

# Attention and perceptual tradeoffs

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## **Covert Spatial attention:**

The selective processing of information at a given location *in the absence of eye movements*

## **Transient attention:**

The relatively fast ( $\sim 100$  ms), stimulus-driven component of spatial attention.

# Outline

- **A possible mechanism of transient attention**
  - ➔ **Supporting evidence**
  
- **A possible physiological instantiation of this mechanism**
  - ➔ **Supporting evidence**

# What happens at the attended location?

	Spatial	Temporal
Segregation	↑	↓
Integration	↓	↑

**Transient attention facilitates spatial segregation and temporal integration, but impairs spatial integration and temporal segregation.**

	Spatial	Temporal
Segregation		
Integration		↑

Attention improves the integration of information over time

\* **Attention prolongs visible persistence**

(e.g., Visser & Enns, 2001; Yeshurun et al., 2002)

\* **Attention prolongs perceived duration**

(e.g., Enns et al., 1999; Yeshurun & Marom, 2008)

\* **Attention extends the temporal integration window**

(Megna, Rocchi, and Baldassi, 2012)

	Spatial	Temporal
Segregation		↓
Integration		

Attention *degrades* the ability to resolve rapid changes over time - **temporal resolution**

\* **Attention degrades detection of brief temporal gaps**  
(e.g., Rolke et al., 2008; Yeshurun, 2004; Yeshurun & Levy, 2003)

\* **Attention impairs temporal order judgement**  
(e.g., Hein et al., 2006)

\* **Attention degrades the perceived apparent motion**  
(Yeshurun & Hein, 2011)

	Spatial	Temporal
Segregation	↑	
Integration		

Attention enhances the ability to resolve fine spatial details - **spatial resolution**

- \* **Attention enhances detection of spatial gaps - acuity**  
(e.g., Yeshurun & Carrasco, 1999)
- \* **Attention enhances discrimination of vernier offsets - hyperacuity** (e.g., Yeshurun & Carrasco, 1999)
- \* **Attention improves or impairs texture segmentation**  
(e.g., Yeshurun & Carrasco, 1998, 2000; 2008)

	Spatial	Temporal
Segregation		
Integration	↓	

Attention impairs the ability to integrate information across space - **spatial integration**

\* **Attention improves or impairs texture segmentation**

(e.g., Yeshurun & Carrasco, 1998, 2000, 2008)

\* **Attention alleviates spatial crowding**

(Yeshurun & Rashal, 2010)



	Spatial	Temporal
Segregation	↑	↓
Integration	↓	↑

## Possible physiological implementation:

Transient attention favors **Parvocellular** over **Magnocellular** neuronal activity.

Attention **facilitates** **Parvocellular** neurons at the attended location, which in turn **inhibits** the activity of **Magnocellular** neurons at the same location.

	<b>Parvocellular</b>	<b>Magnocellular</b>
<b>receptive fields</b>	small	large
<b>sampling density</b>	high	low
<b>spatial resolution</b>	high	low

	Spatial	Temporal
Segregation	↑	
Integration		

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<b>spatial resolution</b>	high	low

	Spatial	Temporal
Segregation		
Integration	↓	

	<b>Parvocellular</b>	<b>Magnocellular</b>
<b>receptive fields</b>	small	large
<b>sampling density</b>	high	low
<b>spatial resolution</b>	high	low
<b>response duration</b>	long	short
<b>Response decay</b>	slow	fast
<b>temporal integration</b>	long	short

Spatial    Temporal

Segregation

Integration

	↑

	<b>Parvocellular</b>	<b>Magnocellular</b>
<b>receptive fields</b>	small	large
<b>sampling density</b>	high	low
<b>spatial resolution</b>	high	low
<b>response duration</b>	long	short
<b>Response decay</b>	slow	
<b>temporal integration</b>	long	
<b>temporal resolution</b>	low	high
<b>Motion perception</b>	X	✓

Segregation  
Integration

Spatial	Temporal
	↓

# Transient attention favors **Parvocellular** over **Magnocellular** neuronal activity.

- **Selective adaptation** (Yeshurun, 2013)
- **Steady-pedestal and pulsed-pedestal paradigms** (Yeshurun & Sabo, 2012)
- **Reversed apparent motion** (Yeshurun & Hein, 2011)
- **Isoluminant stimuli** (Yeshurun, 2004)
- **Red background** (Yeshurun, 2004)

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# Selective adaptation

- The Magno system mediates the processing of low spatial frequencies while the Parvo system mediates the processing of high spatial frequencies (e.g., Kulikowski & Tolhurst, 1973; Legge, 1978).
- ➔ If attention facilitates Parvo activity but inhibits Magno activity it should increase adaptation with high frequencies but decrease adaptation with low frequencies



# Selective adaptation

Attention  $\uparrow$  **Parvo** activity, and Parvo  $\rightarrow$  high frequencies

$\Rightarrow \uparrow$  adaptation for high frequencies with attention

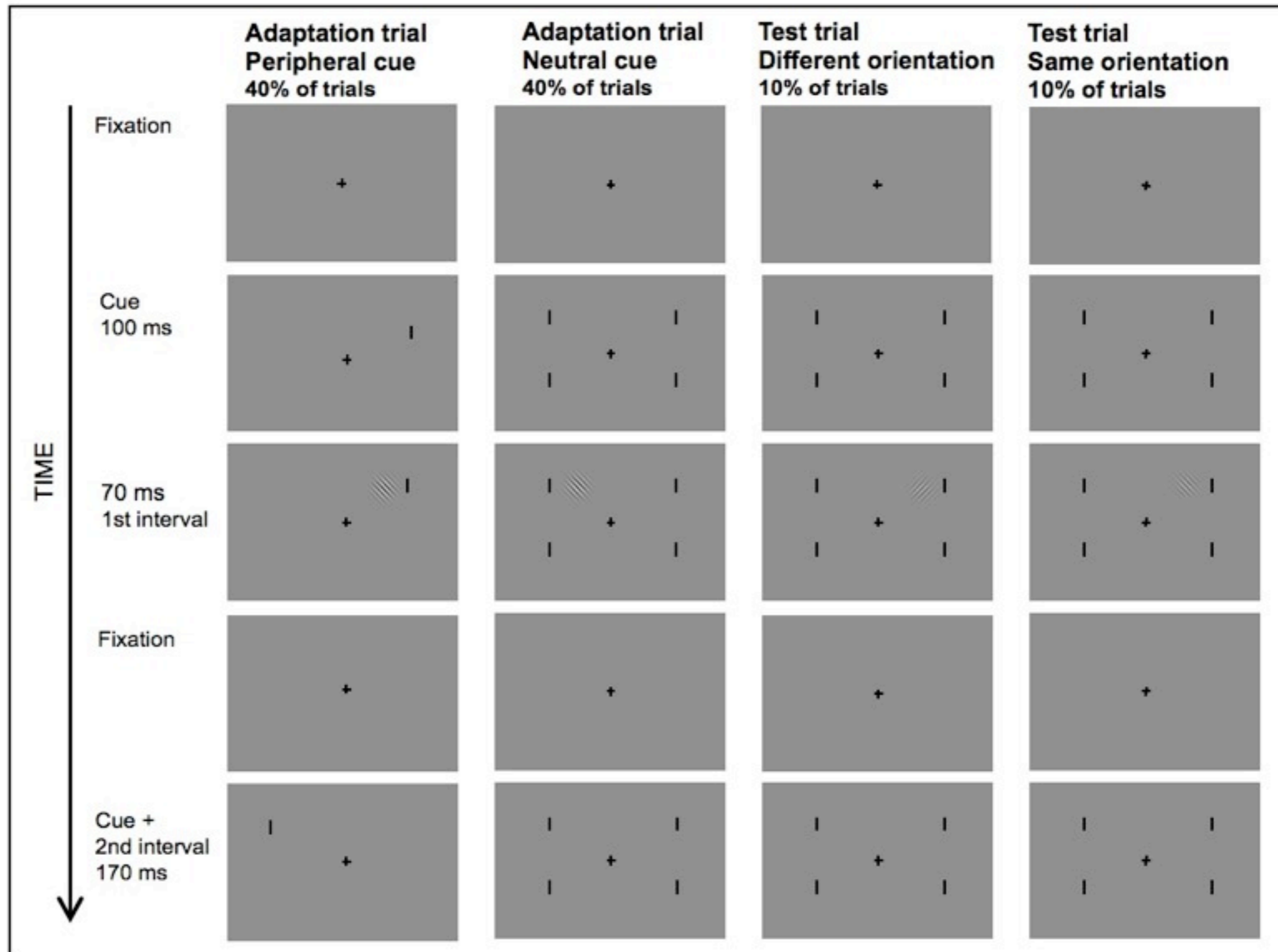
Attention  $\downarrow$  **Magno** activity, and Magno  $\rightarrow$  low frequencies

$\Rightarrow \downarrow$  adaptation for low frequencies with attention

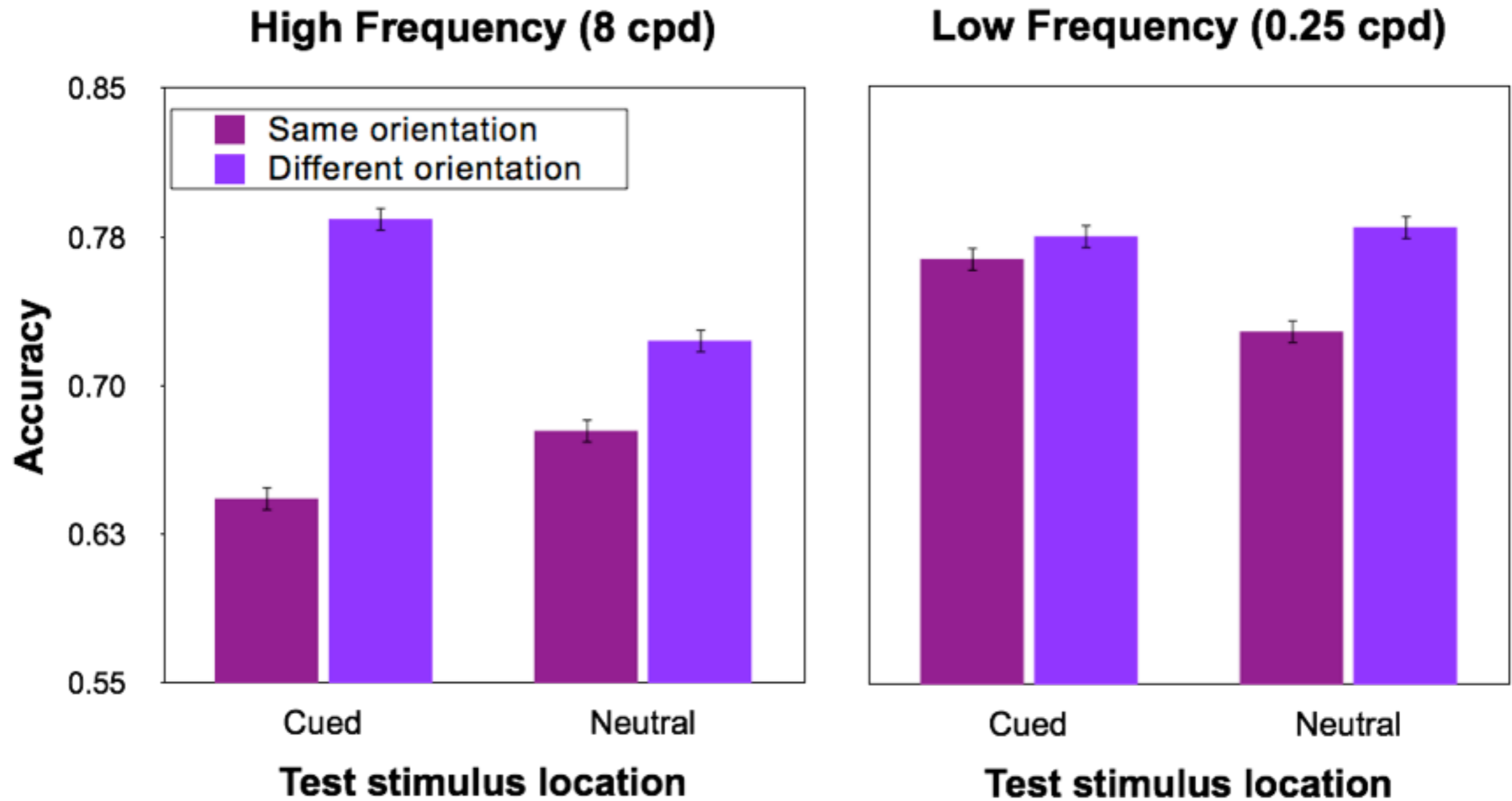
**Selective adaptation:** spatial frequency (8 cpd, 0.25 cpd),  
orientation ( $45^\circ$ ,  $135^\circ$ )



# Experiment 2



# Experiment 2



Transient attention favors **Parvocellular** over **Magnocellular** neuronal activity.

- **Selective adaptation**
- Steady-pedestal and pulsed-pedestal paradigms
- Reversed apparent motion
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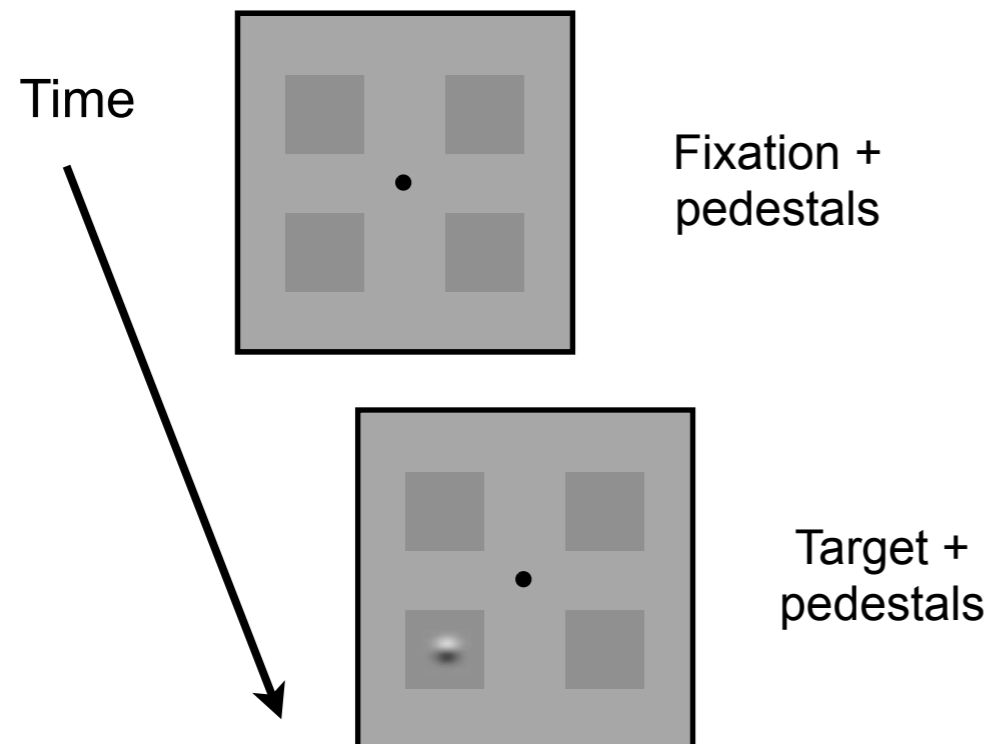
Transient attention favors **Parvocellular** over **Magnocellular** neuronal activity.

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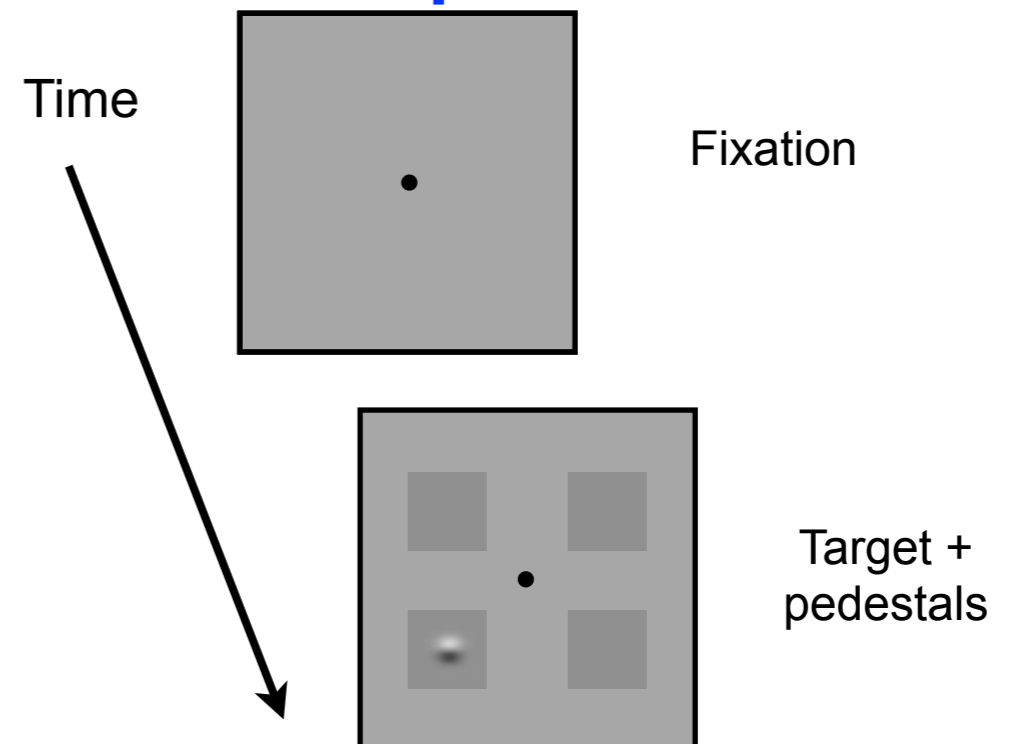
# Steady-Pedestal & Pulsed-Pedestal paradigms

- Pokorny & Smith designed the steady- and Pulsed- Pedestal paradigms to separately assess Magno and Parvo activity (e.g., Pokorny & Smith, 1997; Smith & Pokorny, 2003)
- The **Steady-Pedestal** paradigm biases processing toward the Magno pathway while the **Pulsed-Pedestal** paradigm biases processing toward the Parvo pathway

## Steady-pedestal



## Pulsed-pedestal

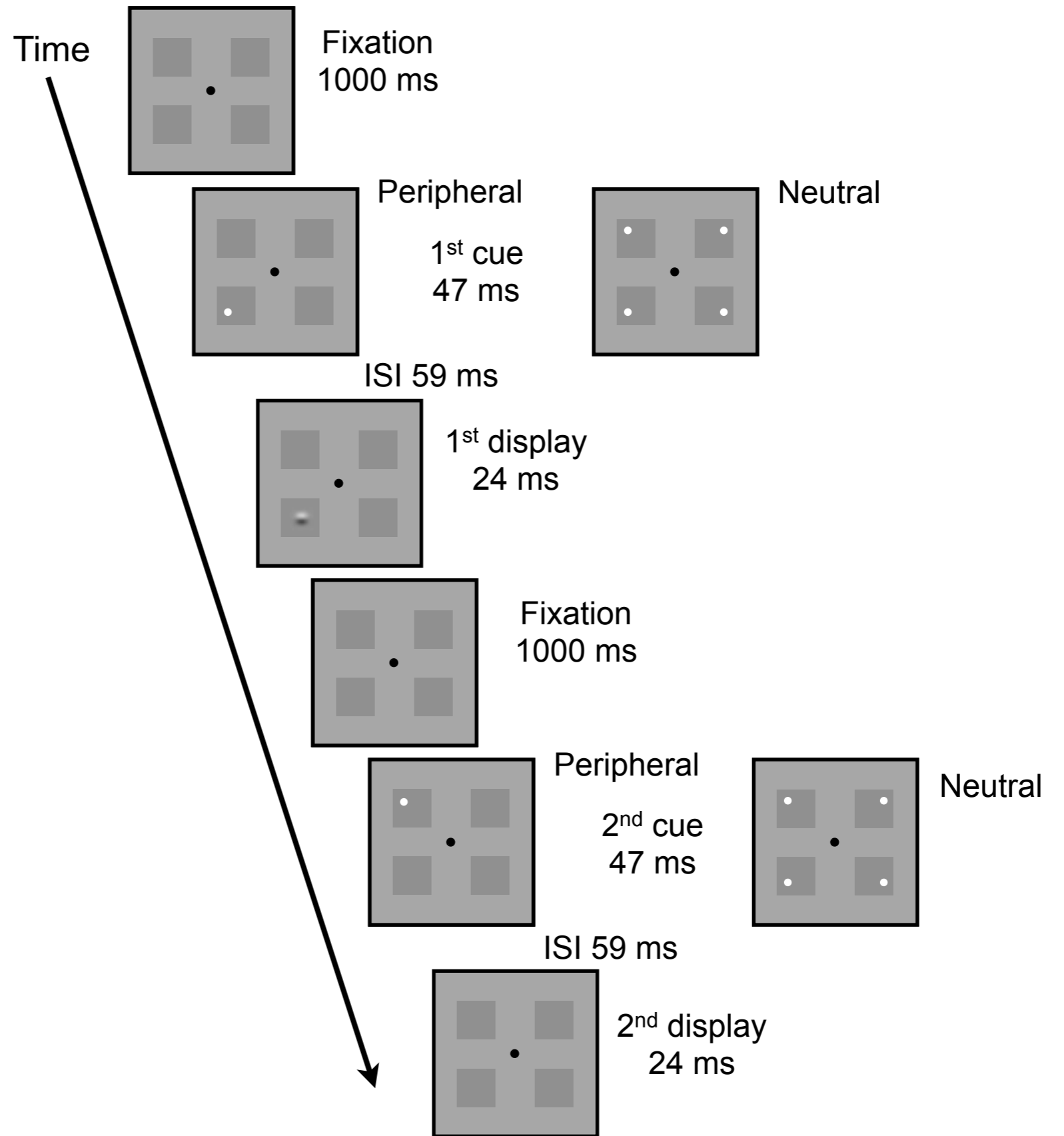


# Steady-Pedestal & Pulsed-Pedestal paradigms

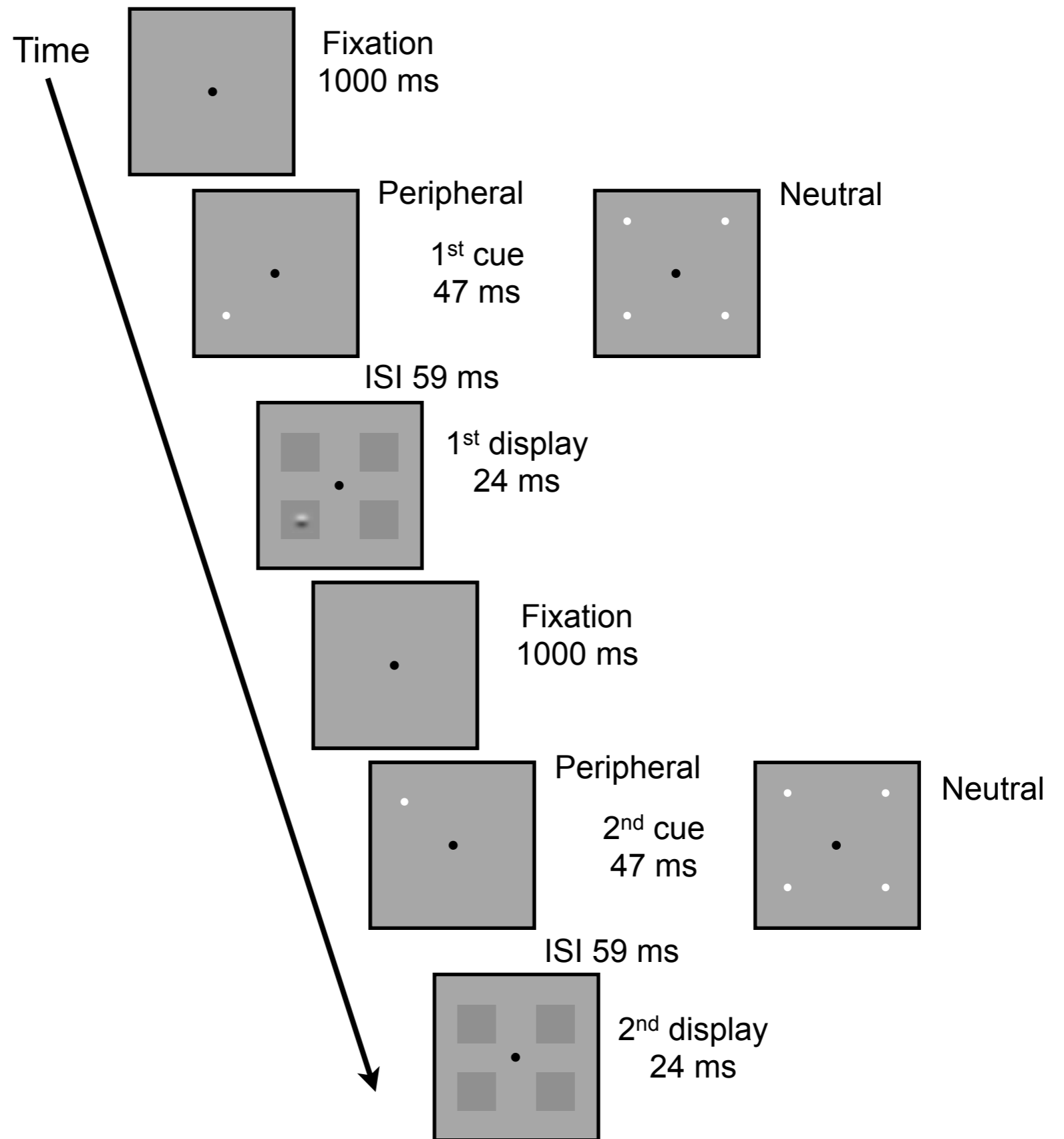
- Combining these paradigms with peripheral cues allows to examine separately the effects of attention on the Parvo and Magno systems while employing similar experimental conditions
- ➔ If attention favors Parvo over Magno activity it should improve performance with the Pulsed-Pedestal paradigm but not with the Steady-Pedestal paradigm



# Steady-Pedestal:

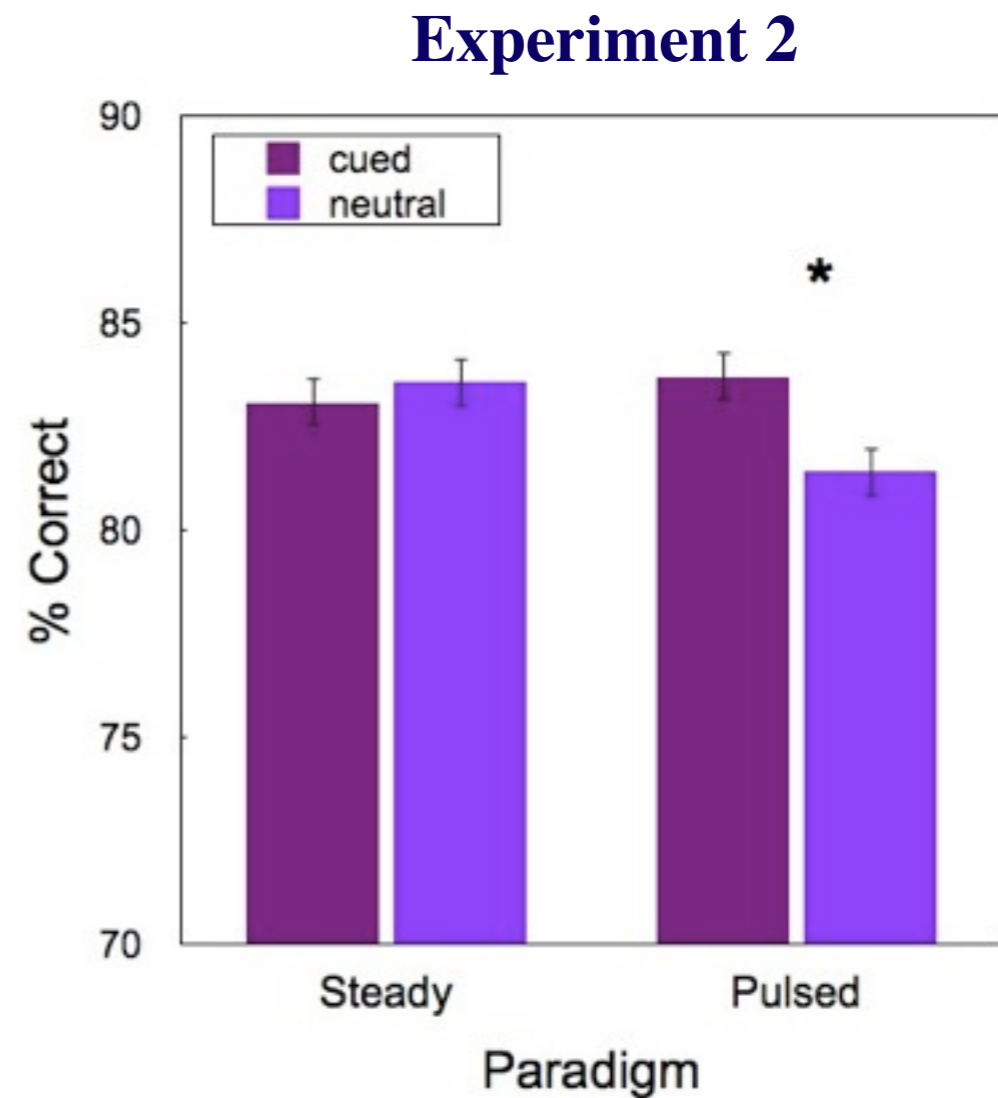
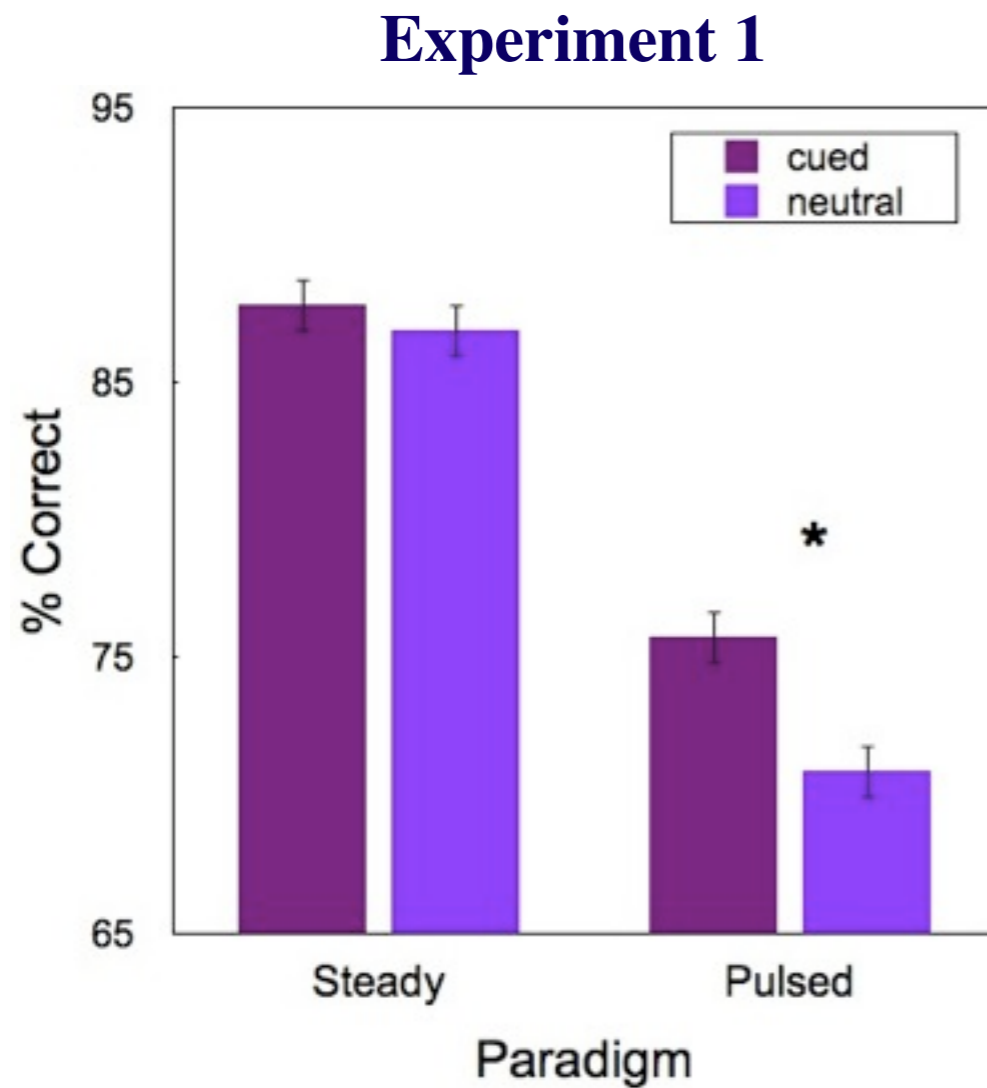


# Pulsed-Pedestal:



**Experiment 1: same contrast in both paradigms**

**Experiment 2: different contrast to equate performance level**



Transient attention favors **Parvocellular** over **Magnocellular** neuronal activity.

- Selective adaptation
- **Steady-pedestal and pulsed-pedestal paradigms**
- Reversed apparent motion
- Isoluminant stimuli
- Red background

## Summary

### \* A possible mechanism of transient attention:

Attention facilitates spatial segregation and temporal integration but impairs spatial integration and temporal segregation.

#### ➔ Supporting evidence:

Transient attention -

- Enhances spatial resolution
- Degrades temporal resolution
- Impairs temporal order judgement
- Prolongs the perceived duration
- Prolongs visible persistence
- Extends temporal window
- Impairs perceived motion
- Alleviates spatial crowding

### \* A possible physiological instantiation of this mechanism:

Attention favors Parvocellular over Magnocellular neuronal activity.

#### ➔ Supporting evidence:

- Selective adaptation
- Steady-pedestal and pulsed-pedestal paradigms
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Segregation	↑	↓
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**Transient attention** facilitates spatial segregation and temporal integration but impairs spatial integration and temporal segregation.

# Thanks!

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