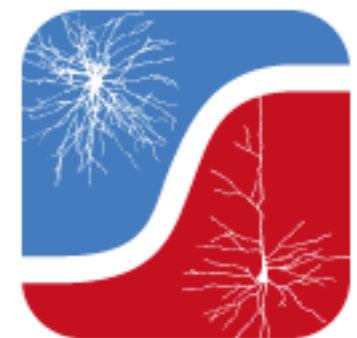


Disentangling **sensory** and **top-down** information during perceptual decision making

Paola Suárez

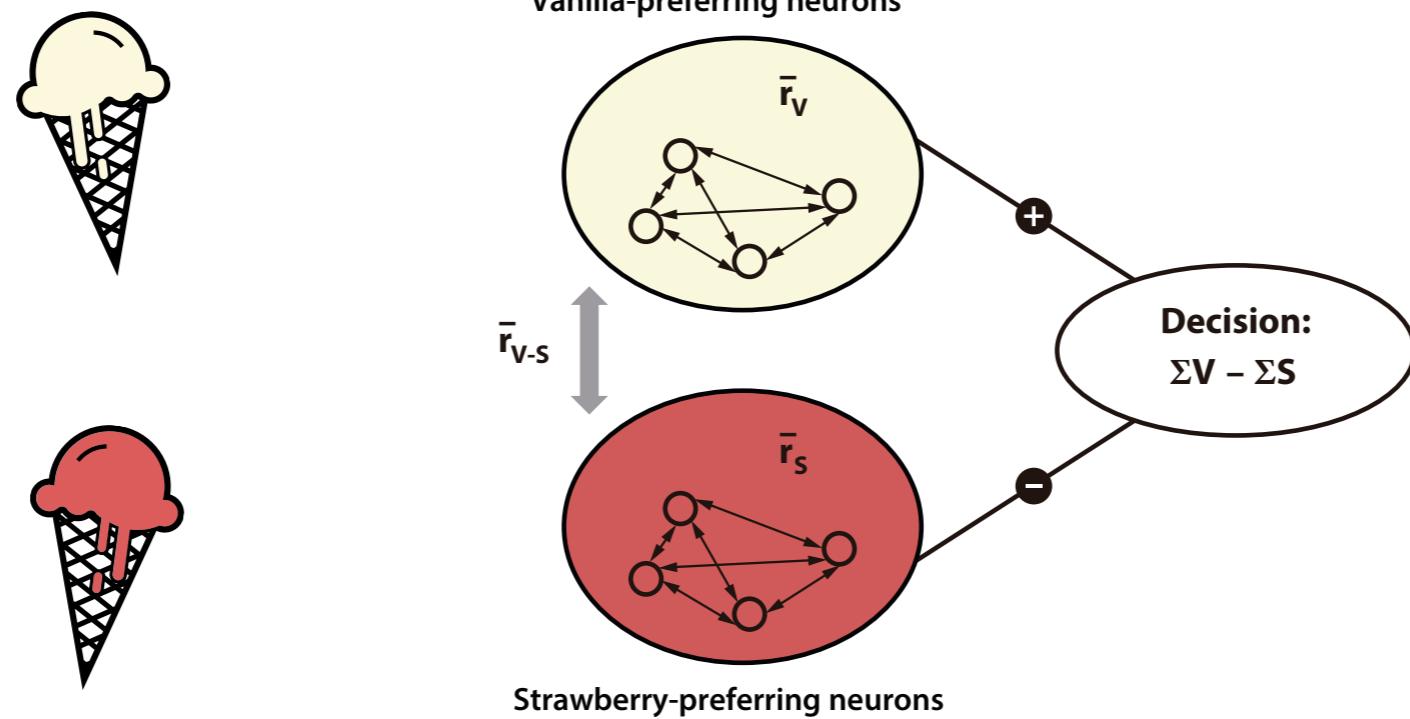


Master defense presentation
16.08.19



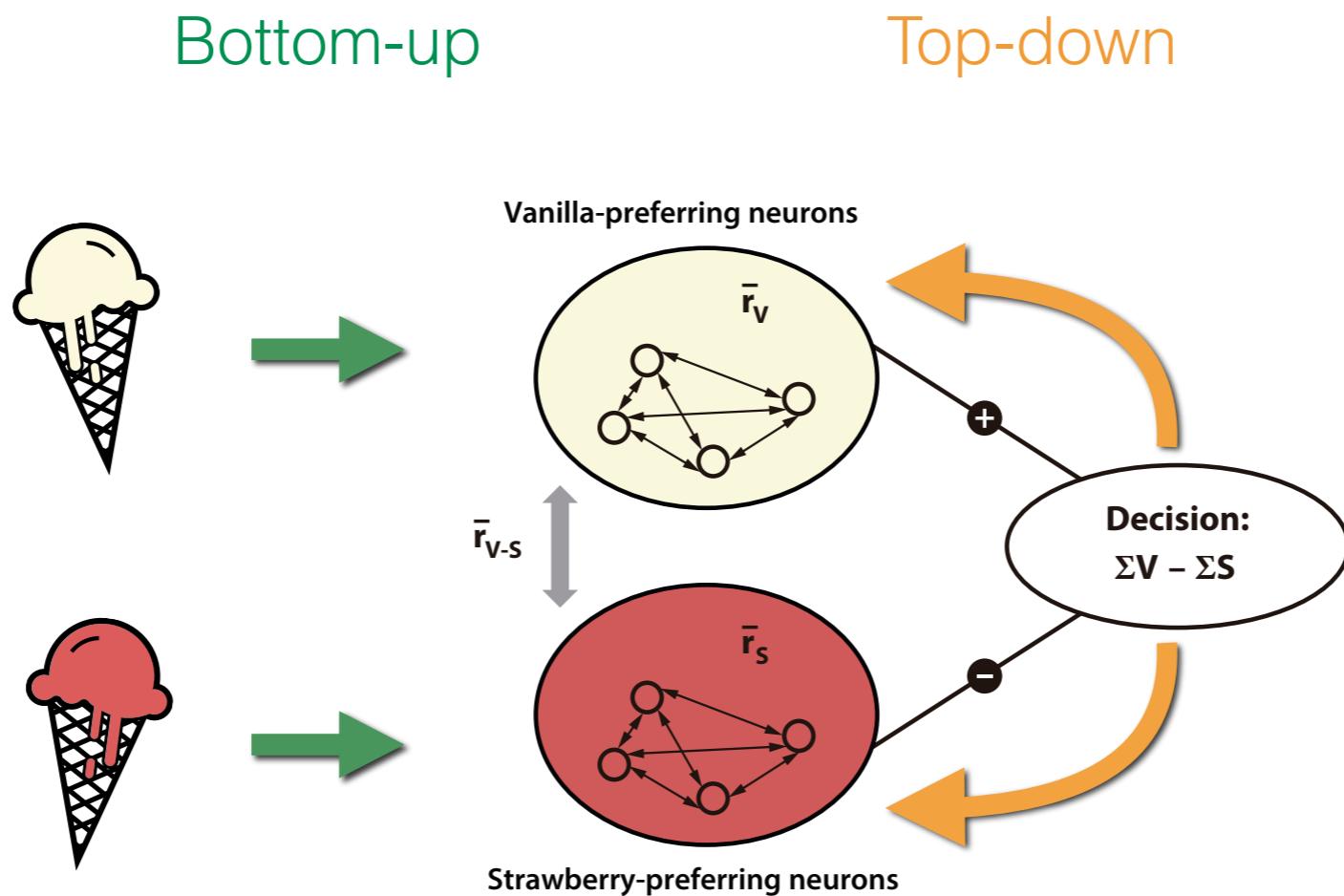


Sensory neuronal activity correlates with decisions



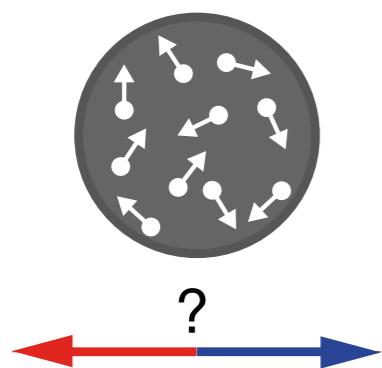
Modified from Nienborg *et al.* 2012, *Annu Rev Neurosci.*

But what is the origin of the relationship?



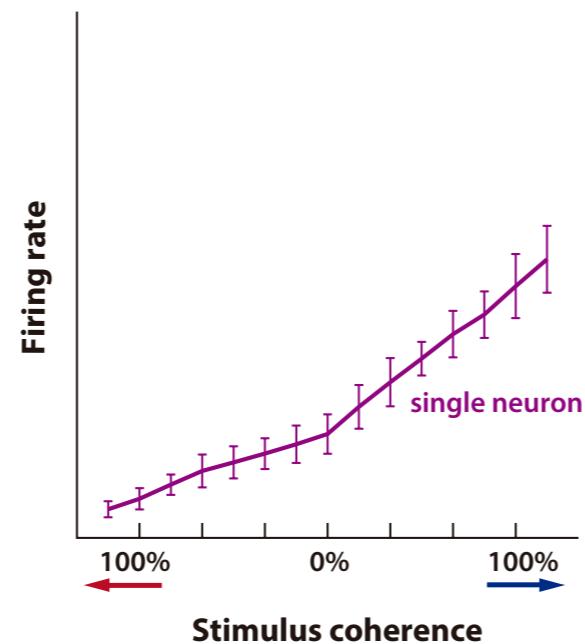
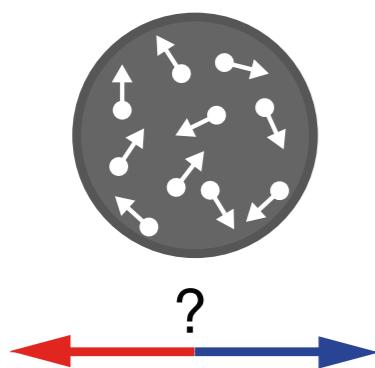
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Perceptual decision making



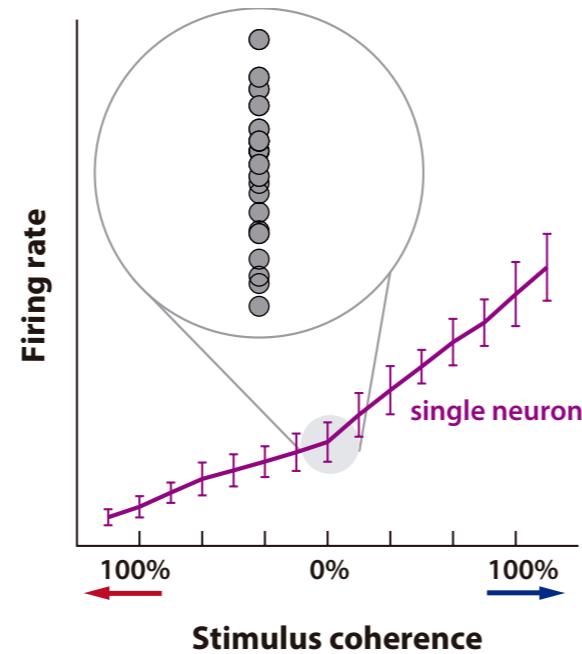
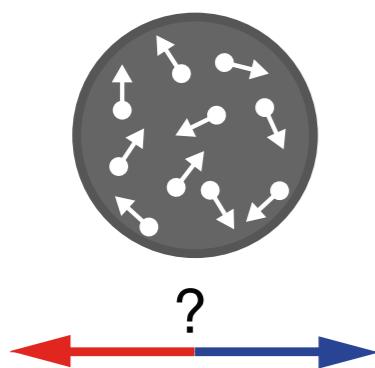
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and Crapse & Basso 2002, *Neuron*

Perceptual decision making



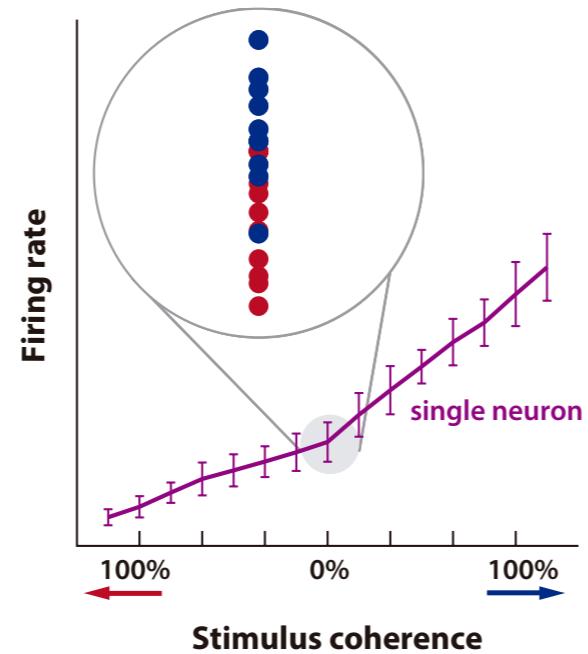
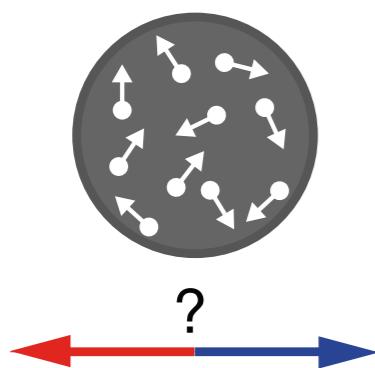
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Perceptual decision making



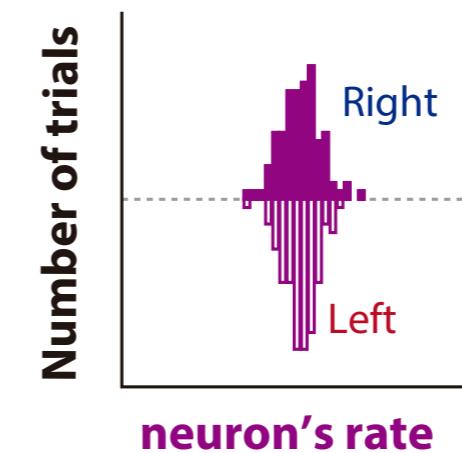
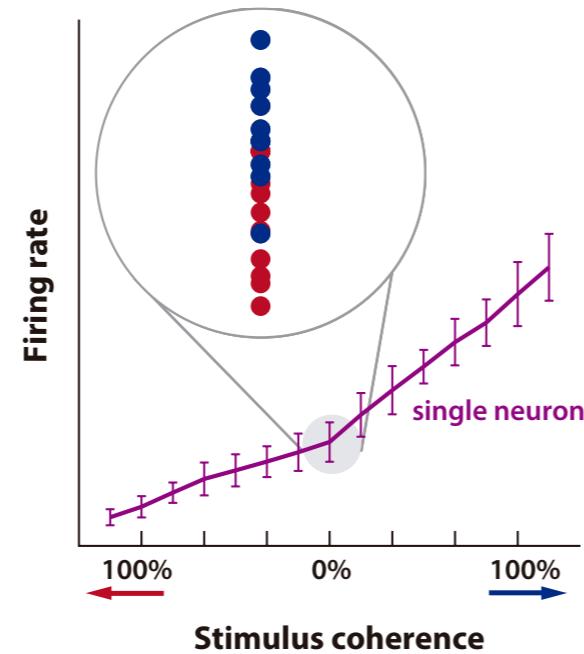
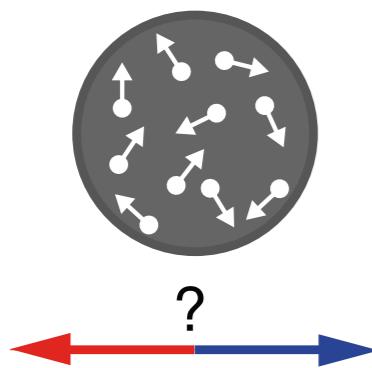
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Perceptual decision making



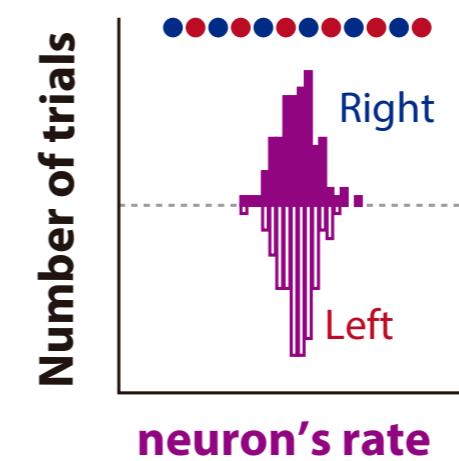
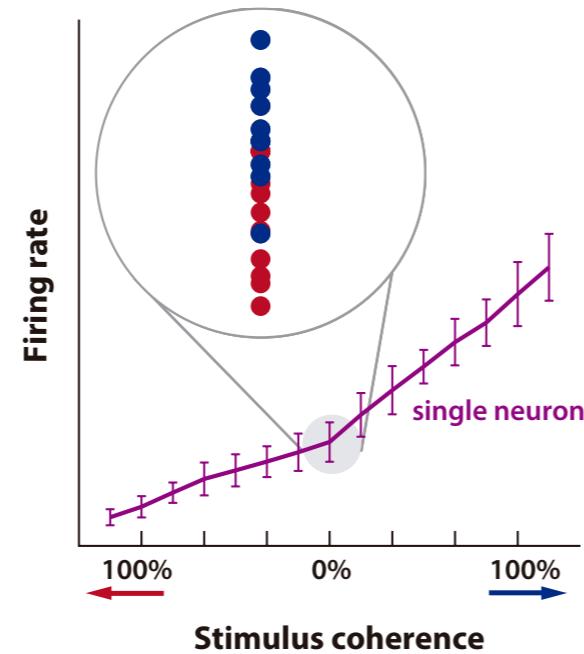
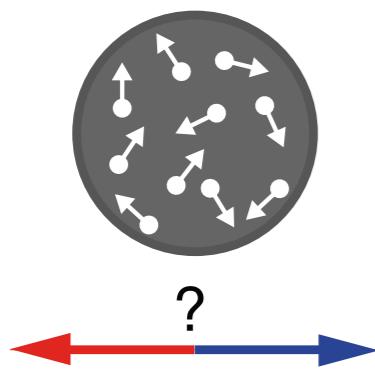
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Perceptual decision making



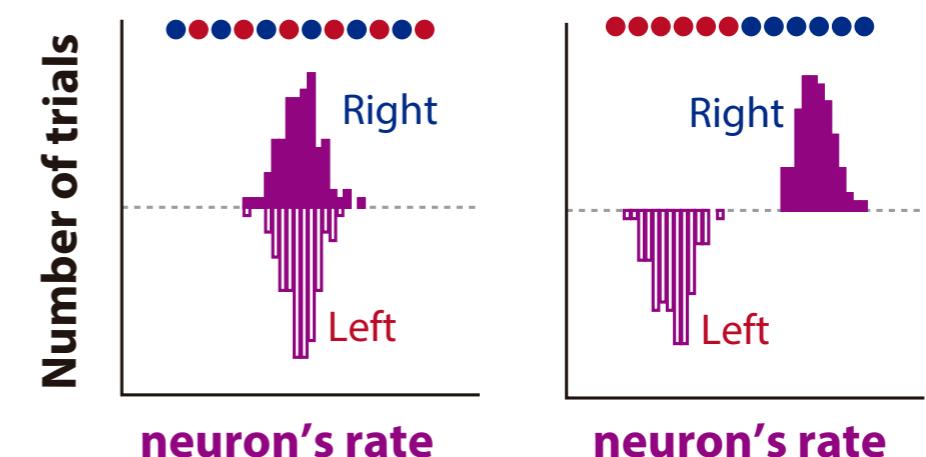
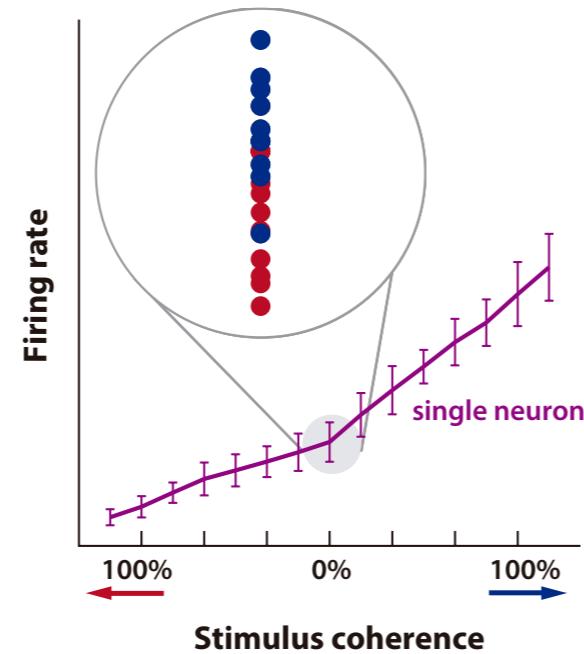
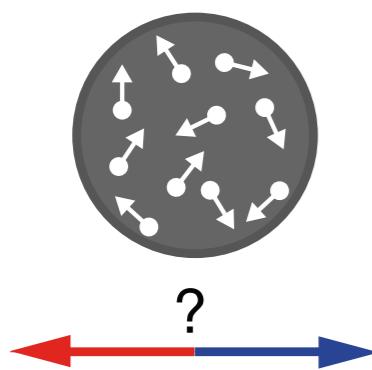
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Perceptual decision making



Modified from Nienborg *et al.* 2012, *Annu Rev Neurosci.*
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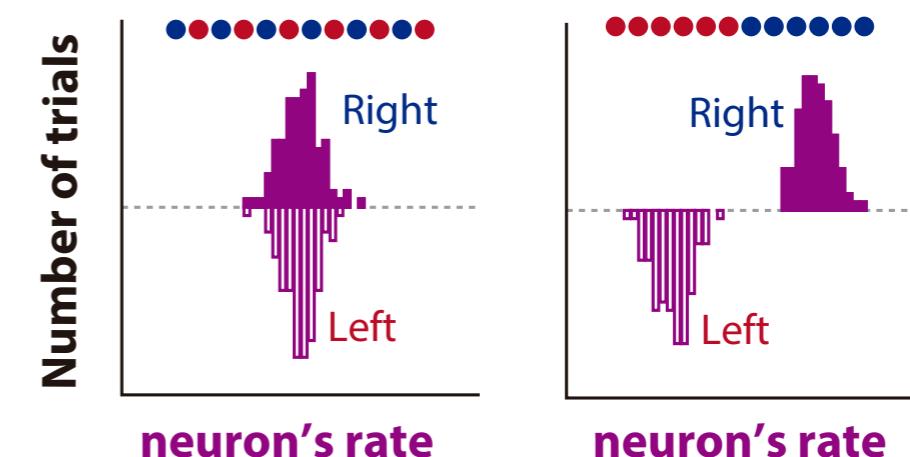
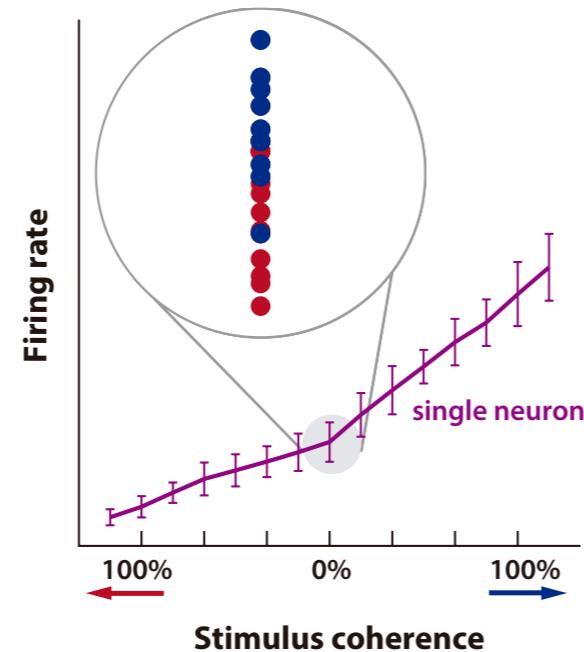
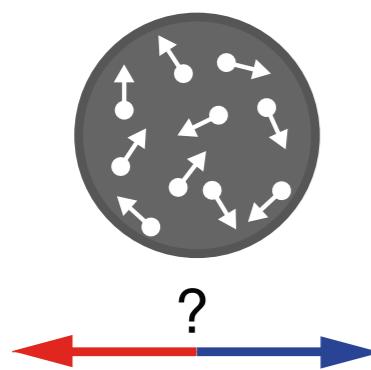
Perceptual decision making



Modified from Nienborg *et al.* 2012, *Annu Rev Neurosci.*
and Crapse & Basso 2002, *Neuron*

Choice probability measures how well neuronal activity predicts choices

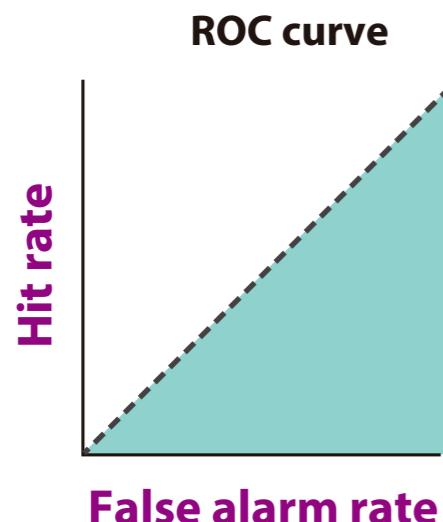
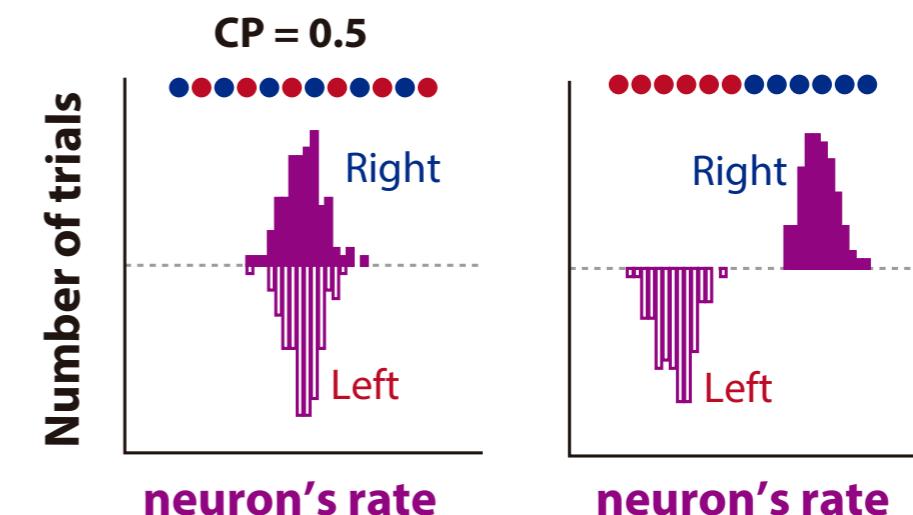
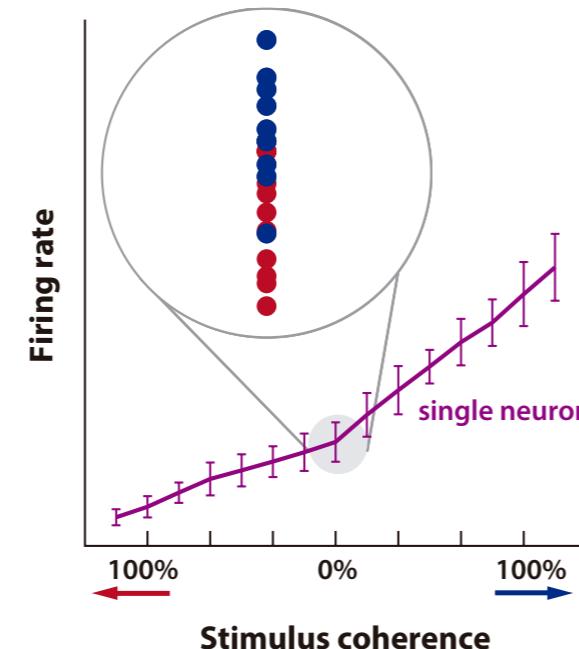
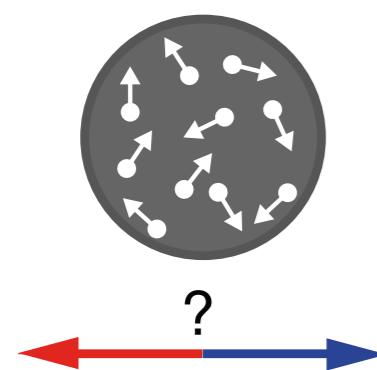
Perceptual decision making



Modified from Nienborg *et al.* 2012, *Annu Rev Neurosci.*
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Choice probability measures how well neuronal activity predicts choices

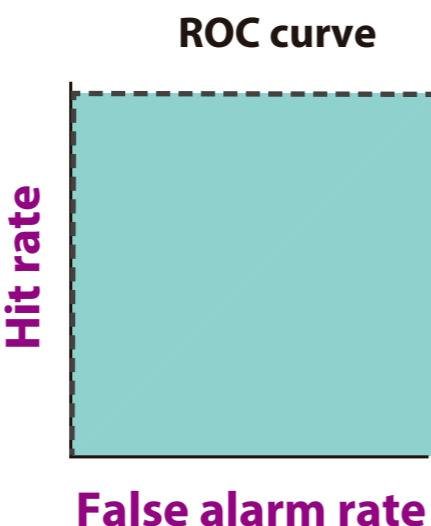
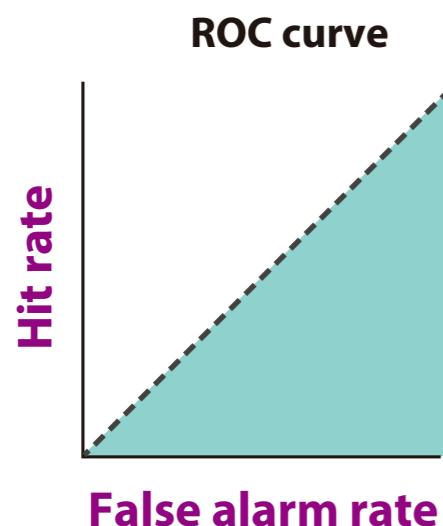
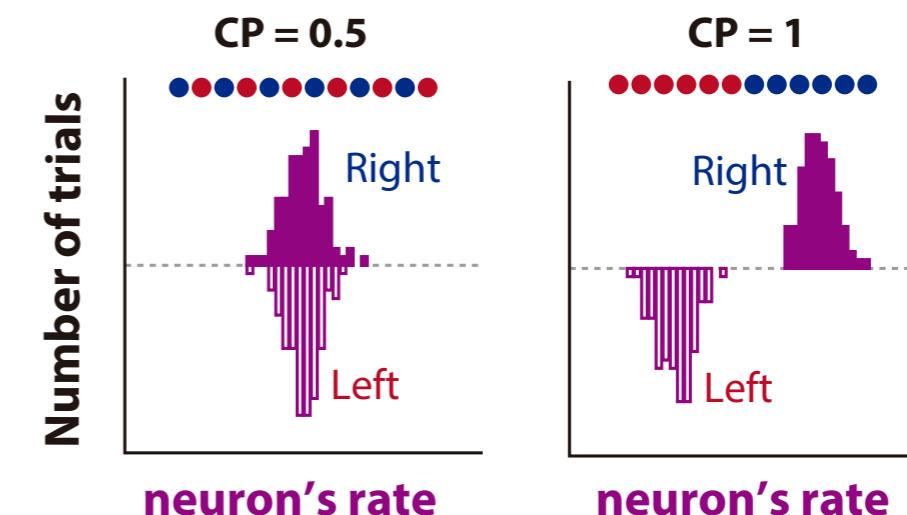
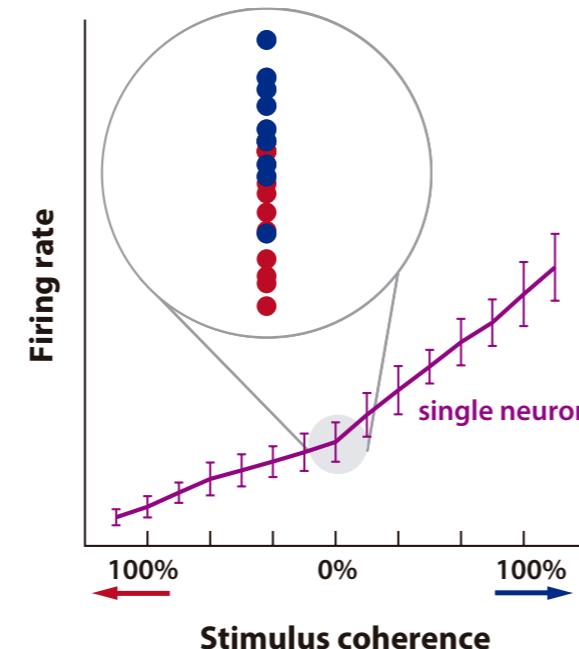
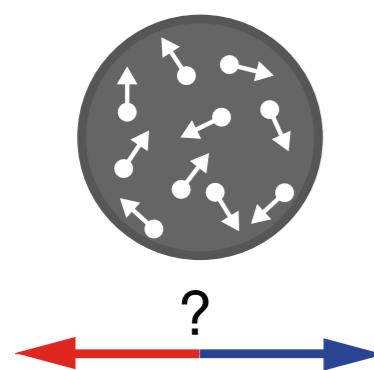
Perceptual decision making



Modified from Nienborg *et al.* 2012, *Annu Rev Neurosci.*
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Choice probability measures how well neuronal activity predicts choices

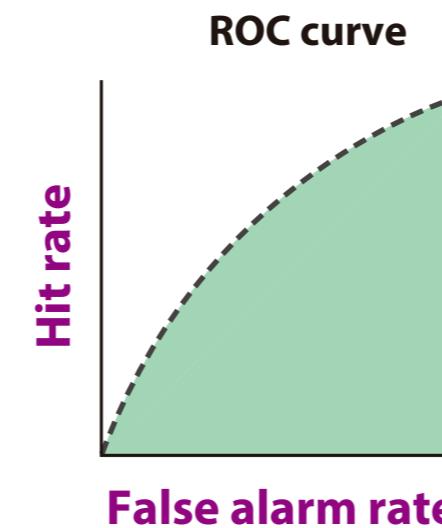
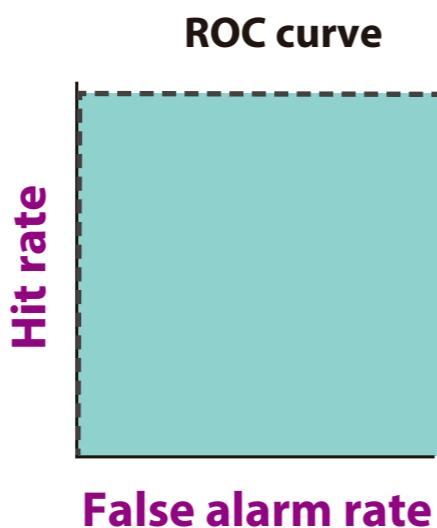
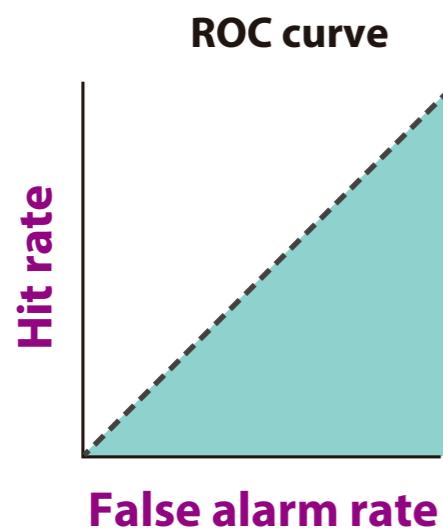
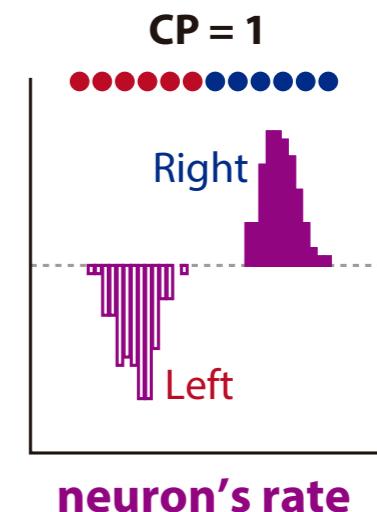
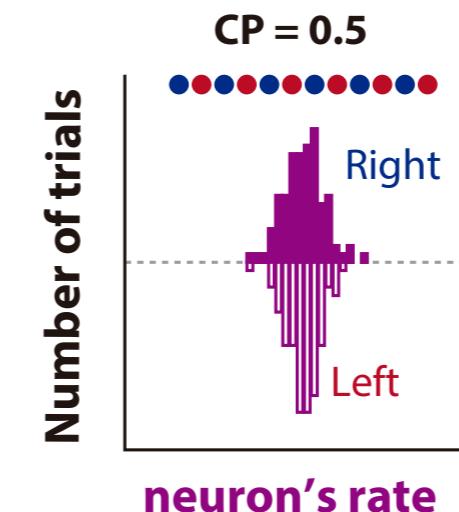
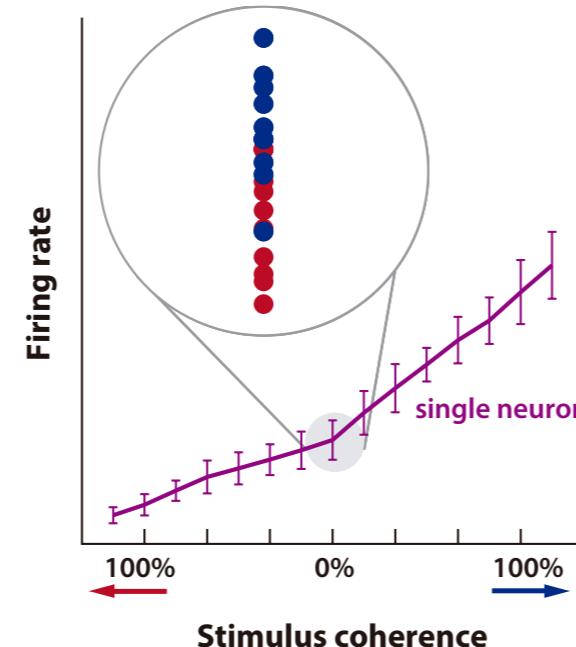
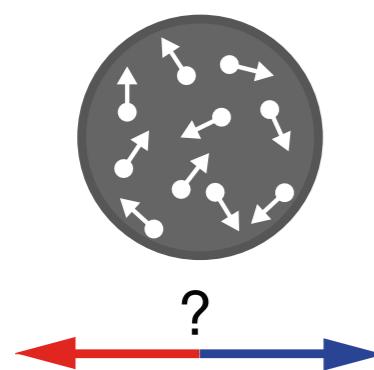
Perceptual decision making



Modified from Nienborg *et al.* 2012, *Annu Rev Neurosci.*
and Crapse & Basso 2002, *Neuron*

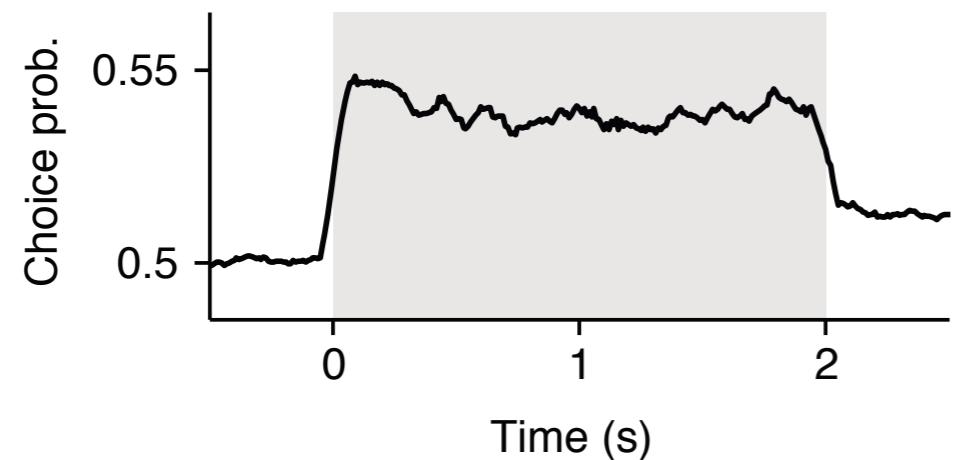
Choice probability measures how well neuronal activity predicts choices

Perceptual decision making

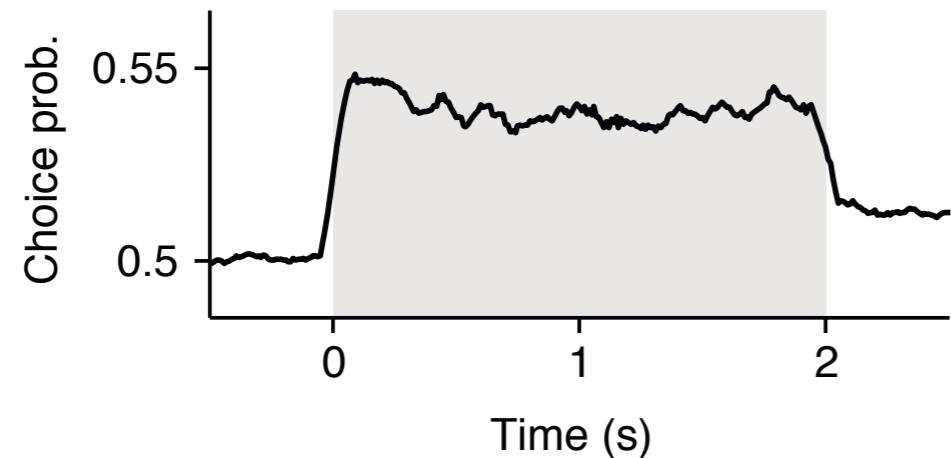


- Sensory neurons show sustained CP ~ 0.55

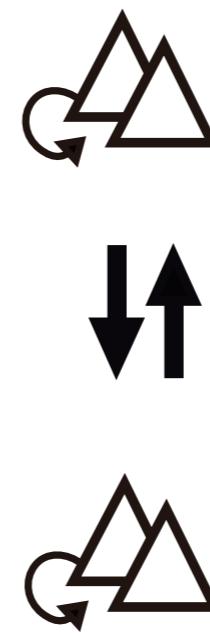
Neuronal correlates with choices



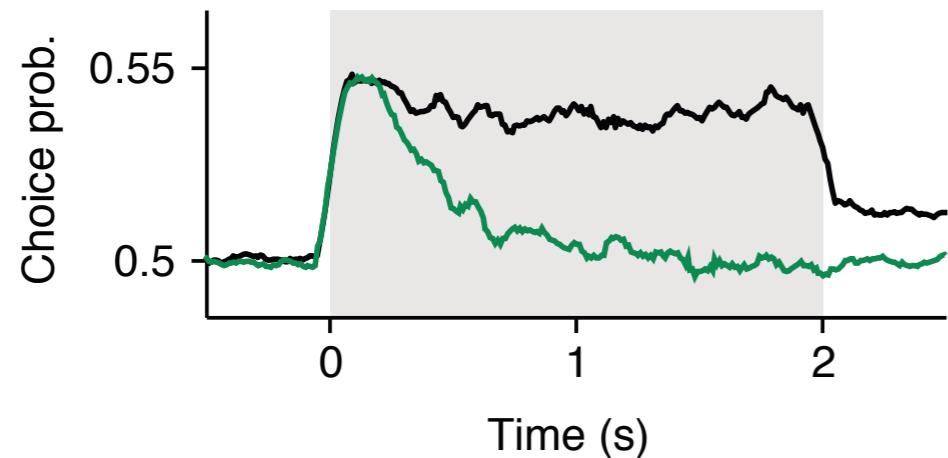
Neuronal correlates with choices



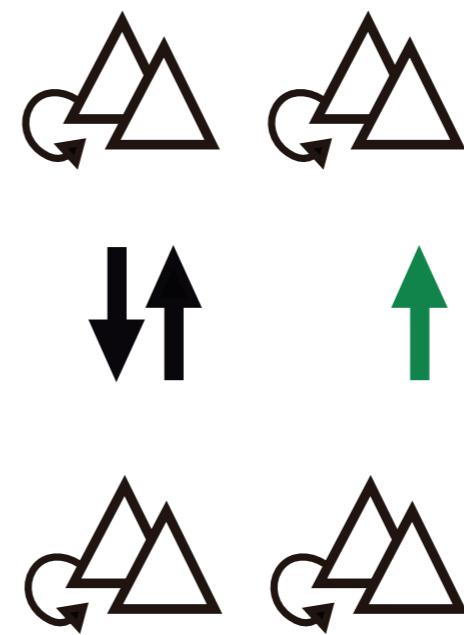
Hierarchical network



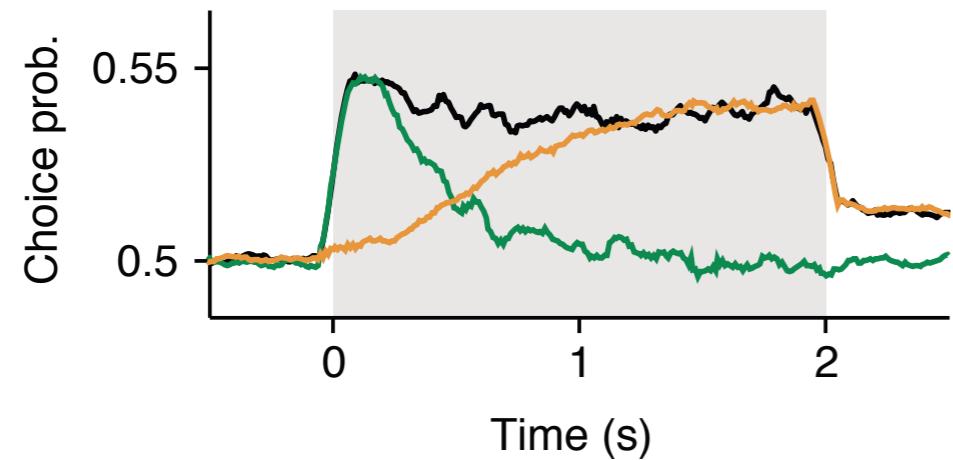
Neuronal correlates with choices



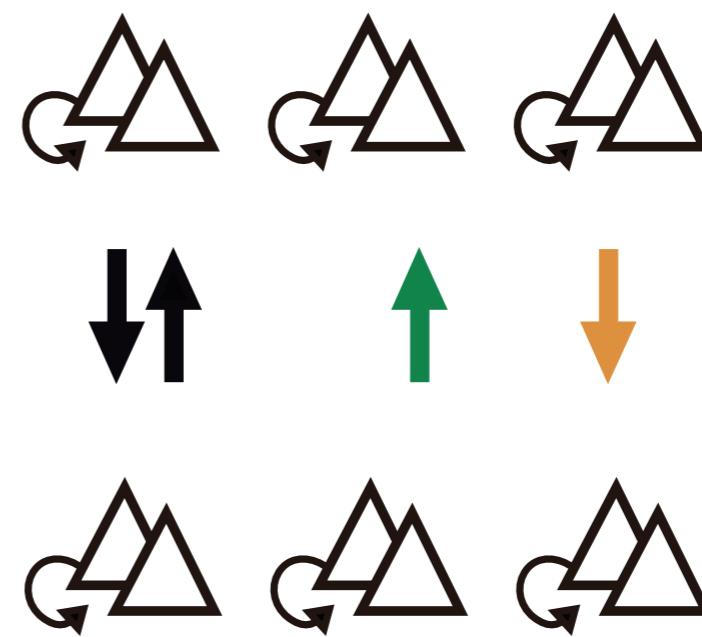
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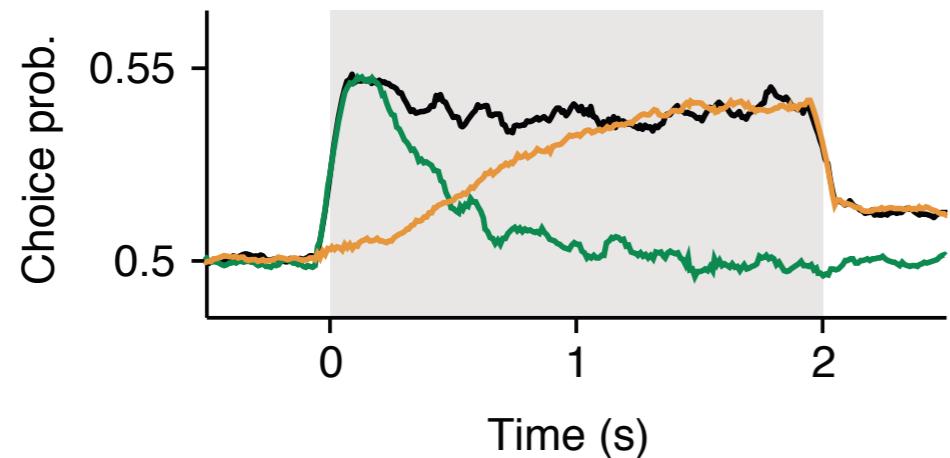
Neuronal correlates with choices



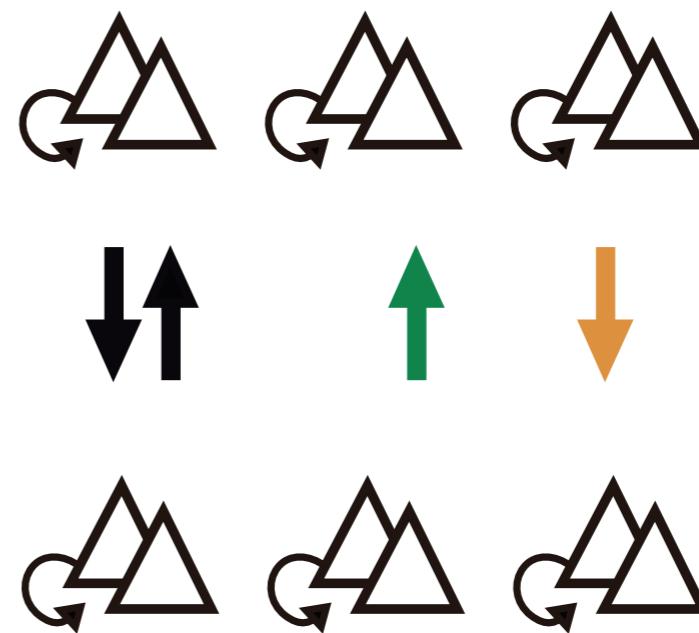
Hierarchical network



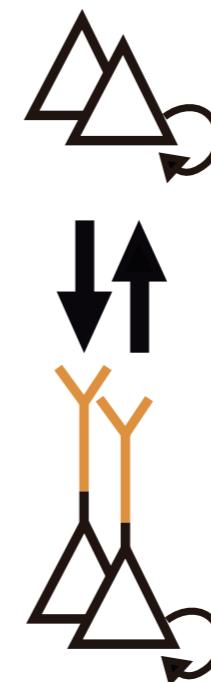
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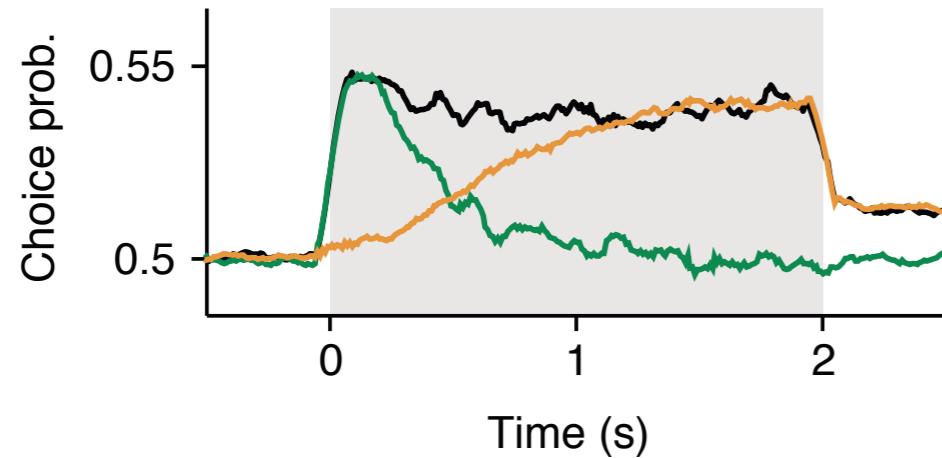
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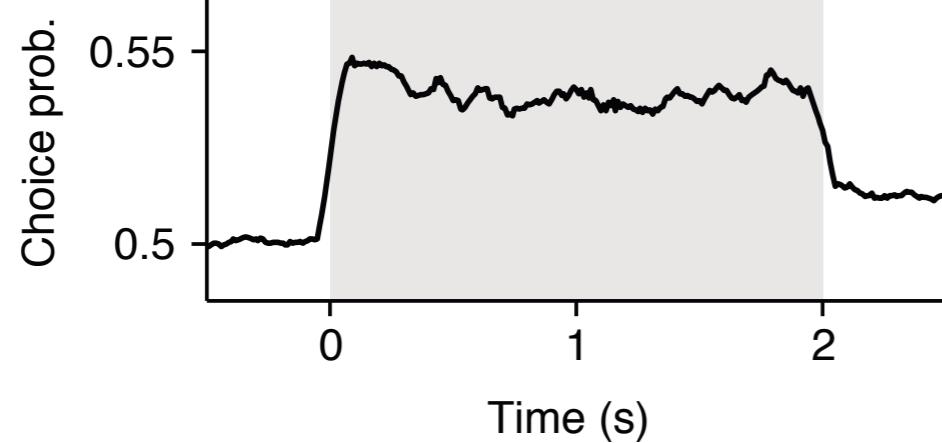
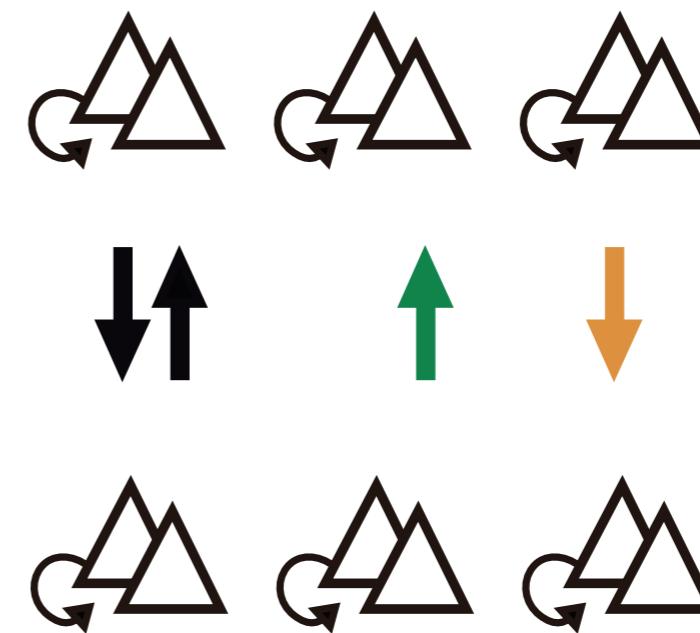
Extended hierarchical network



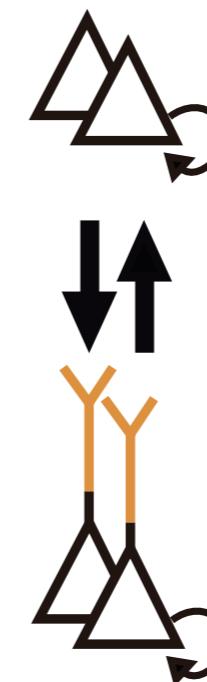
Neuronal correlates with choices



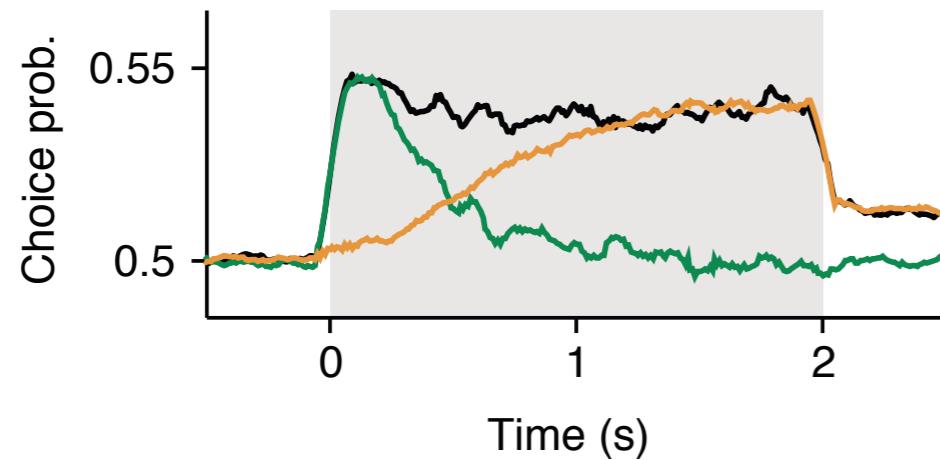
Hierarchical network



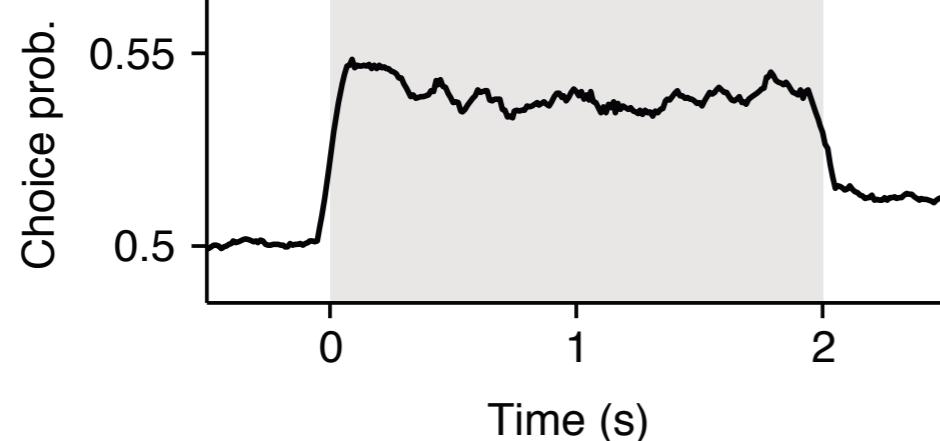
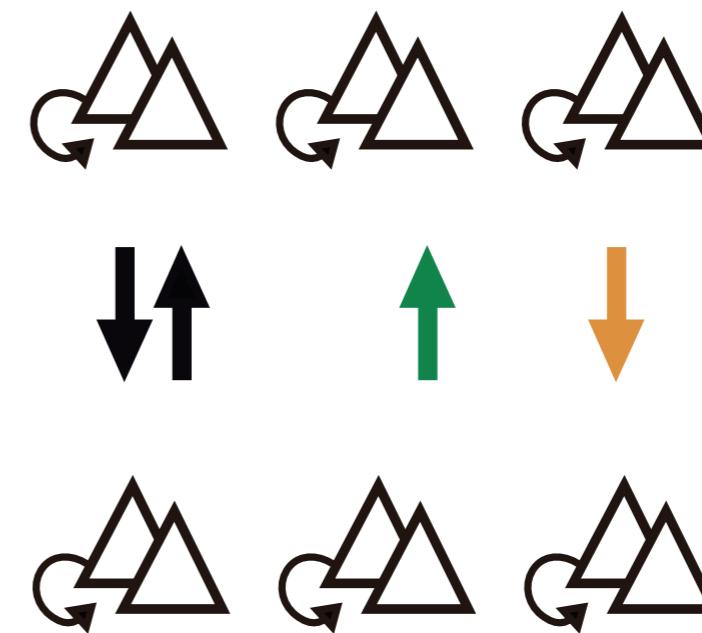
Extended hierarchical network



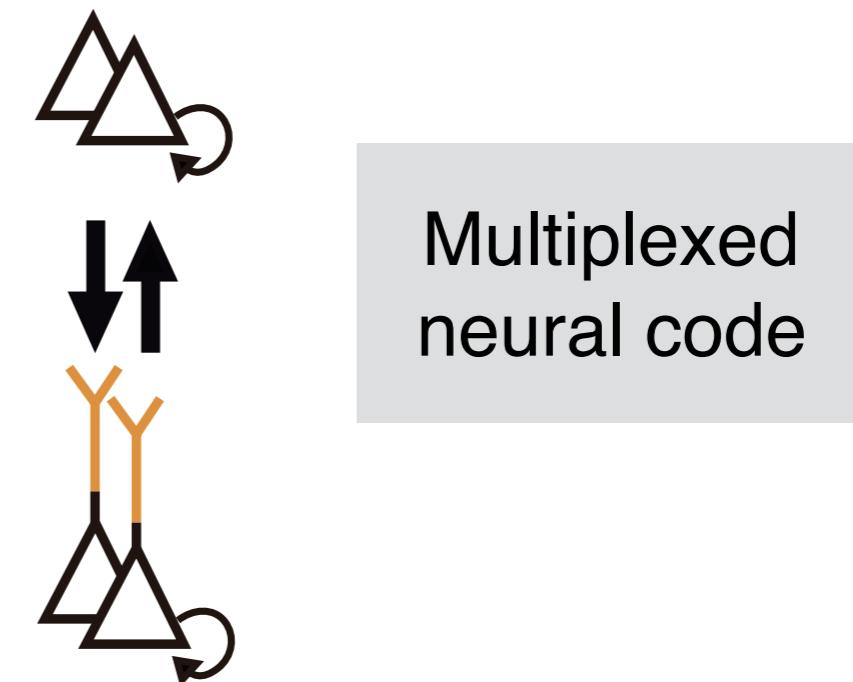
Neuronal correlates with choices



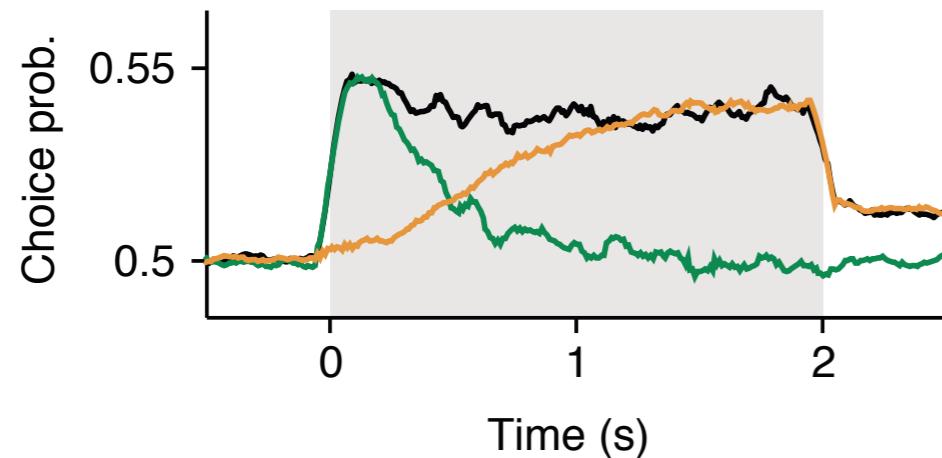
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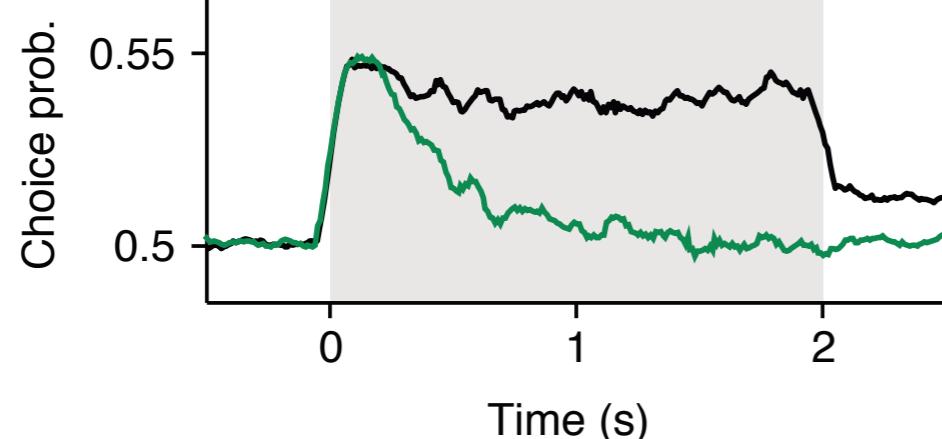
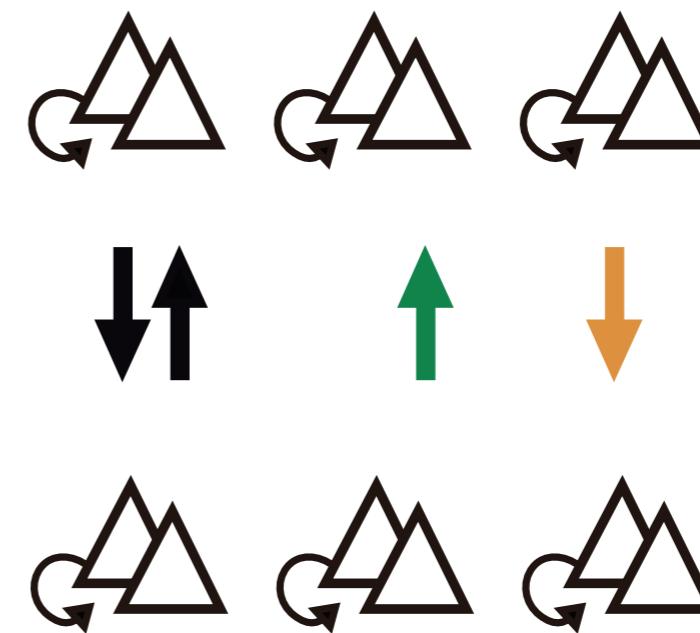
Extended hierarchical network



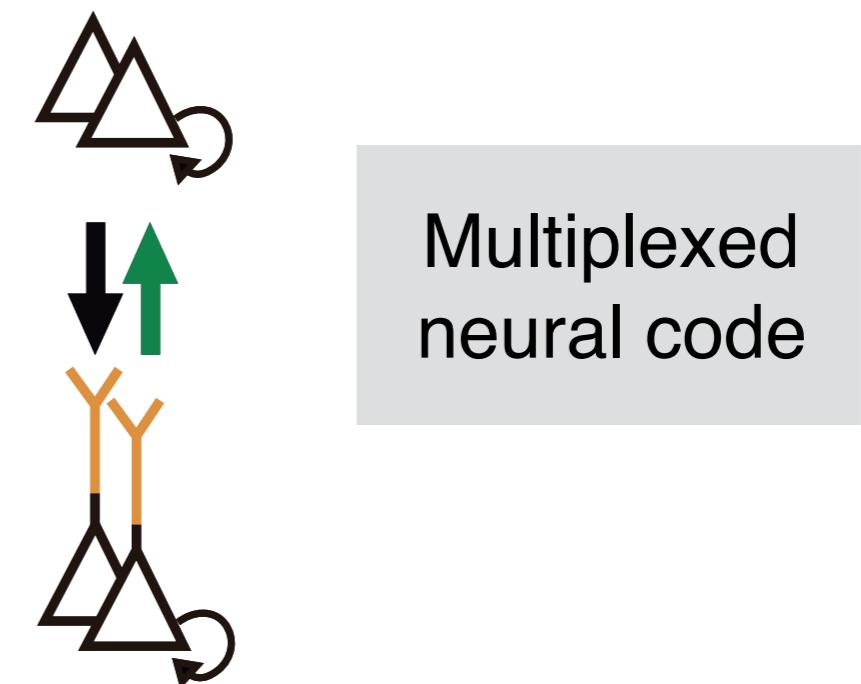
Neuronal correlates with choices



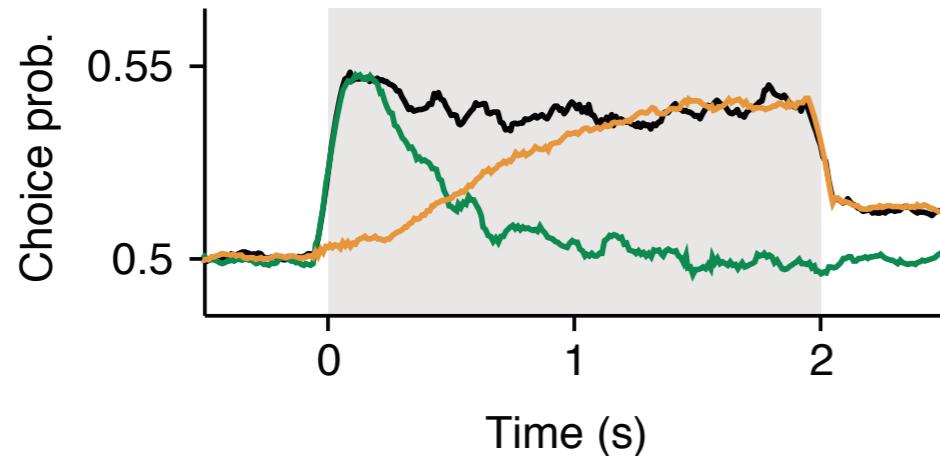
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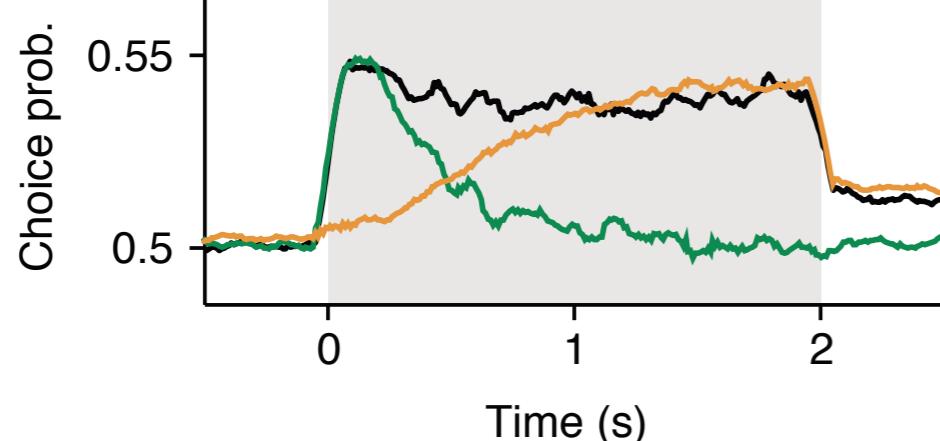
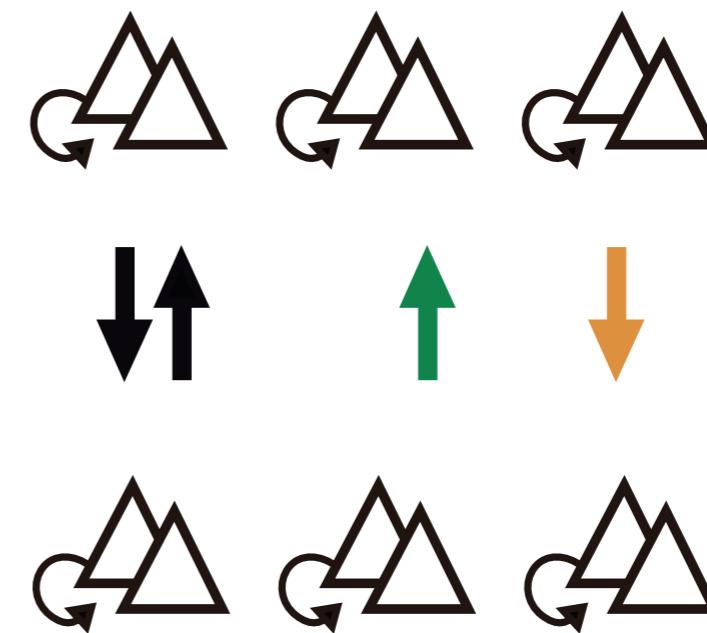
Extended hierarchical network



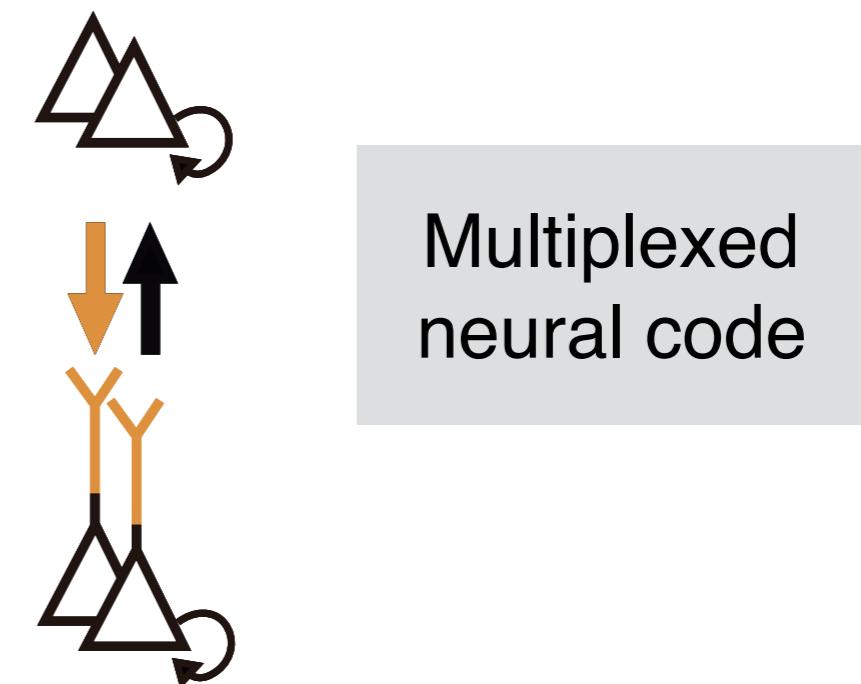
Neuronal correlates with choices



Hierarchical network

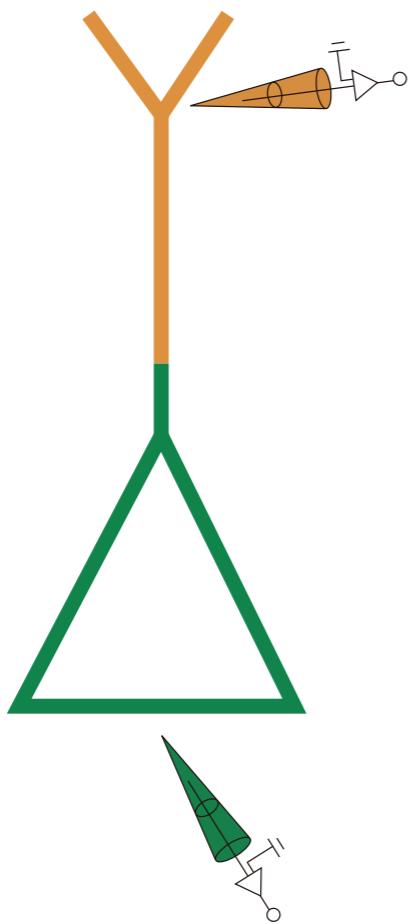


Extended hierarchical network

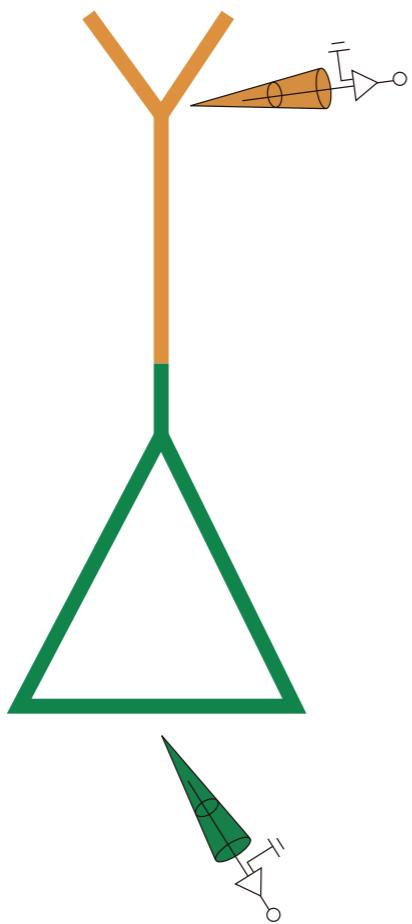


Two-compartment neurons encode different input streams via spiking patterns

Two-compartment neurons encode different input streams via spiking patterns

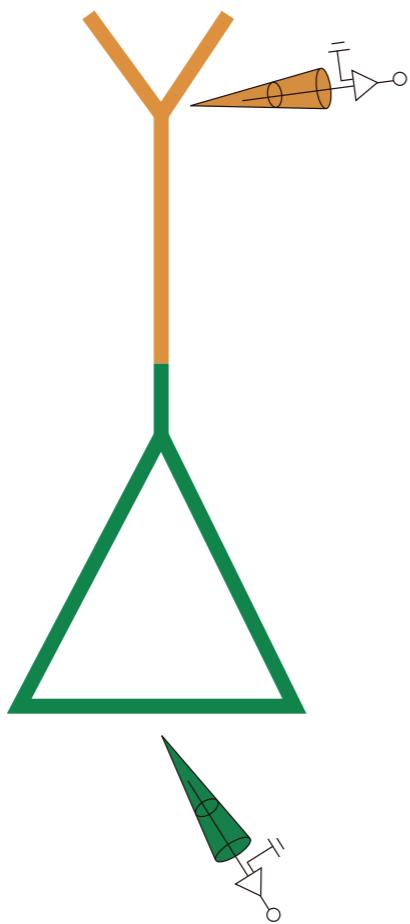


Two-compartment neurons encode different input streams via spiking patterns



Multiplexed neural code

Two-compartment neurons encode different input streams via spiking patterns



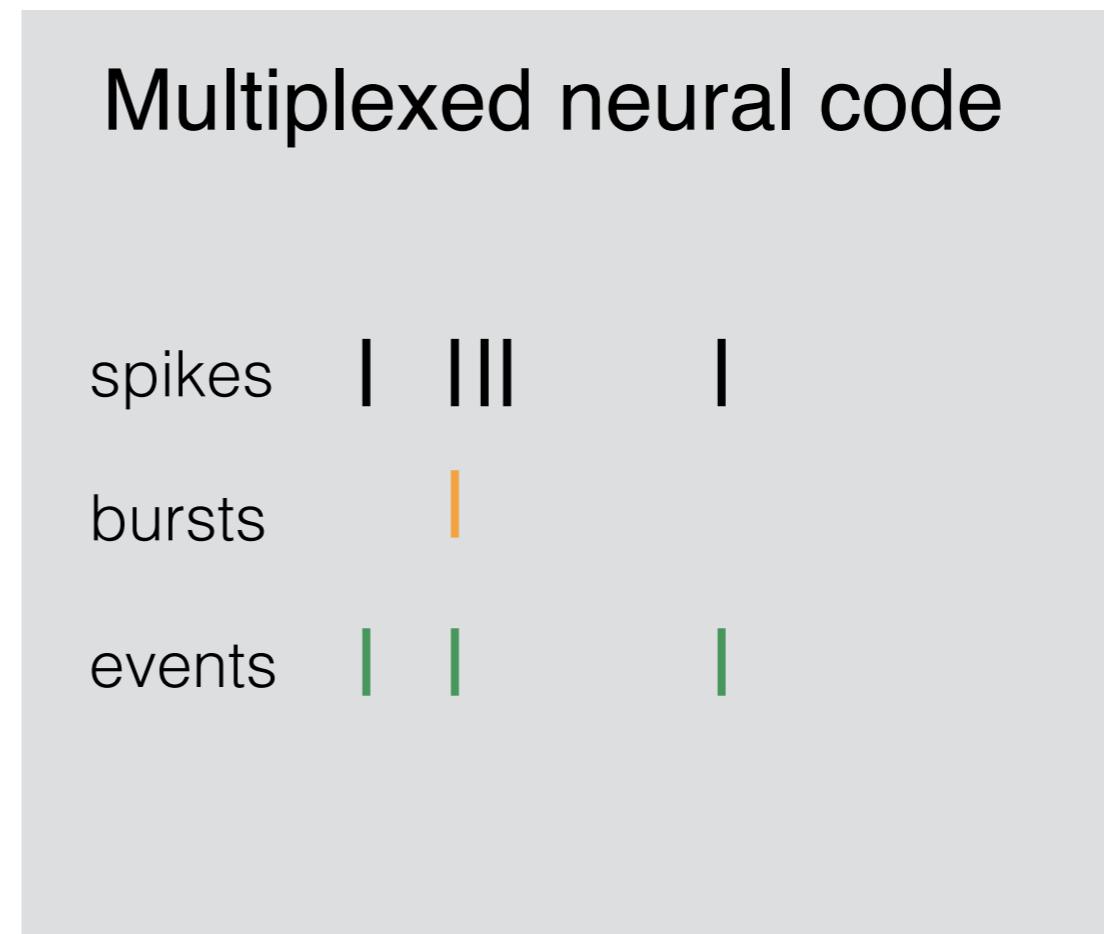
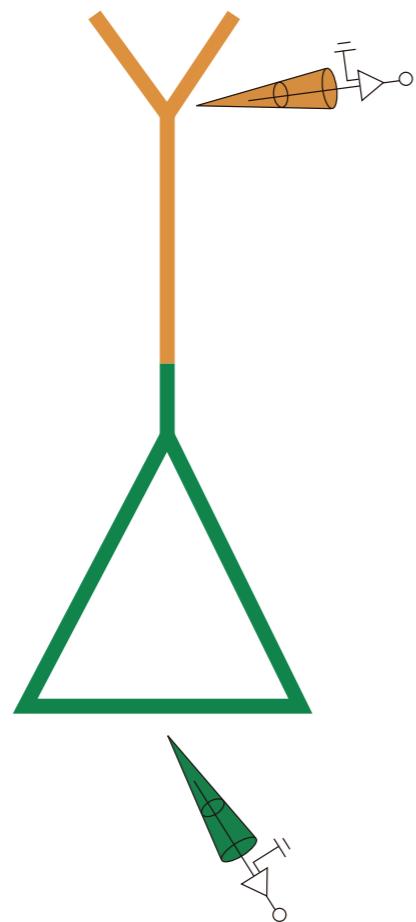
Multiplexed neural code

spikes

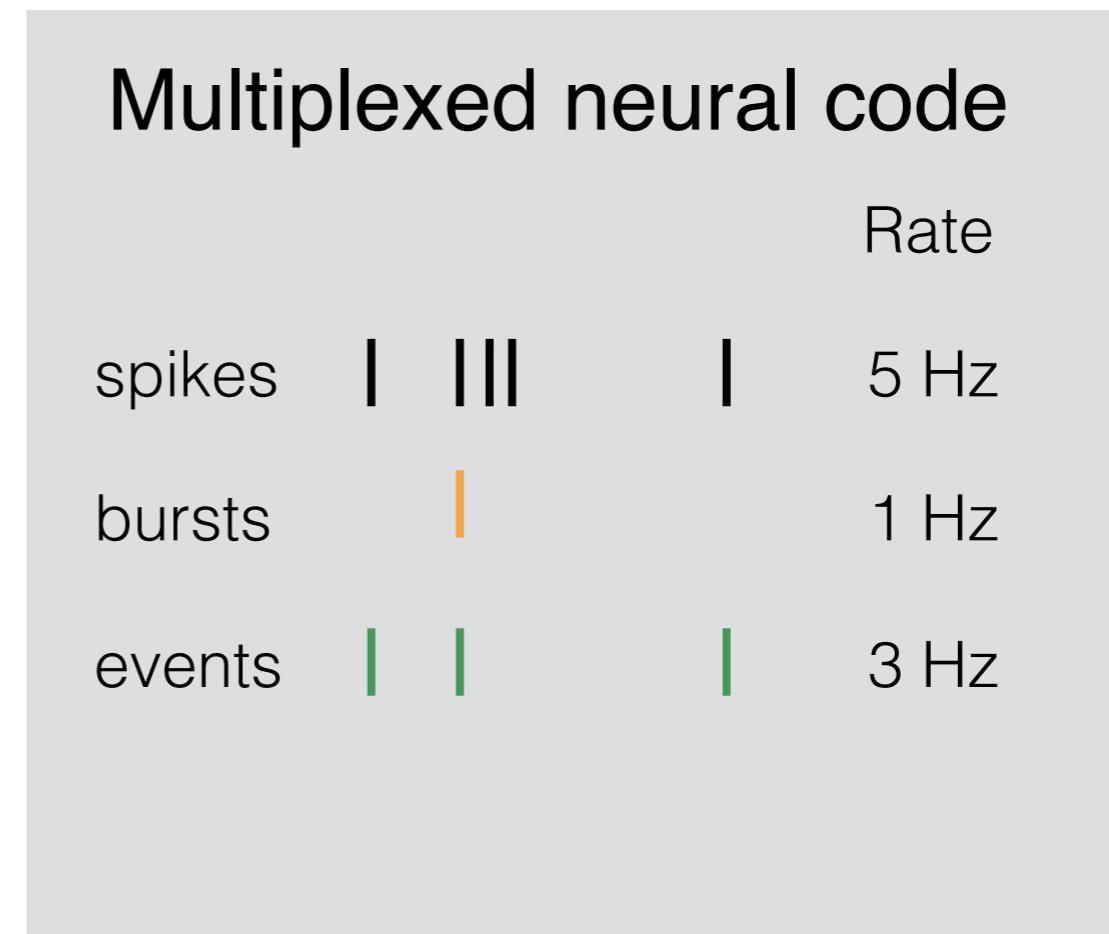
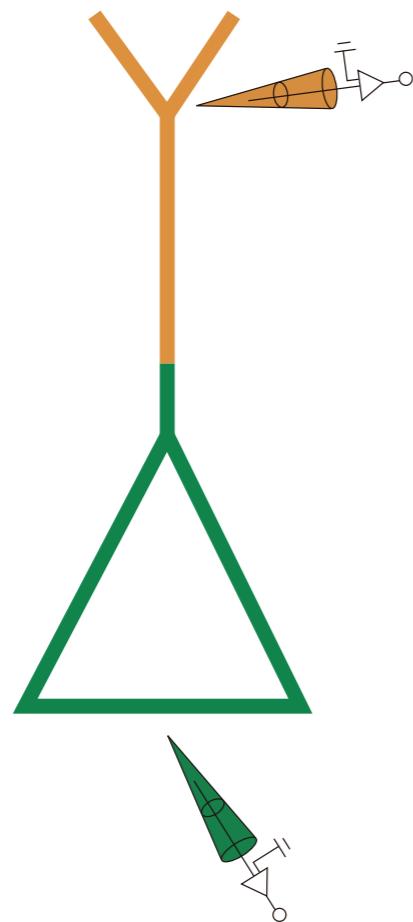
bursts

events

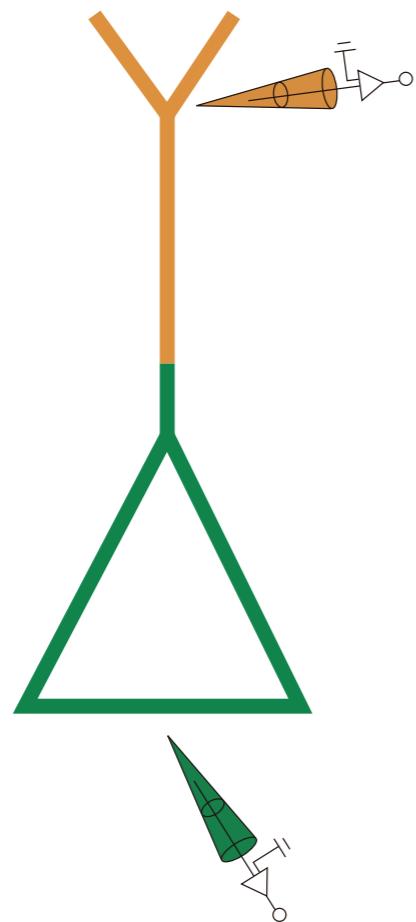
Two-compartment neurons encode different input streams via spiking patterns



Two-compartment neurons encode different input streams via spiking patterns



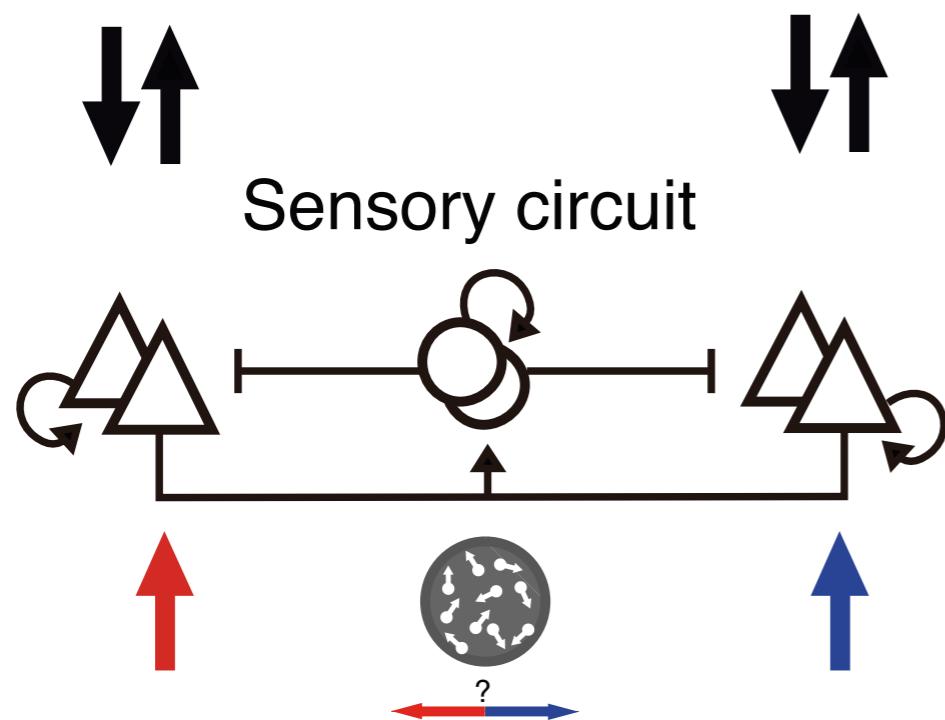
Two-compartment neurons encode different input streams via spiking patterns



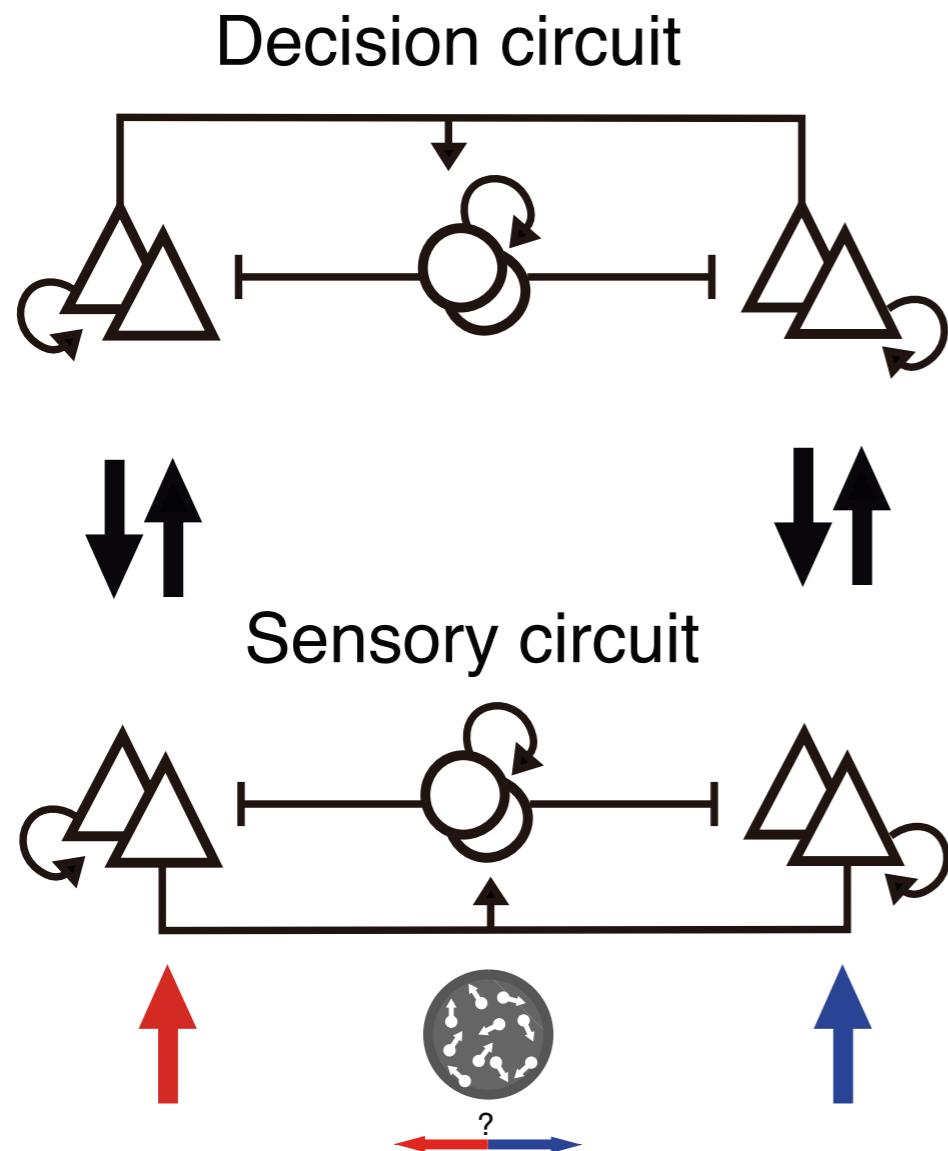
Multiplexed neural code			
			Rate
spikes			5 Hz
bursts			1 Hz
events			3 Hz
BF = bursts / events =			0.33

Hierarchical network found early and late
components of CP

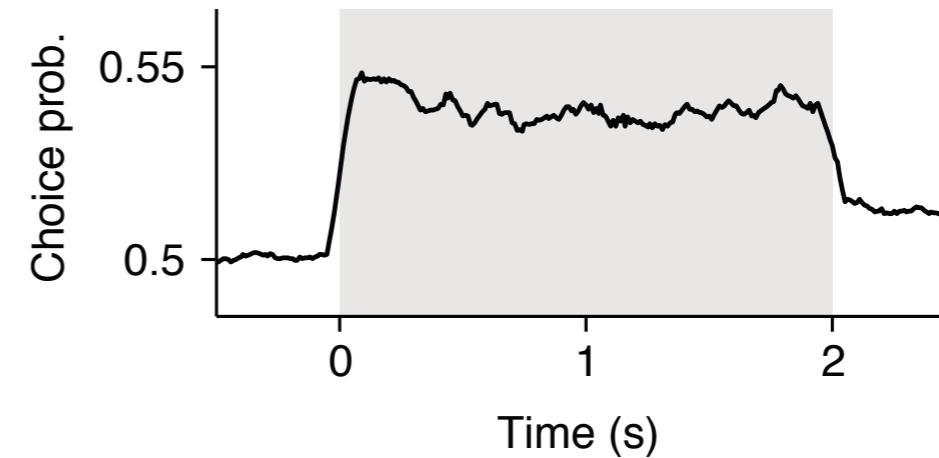
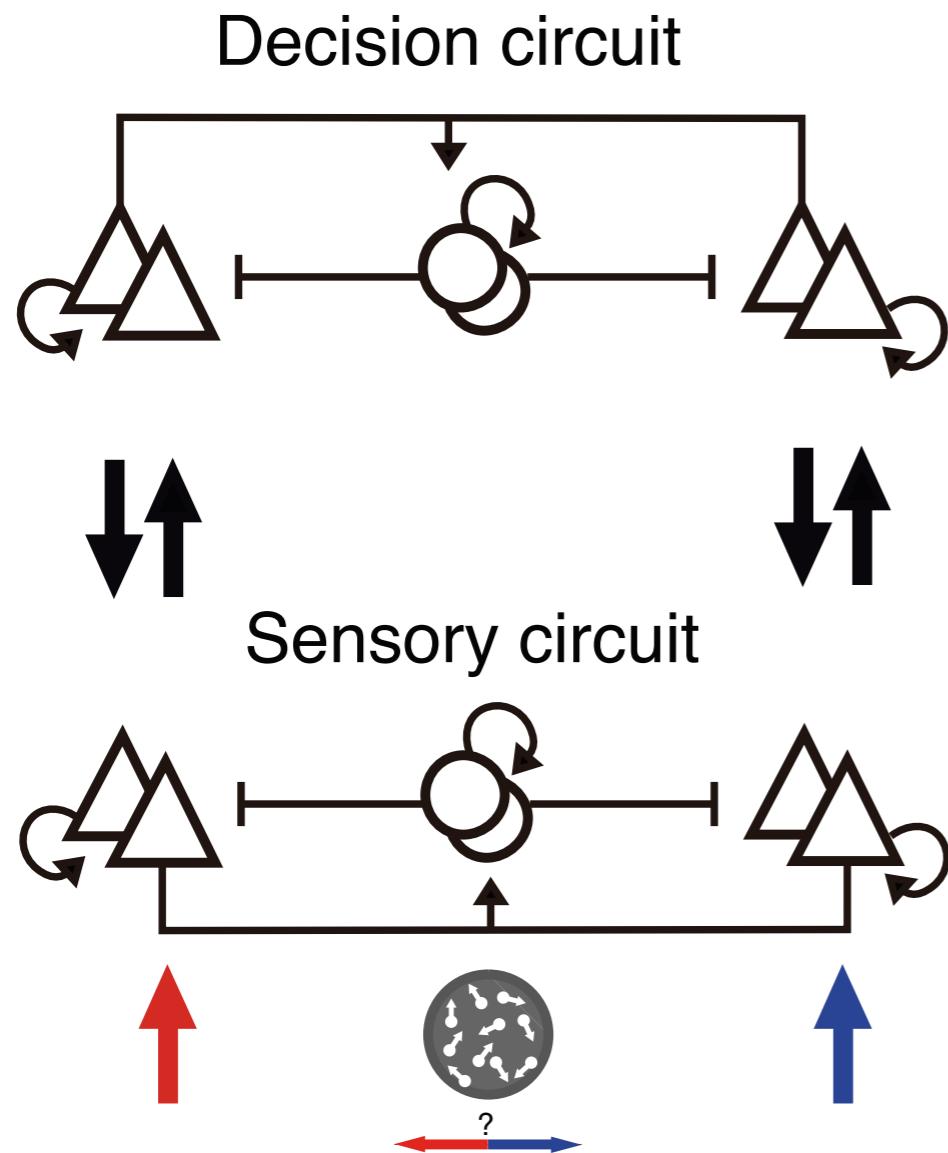
Hierarchical network found early and late components of CP



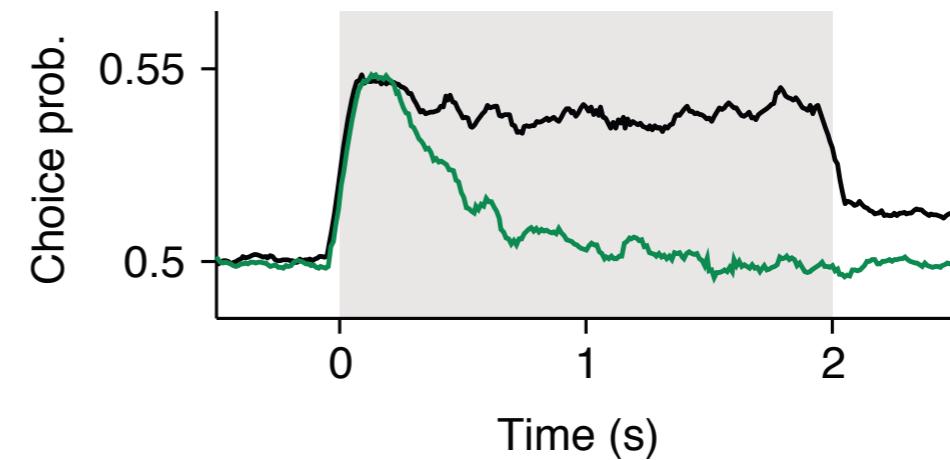
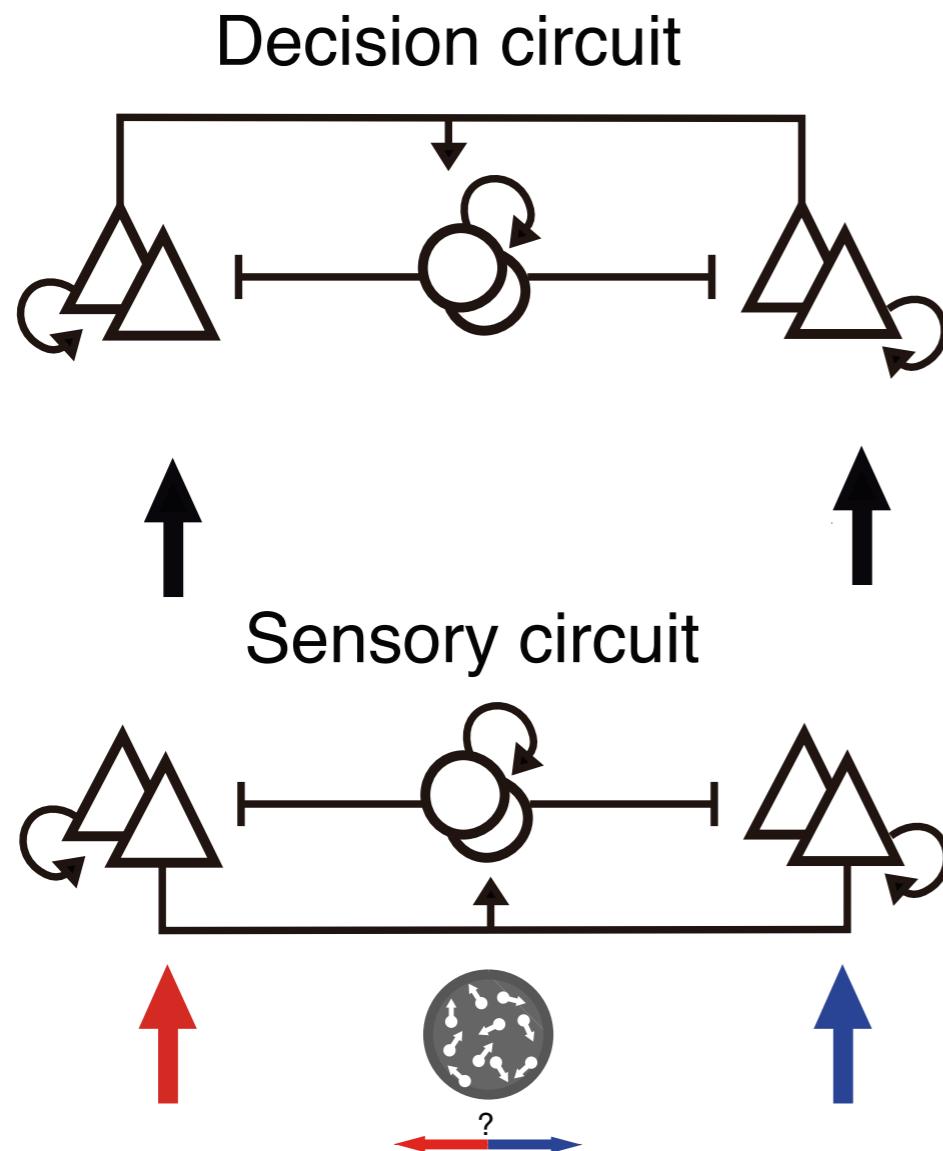
Hierarchical network found early and late components of CP



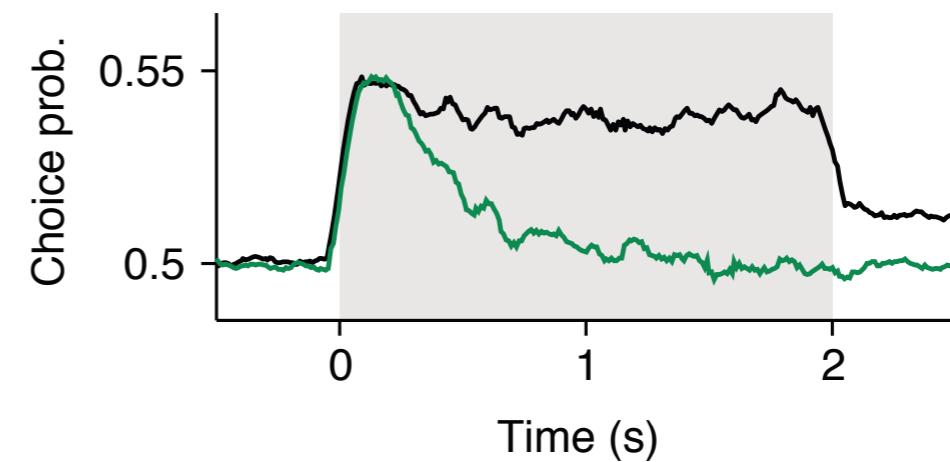
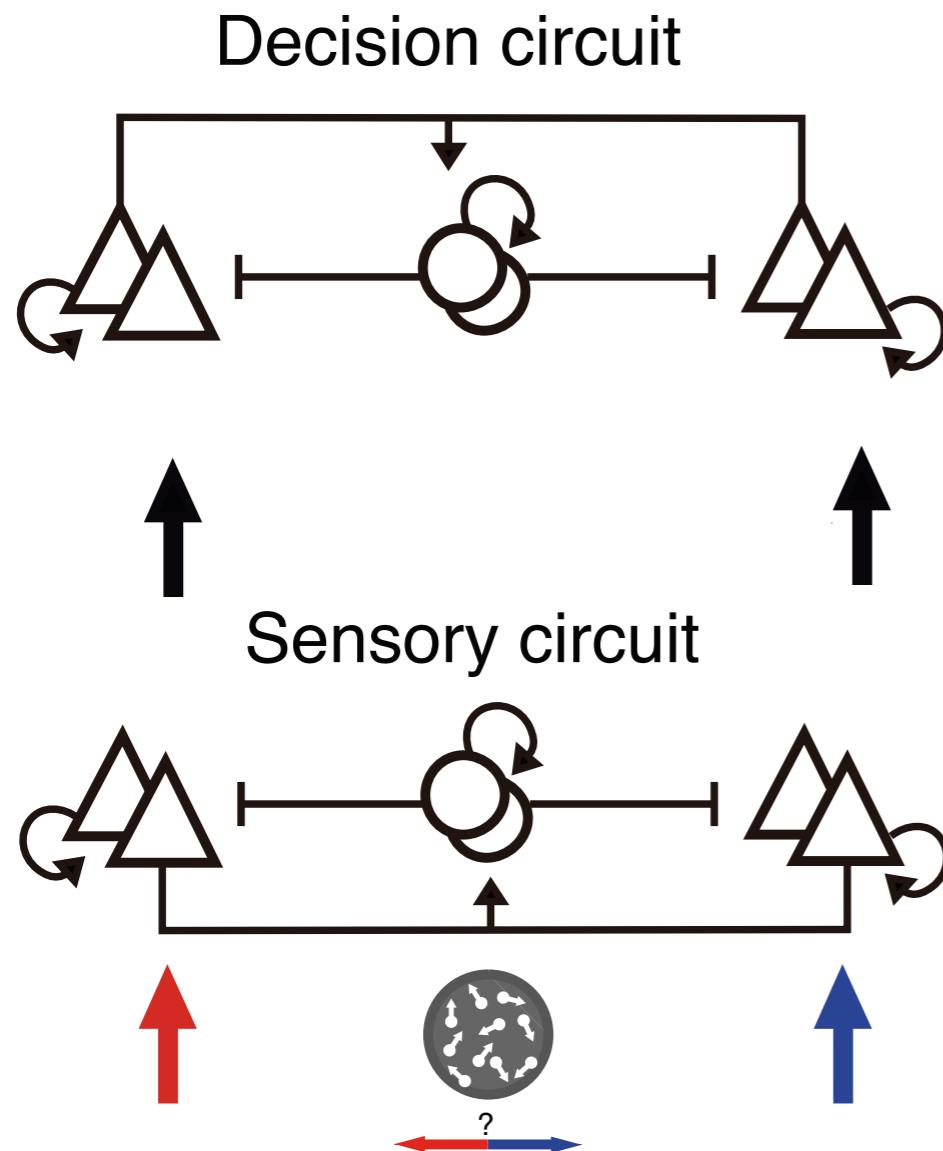
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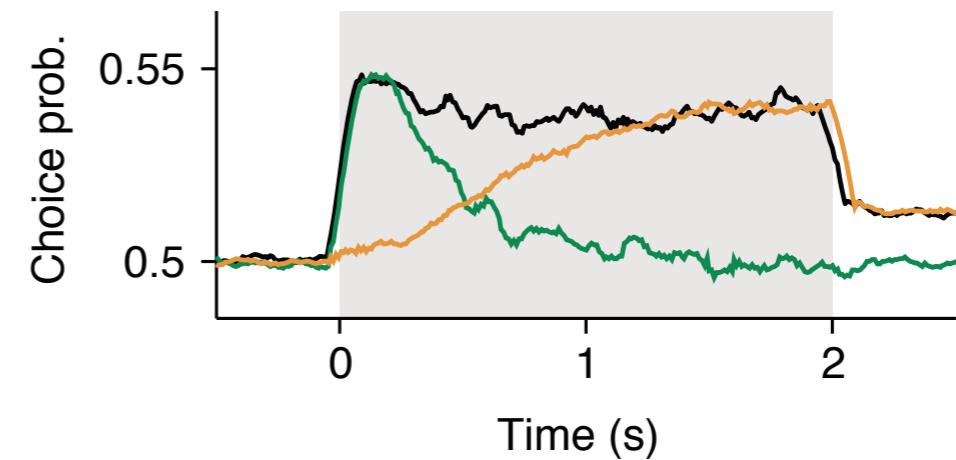
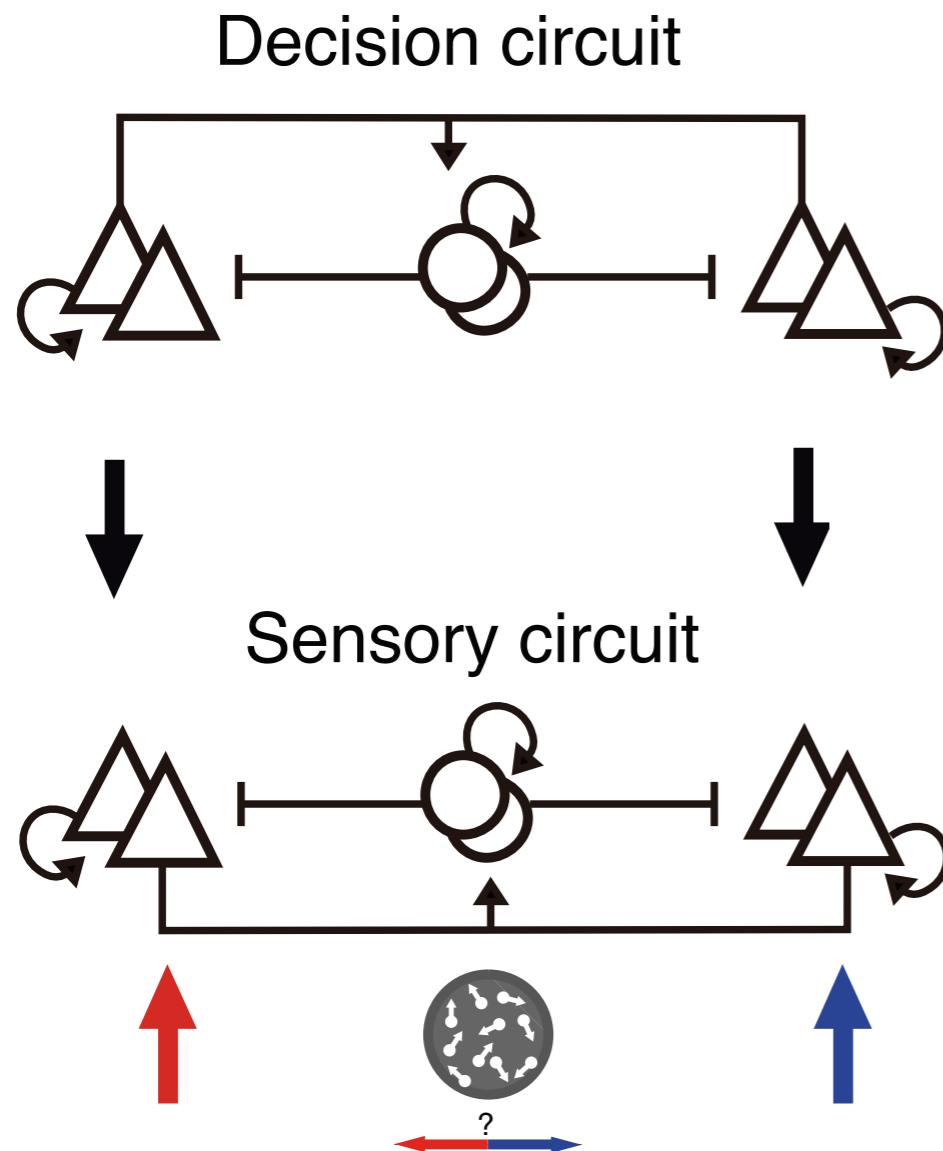


Hierarchical network found early and late components of CP



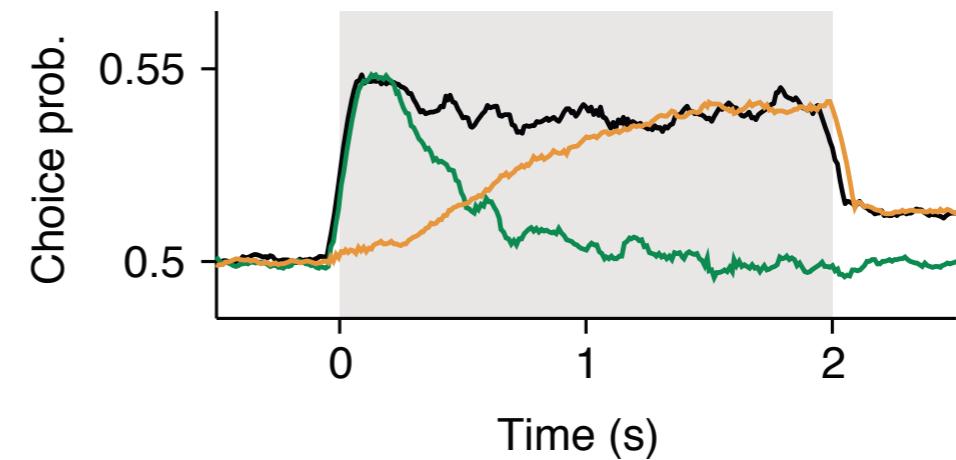
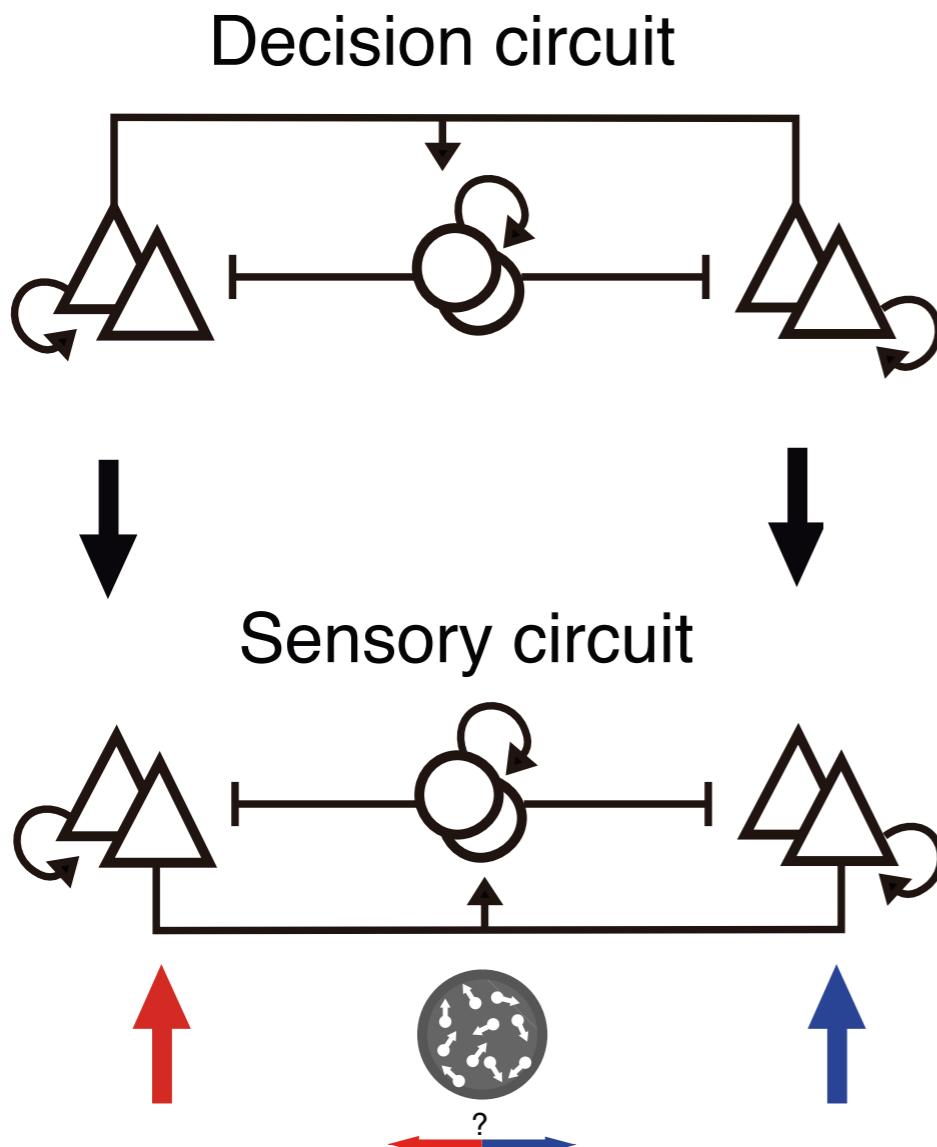
Only bottom-up influence
Early, transient component of CP

Hierarchical network found early and late components of CP

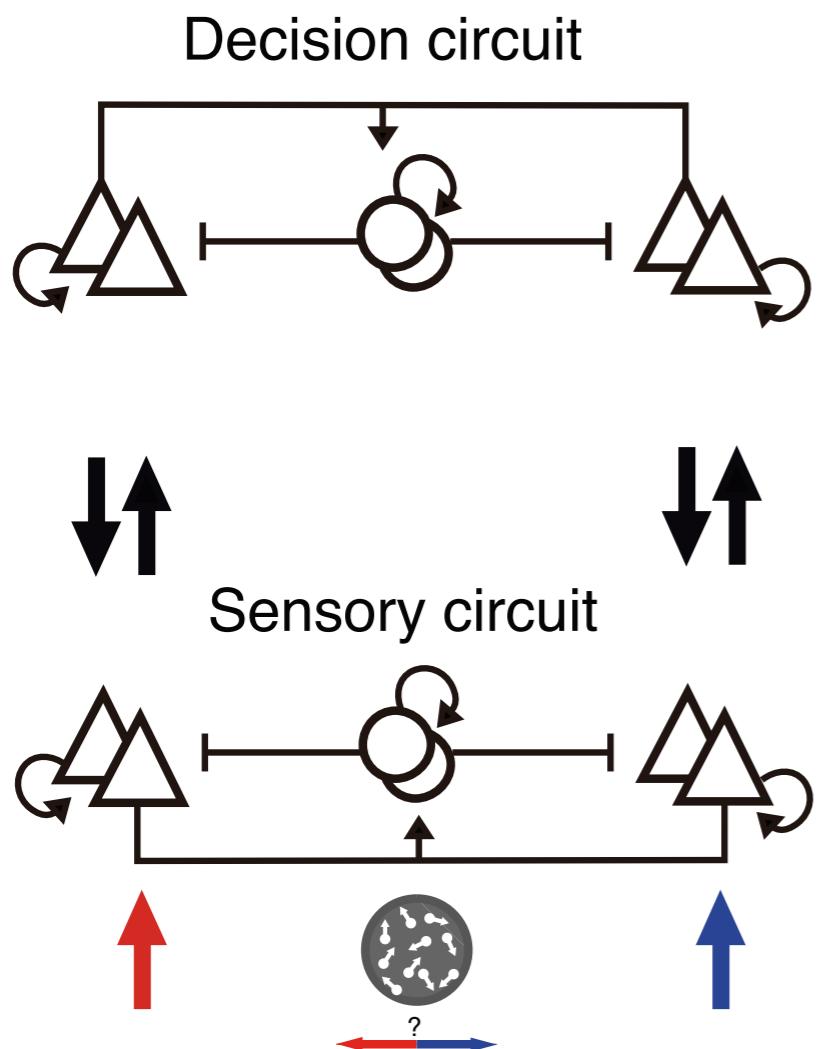


Only bottom-up influence
Early, transient component of CP

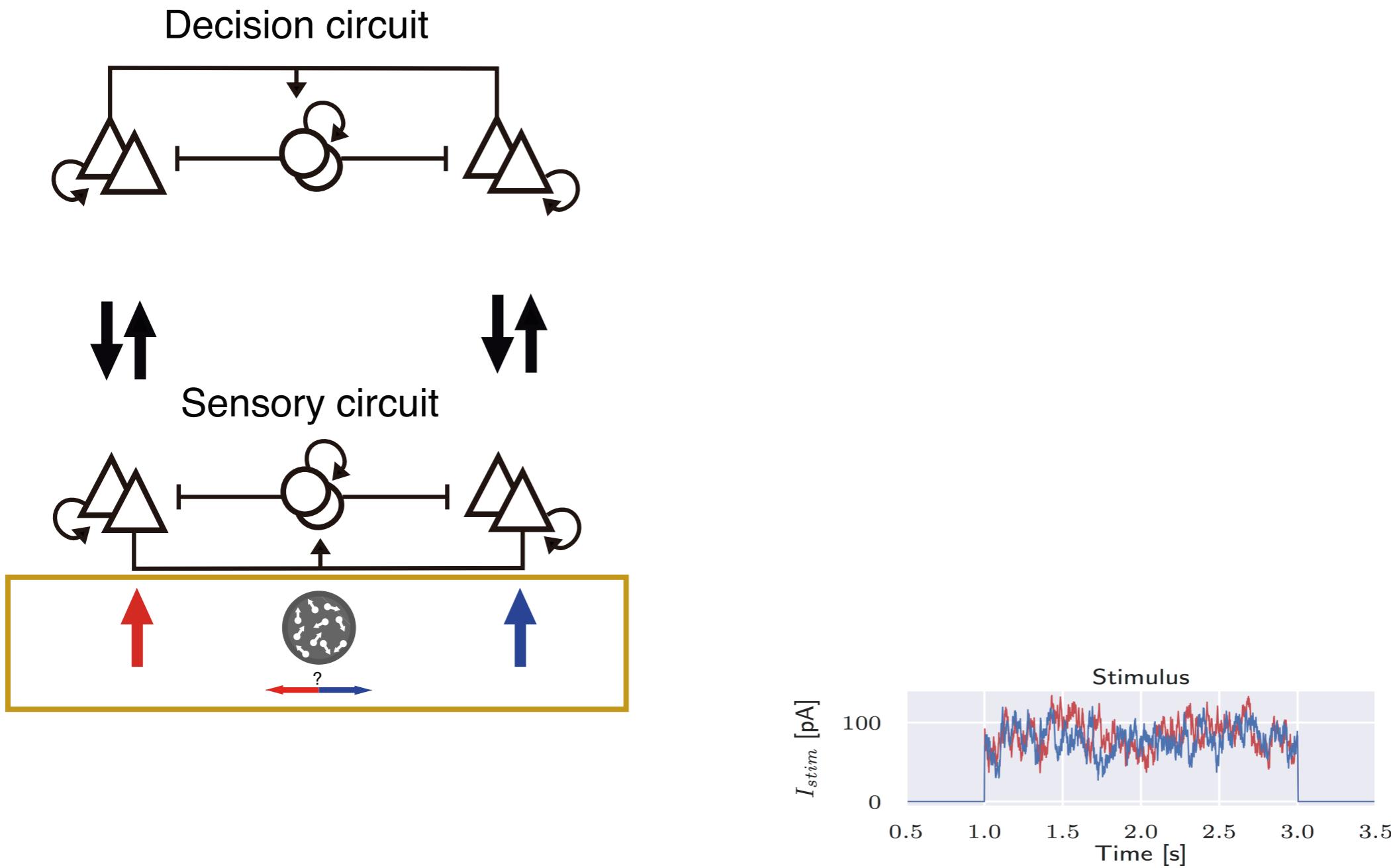
Hierarchical network found early and late components of CP



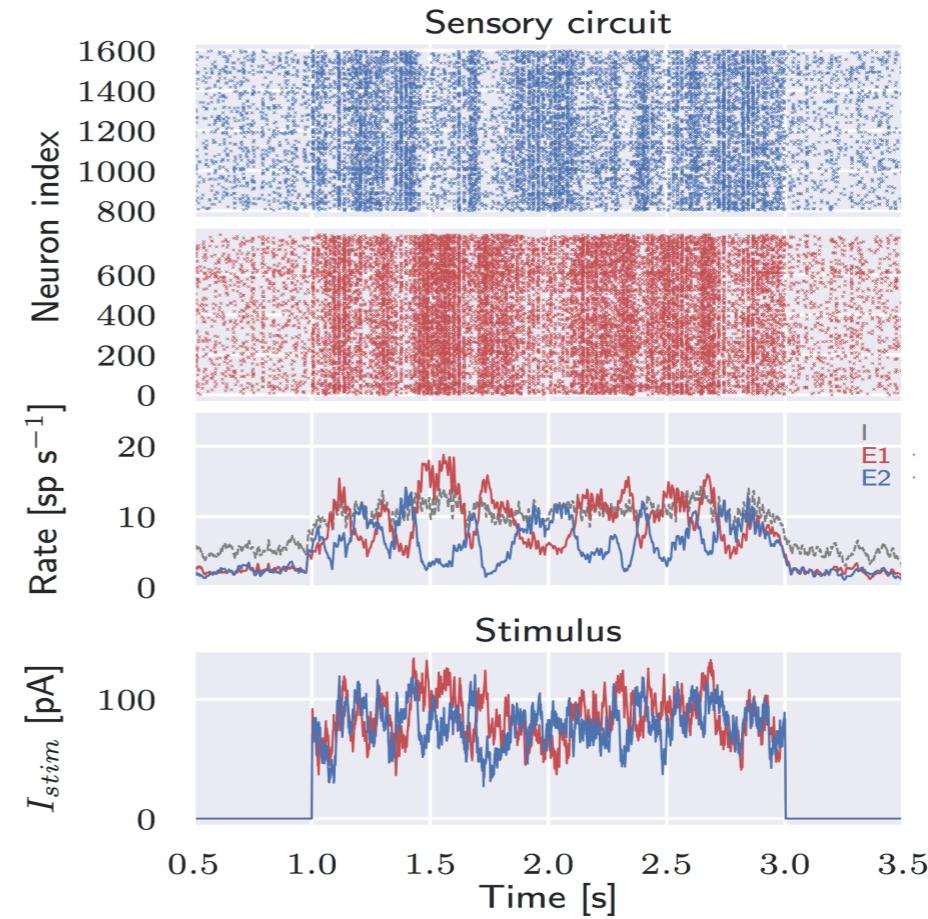
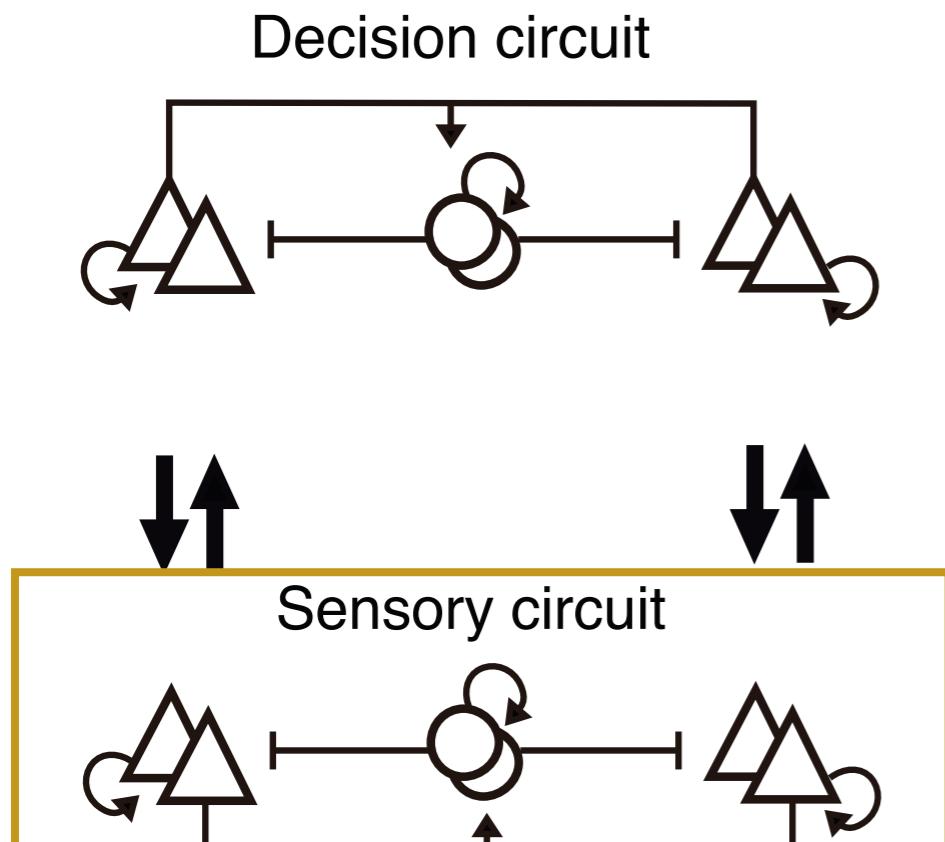
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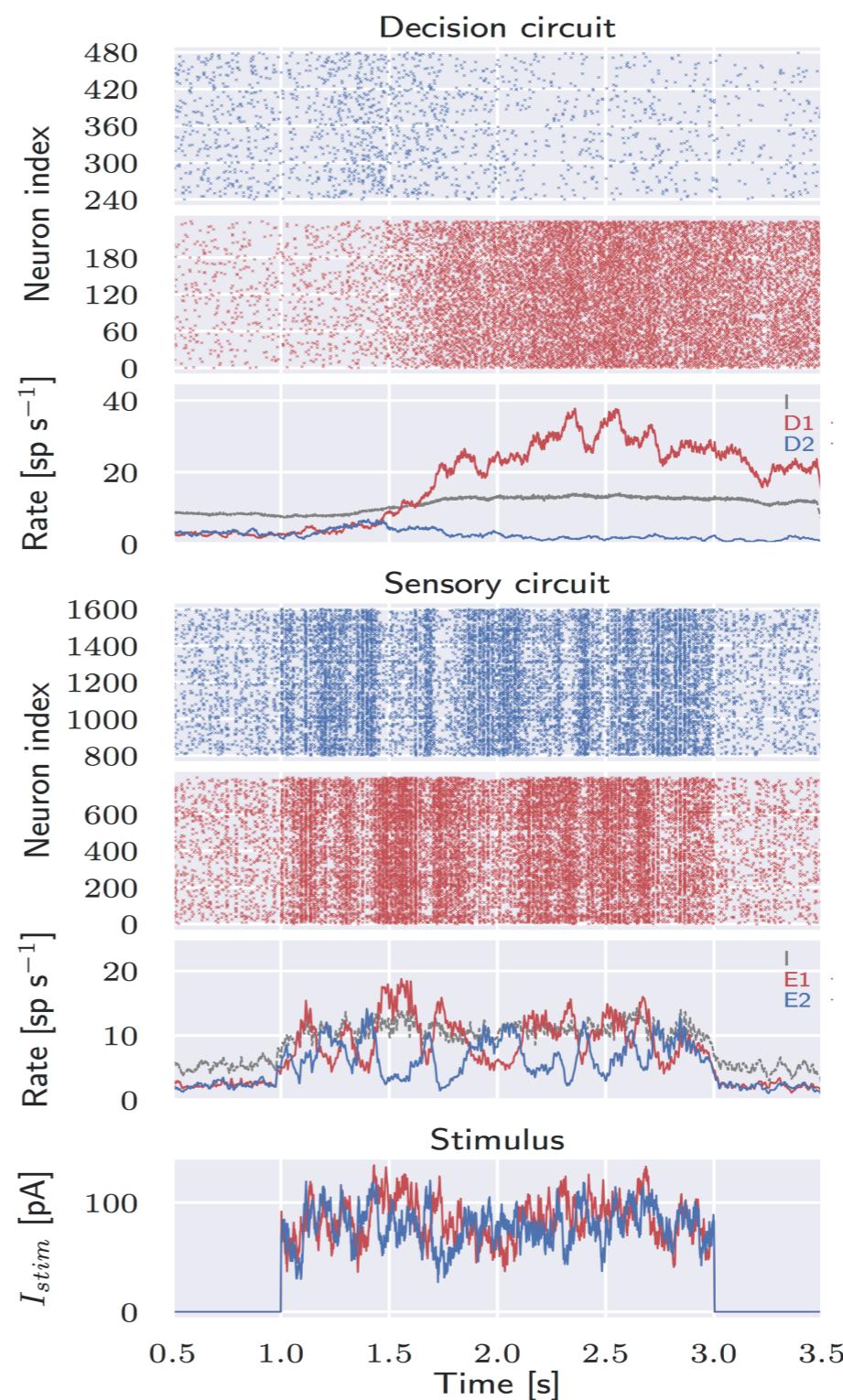
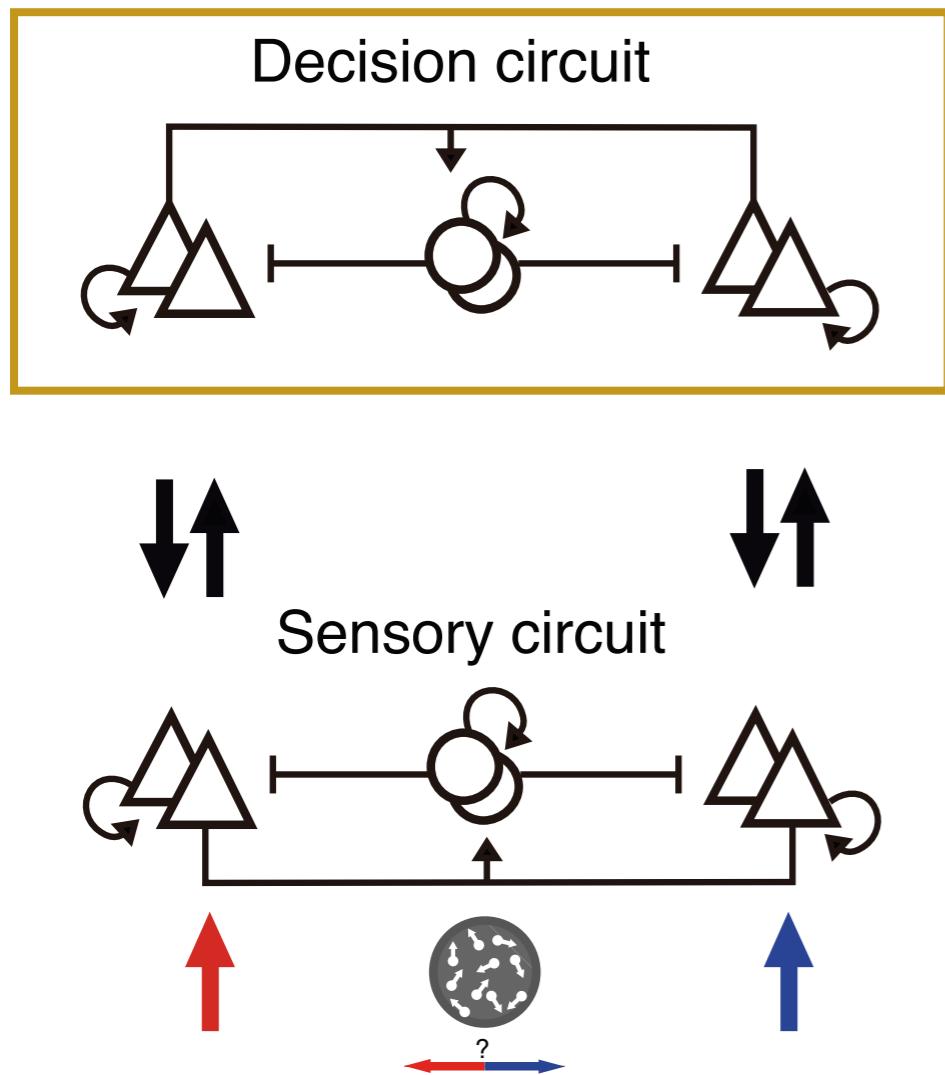
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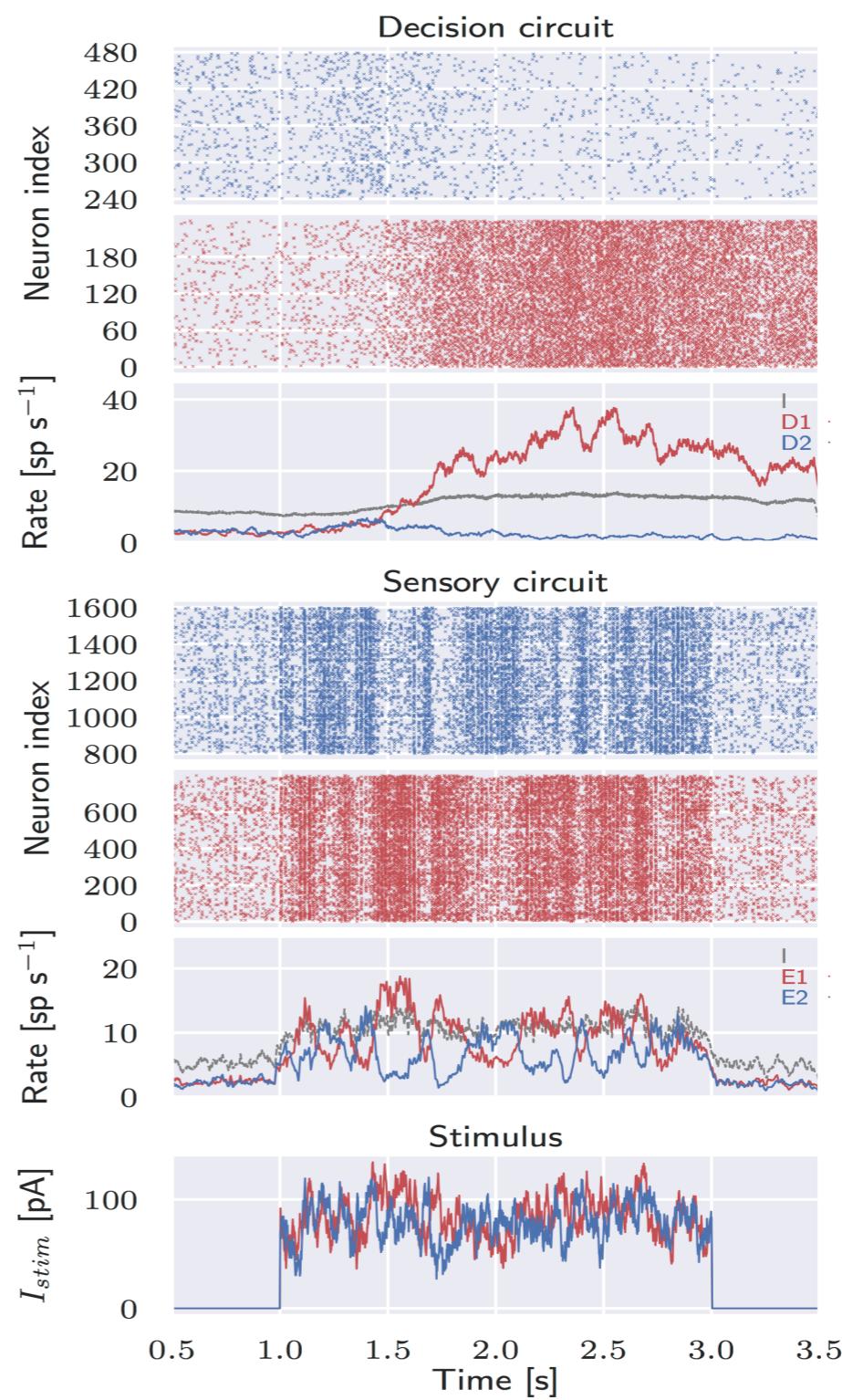
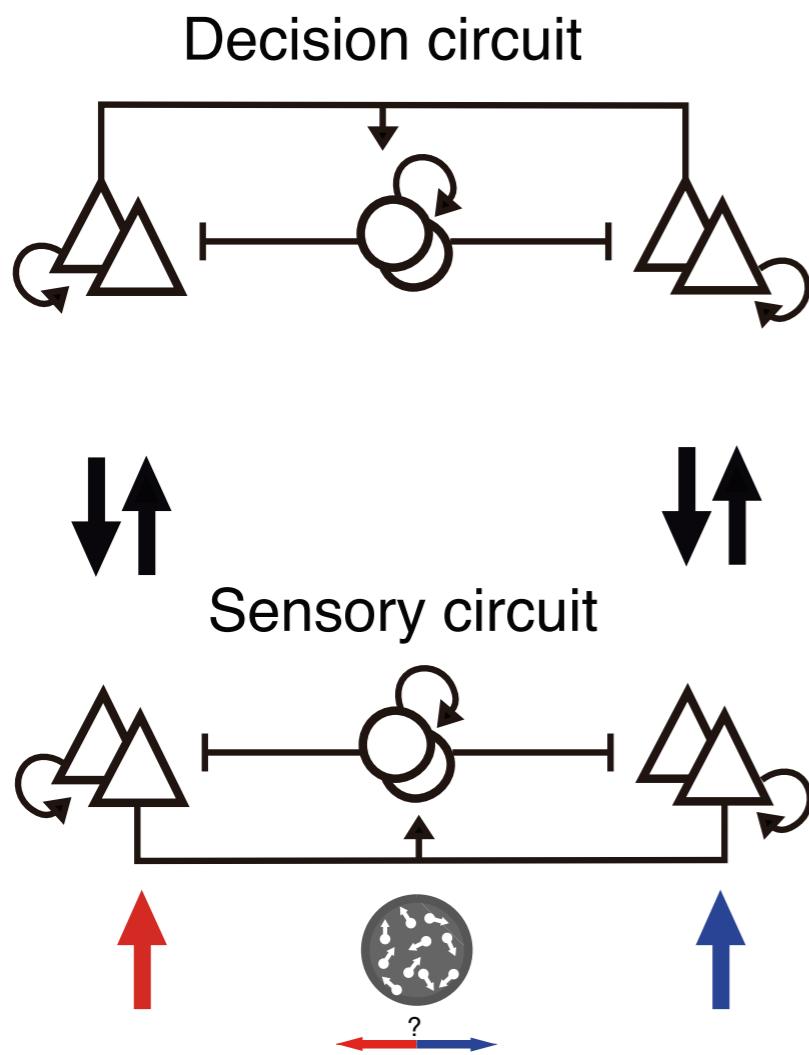
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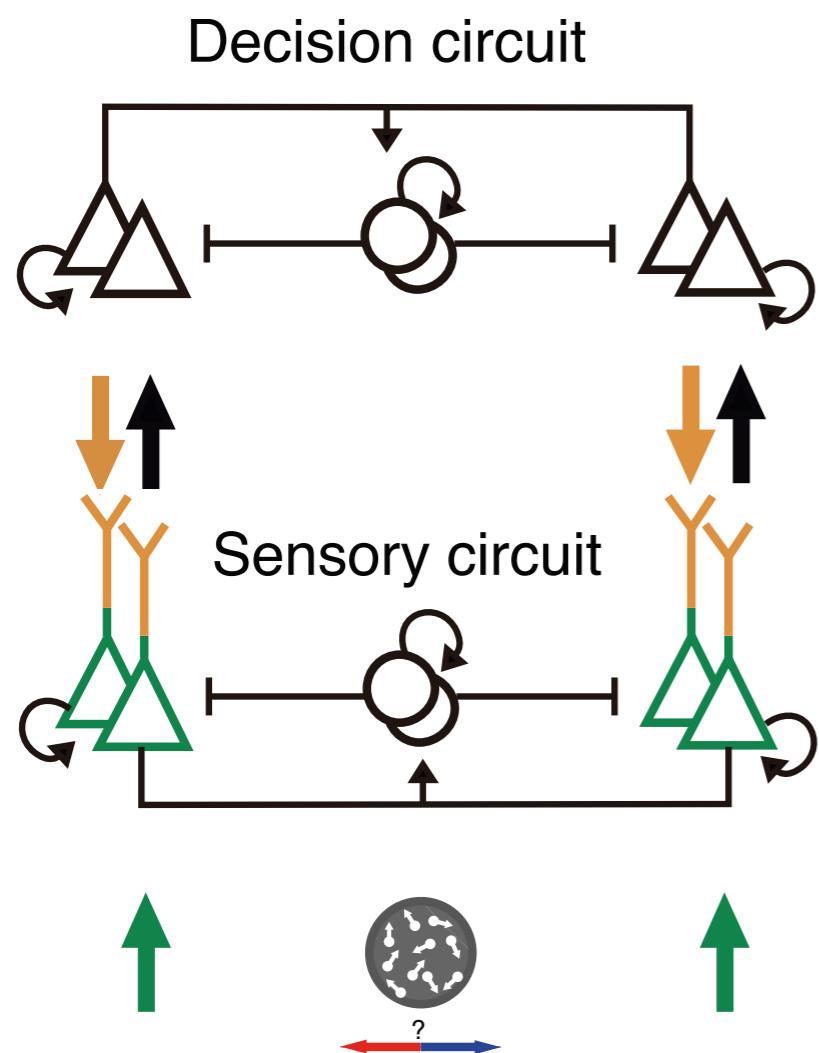
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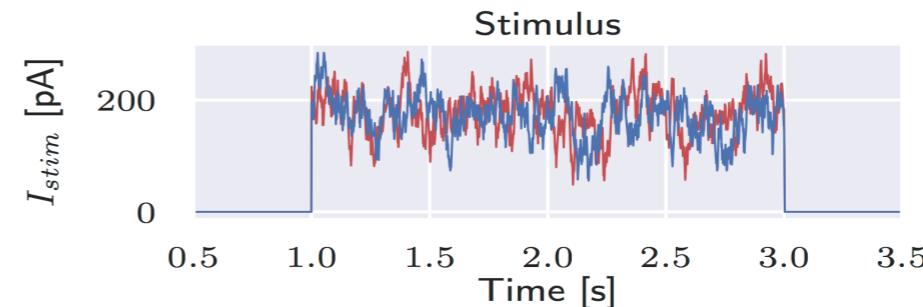
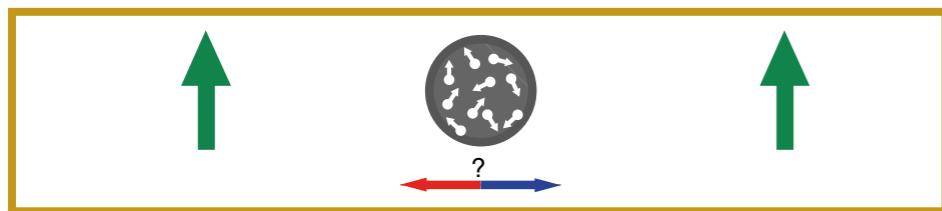
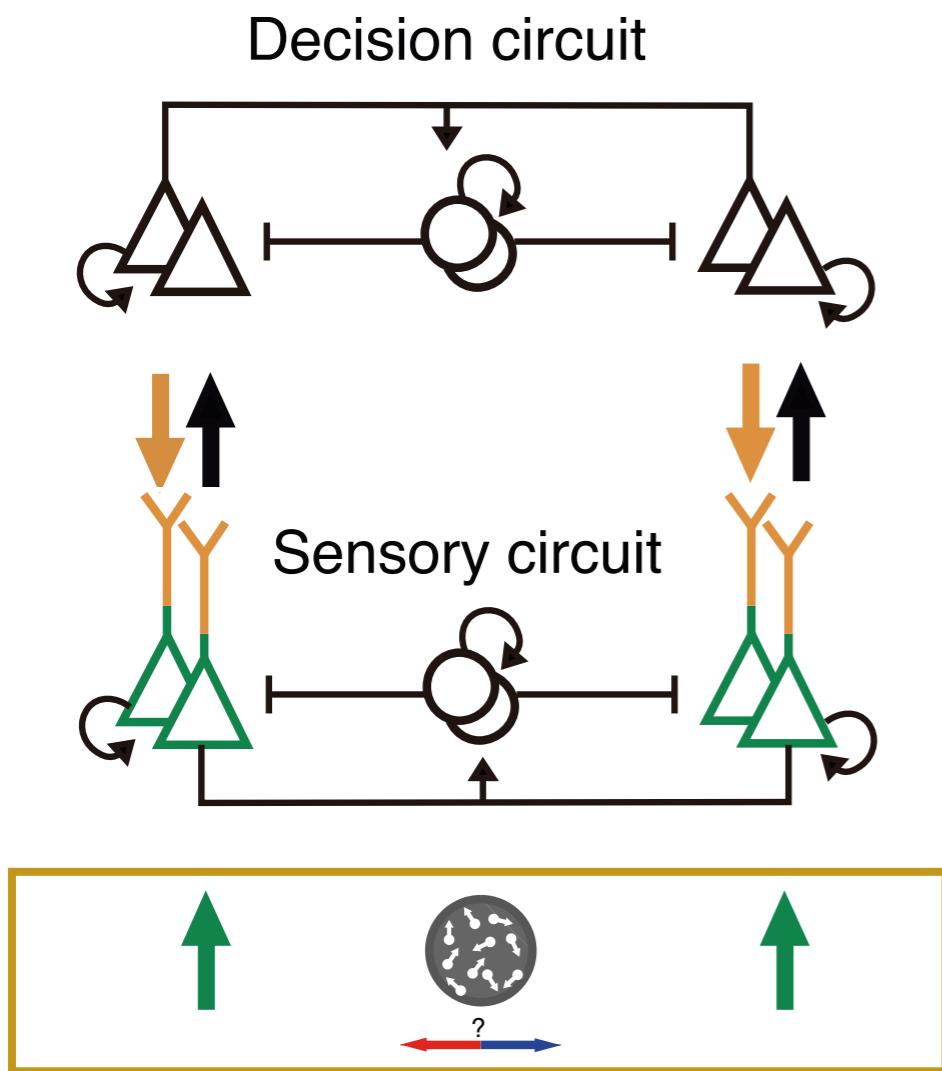
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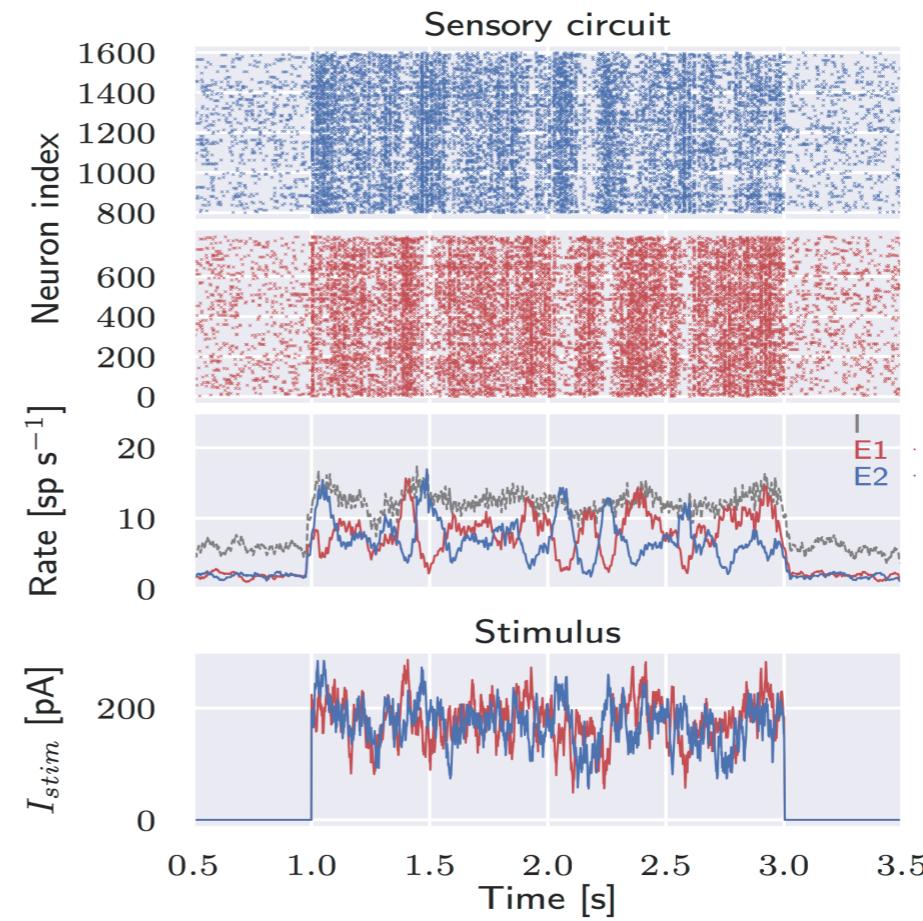
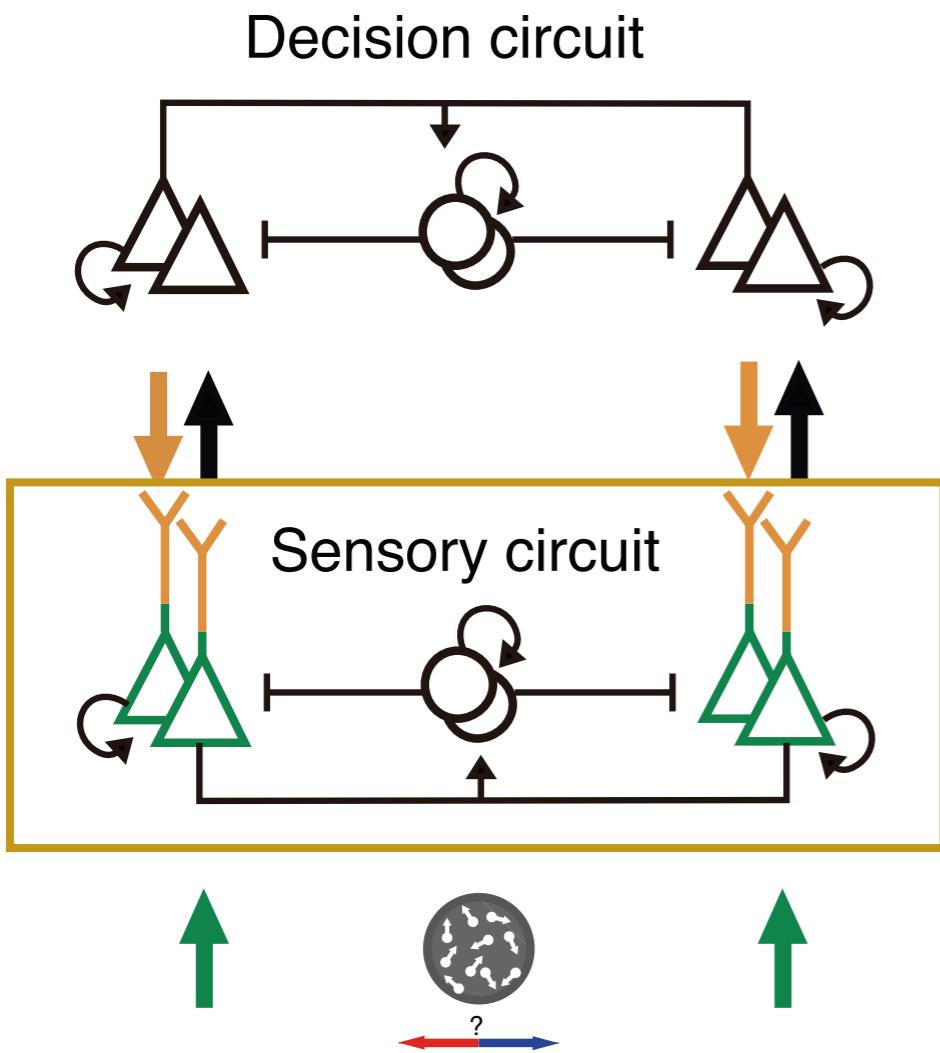
Hierarchical network with two-compartment sensory pyramidal neurons



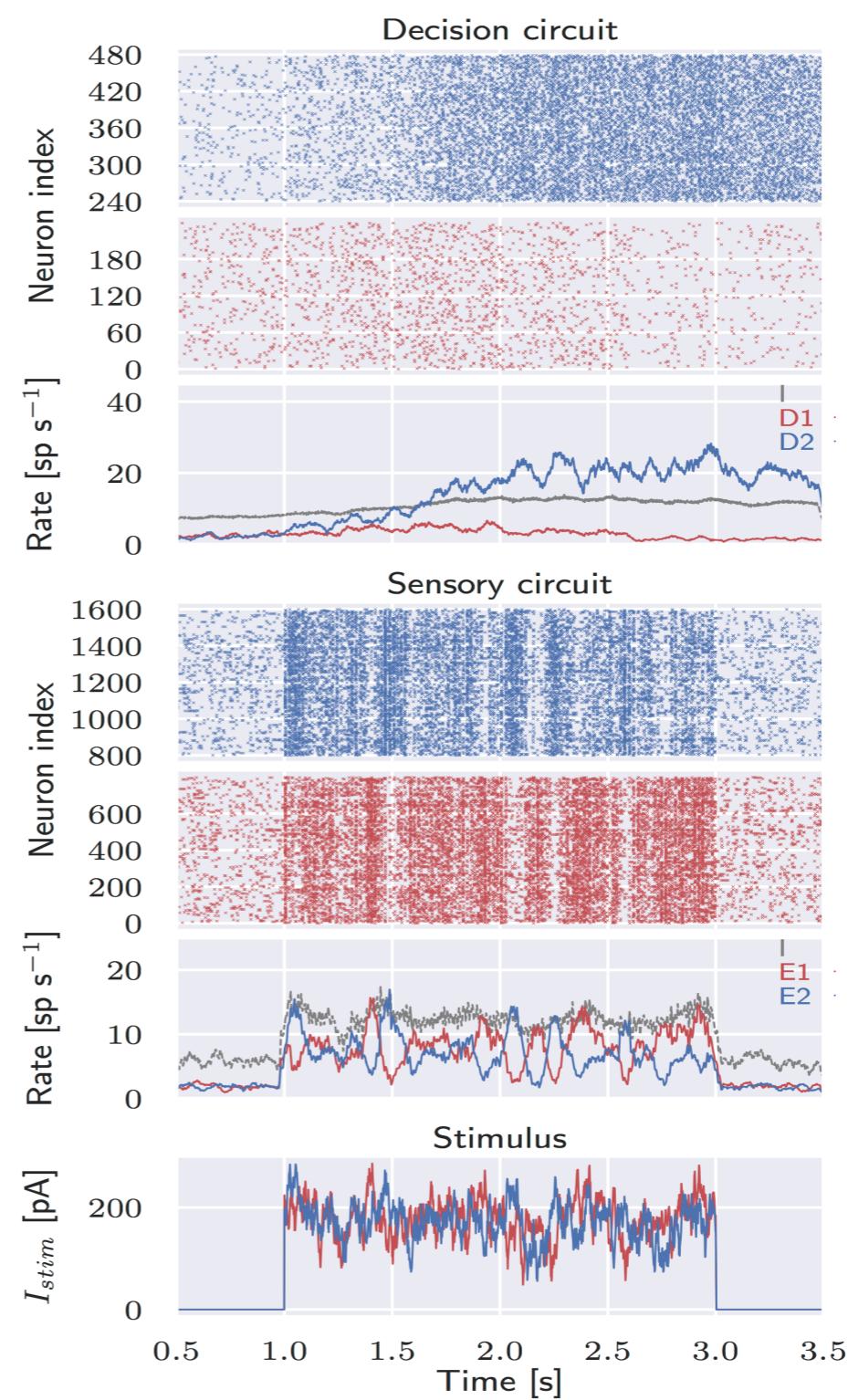
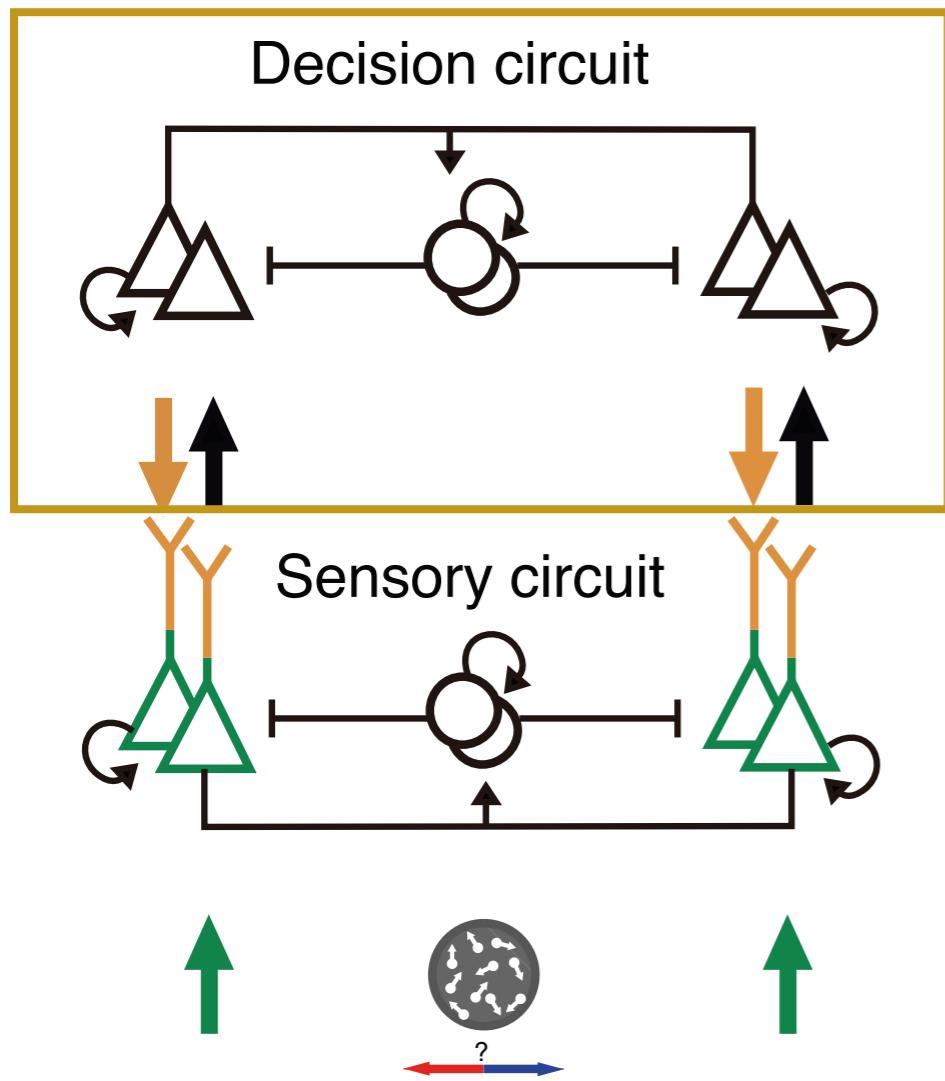
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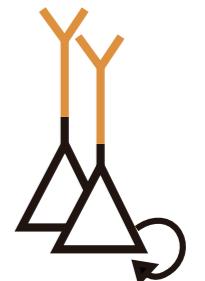
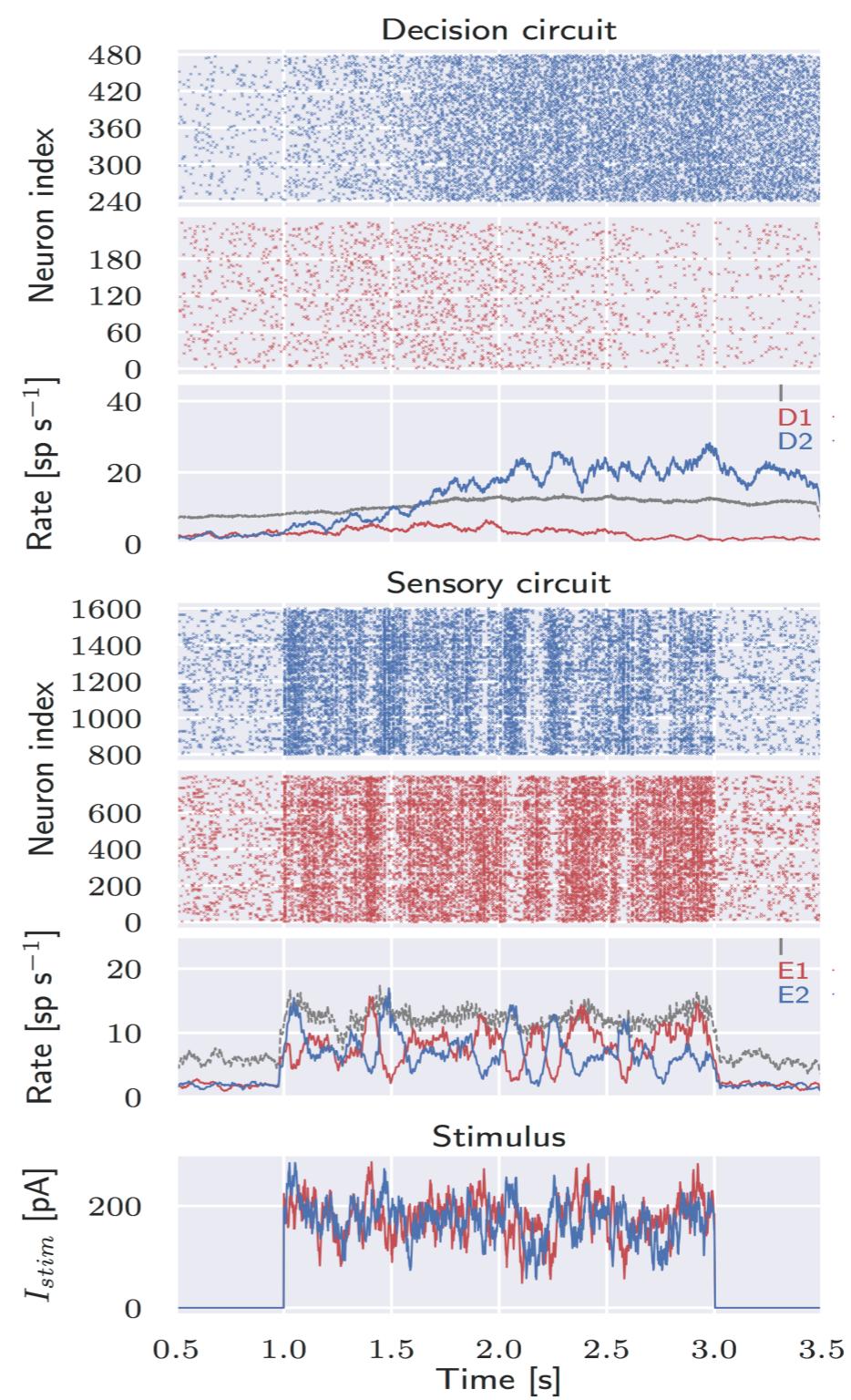
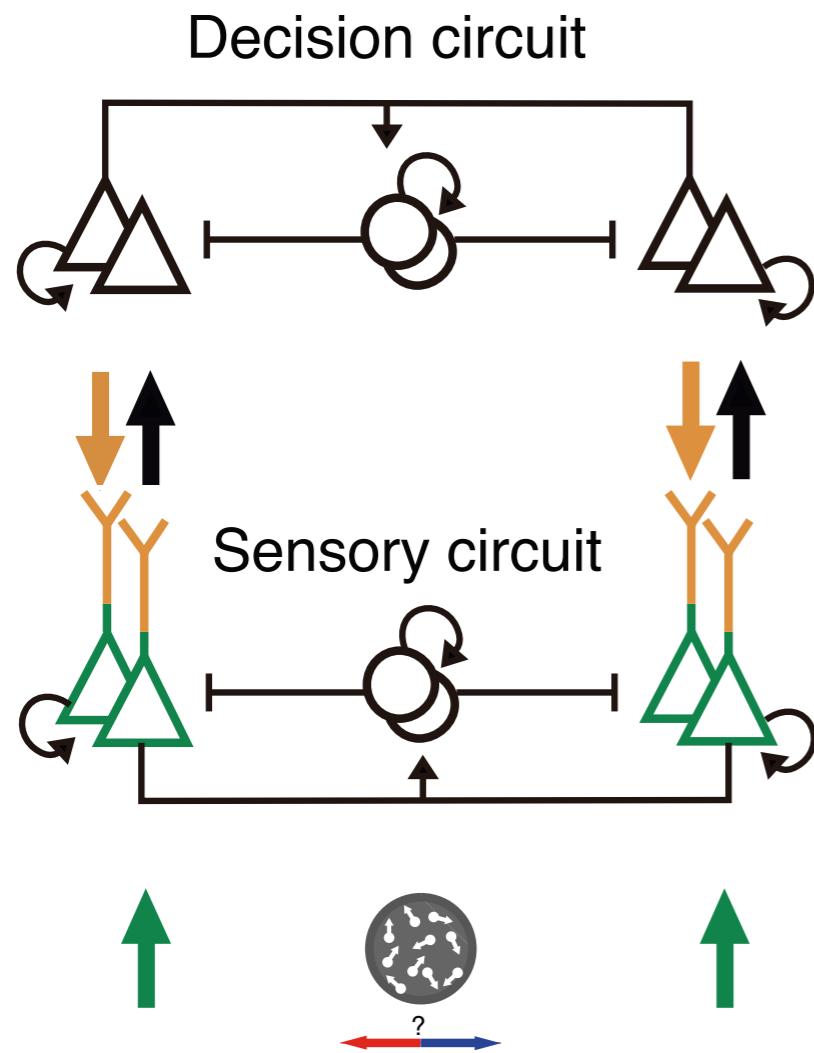
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Hierarchical network with two-compartment sensory pyramidal neurons

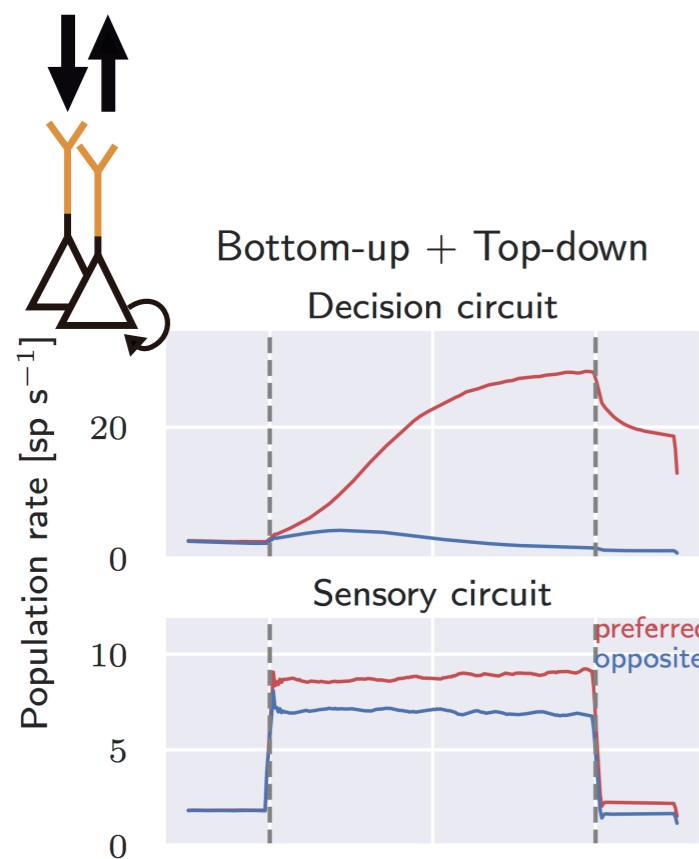


Hierarchical network with two-compartment sensory pyramidal neurons

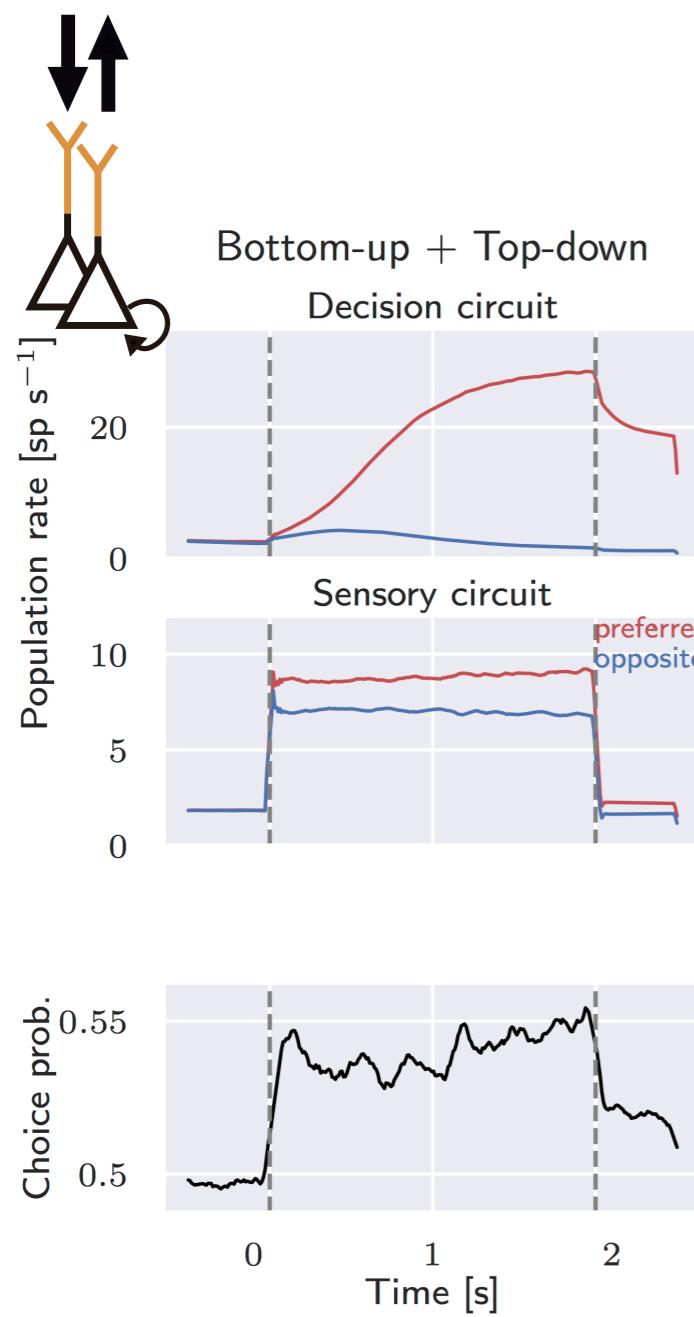


Impact of bottom-up and top-down influences on CP

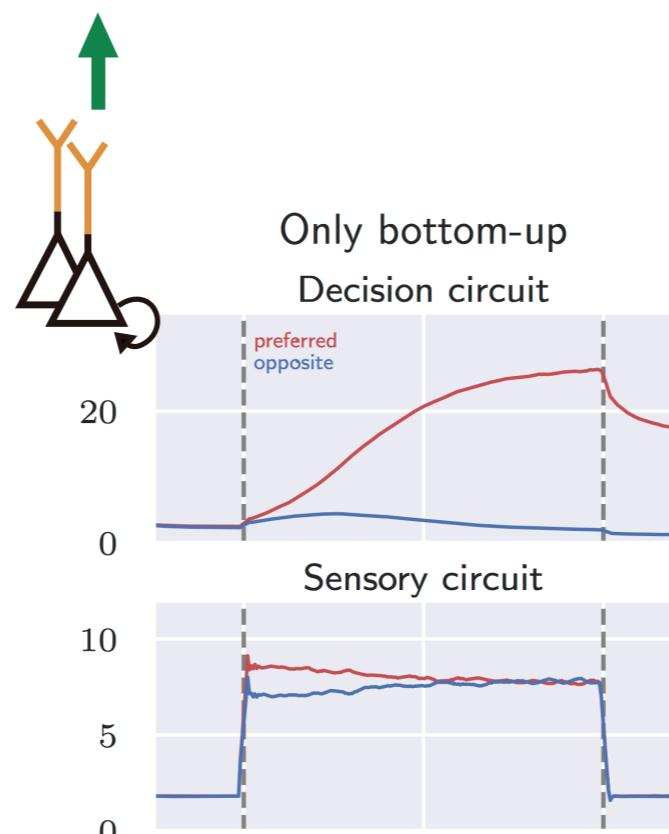
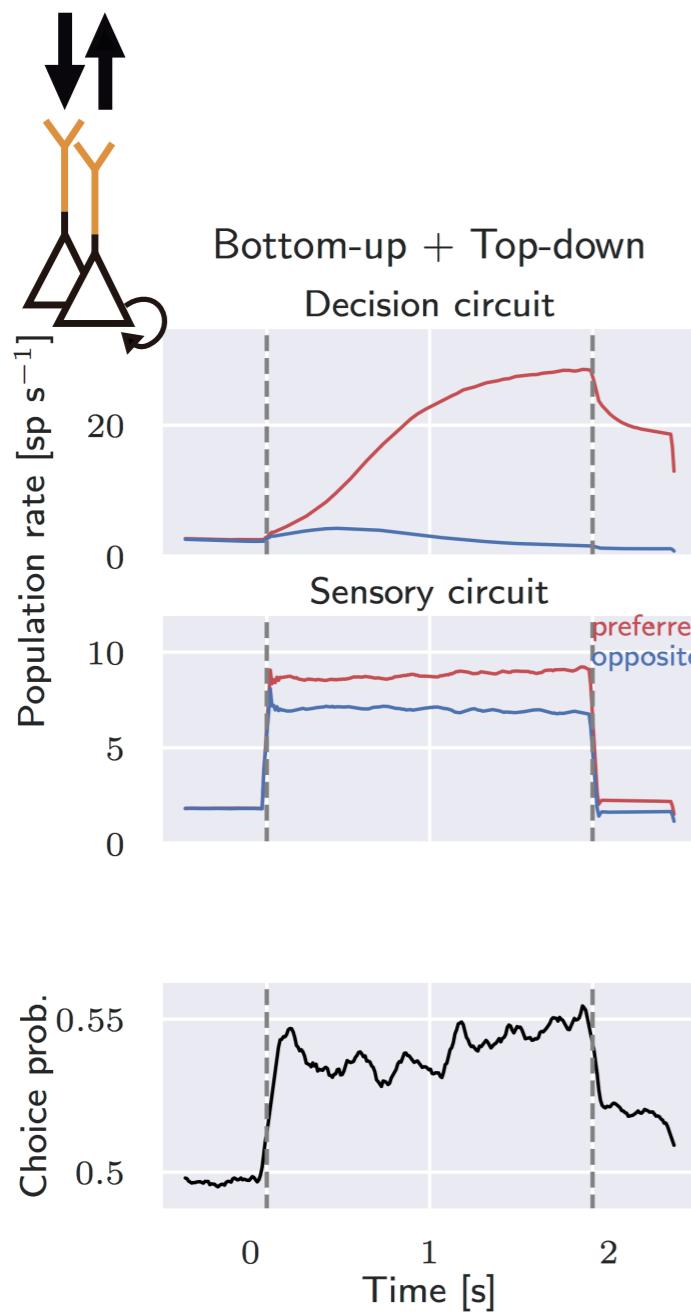
Impact of bottom-up and top-down influences on CP



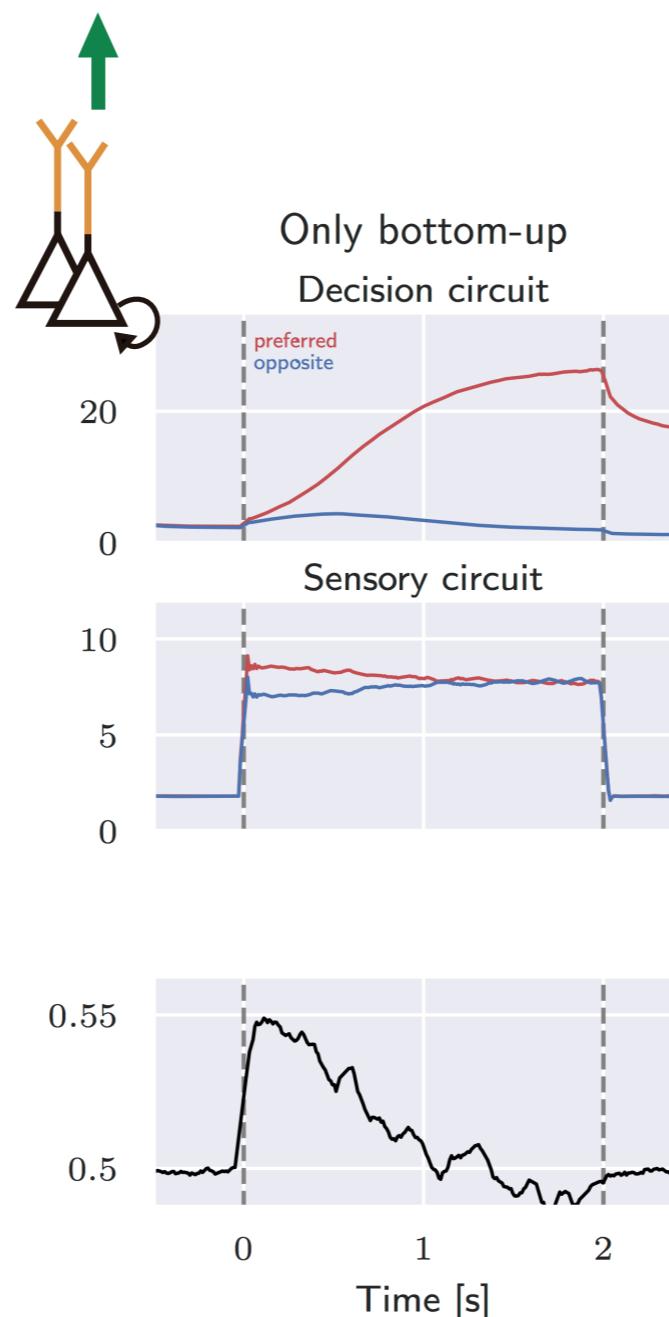
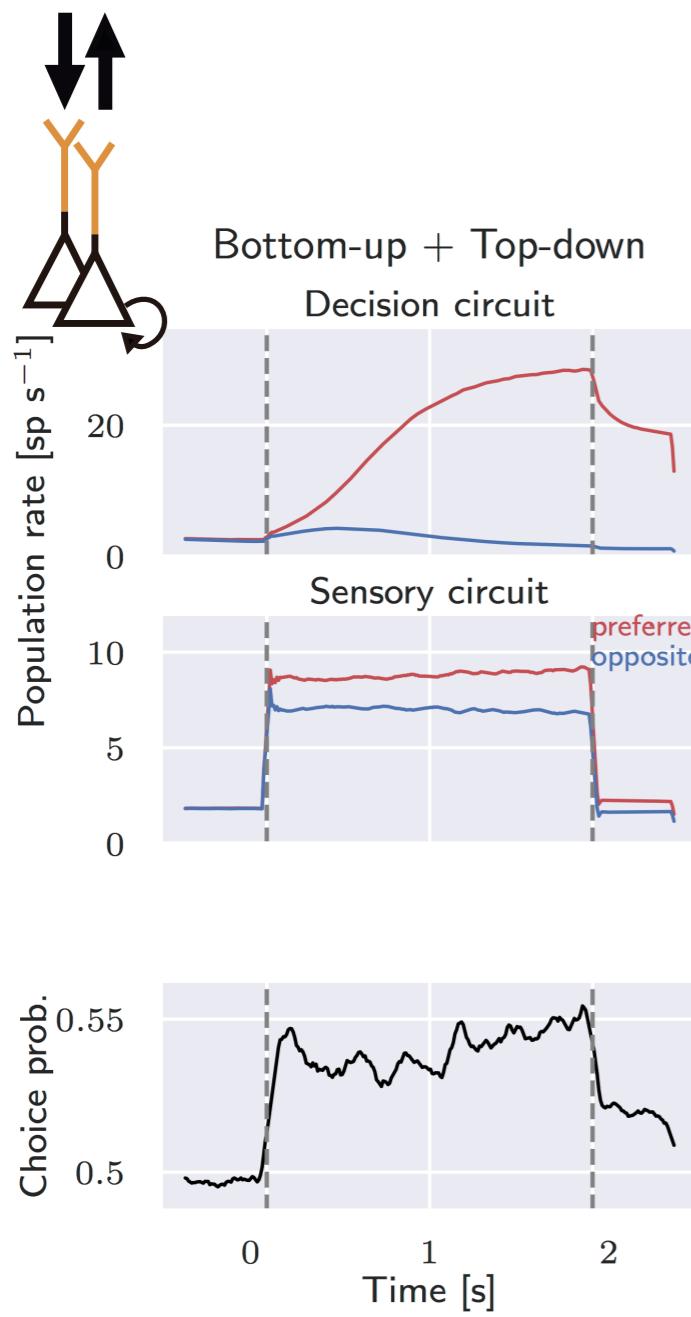
Impact of bottom-up and top-down influences on CP



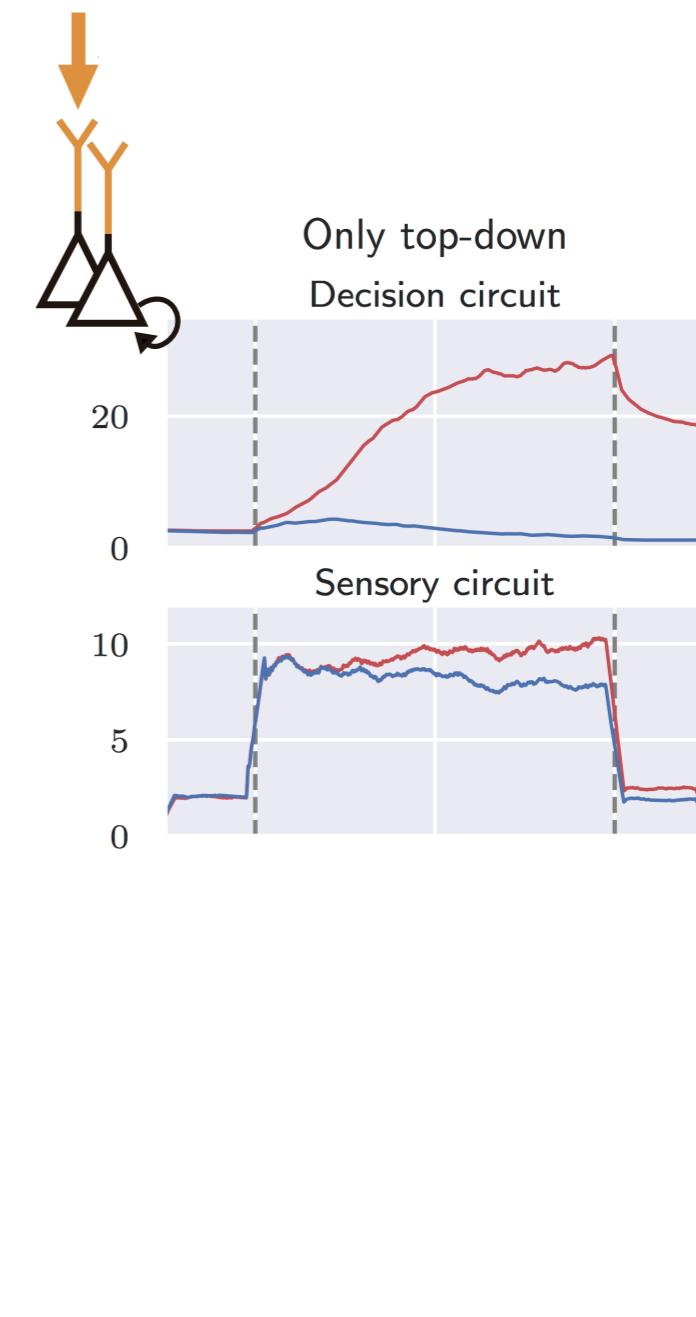
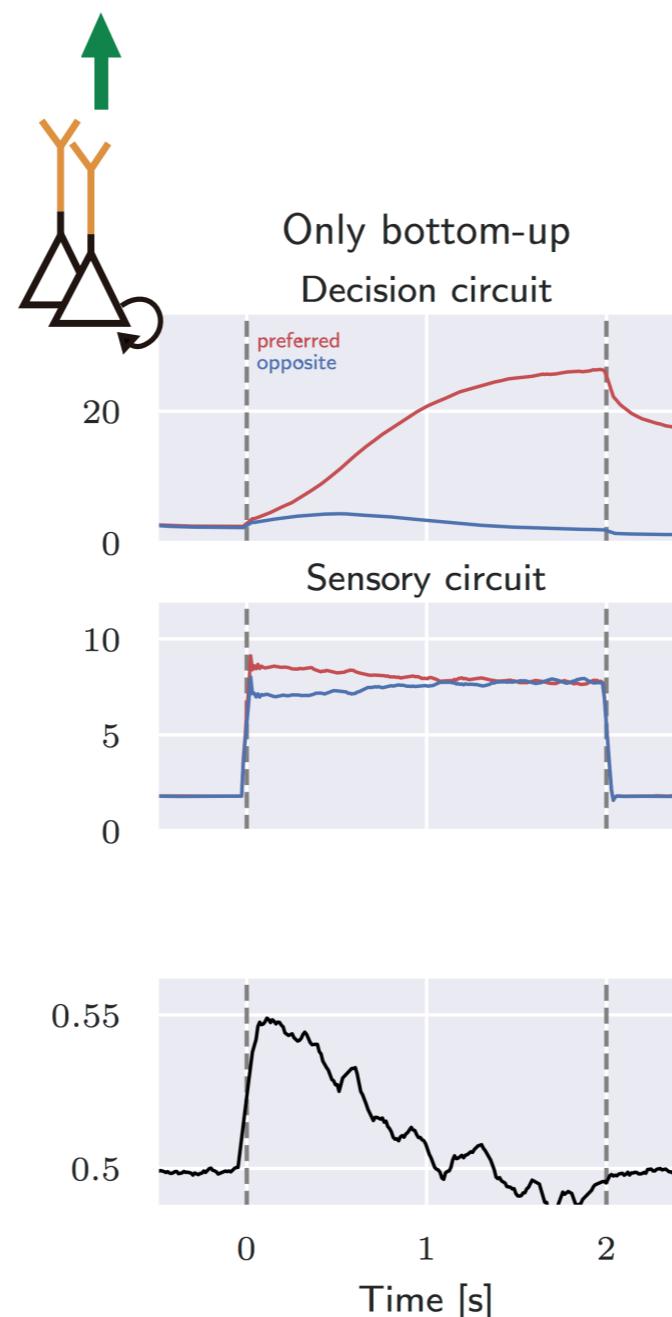
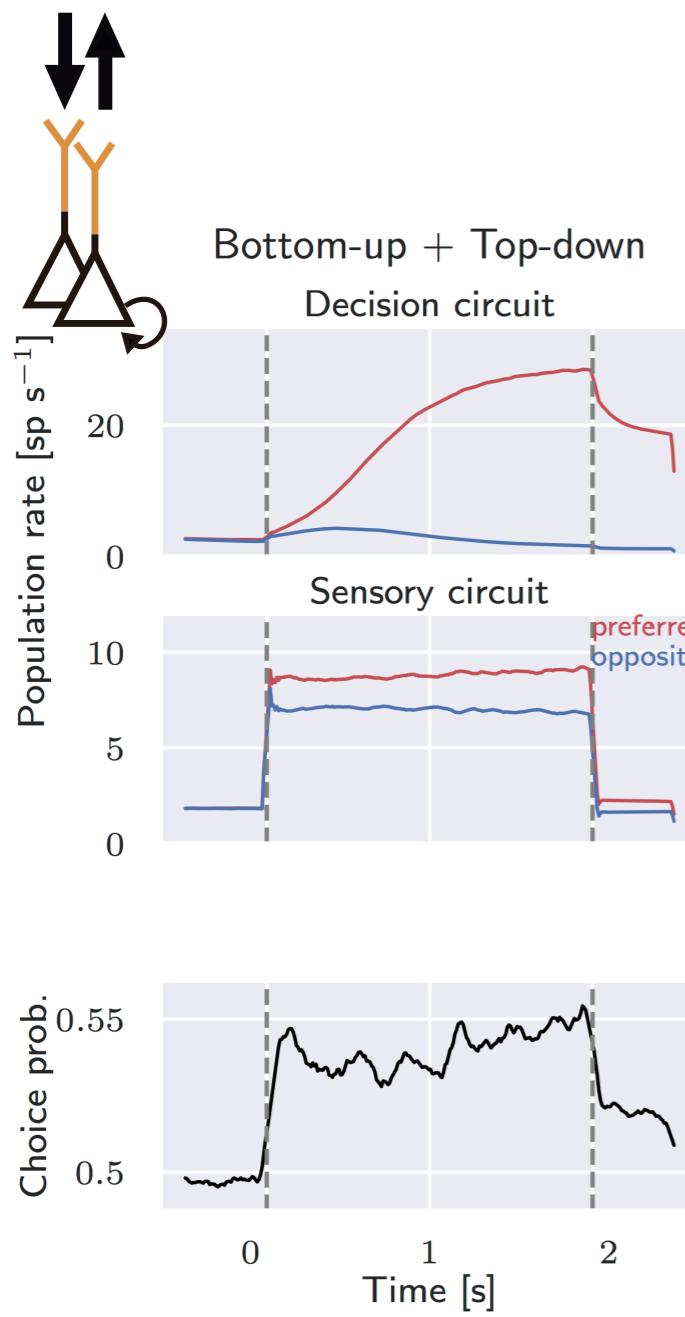
Impact of bottom-up and top-down influences on CP



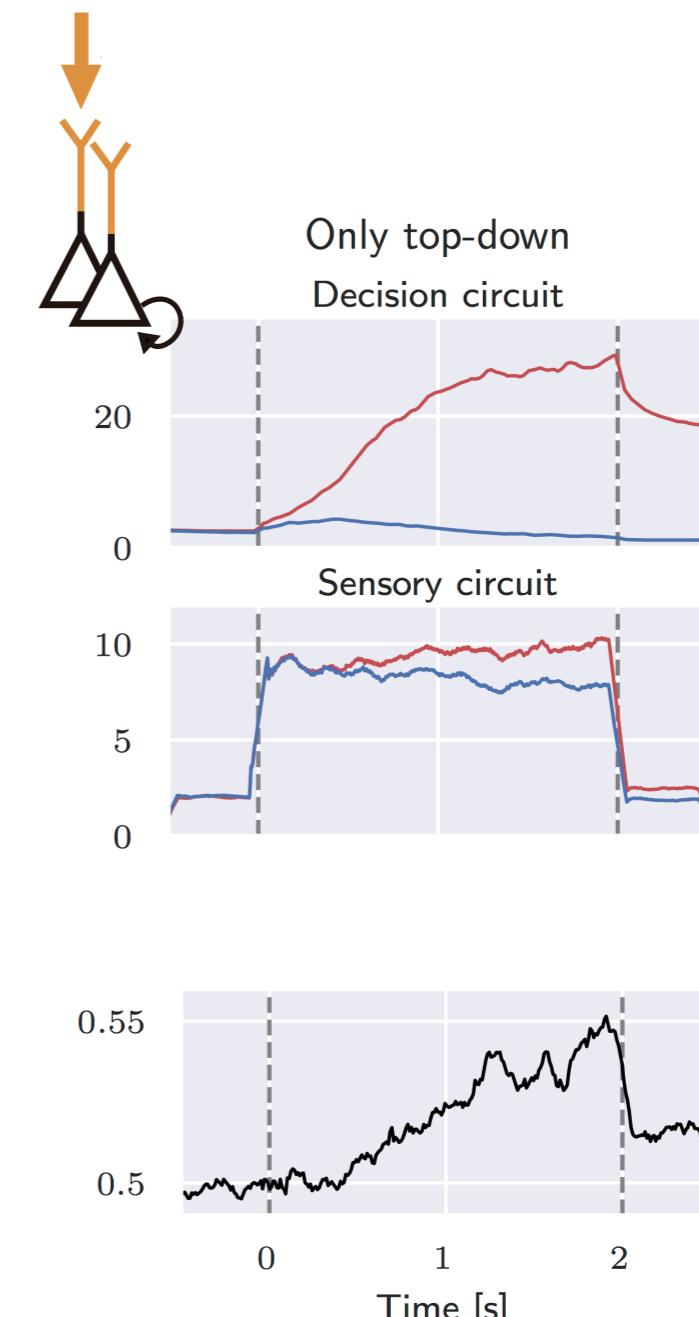
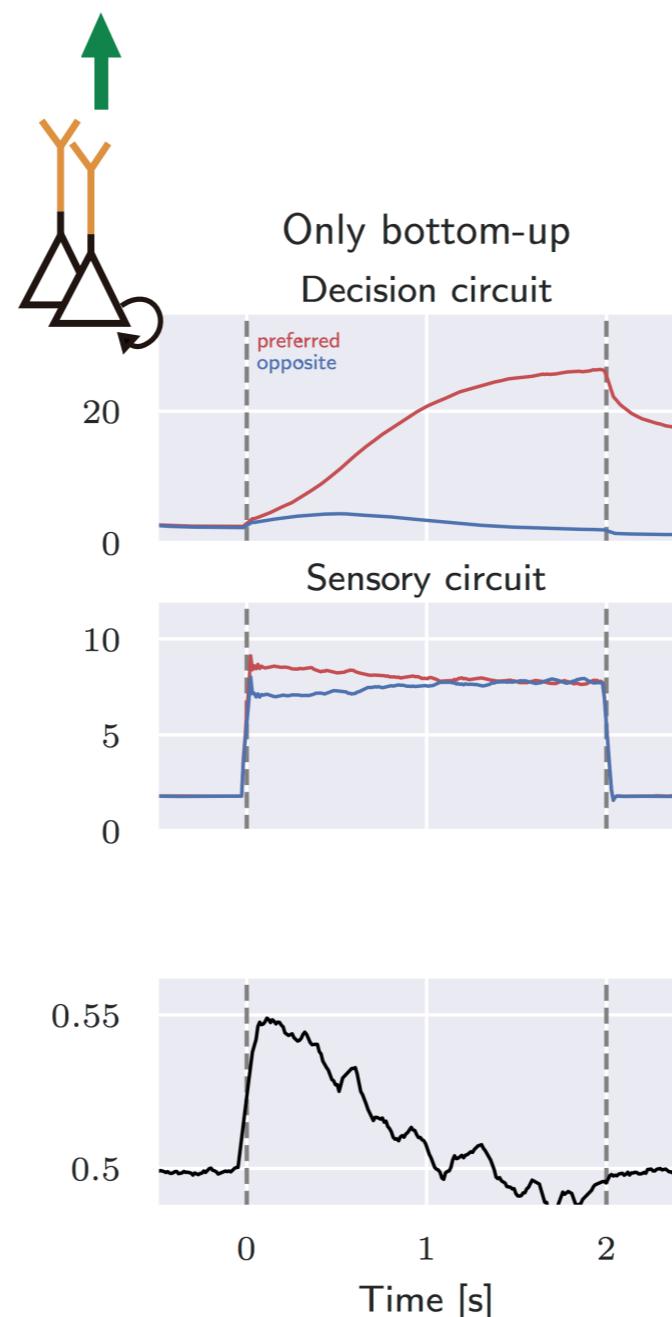
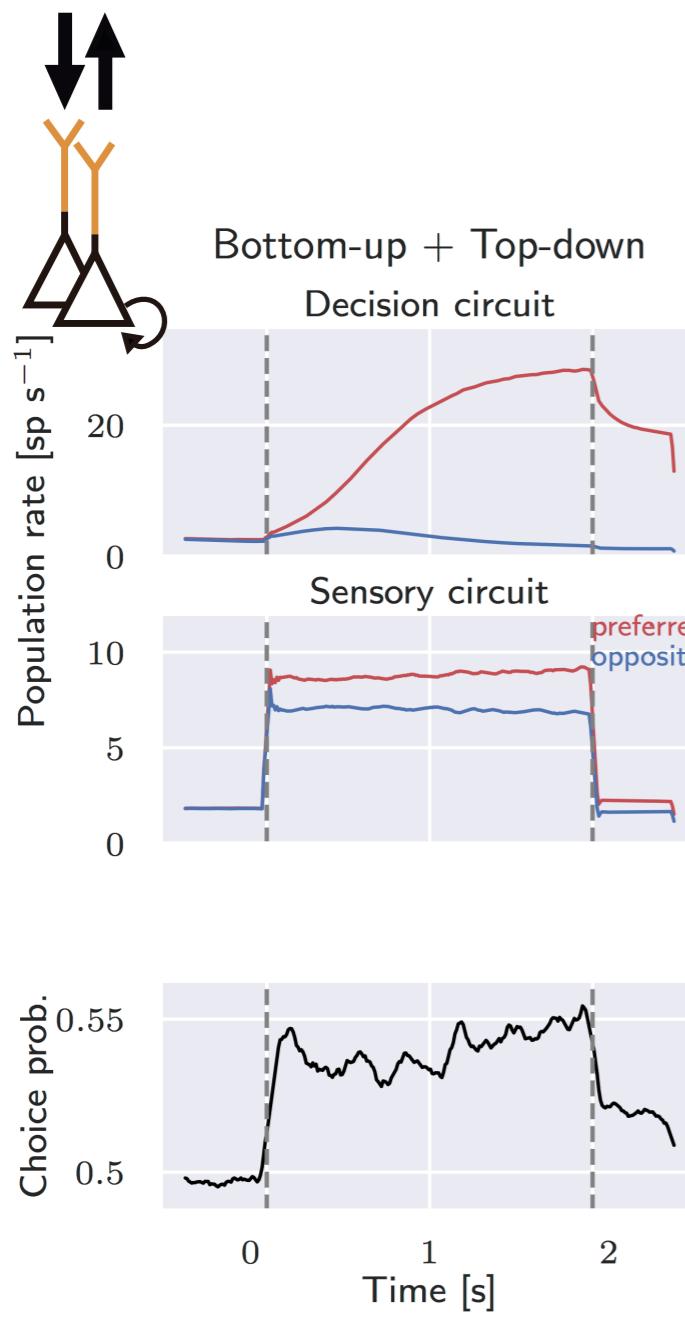
Impact of bottom-up and top-down influences on CP



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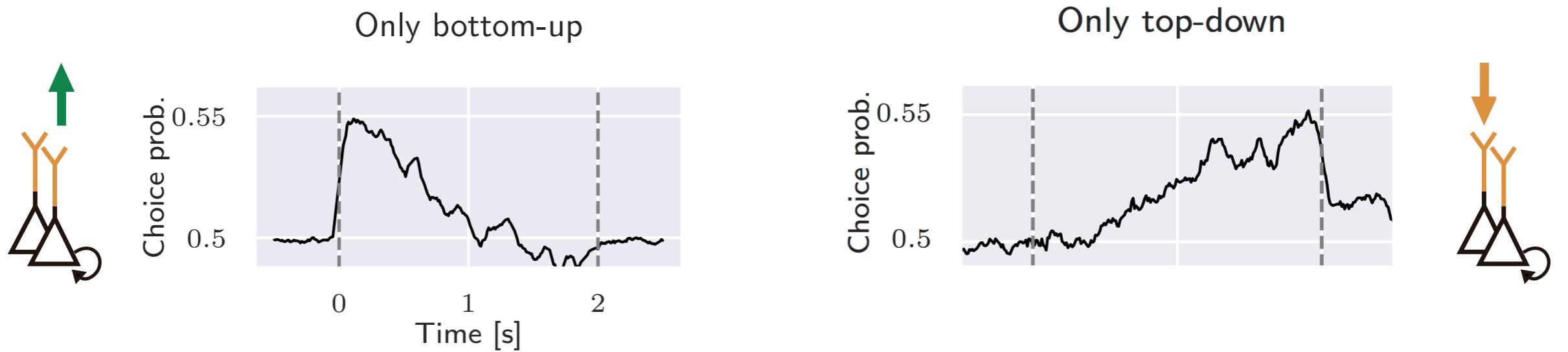


Impact of bottom-up and top-down influences on CP



Burst fraction enables decoding of top-down influences on CP

Burst fraction enables decoding of top-down influences on CP



Burst fraction enables decoding of top-down influences on CP



CP from event rate (E)

Early, transient component of CP

Burst fraction enables decoding of top-down influences on CP



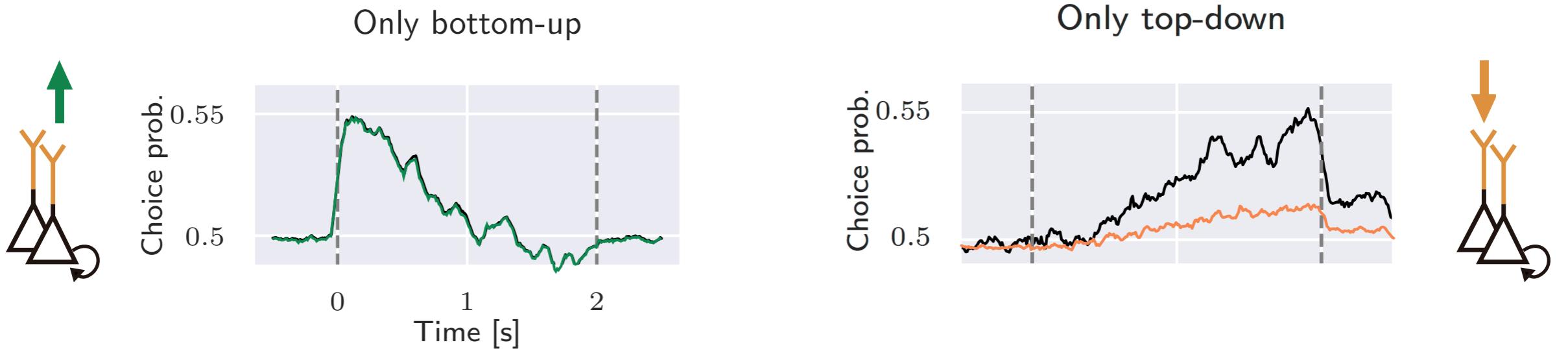
CP from event rate (E)

Early, transient component of CP

CP from burst fraction (F)

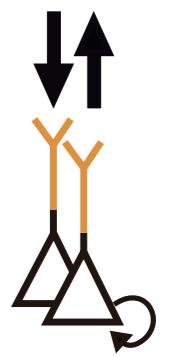
Late, ramping component of CP

Burst fraction enables decoding of top-down influences on CP



CP from event rate (E)

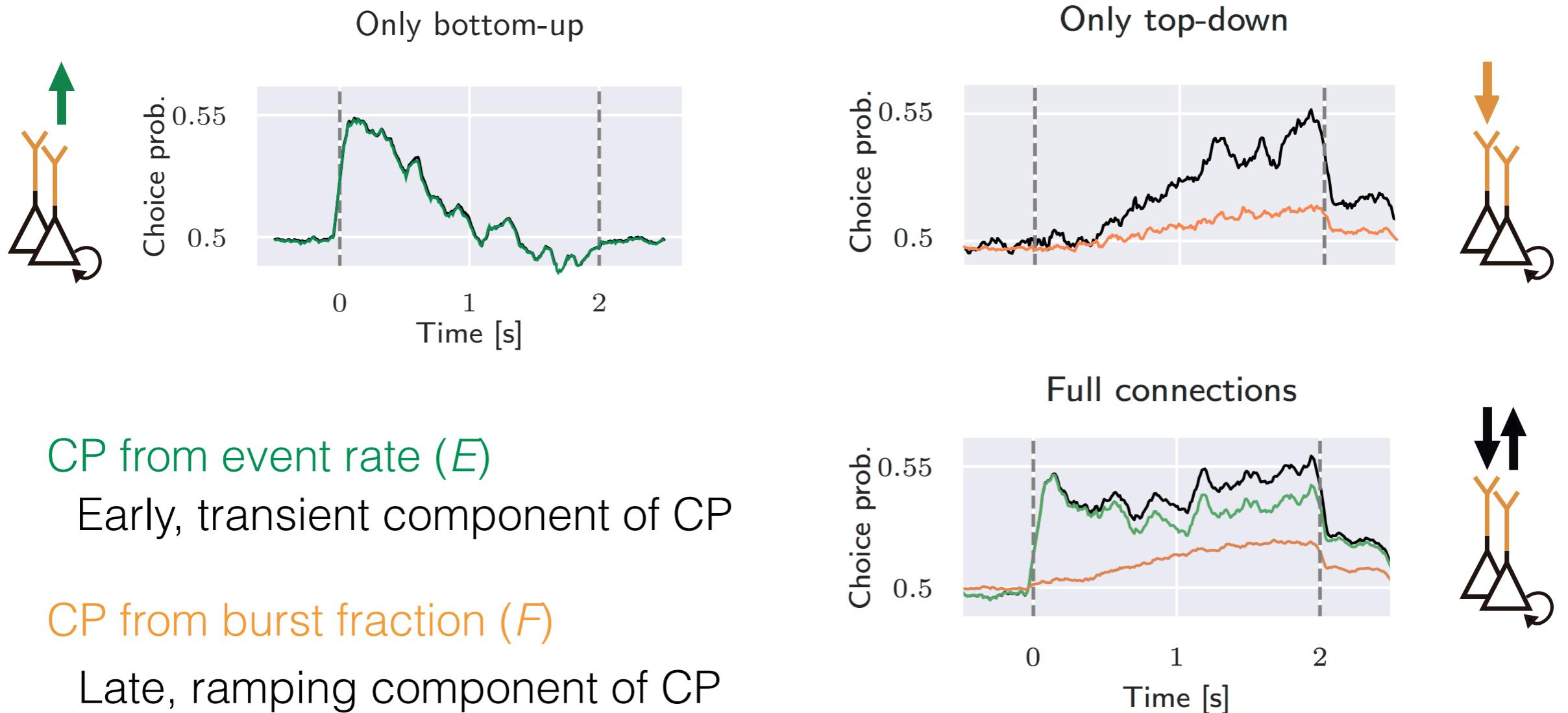
Early, transient component of CP



CP from burst fraction (F)

Late, ramping component of CP

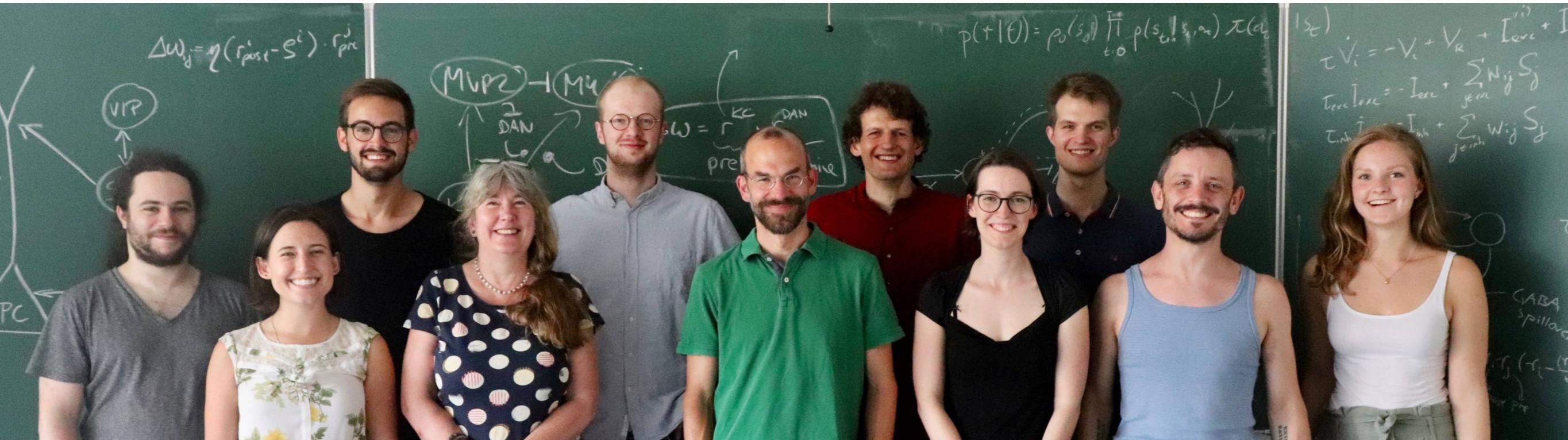
Burst fraction enables decoding of top-down influences on CP



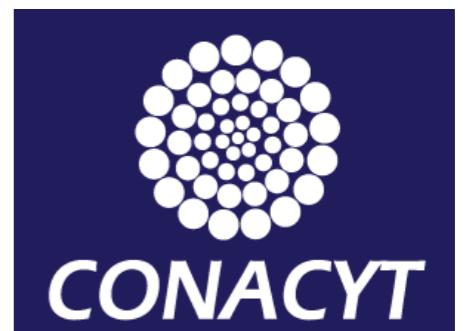
Summary

- Hierarchical network — indirect measurement
- Extended hierarchical network — direct measurement
- L5 pyramidal neurons distinguish the two streams of information by separating single spikes and bursts,:
 - *Event rate* signals the *bottom-up* stream
 - *Burst probability* represents the *top-down* stream

Thank you!



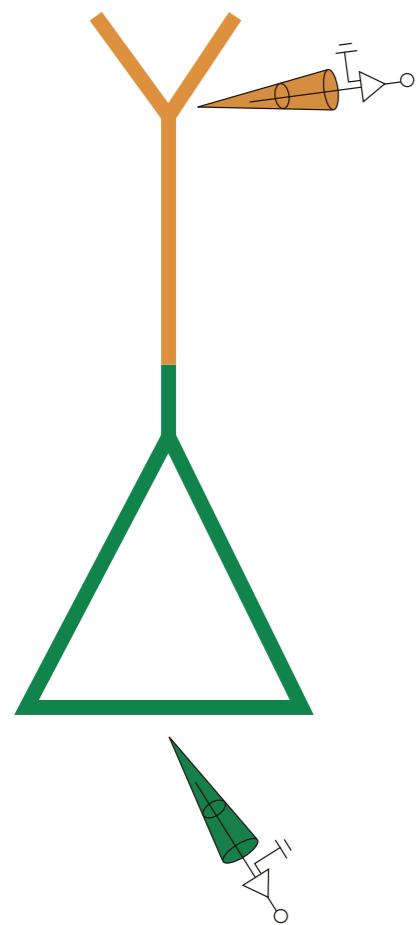
LARKUM LAB



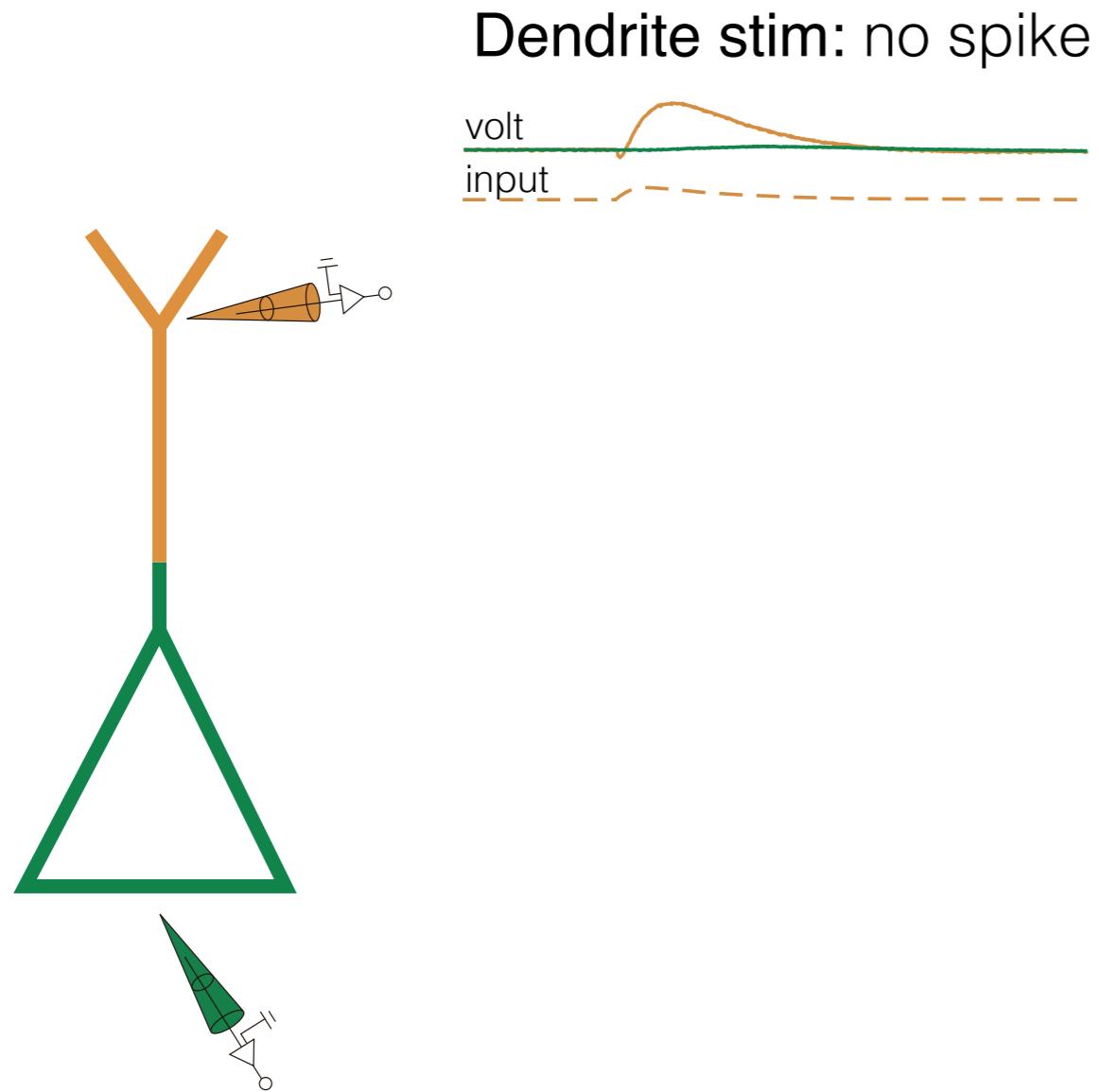
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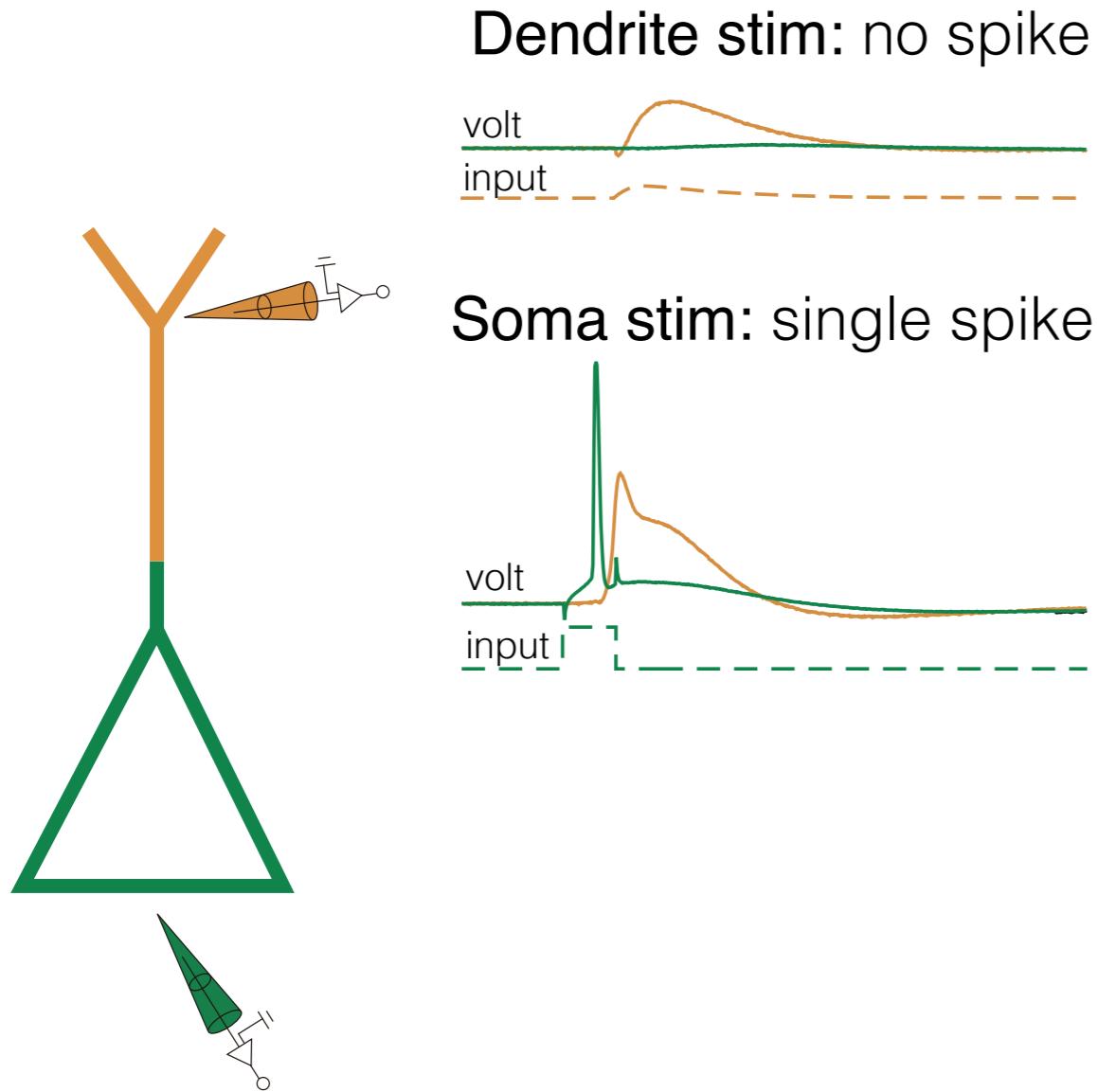
Two-compartment neurons encode different input streams via spiking patterns



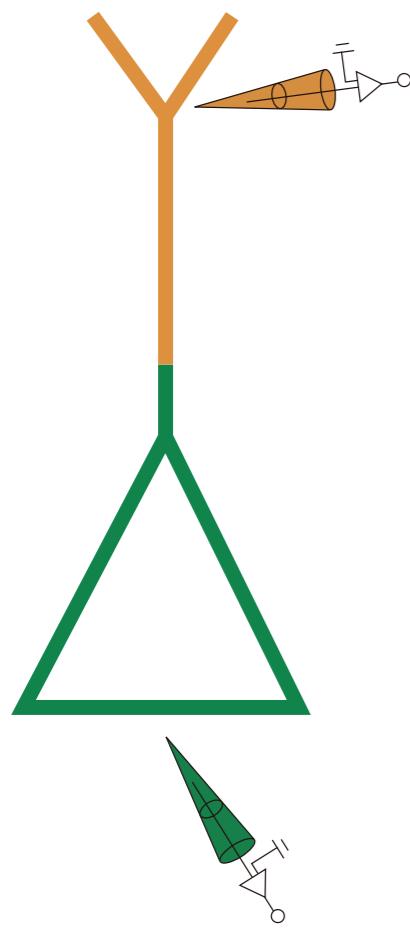
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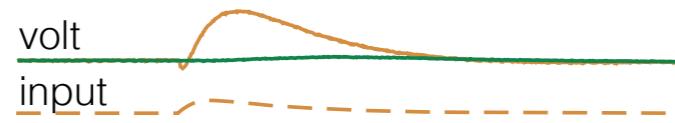
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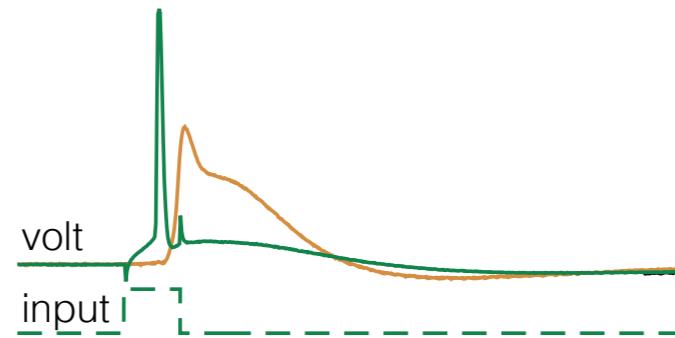
Two-compartment neurons encode different input streams via spiking patterns



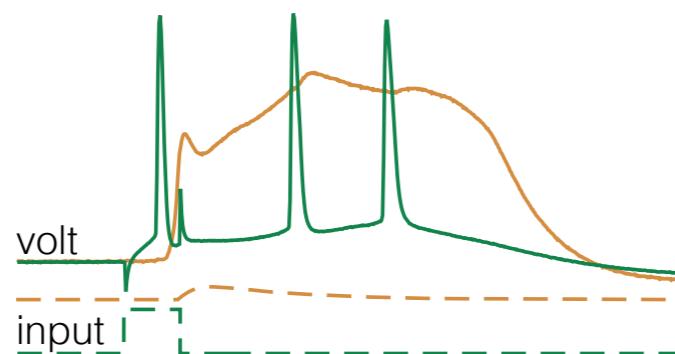
Dendrite stim: no spike



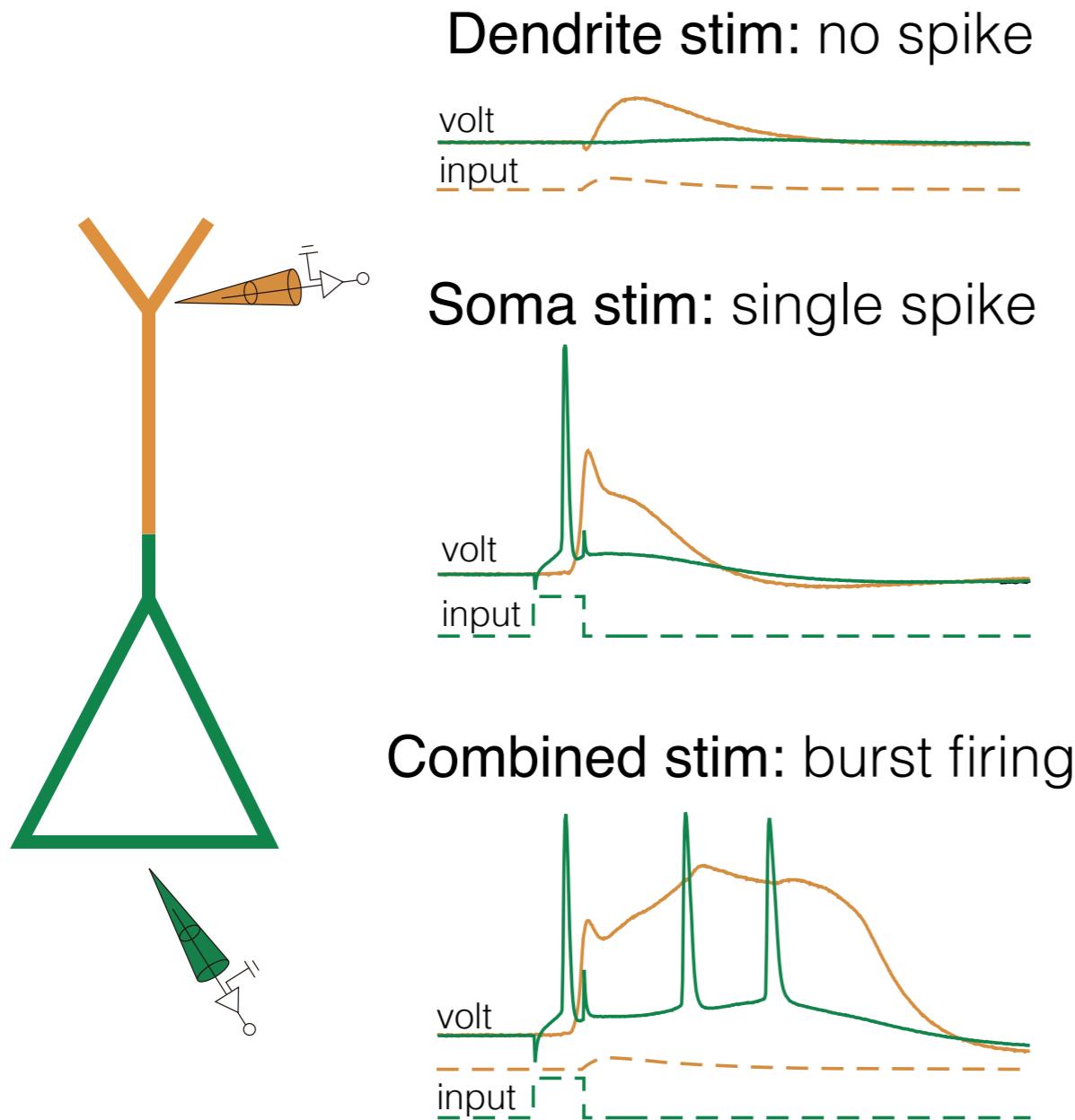
Soma stim: single spike



Combined stim: burst firing

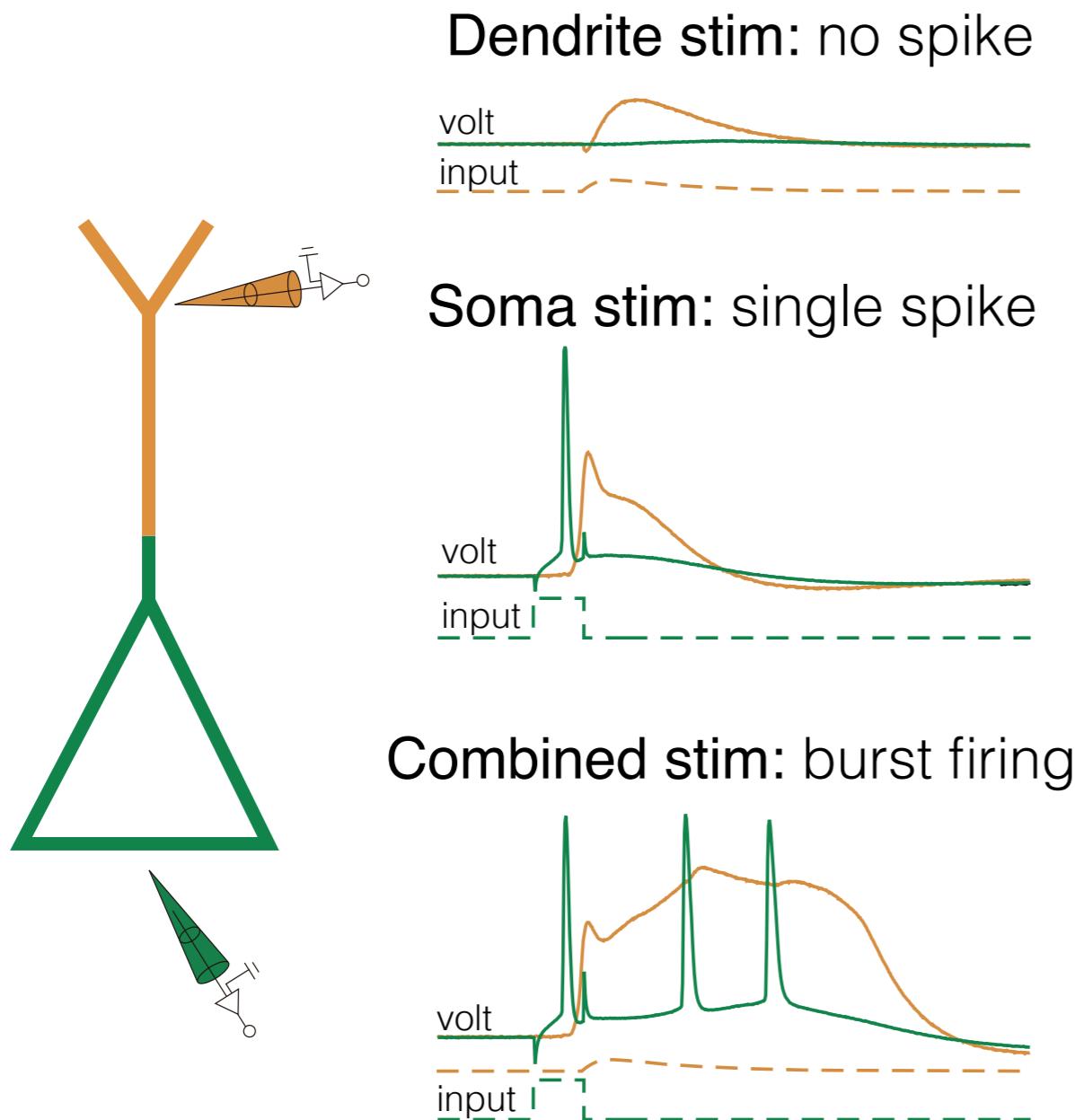


Two-compartment neurons encode different input streams via spiking patterns



Multiplexed neural code

Two-compartment neurons encode different input streams via spiking patterns



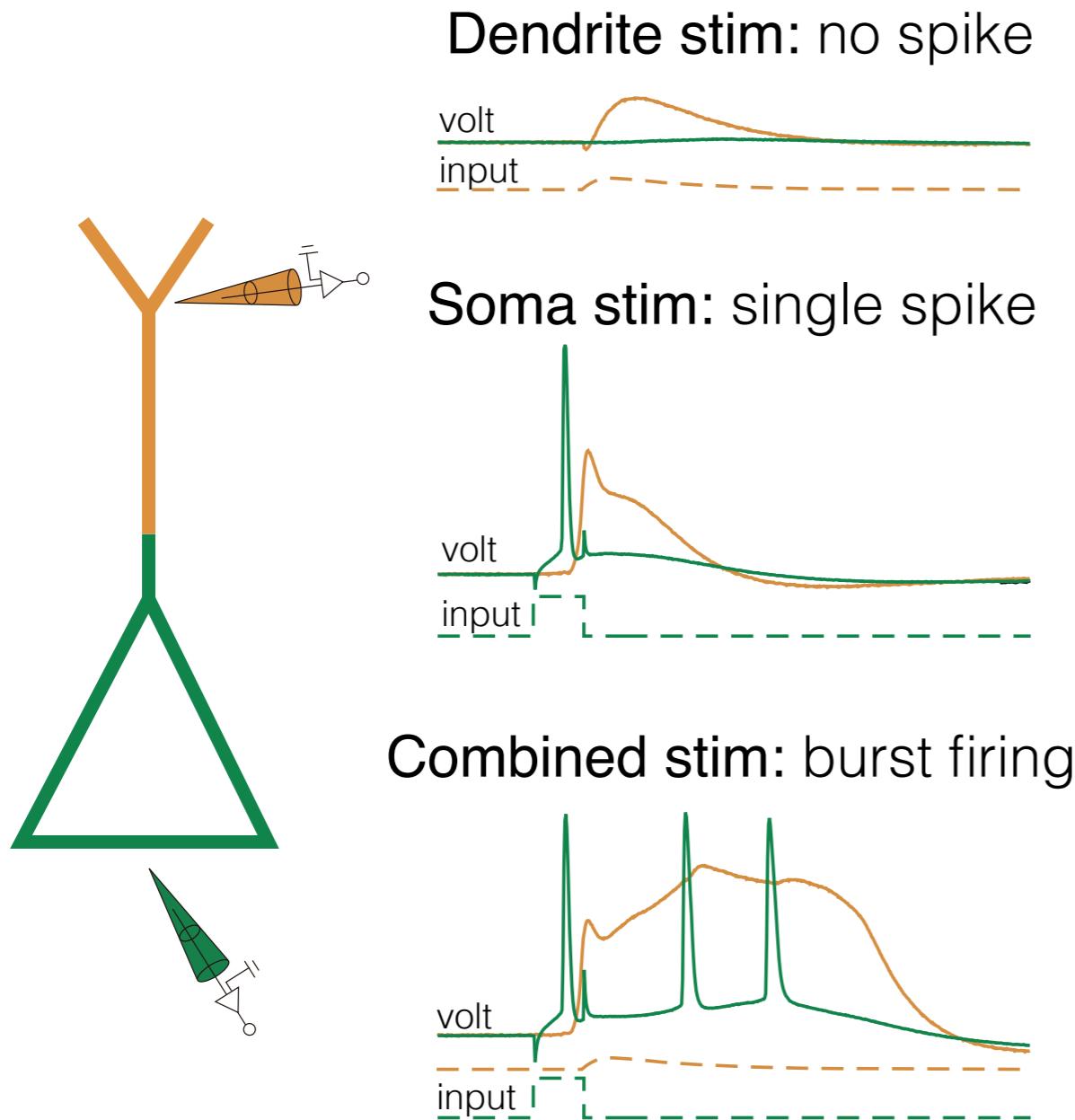
Multiplexed neural code

spikes

bursts

events

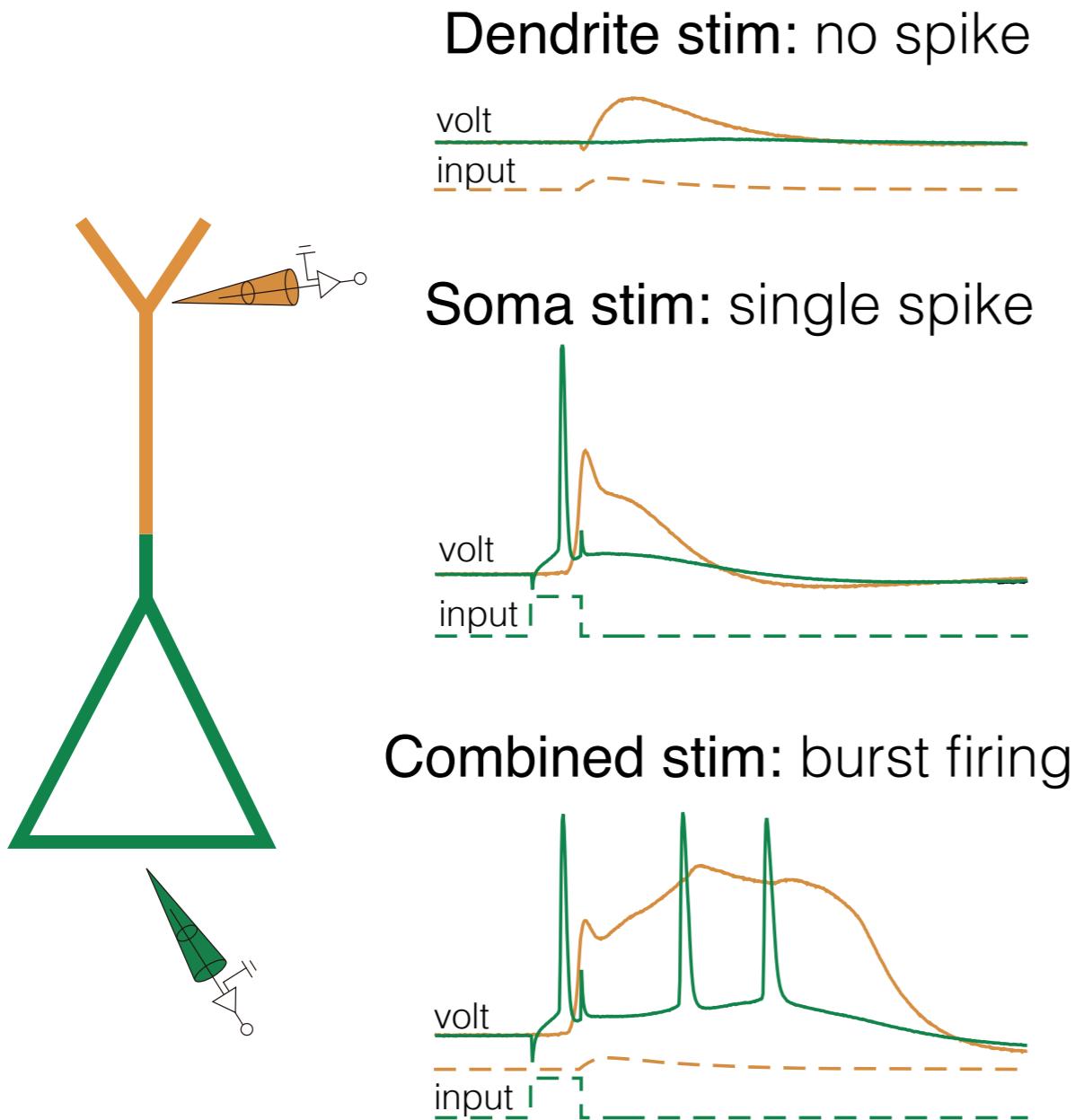
Two-compartment neurons encode different input streams via spiking patterns



Multiplexed neural code

spikes			
bursts			
events			

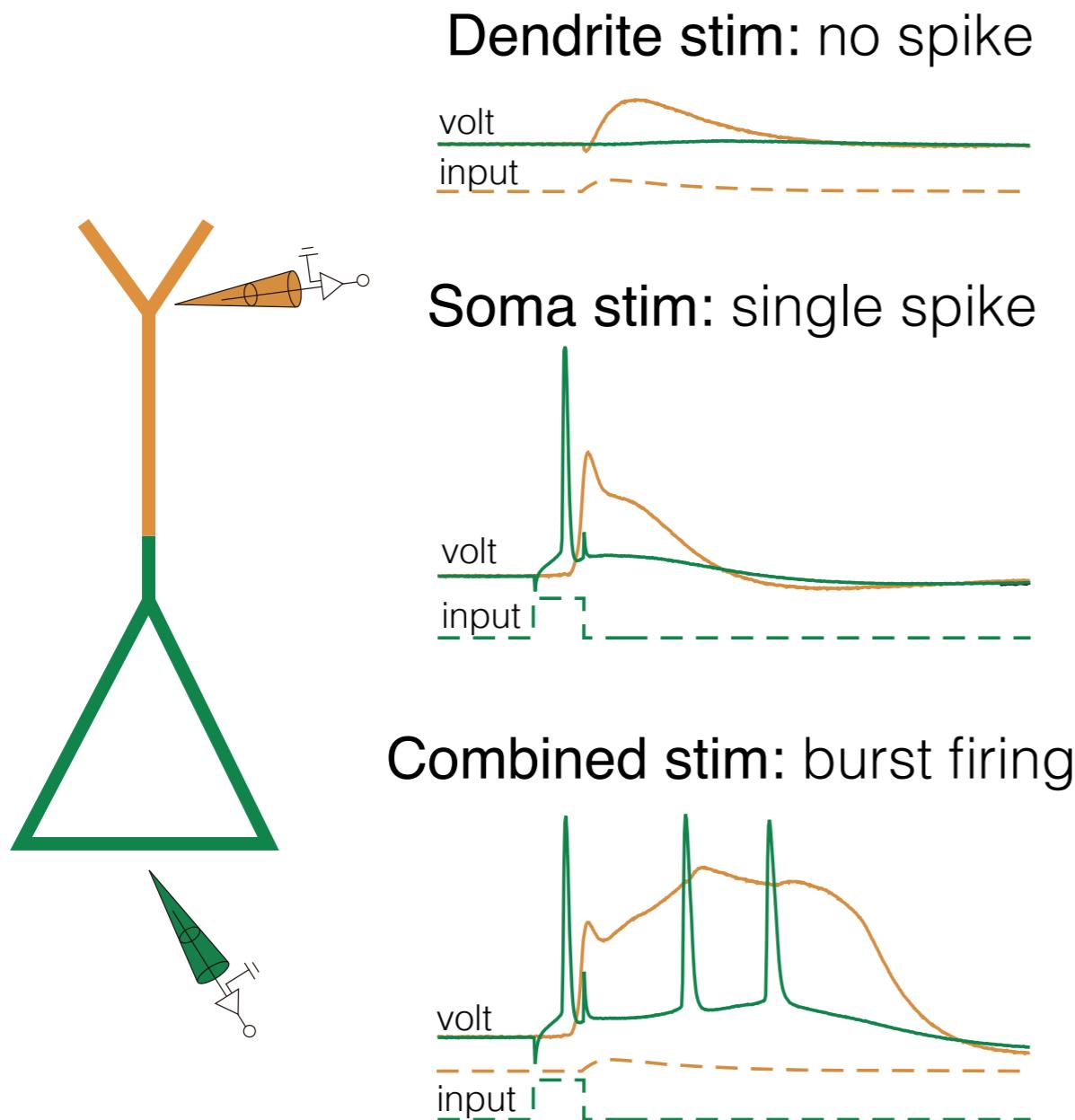
Two-compartment neurons encode different input streams via spiking patterns



Multiplexed neural code

		Rate
spikes		5 Hz
bursts		1 Hz
events		3 Hz

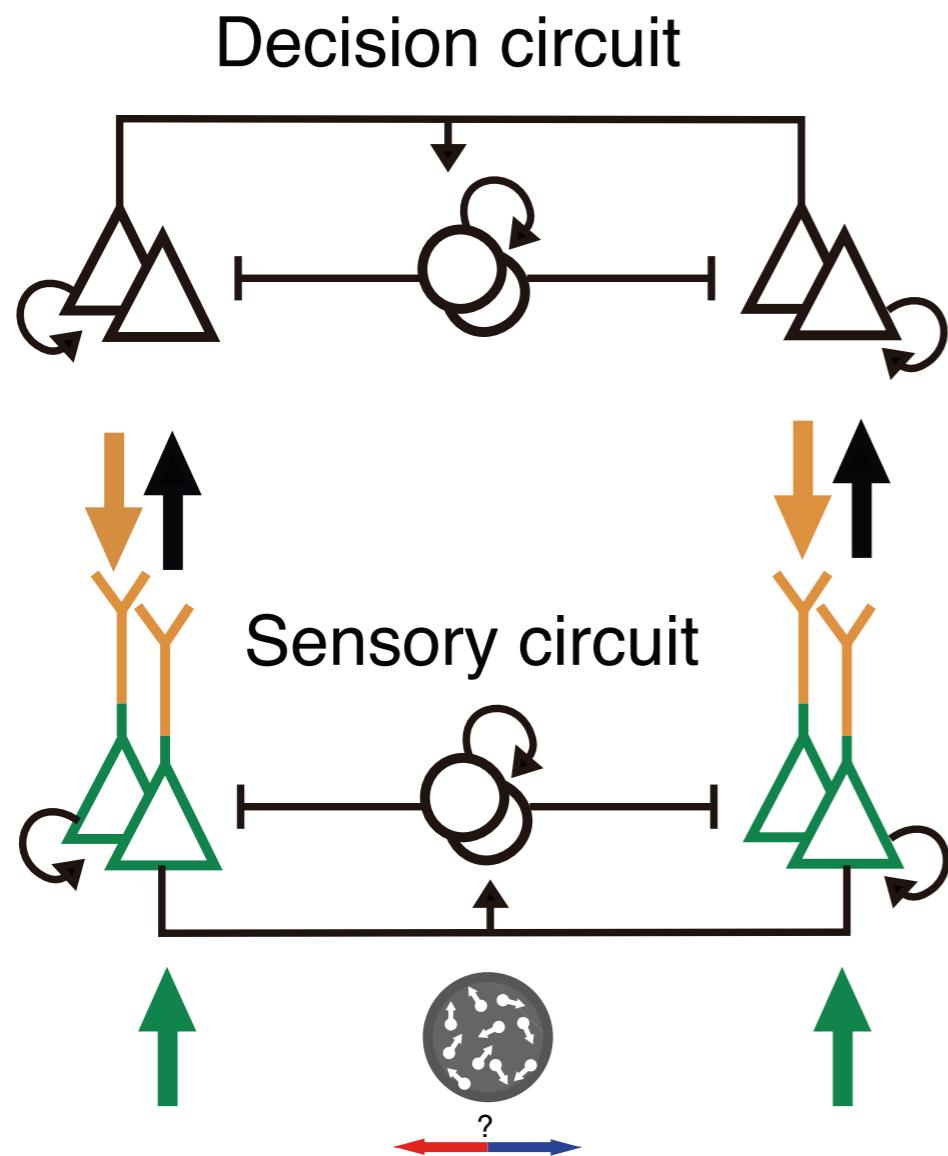
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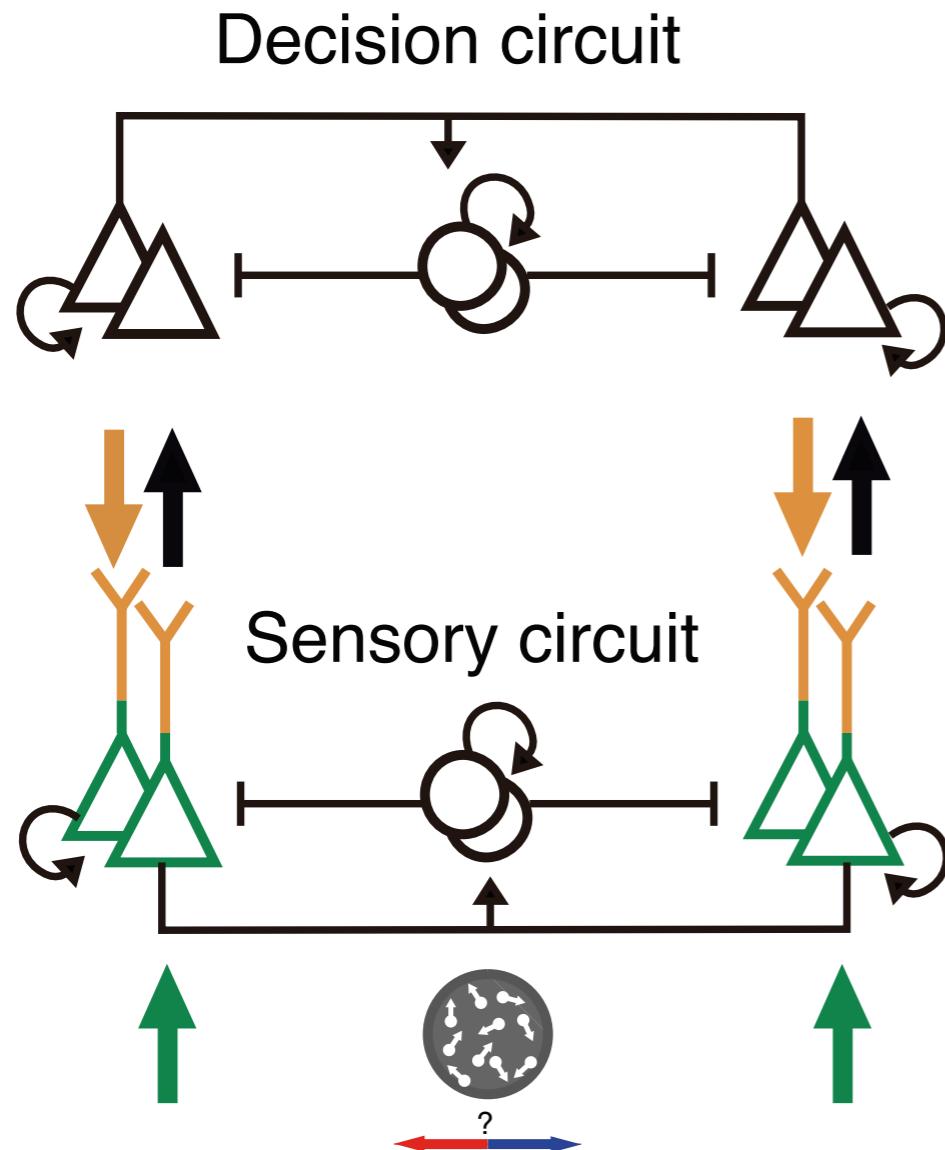
Multiplexed neural code

		Rate
spikes		5 Hz
bursts		1 Hz
events		3 Hz
BF = bursts / events =		0.33

Hierarchical network with two-compartment sensory neurons



Hierarchical network with two-compartment sensory neurons

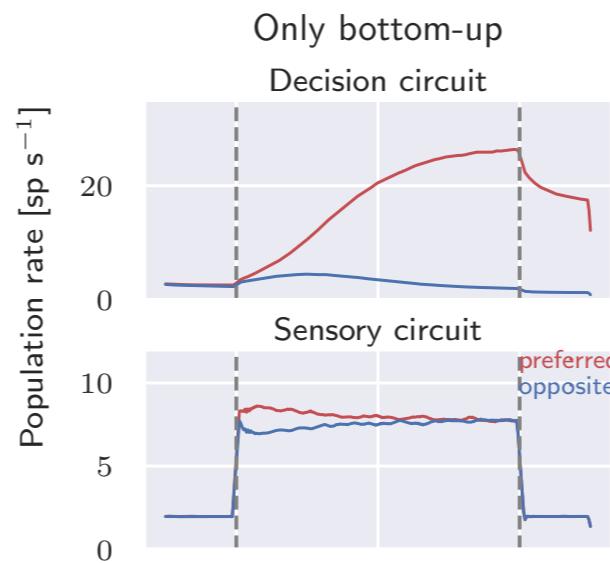


	HN	2c	EHN	
$C_m^{(s)}$	250	370	370	pF
$\tau_m^{(s)}$	15	16	16	ms
τ_{ref}	2	3	3	ms
E_{inh}	-80	-70	-80	mV
$a_w^{(d)}$	-	-13	-30	pA
$b_w^{(s)}$	-	-200	0	pA
$\bar{g}_{\text{I},\text{GABA}_A}$	1.52	-	2	nS
I_0	80	120	175	pA
b_{FB}	1	-	20	-
$\sim \bar{I}_{\text{E},\text{AMPA}}^{(d)}$	-	400	200	pA

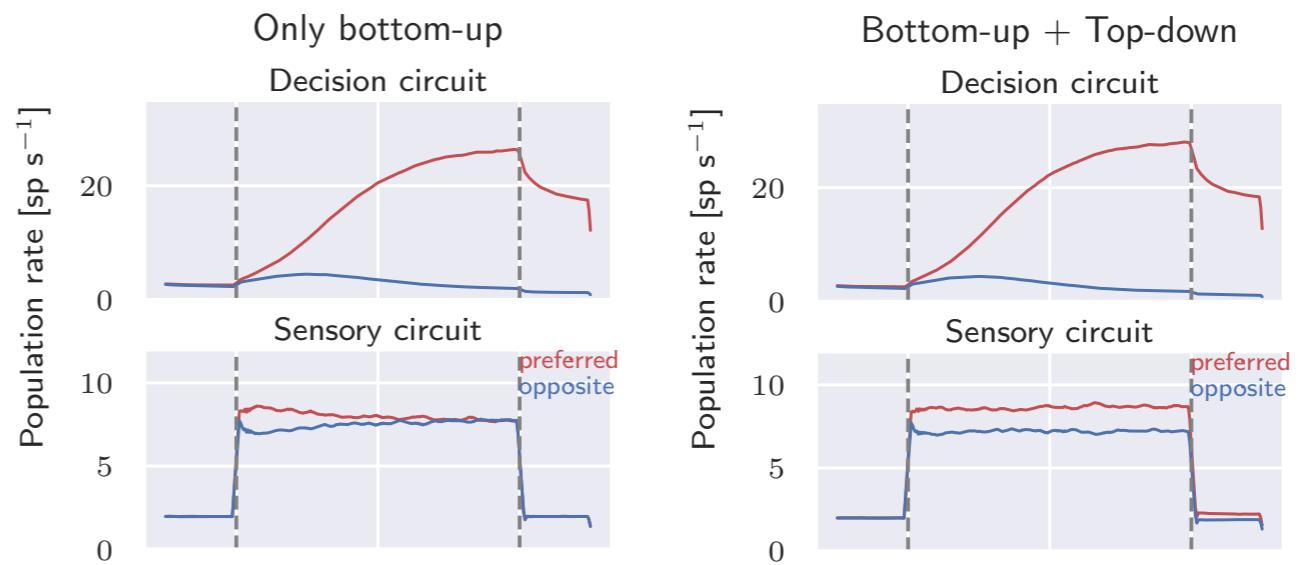
Hierarchical network is a model for perceptual decision making

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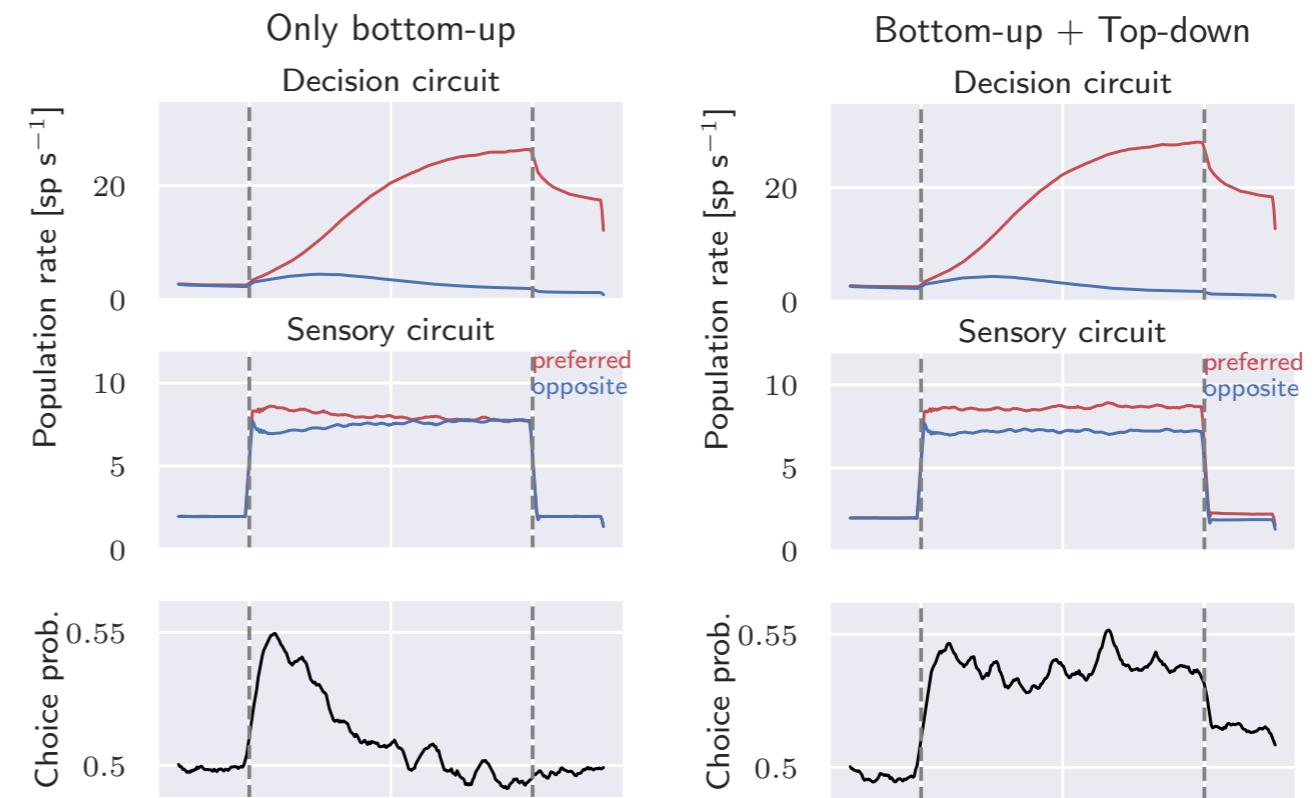
Hierarchical network is a model for perceptual decision making



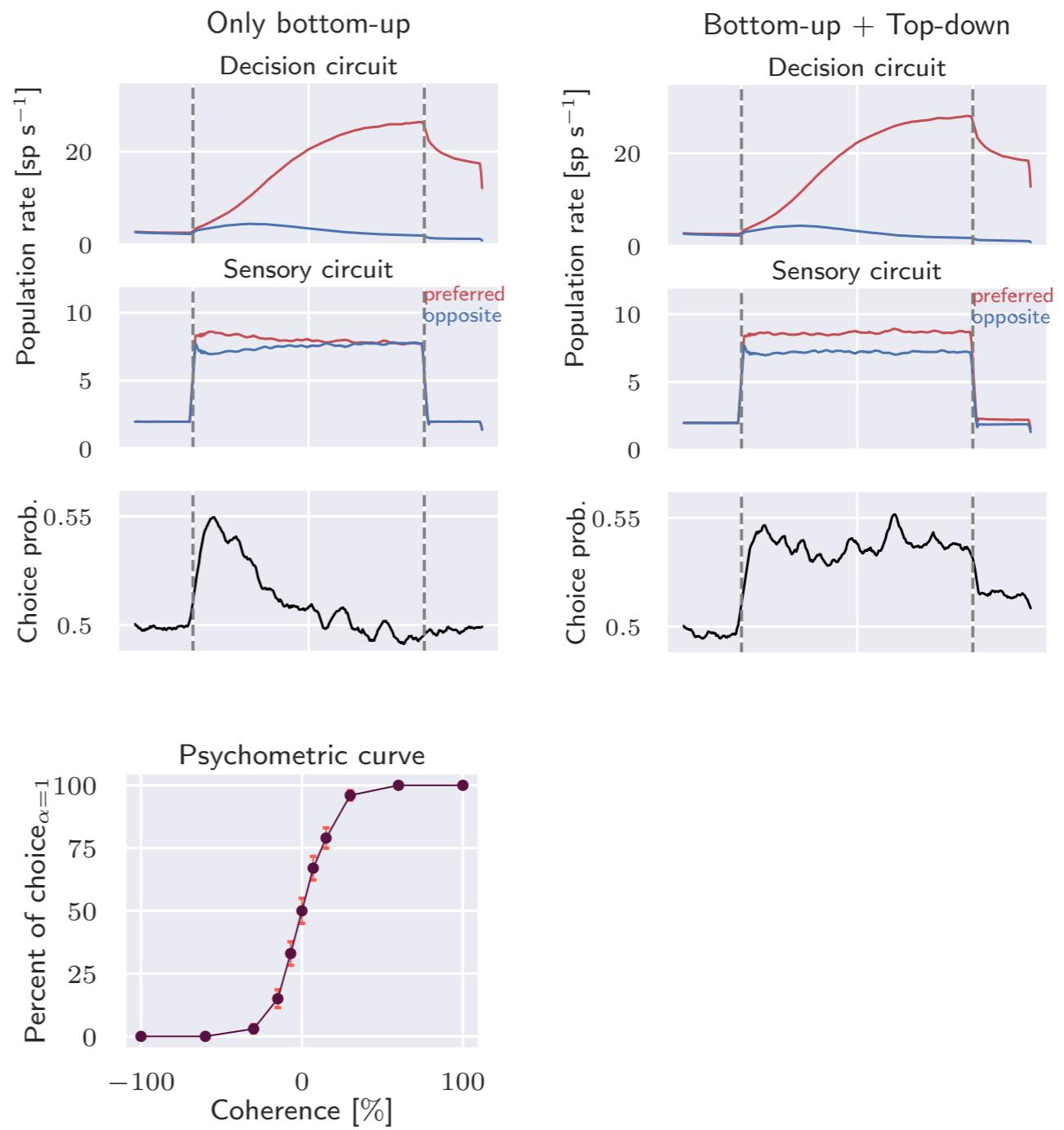
Hierarchical network is a model for perceptual decision making



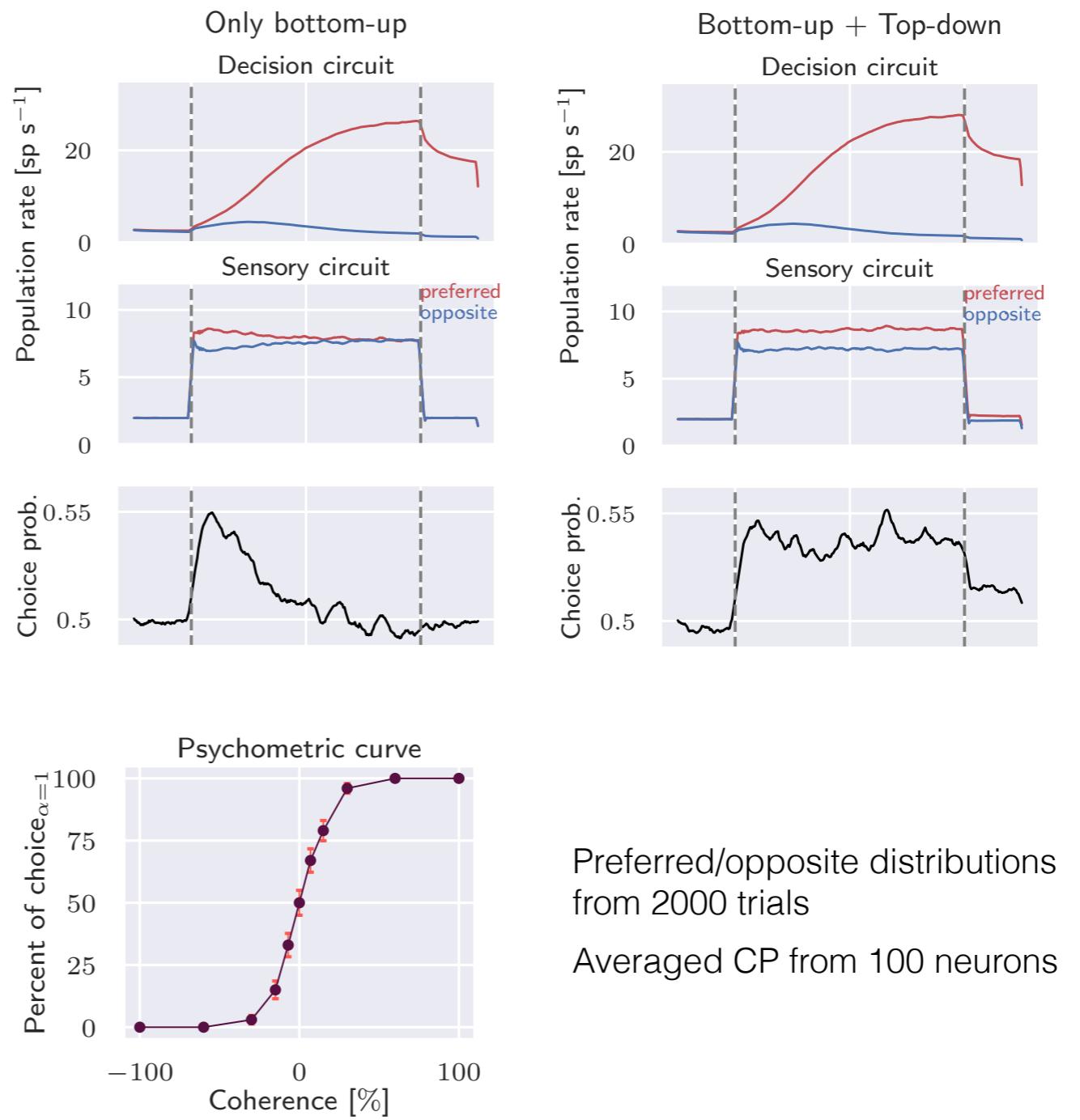
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Hierarchical network is a model for perceptual decision making

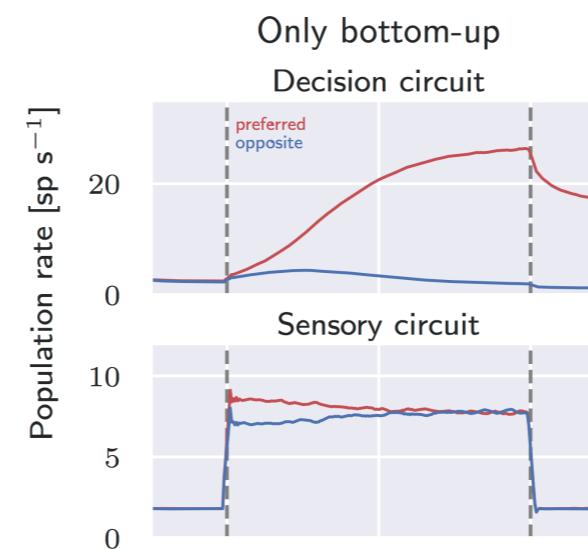


Hierarchical network is a model for perceptual decision making

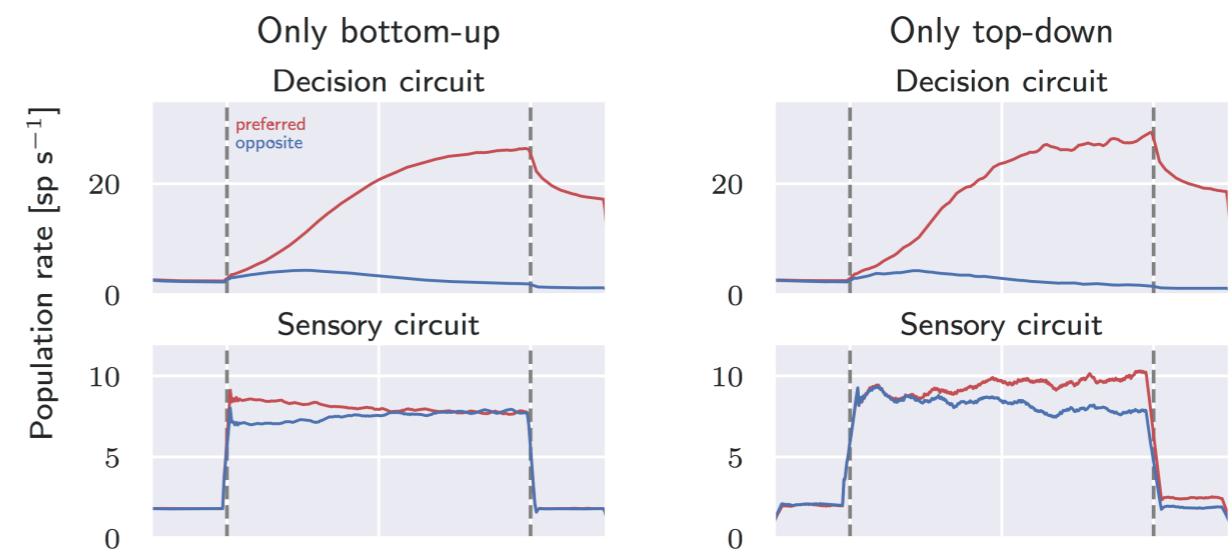


Hierarchical network with 2c sensory neurons still
solves decision making task

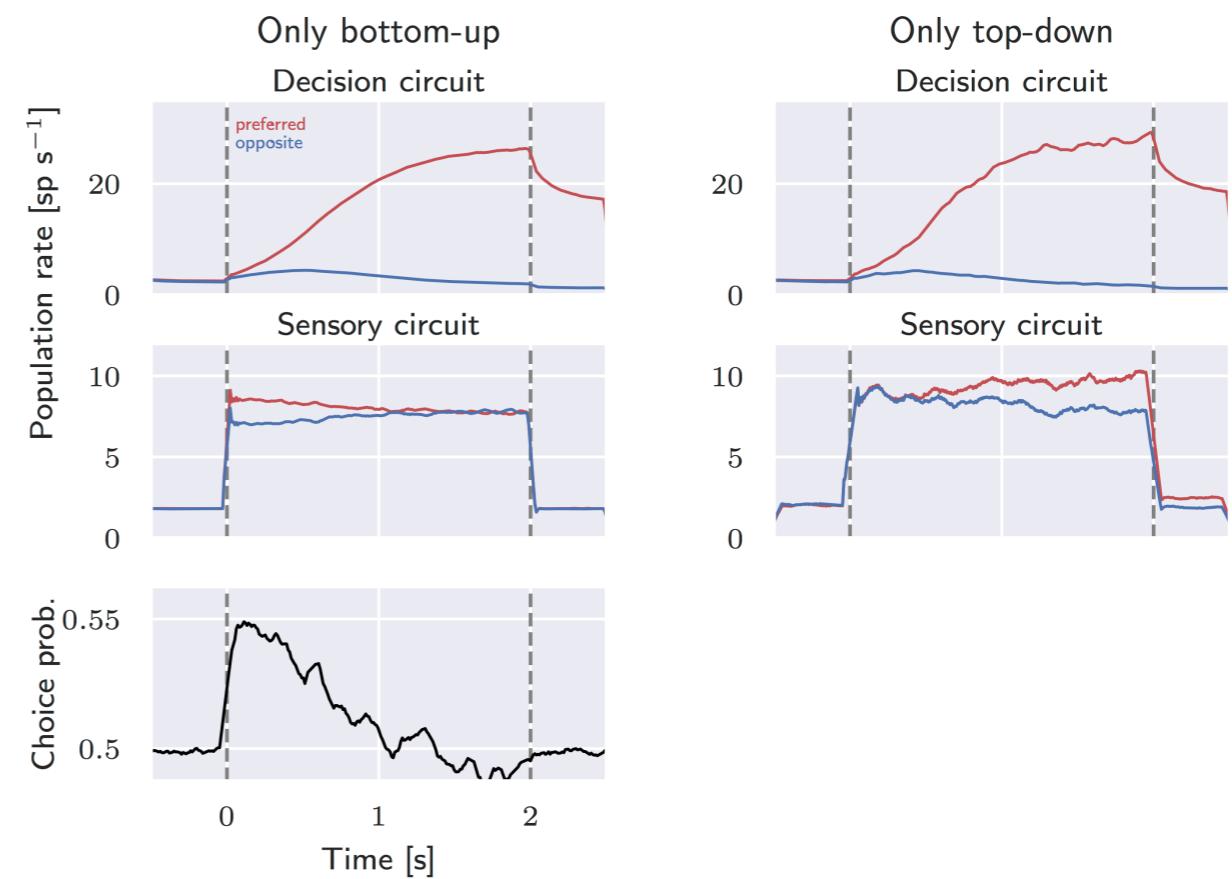
Hierarchical network with 2c sensory neurons still solves decision making task



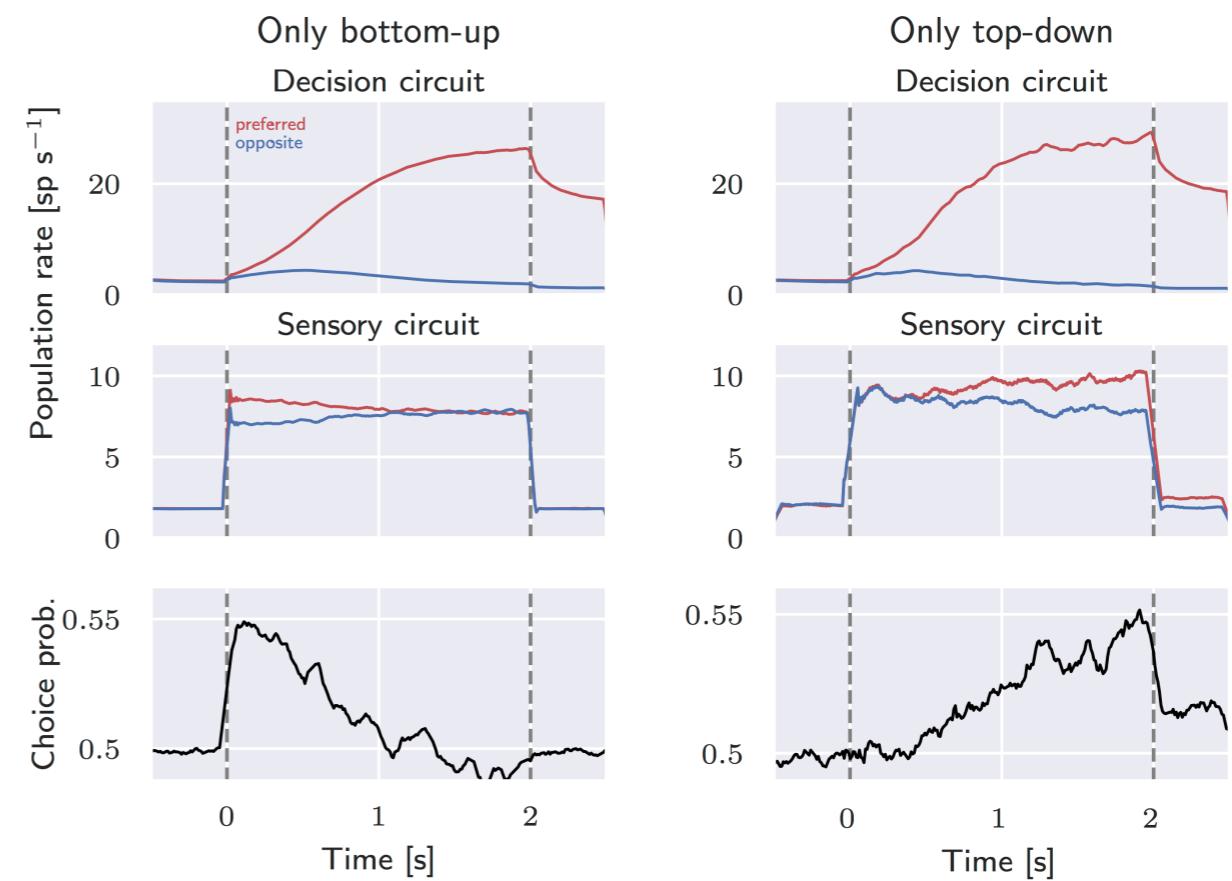
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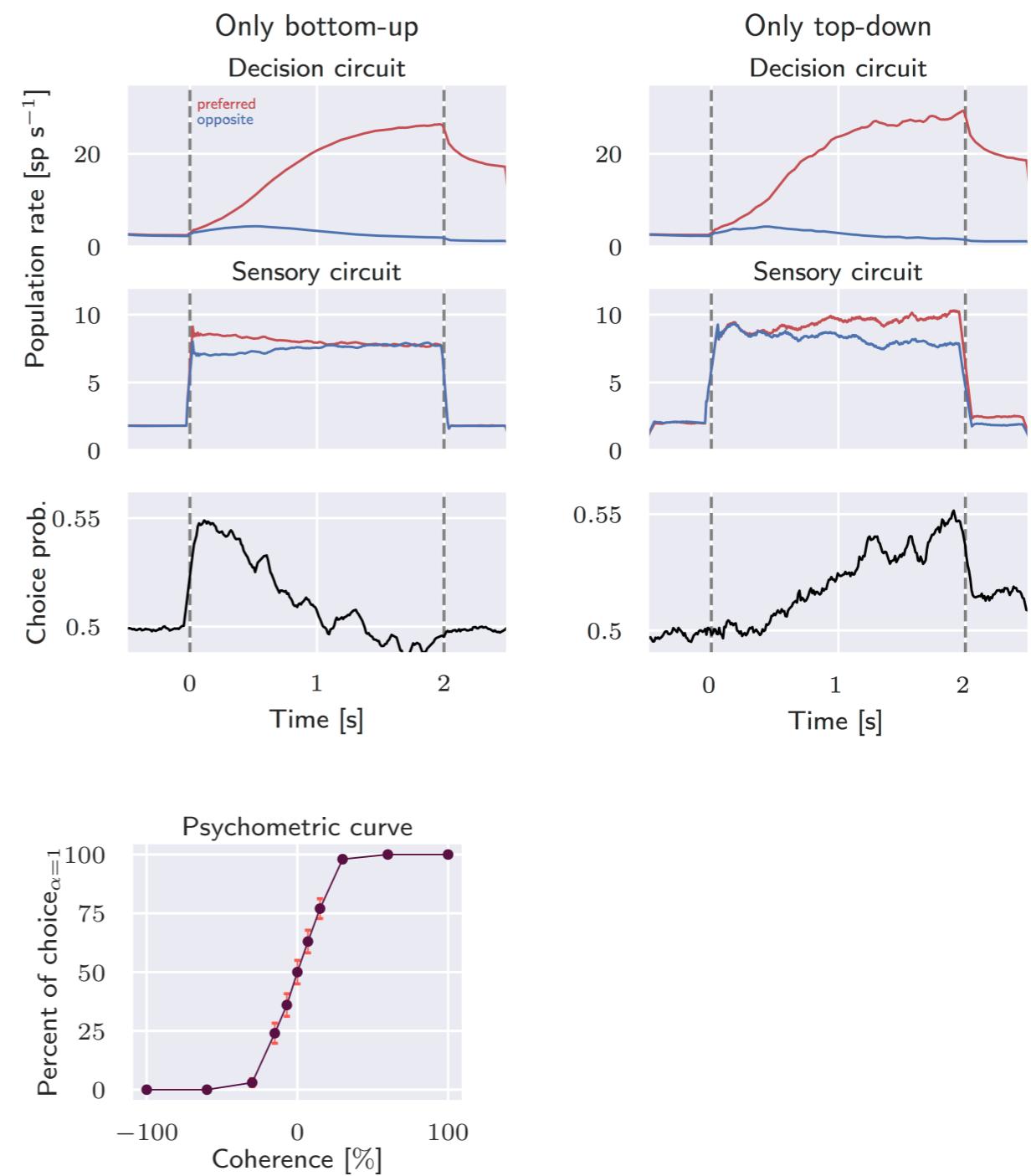
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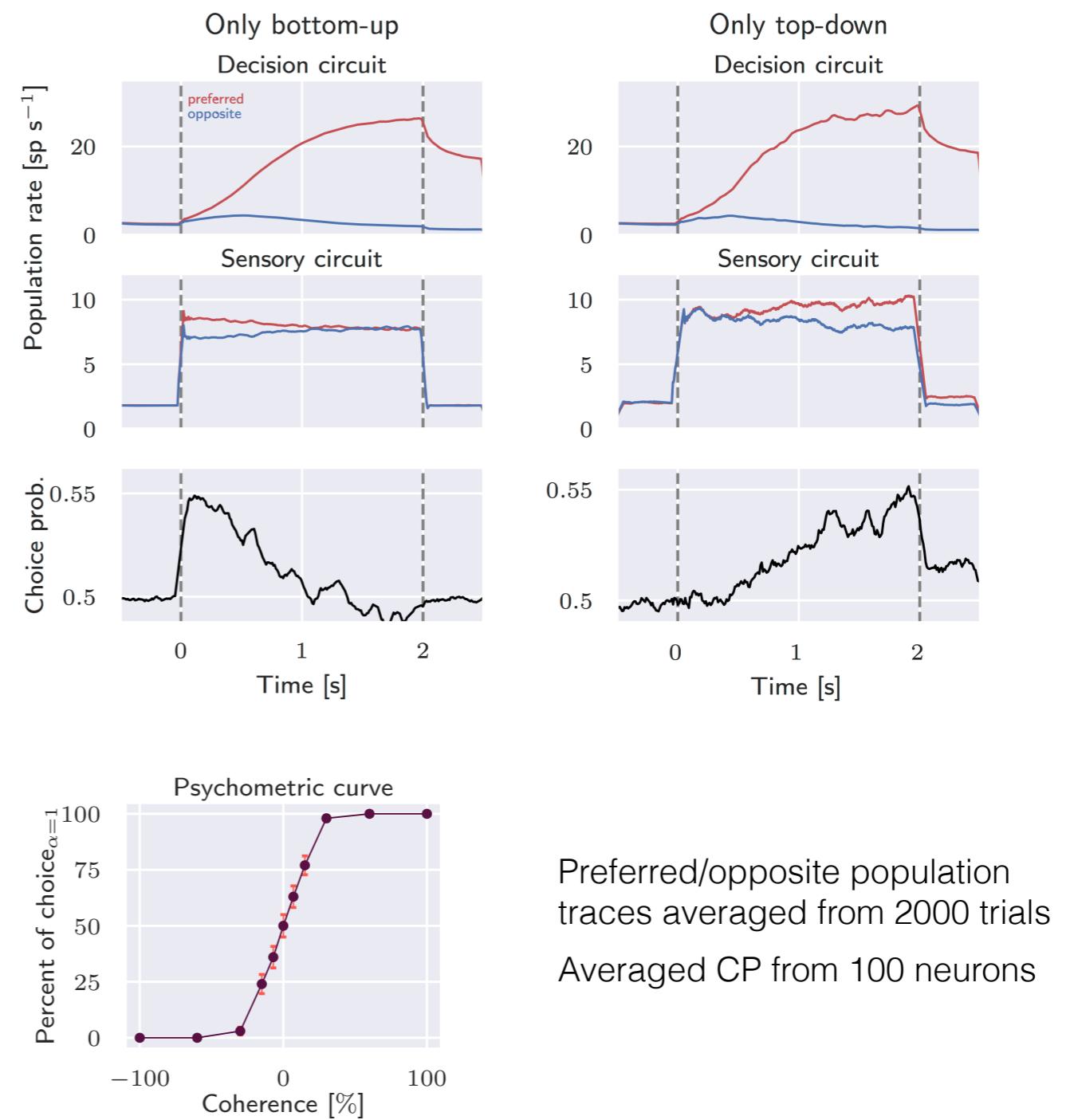
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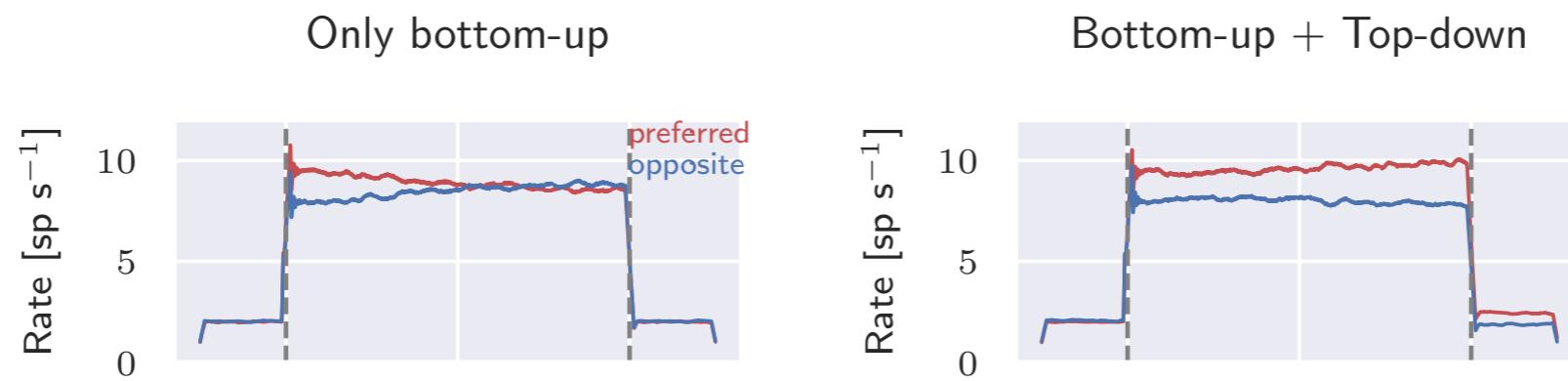


Event rate follows bottom-up input,
burst probability represents top-down input

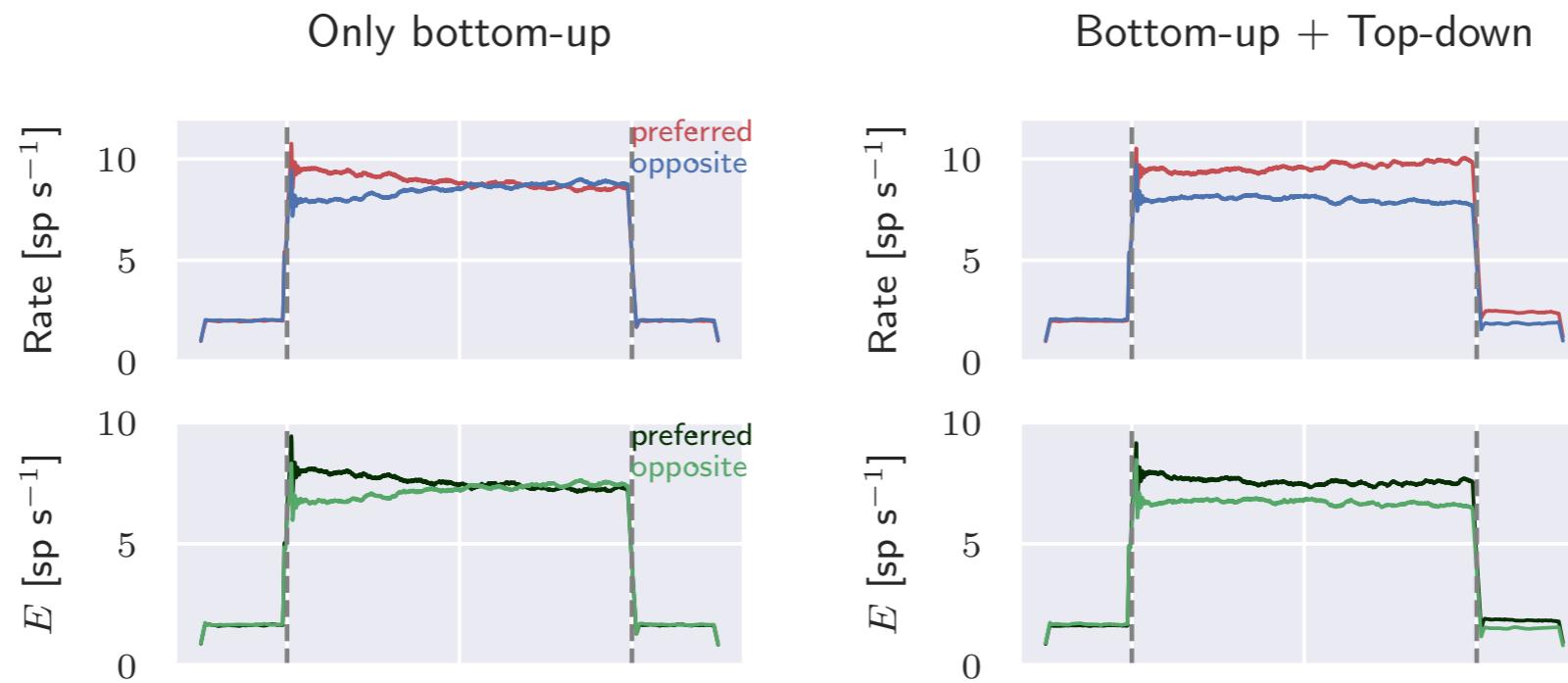
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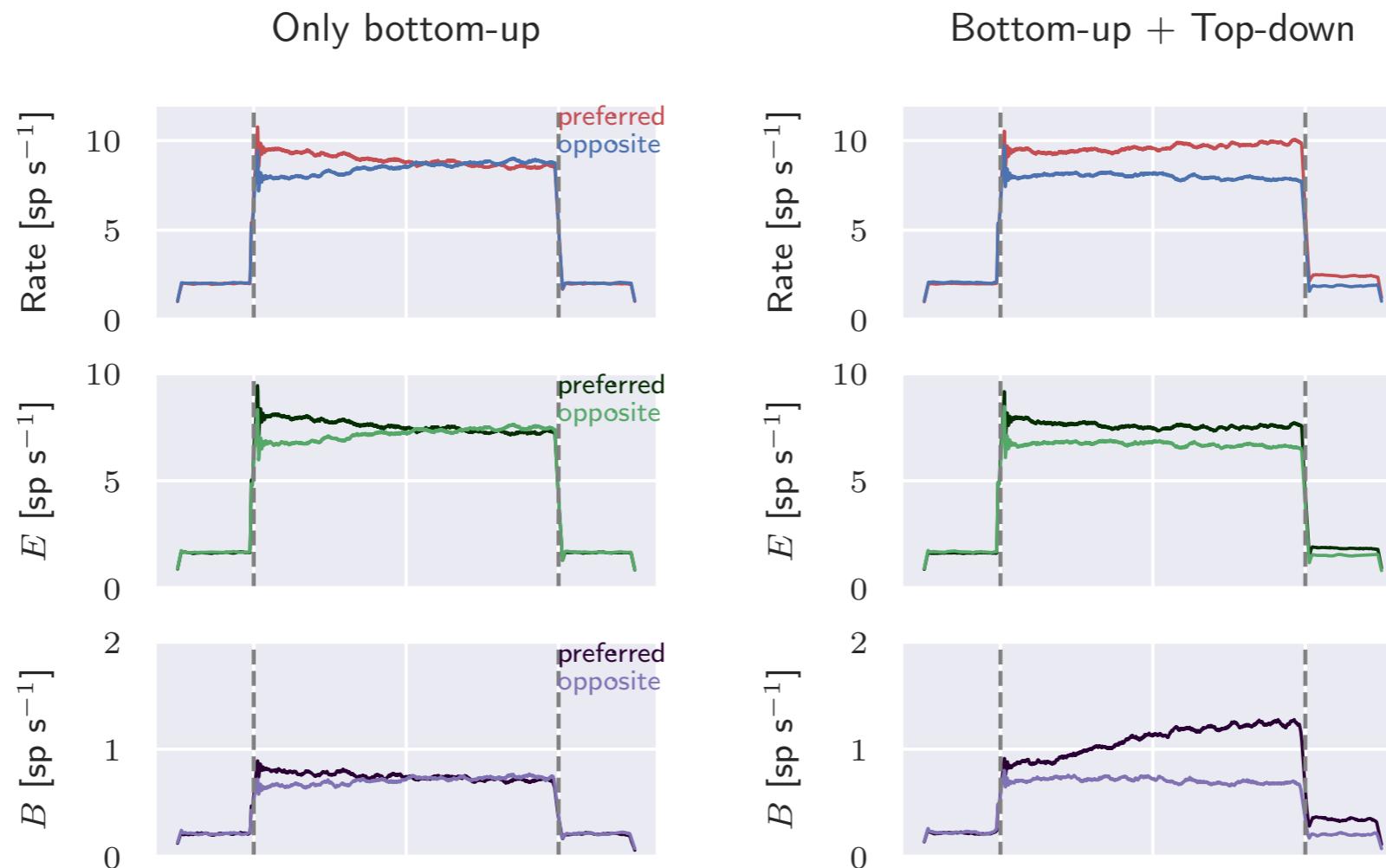
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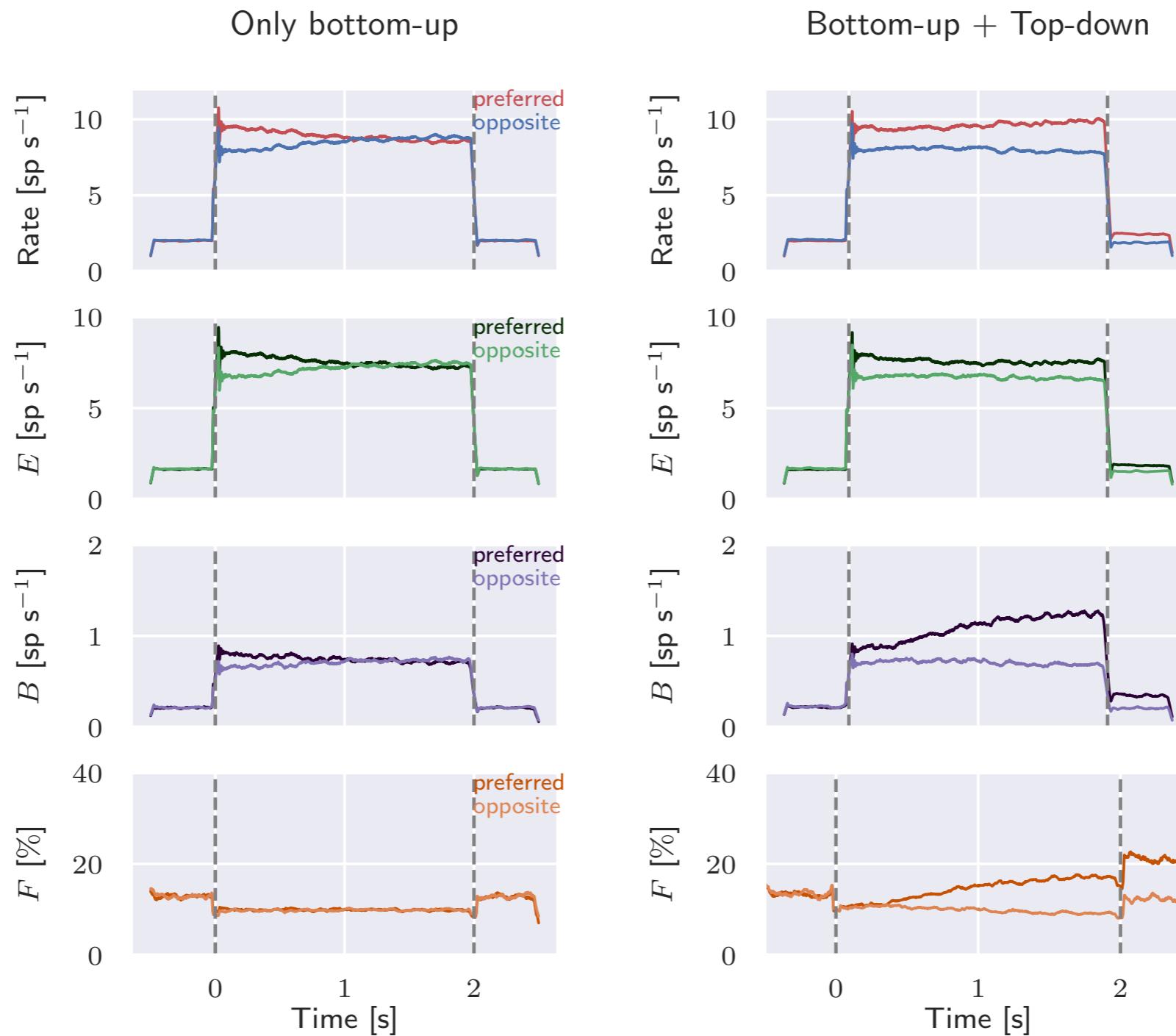
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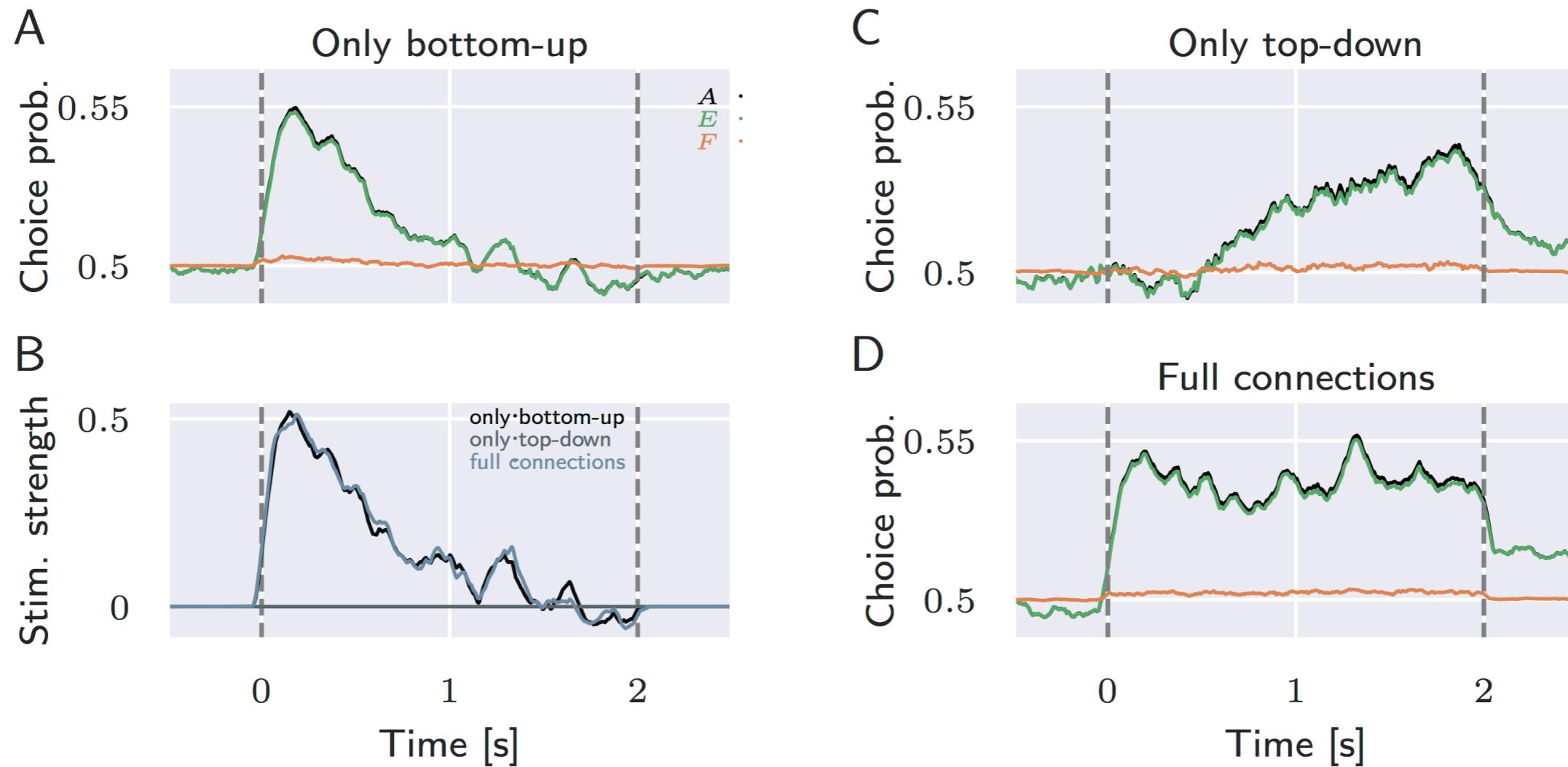
Event rate follows bottom-up input, burst probability represents top-down input



Event rate follows bottom-up input, burst probability represents top-down input



Neurometric fails to decode sensory and top-down influences on CP



Concluding remarks

- Technicalities:
 - *Spiking neural networks are **tricky***
 - *Spiking neural nets with recurrence are **trickier***
 - *Spiking neural nets with recurrence, two circuits, each with two populations, two-compartment neurons are **very complicated!***
- Important to:
 - *Test this method using experimental data*
 - *Exploit its simplicity analysing more complicated tasks*
 - *Think about our decision making processes*