The coordination of consciousness and its neural mechanisms

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Group 1: The neural bases of consciousness and coordination

1. What are our primary assumptions? What are the consequences of our primary assumptions? What can the pilot do that the automatic pilot cannot do? Does it involve the creation of new solutions to new problems? Is 'consciousness' that which 'knows'?

2. What are the degrees and varieties of consciousness, and are states of consciousness unified in time or otherwise, internally or externally?

3. What are the relationships between consciousness and attention, sensory persistence, working memory, and episodic memory, e.g. in relation to the dissolution question?

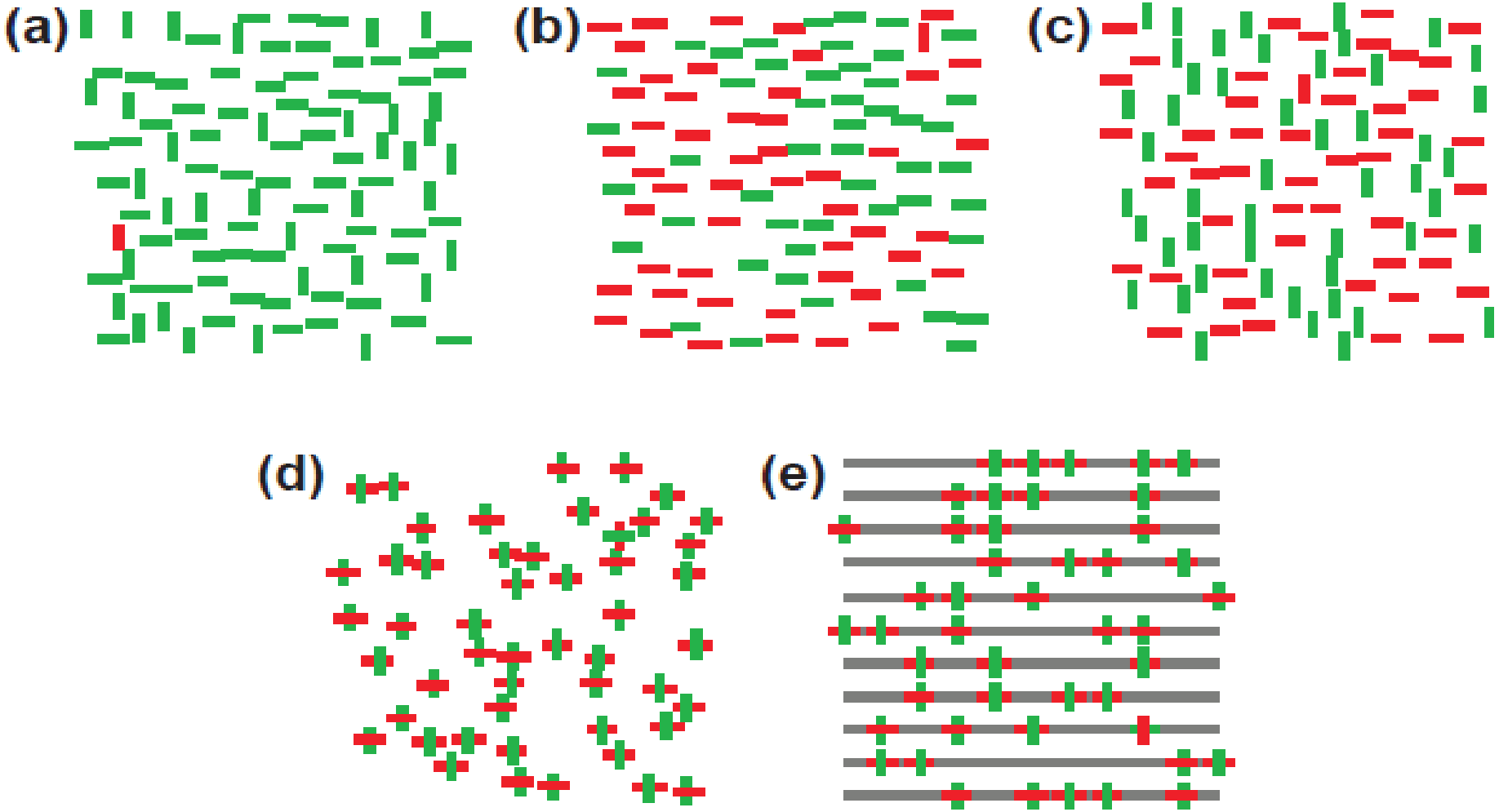
4. What are the neural mechanisms of coordination and how do they relate to consciousness and meditative practice?

Psychological, computational, and neurobiological studies suggest that mental life is coordinated by:

- **Holistic context-sensitive perception (incl. interocep.)**
- **Pre-attentive Gestalt grouping**
- **Attention & Working Memory**
- **Regulation of emotions and mental state**
- **Coherent planning and motor coordination**

All require adaptable neural mechanisms for context-sensitive gain-control that coordinate mental life by amplifying relevant and suppressing irrelevant activities at each level and stage of processing. They may be relevant to meditative practices because the help reduce mental conflict and increase mental harmony.

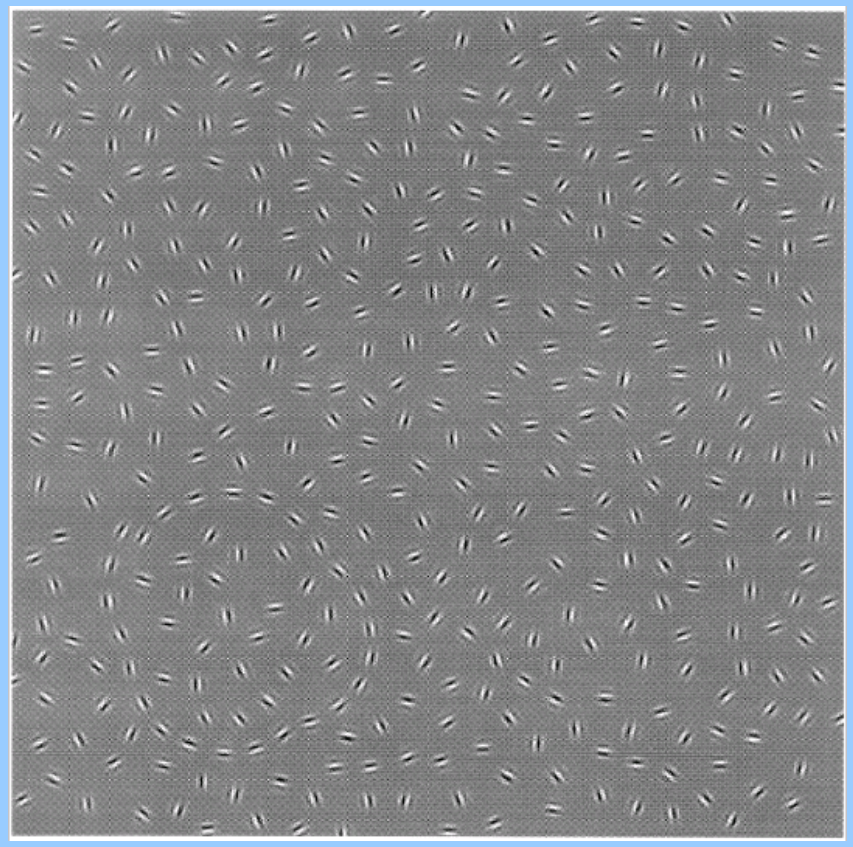
Contrast enhancement by Divisive Normalisation
Task: Find the vertical red bar (Watt and Phillips, 2000)

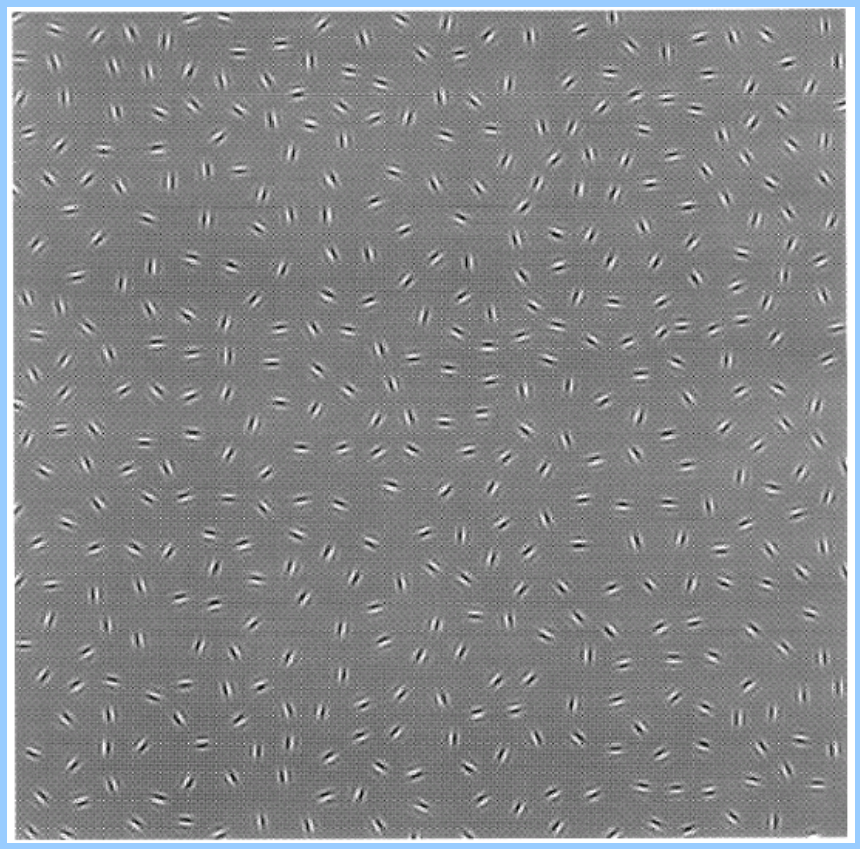


trends in Cognitive Sciences

Gestalt grouping

Figures can be segregated from ground by coherent relations between their elements





Word-sense disambiguation

To celebrate the end of the financial crisis he held a ball in the bank.

He rolled a ball down the bank.

He held a ball in his hand.

A major goal of our workshop was to reduce terminological ambiguities and examine our implicit assumptions.

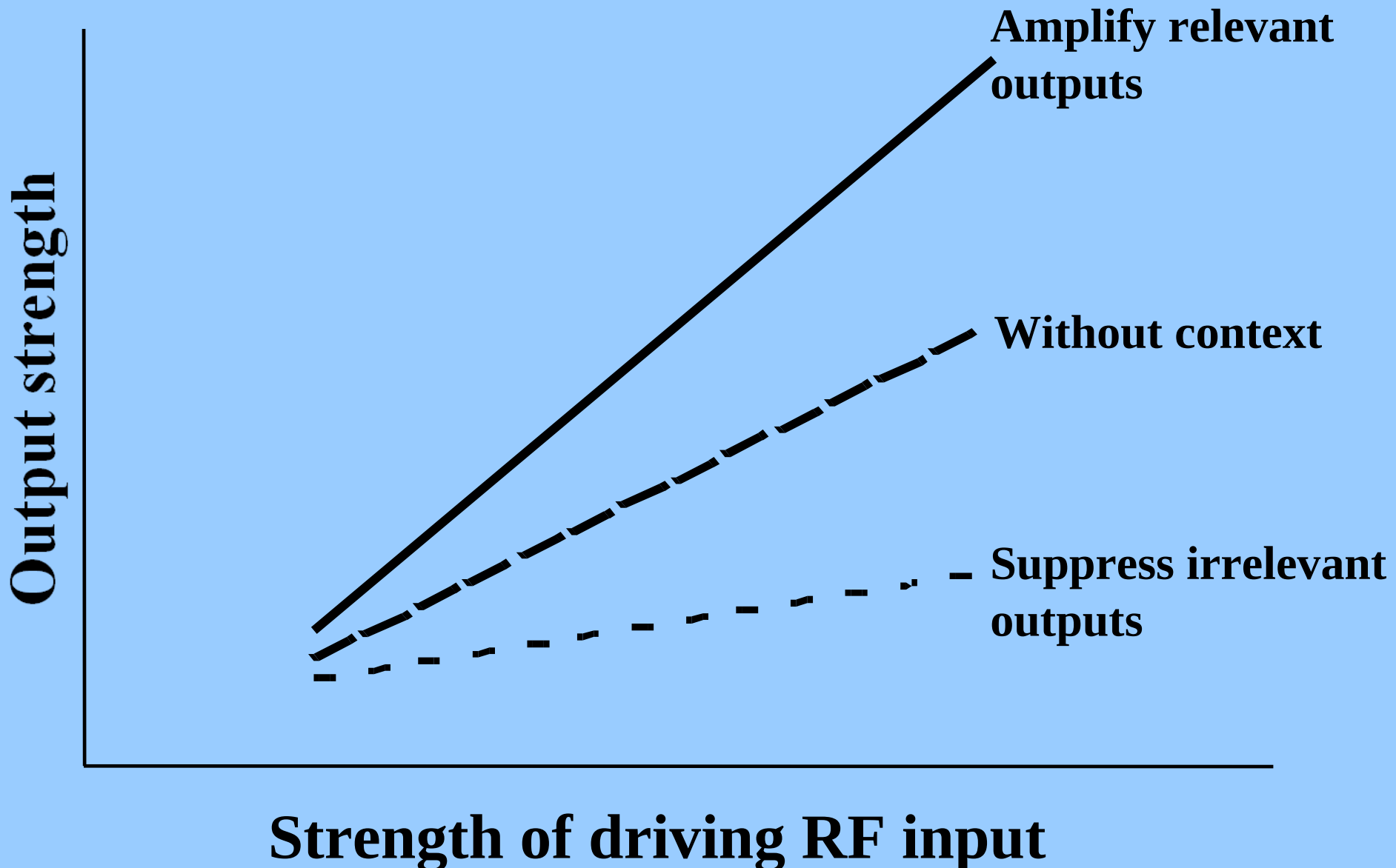
Evidence on the neural mechanisms of context-sensitive gain-control at:

systems

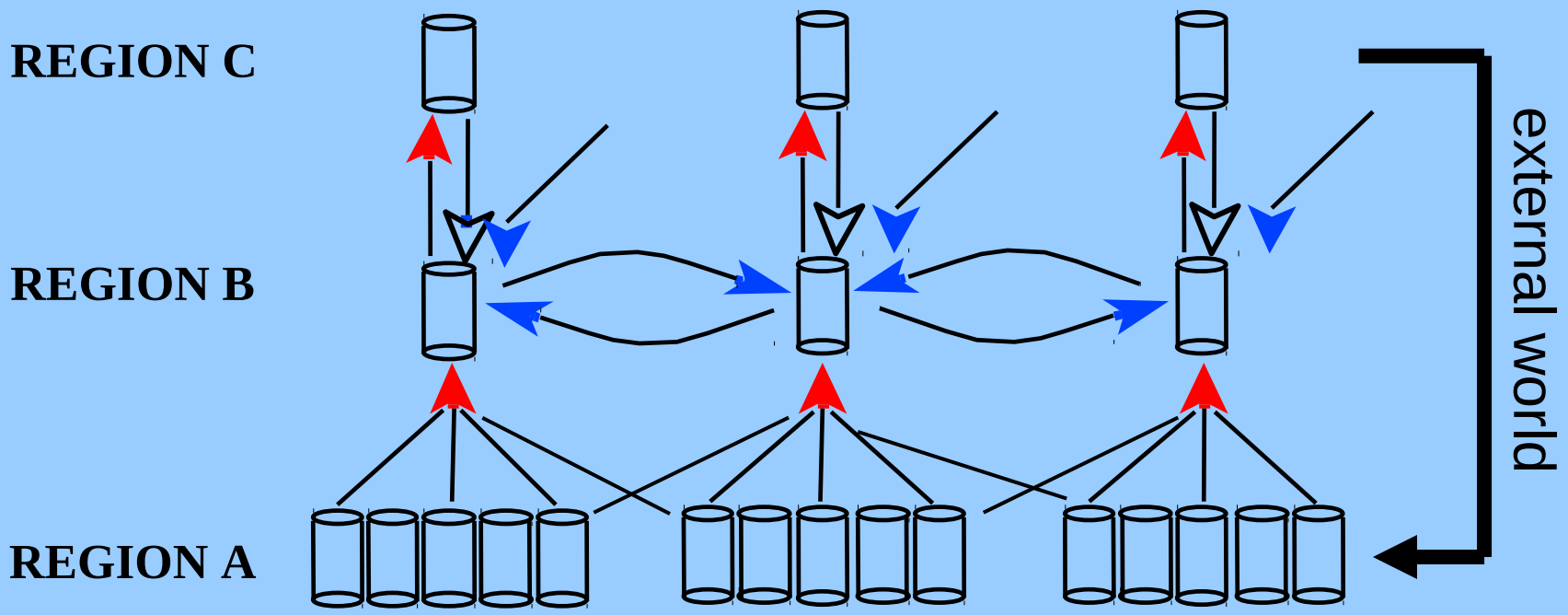
microcircuit

synaptic levels

Context-sensitive gain-control at the level of individual pyramidal cells



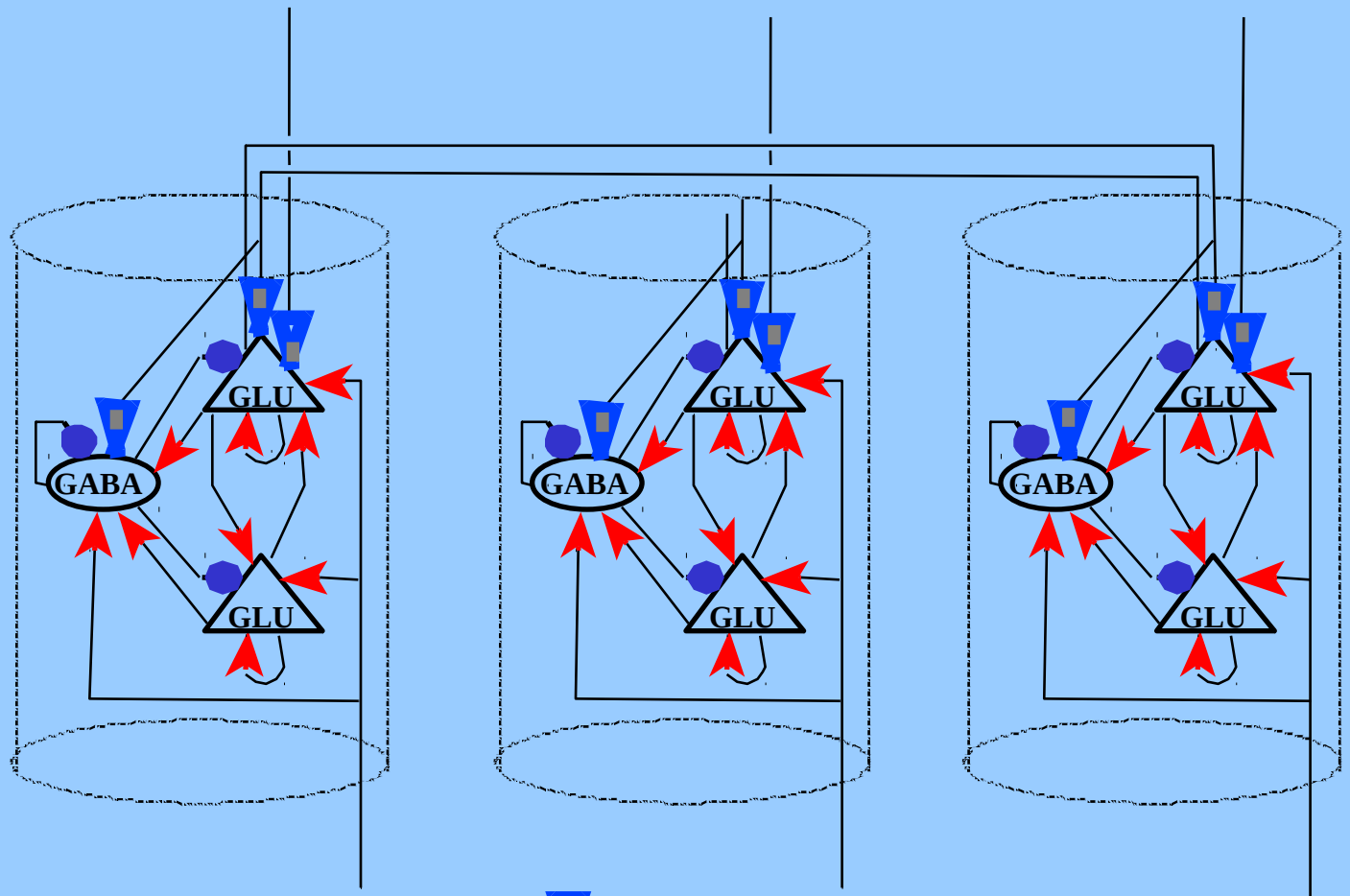
Coordination of feed-forward transmission



Pyramidal cell input: 5% feed-fwd drive, 95% other (K. Martin)
Drivers are few, strong, fast, focussed; modulators are many, weak, slow, diffuse (Bullier).

Hierarchies of **Abstraction** with **Divergence**,
because different uses/contexts require different information.

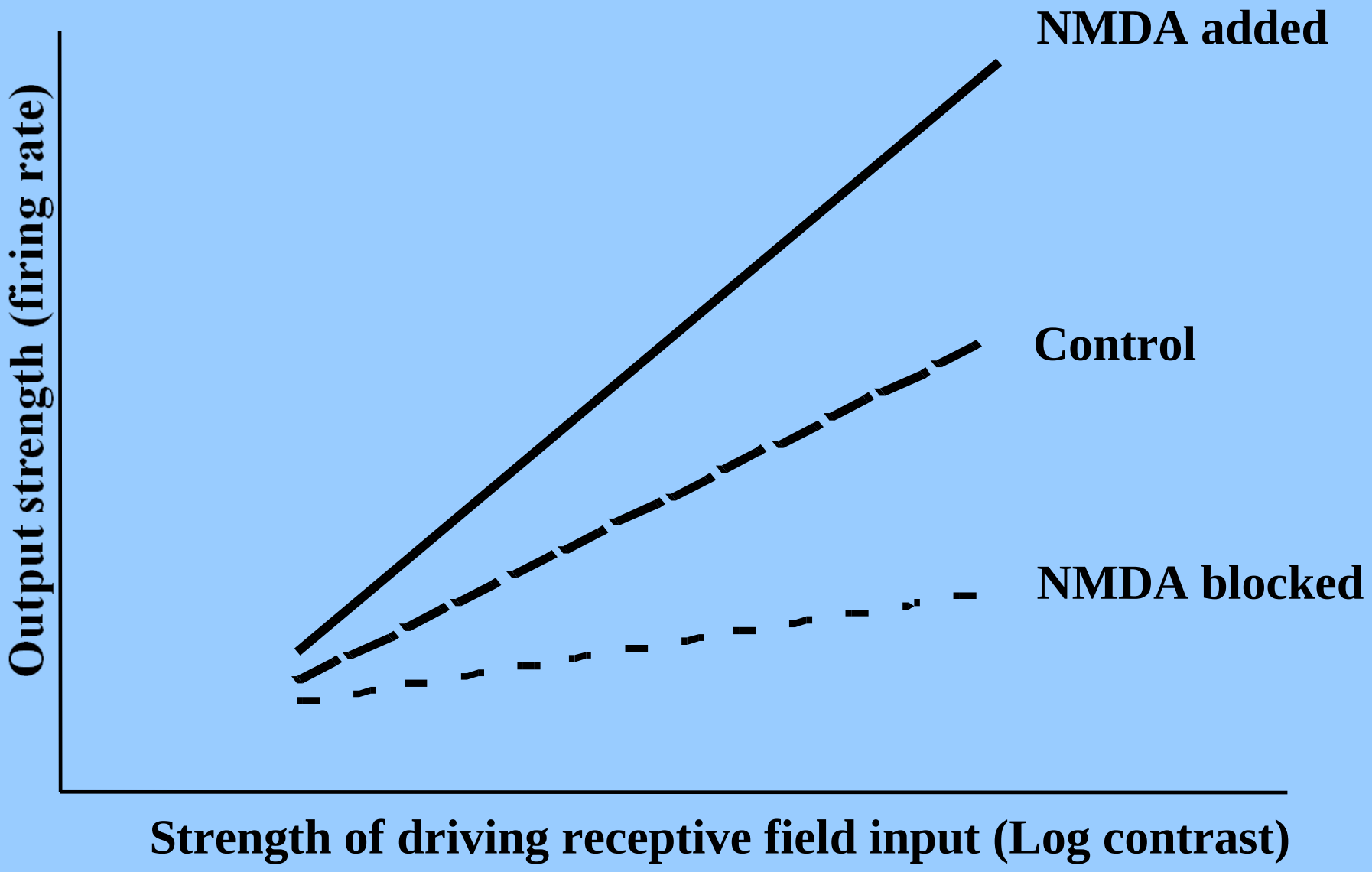
Mechanisms for context-sensitive gain-control at the local circuit level include NMDA Receptors, distal dendritic modulation of proximal drive, synchronised disinhibition.



: GLU(AMPA/K) : GLU(NMDA) : GABA

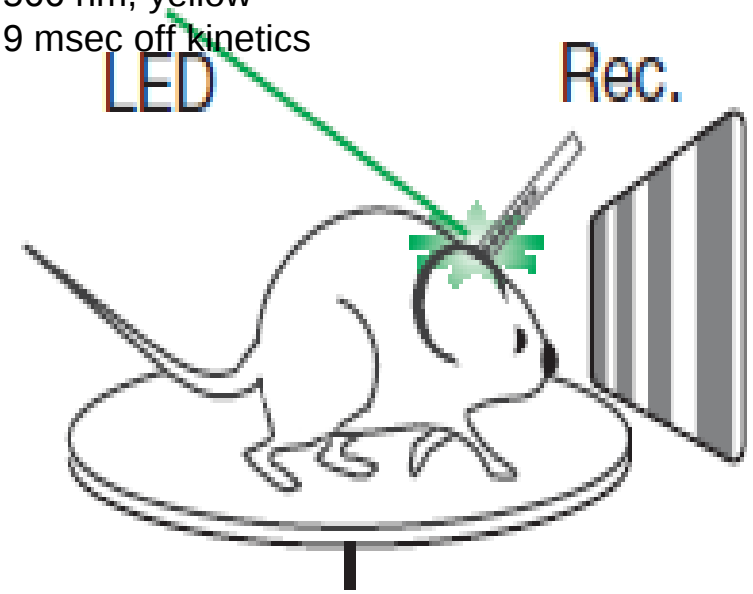
Based on Douglas & Martin's canonical cortical circuit

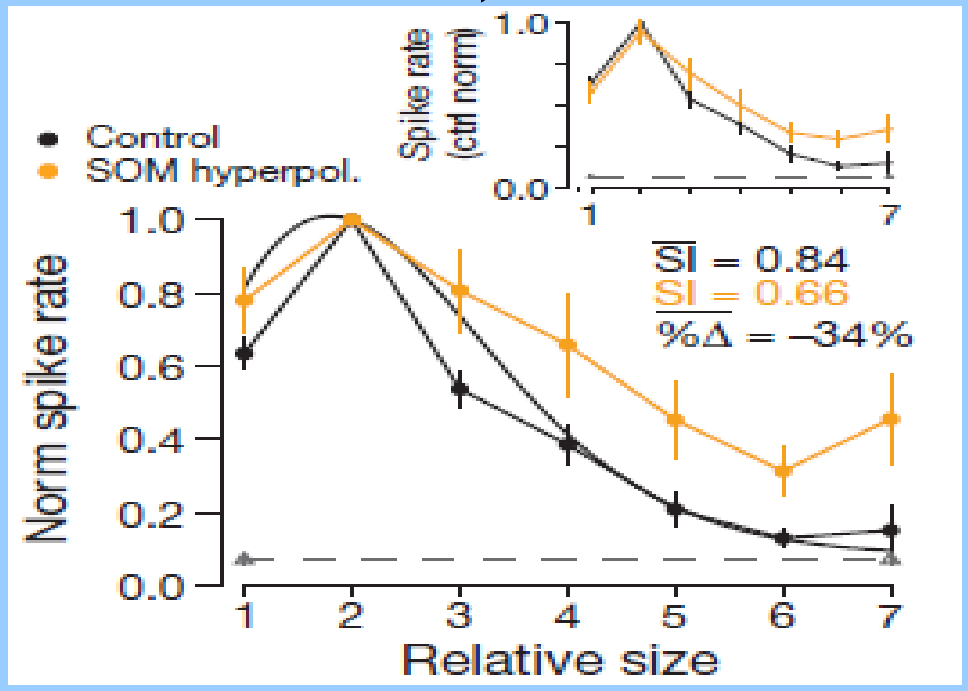
Control of gain by NMDAR-mediated input in cat V1 pyramidal cells (Fox, Sato, and Daw, 1990)

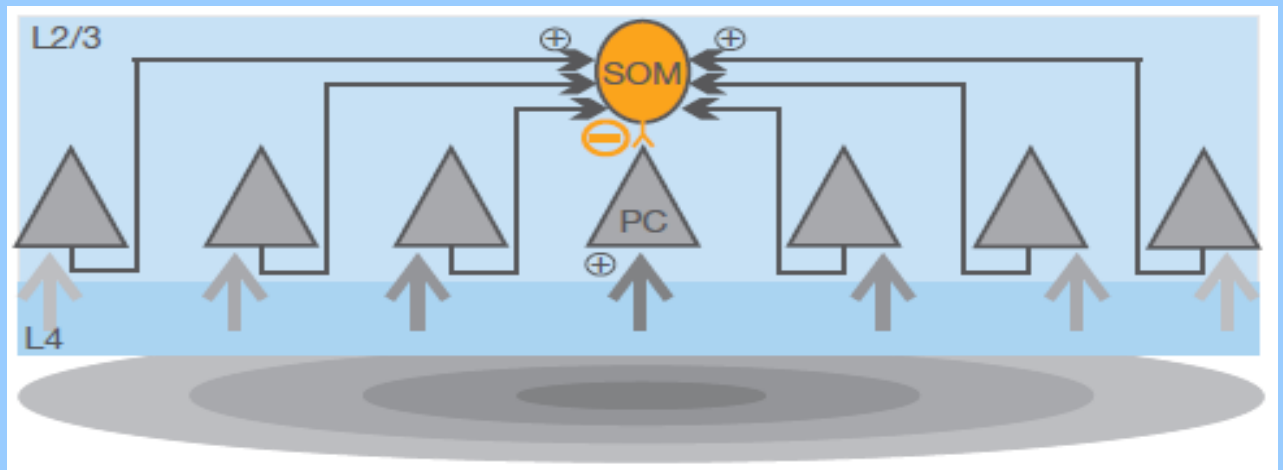


SOM inhibitory interneurons (Martinotti cells) contribute to surround suppression (Adesnik et al., Nature, 2012)

Archeorhodopsin
566 nm, yellow
9 msec off kinetics



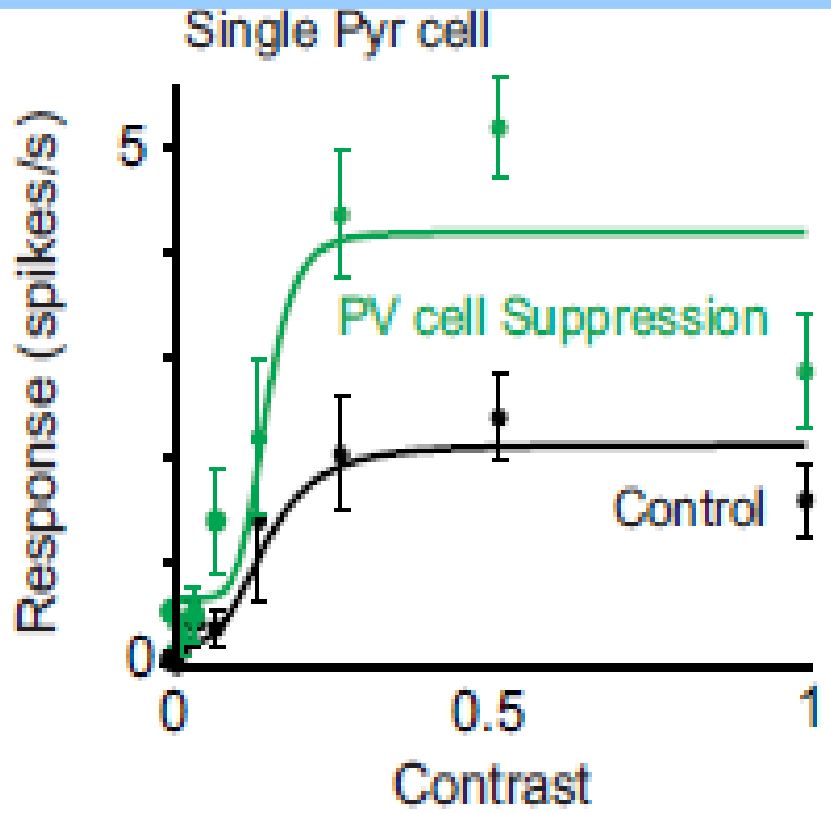


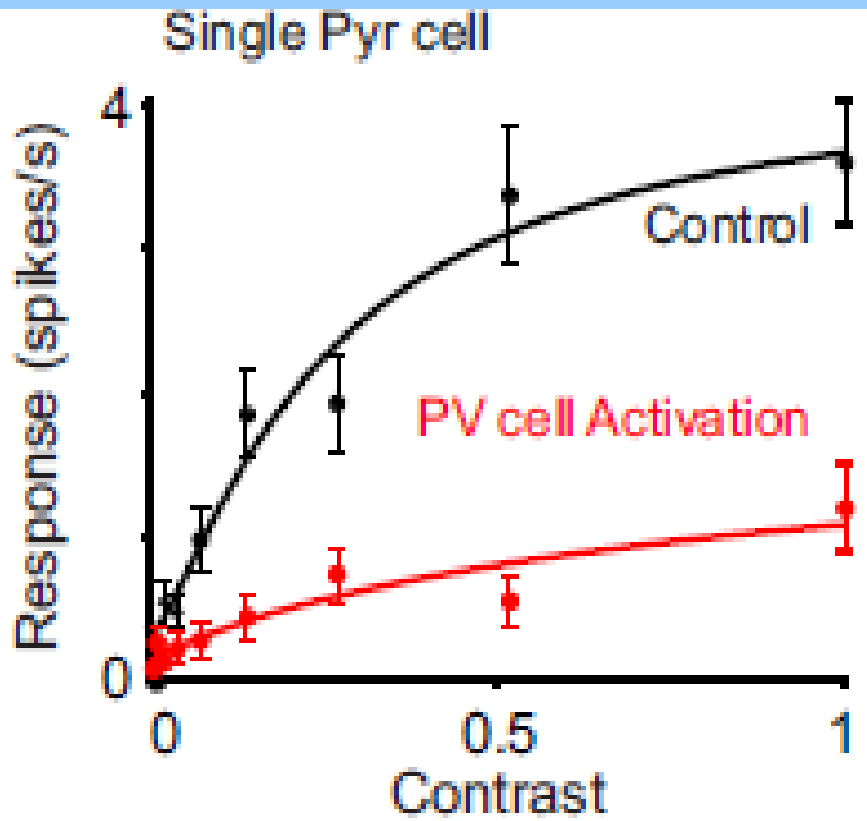


PV inhibitory interneurons (Basket cells) modulate the gain of pyramidal cell response (Atallah et al., Neuron 2012).

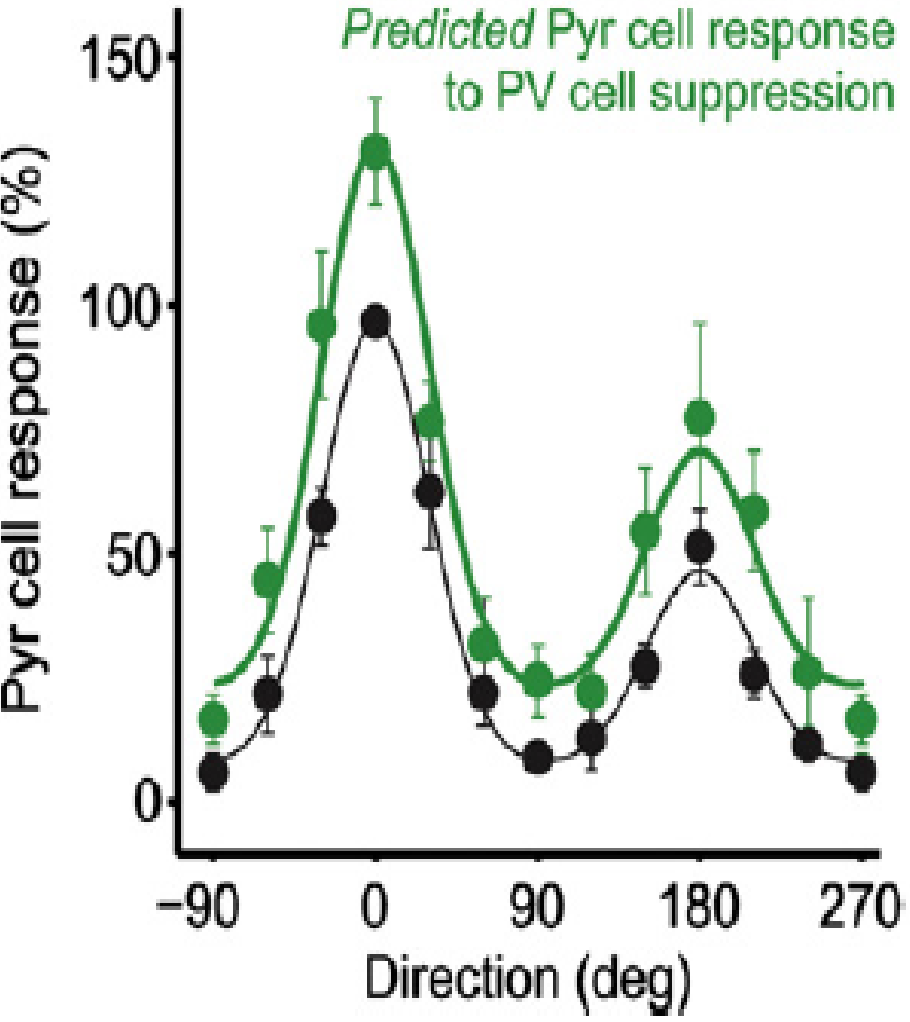
PV SUPPRESSION Arch

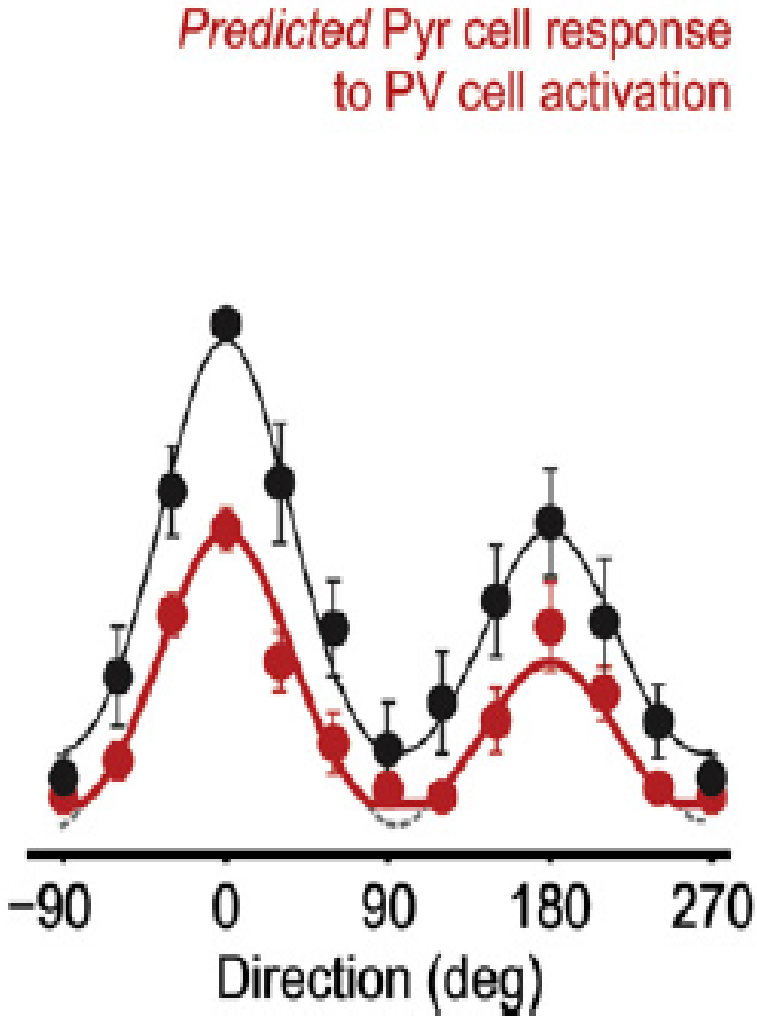
PV ACTIVATION ChR2





Pyramidal-cell tuning does not depend on PV-cell activity (Atallah et al., (2012)





How are these coordinating mechanisms related to mindfulness and consciousness?

They reduce conflict and increase harmony, as may mindfulness. However, they operate on signals without distinguishing them from what they signal, and their capabilities are constrained by various limitations. Conscious intentional representation implies a knower that makes this distinction. Novel but solvable problems and theory-of-mind tasks, etc, suggest some of the additional capabilities that may arise from such intentional representations, but their neural bases remains unknown.

1. The known mechanisms help explain why so much of conscious experience is well-coordinated.

2. Their limitations indicate what there is for intentionality to add, e.g. the creation of new solutions to new problems, and T-of-Mind skills.

3. They suggest some of the neuro-computational mechanisms from which those additional capabilities are probably built. Mechanisms such as these have already been used by rigorous computational models to explain the senses of self and presence as interoceptive inferences (Seth, et al., 2011).