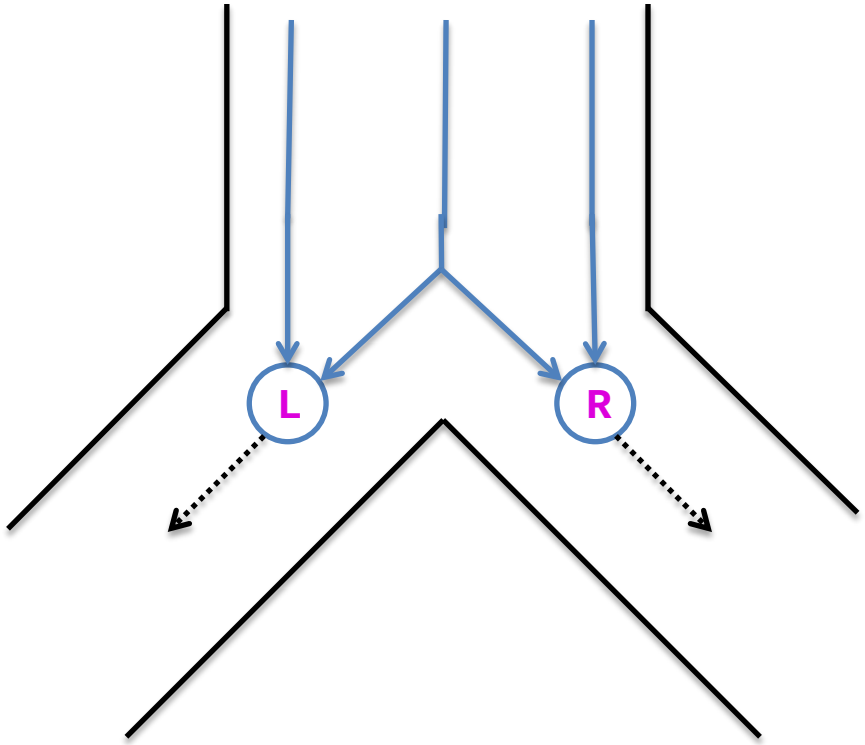
Routing



Routing

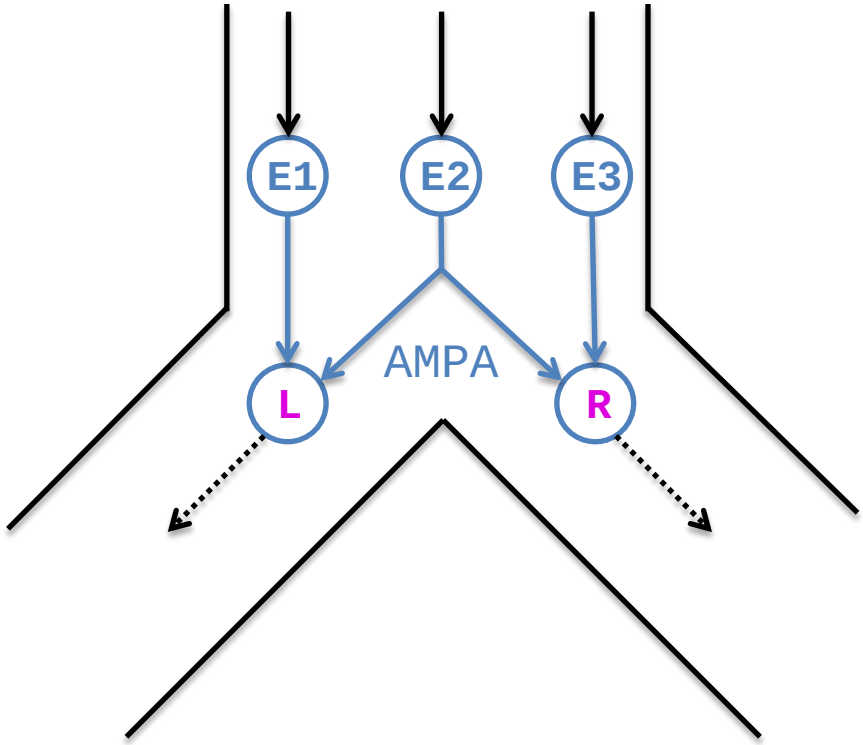
cell types

L,R: (Na,K,L)



Routing

cell types
L,R: (Na,K,L)
E: (multiple models)



Routing

cell types
L,R: (Na,K,L)
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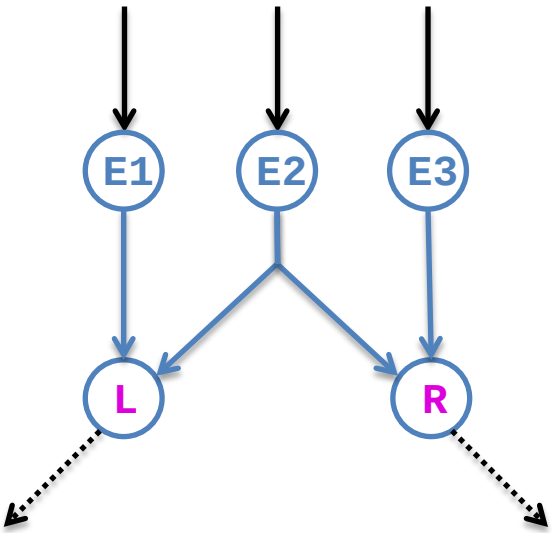
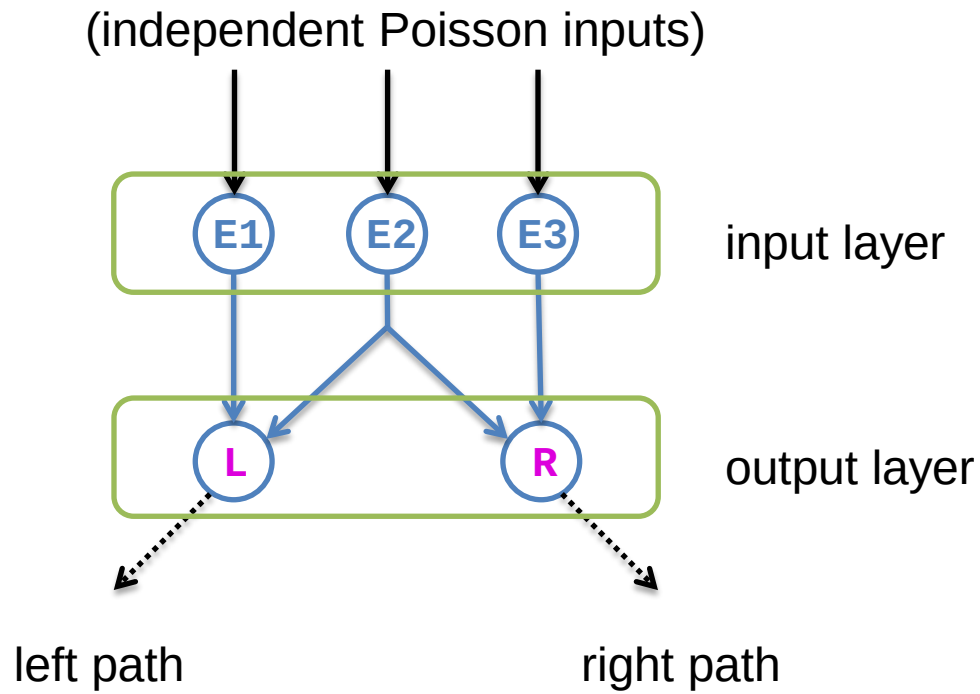


Neural routing model

cell types
L,R: (Na,K,L)
E: (multiple models)

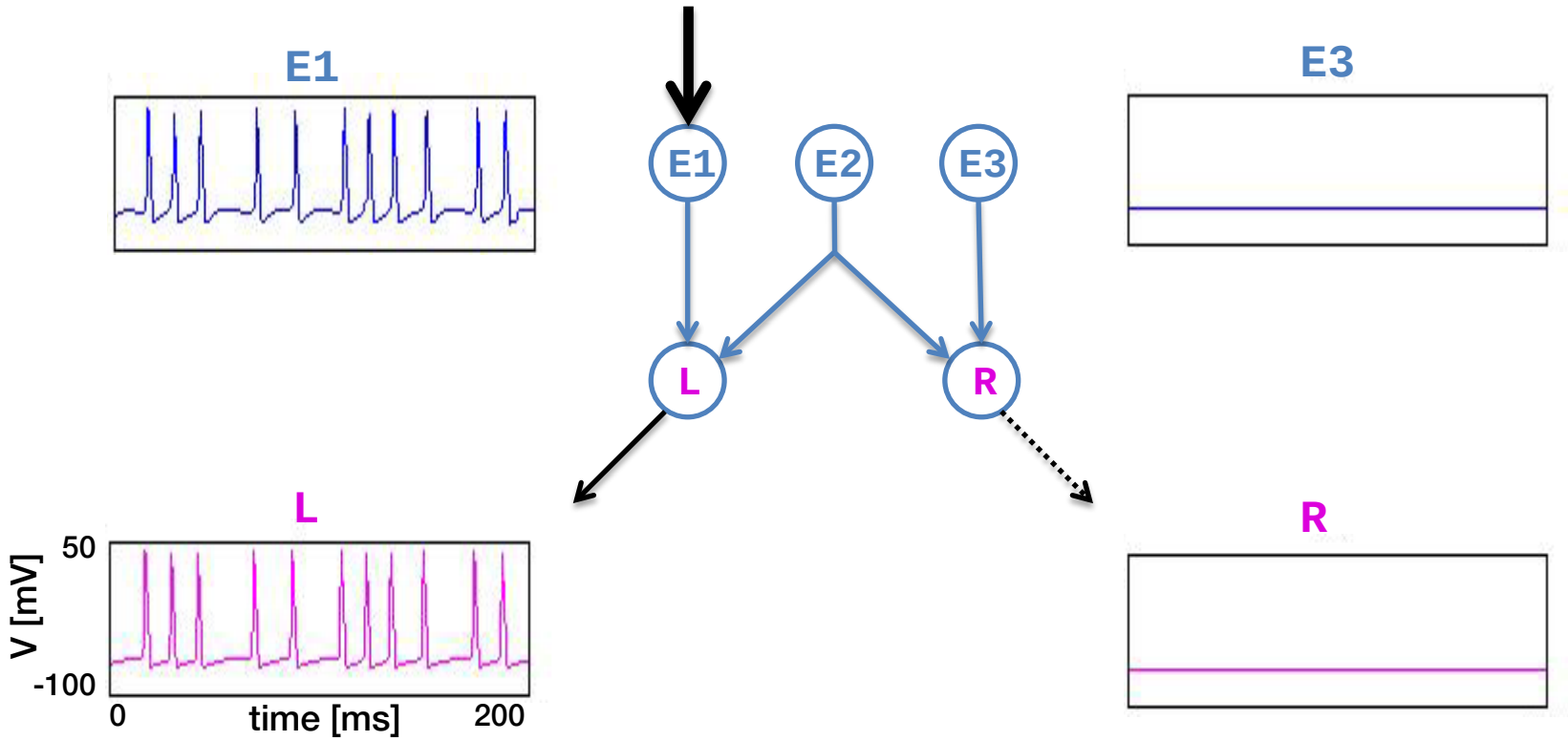


$$c_m \frac{dV}{dt} = -\sum I_{\text{memb}} - \sum I_{\text{syn}} + I_{\text{app}}.$$

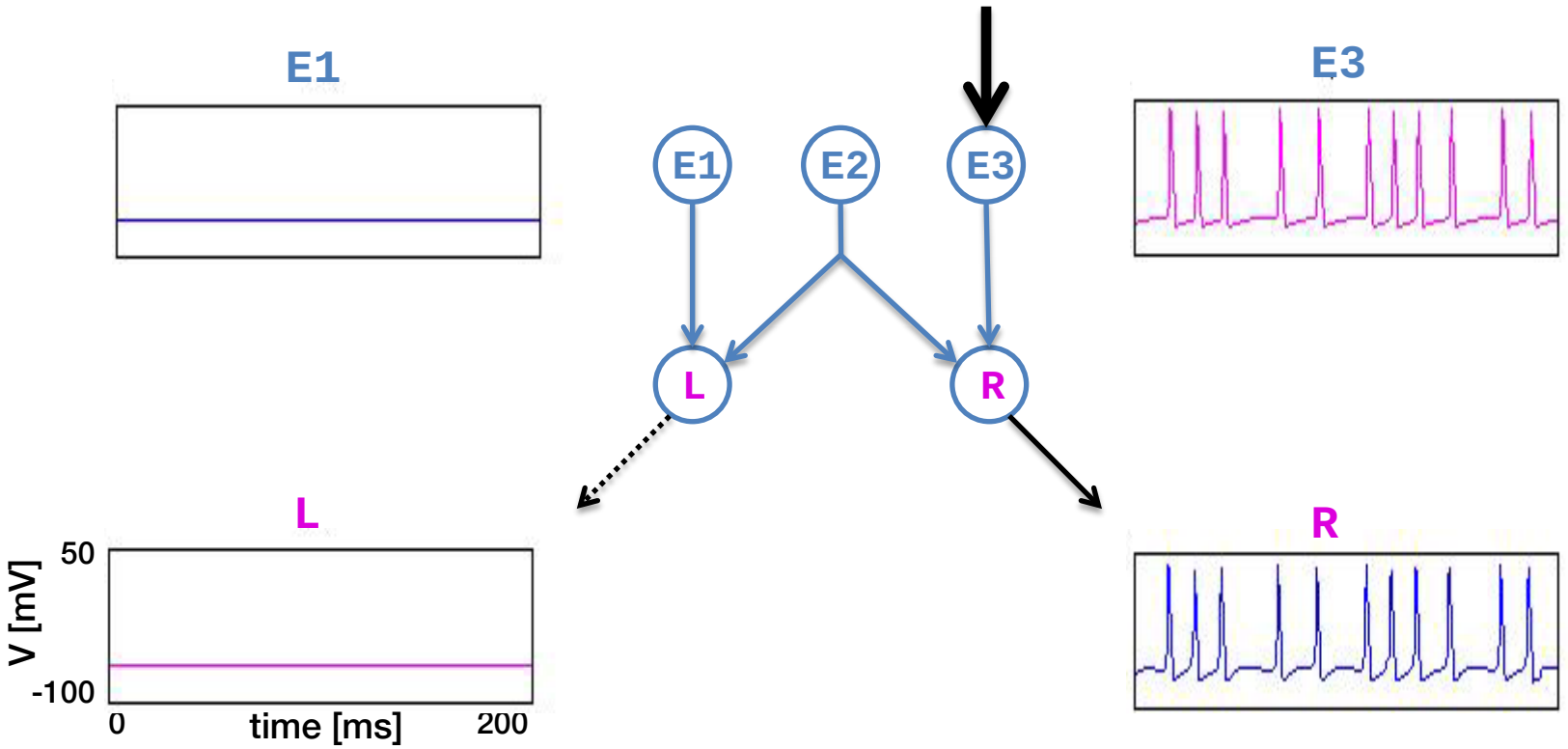
$$I = \bar{g} m^n h^k (V - E_{\text{ion}}).$$

$$\frac{dm}{dt} = \frac{m_\infty - m}{\tau_m}.$$

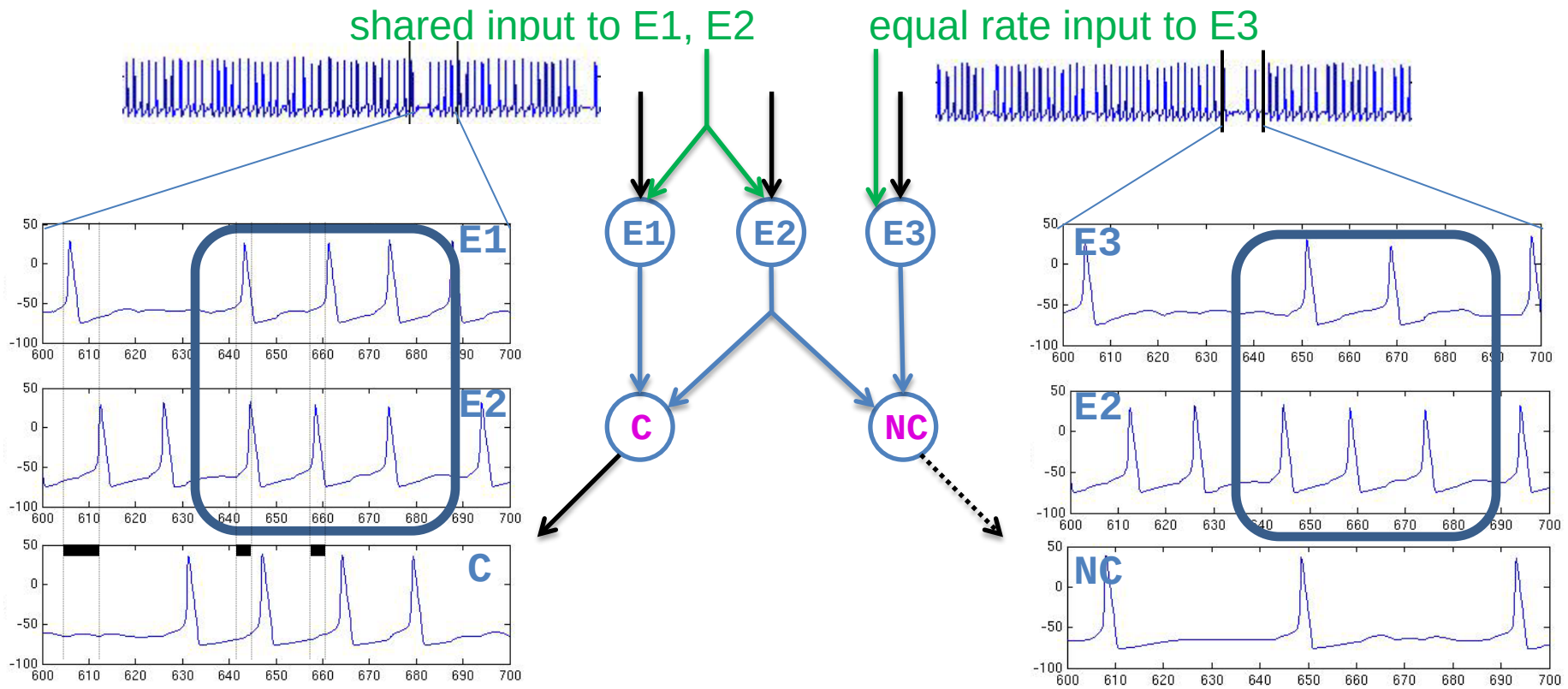
More active cells drive more output



More active cells drive more output



Shared input increases spike coherence



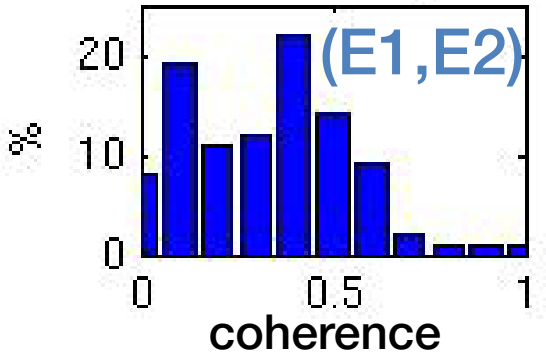
measure spike coherence:

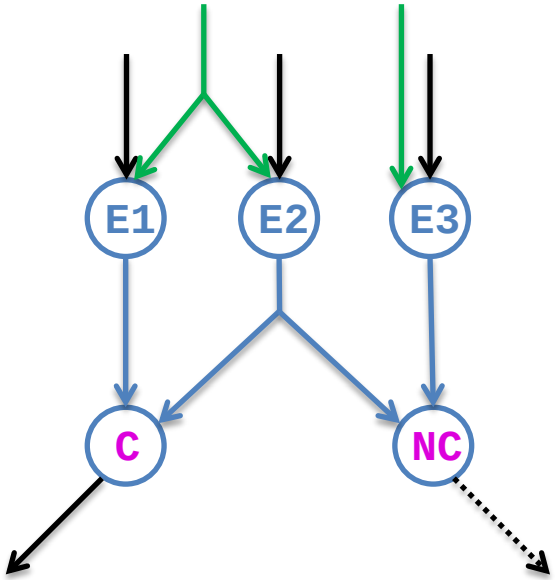
$c_{12} = 1$

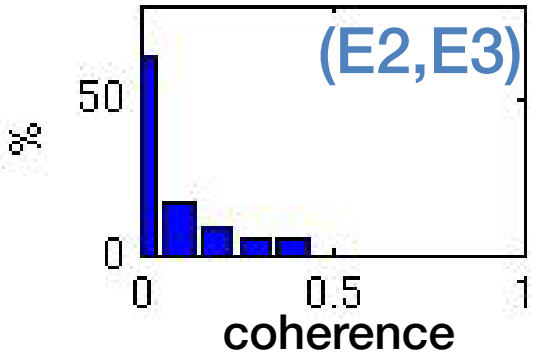
$c_{23} = 0$

Spike coherence facilitates routing

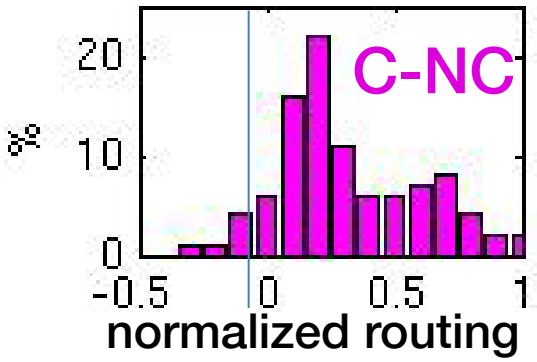
(varied strength and rate of shared input)







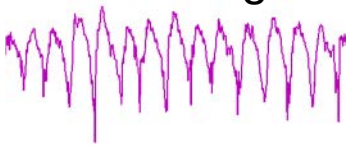
output C > NC



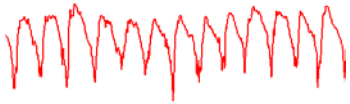
Prefrontal cortex generates rhythms

Carbachol/Kainate

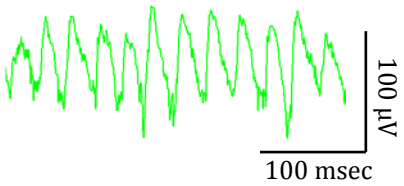
Anterior cingulate

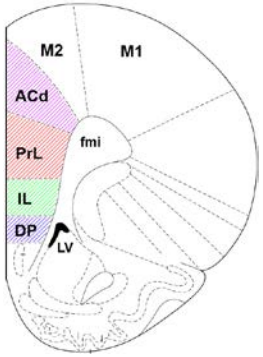


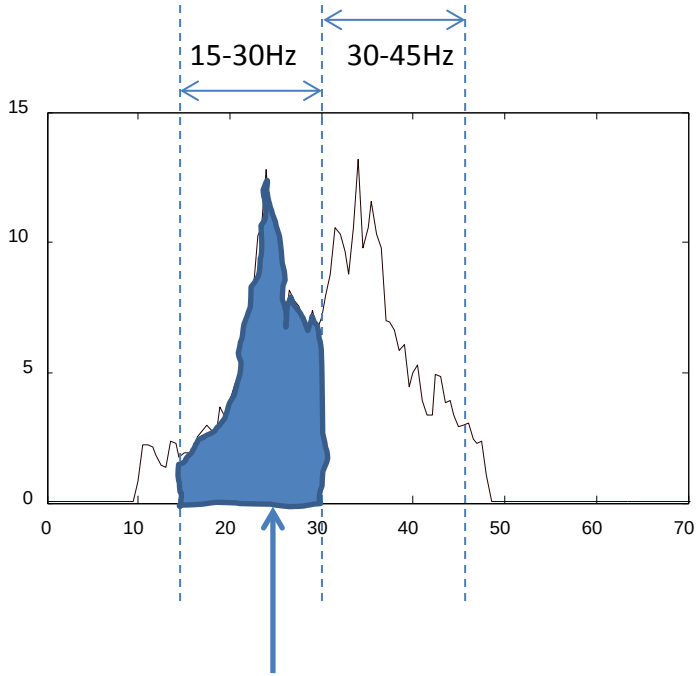
Prelimbic cortex



Infralimbic cortex

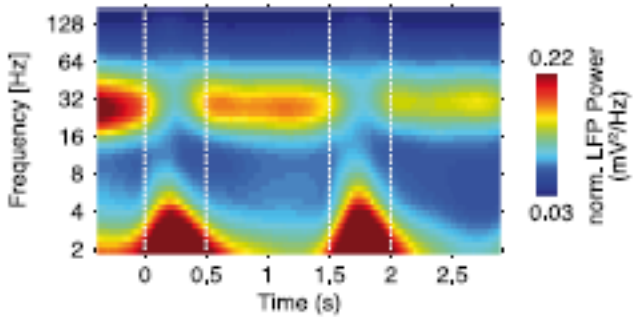




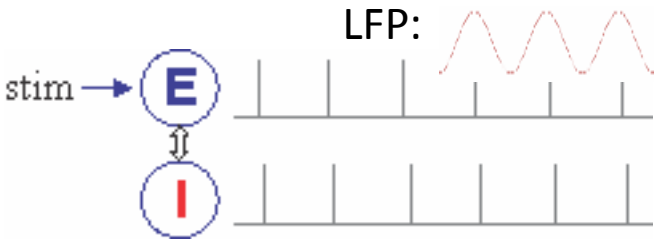


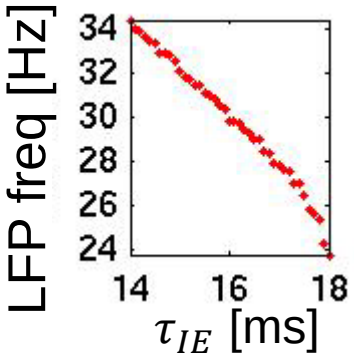
measure rhythm strength:
PA = (area around spectral peak)

WM task (DLPFC)

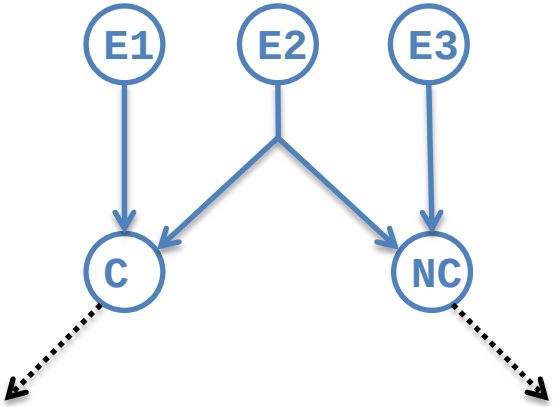


Feedback inhibition supports rhythms

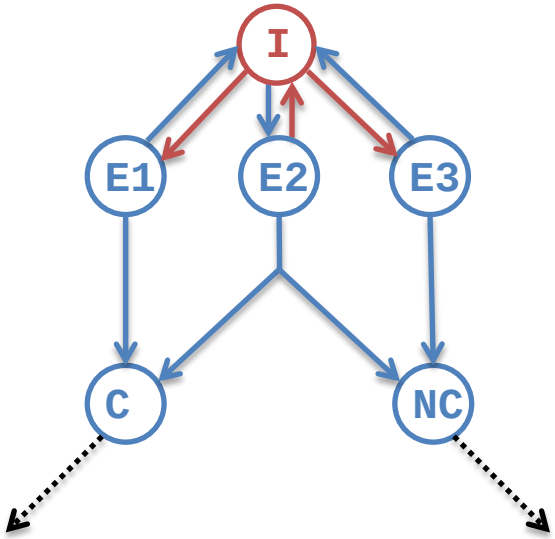




Rhythm paced by inhibition time, τ_{IE}



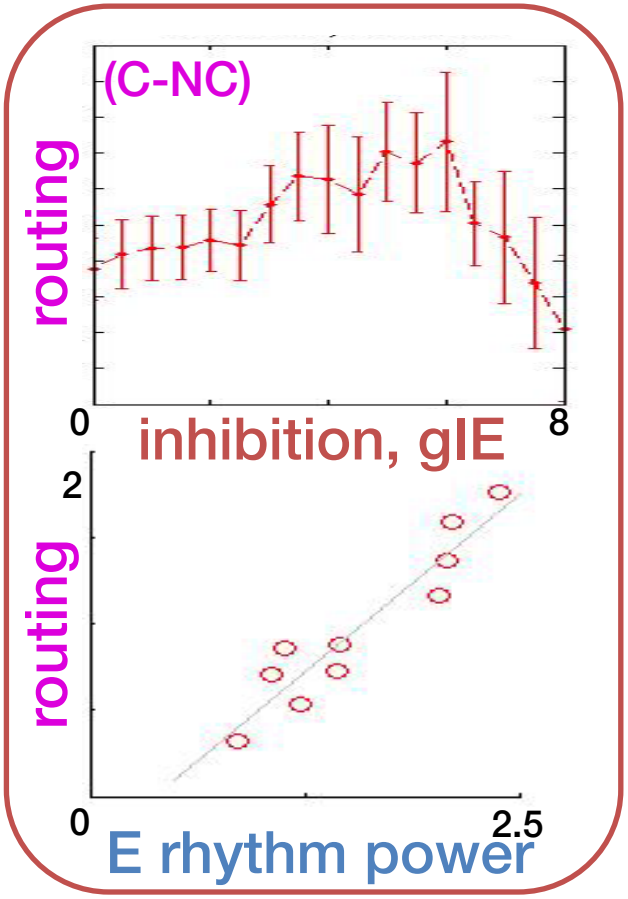
E-cells only



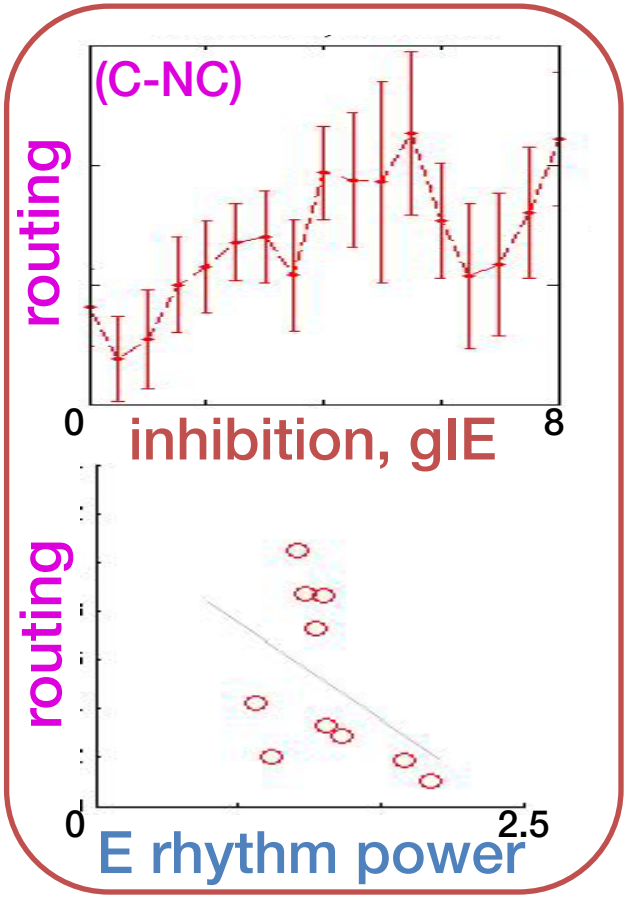
E-I networks

Routing increases with rhythm power

$f_{LFP} = 25Hz$

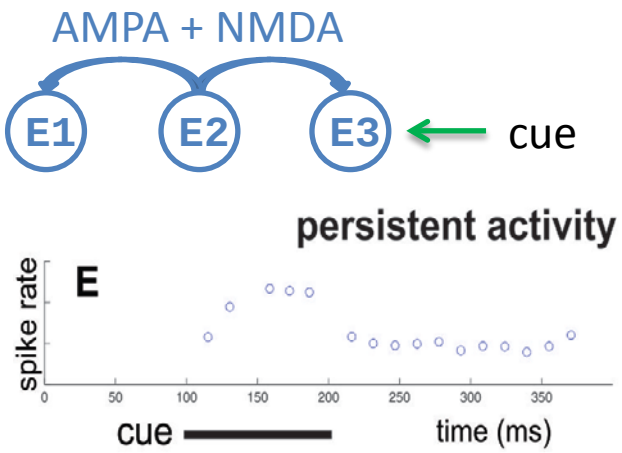


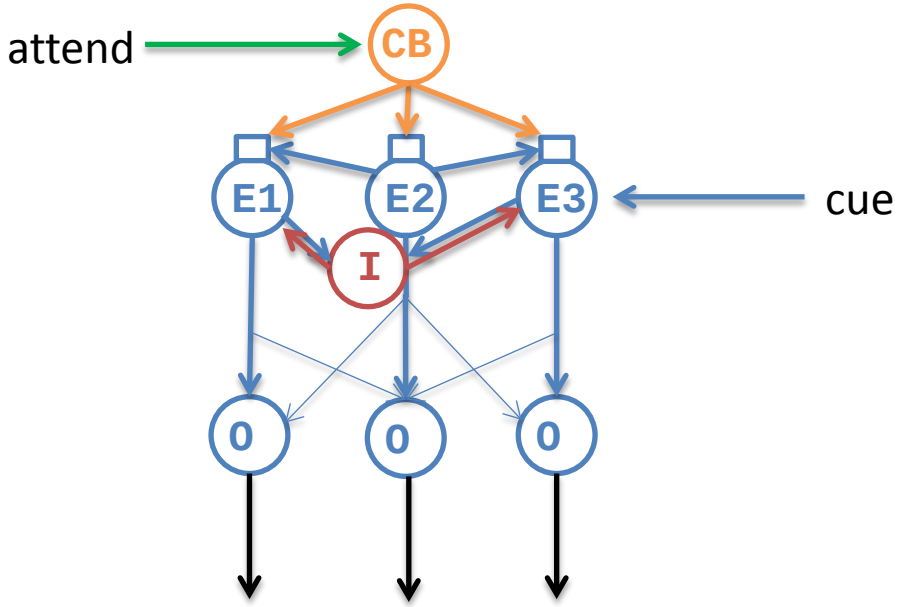
$f_{LFP} = 35Hz$



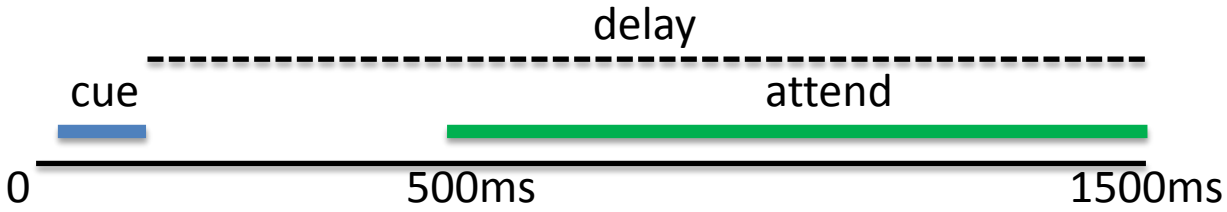
- **non-monotonic relation between routing and inhibition**
- **linear increase in routing with rhythm power**
- **breaks down for shorter time constants (faster rhythms)**

Application to read-out of working memory (in progress)

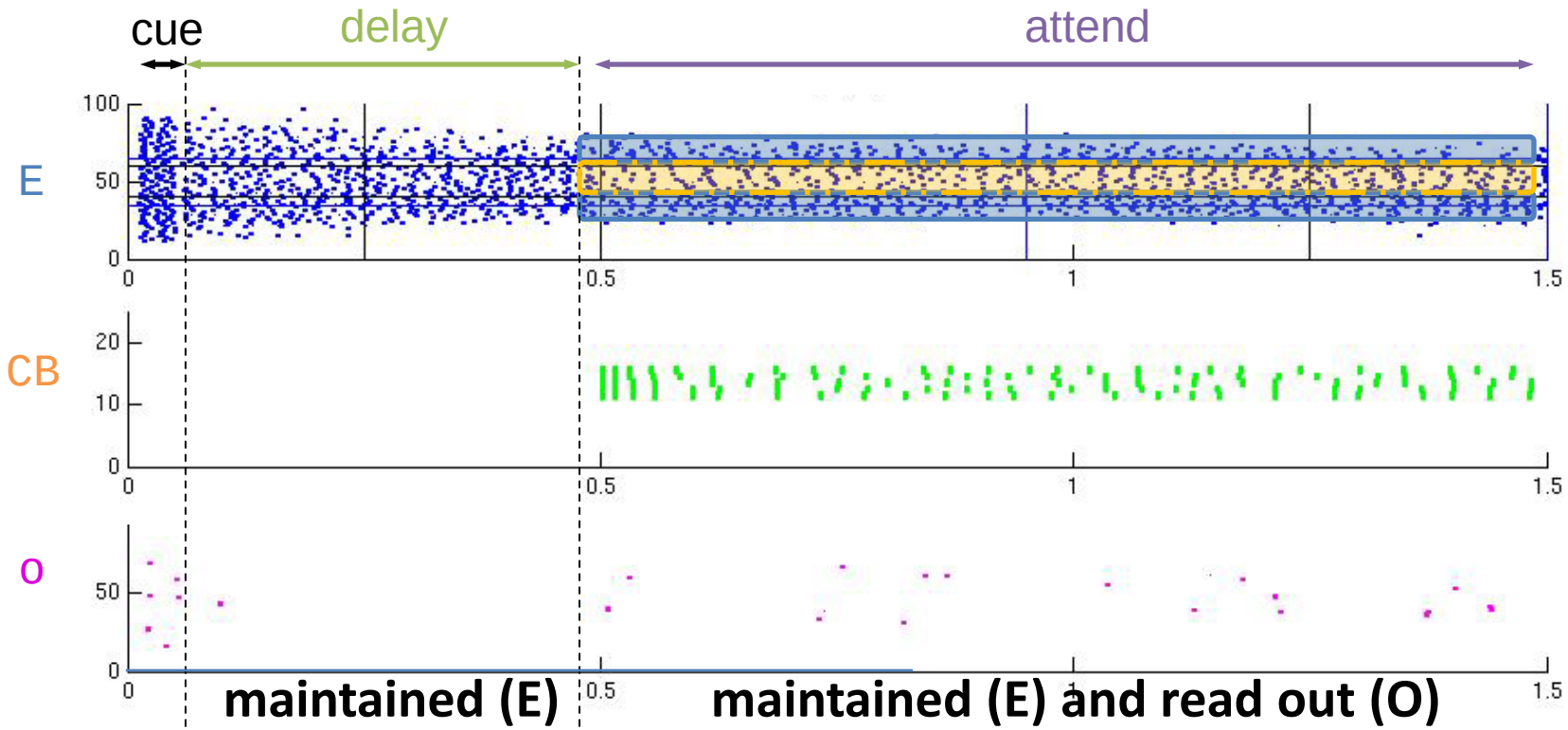




Working memory task

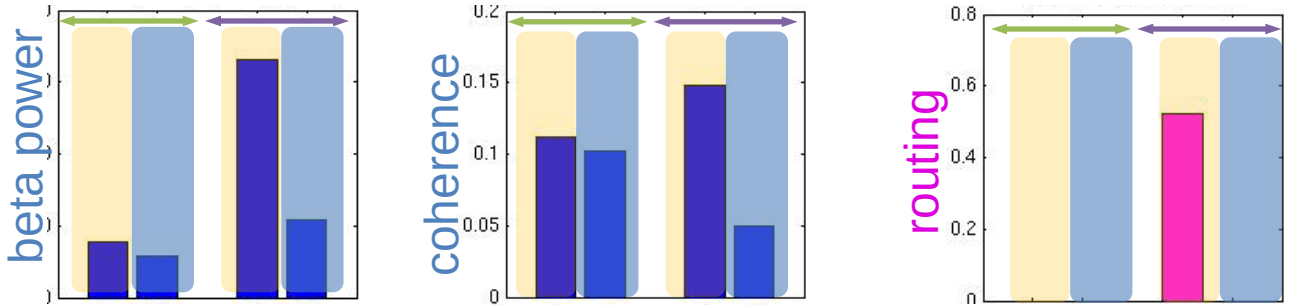


Rhythm allows selective WM read-out

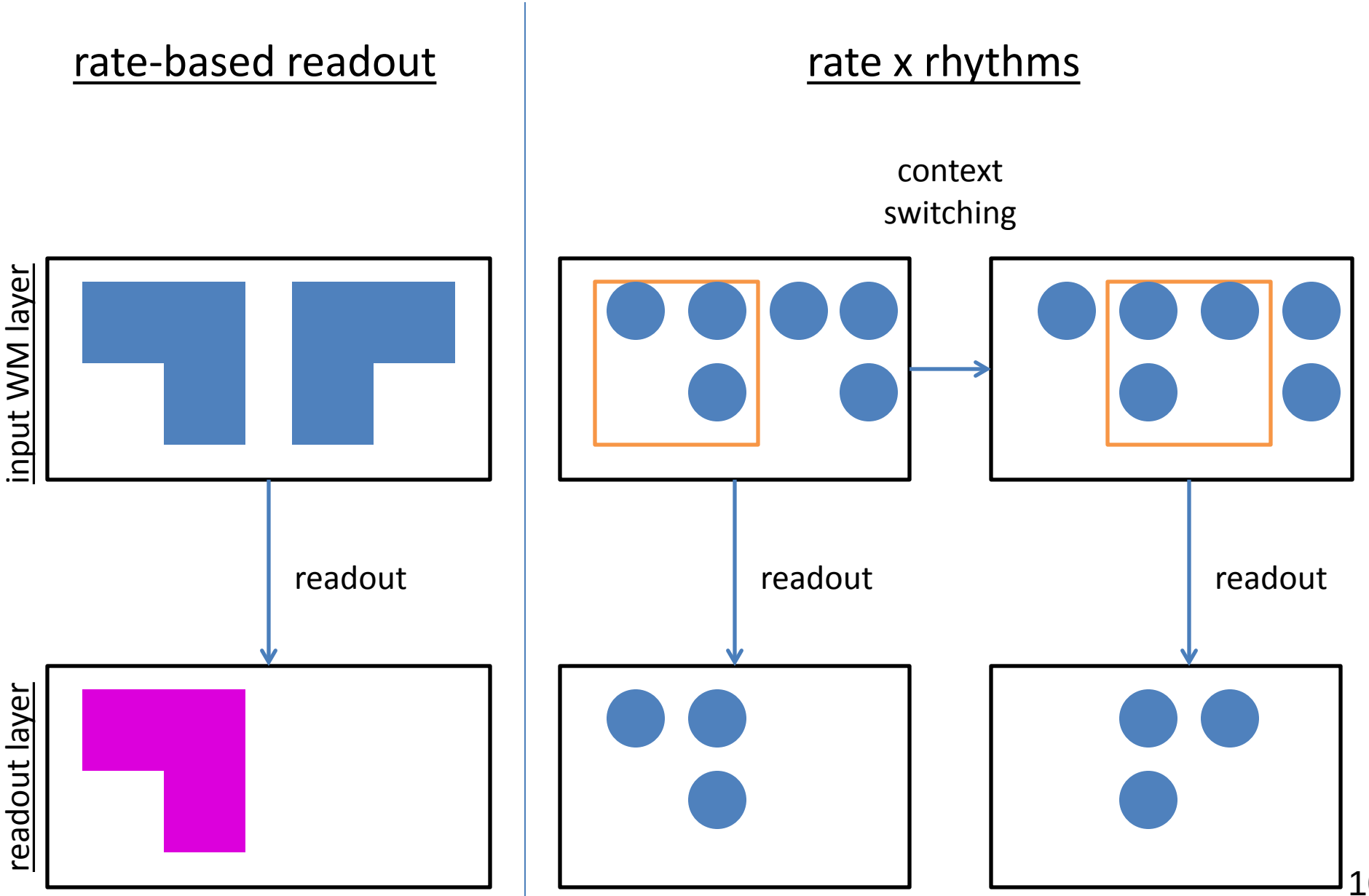


E-cell assemblies

output assemblies



Implications for working memory



Conclusions

- Beta rhythms enhance routing by increasing spike coherence
- Application to working memory: coherent inputs to selected CB cells determine which persistent assemblies can drive downstream targets

Acknowledgments

- Joint with N Kopell
- Consulting from: H Barbas, M Whittington, F LeBeau, N Adams