Combining texture and colour cues in visual segmentation

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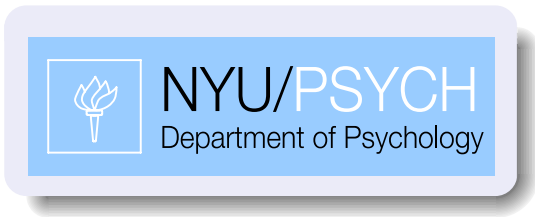
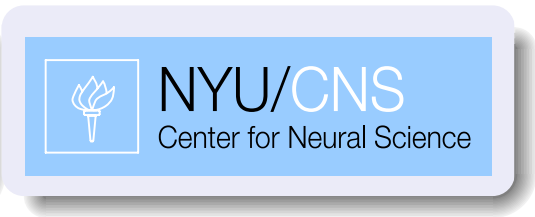
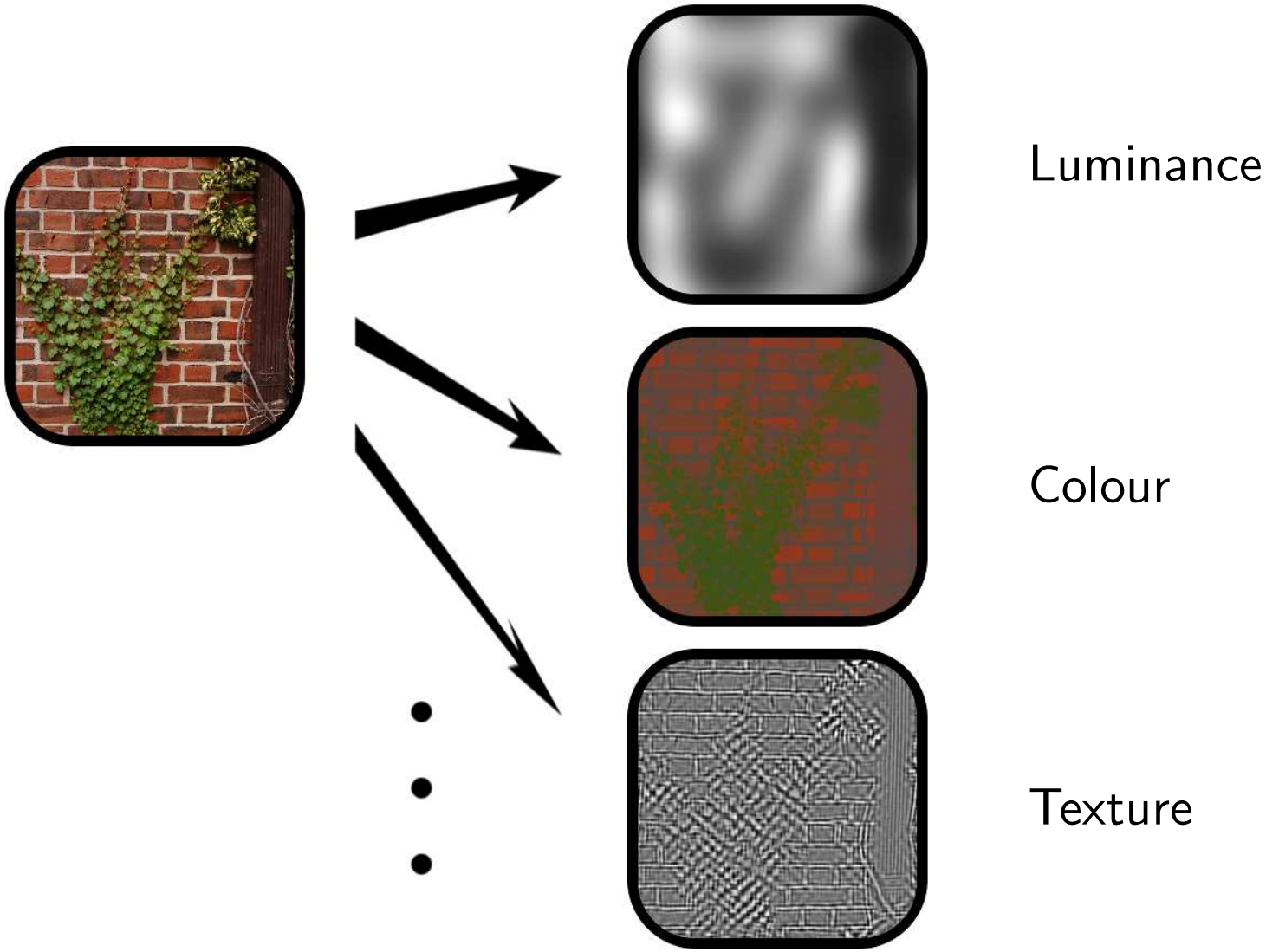




Cues for visual segmentation



Texture and colour

- Both texture and colour are robust cues that can provide information for segmentation under varying brightness or illumination
  - *Texture:* e.g., Schofield, 2000
  - *Colour:* e.g., Li & Lennie, 2001
- Both have been studied, but mostly in isolation

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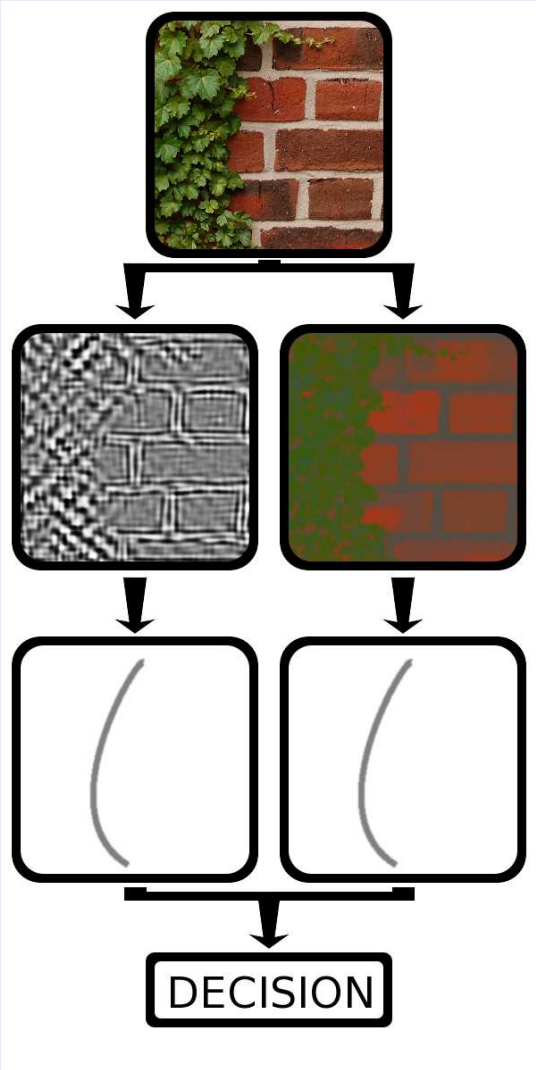
Questions

- If both cues are available, how are they combined?
- Independent or common neural mechanisms?

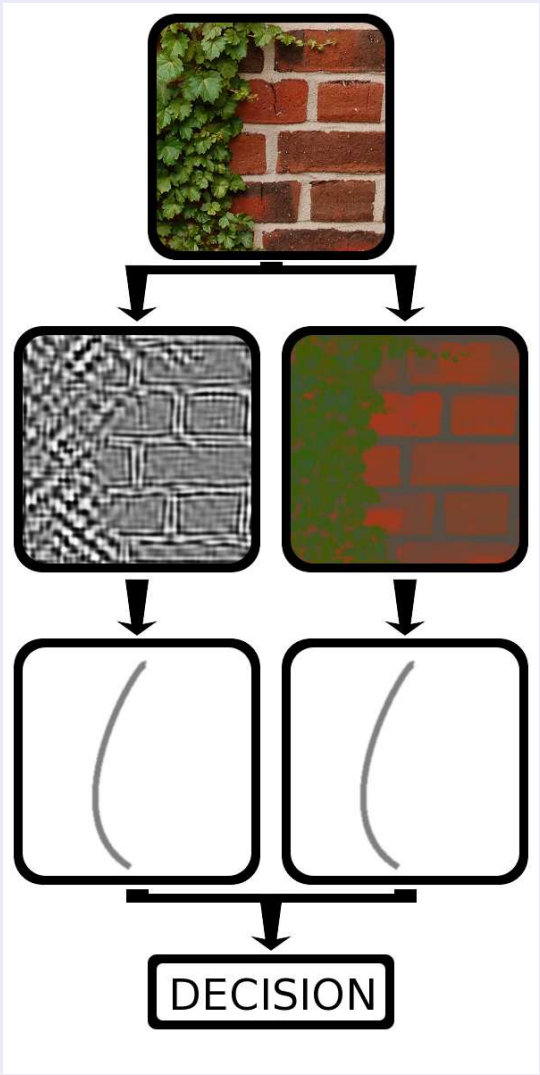
Independent or common segmentation mechanisms?

Independent

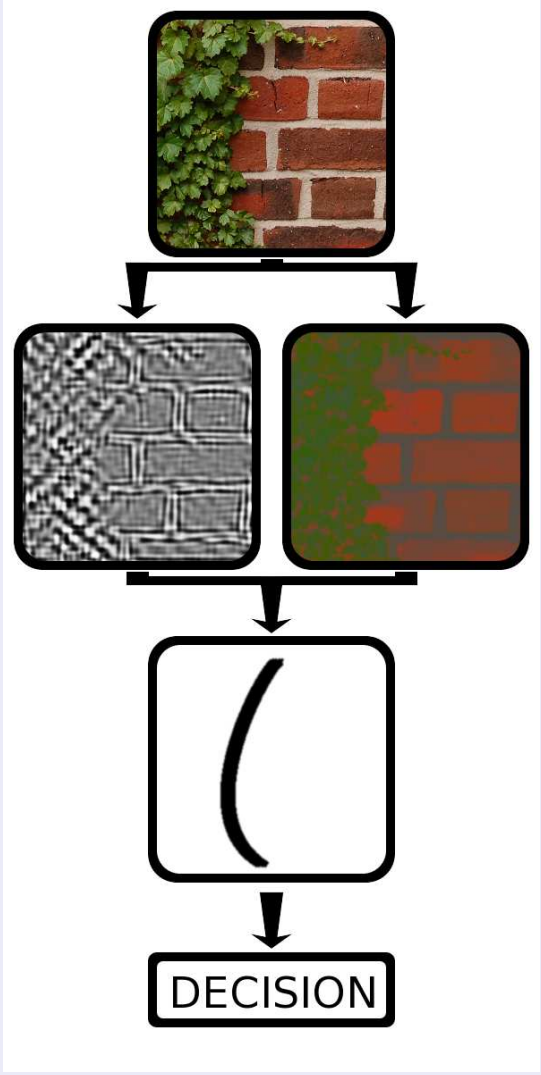


Independent or common segmentation mechanisms?

Independent



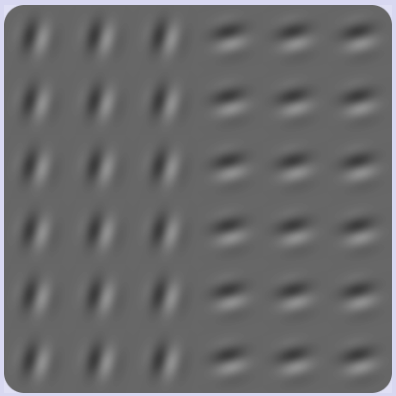
Common



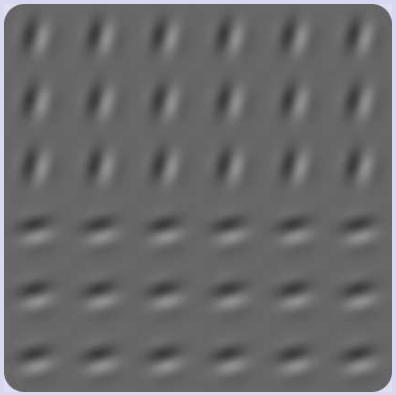
Segmentation task: vertical or horizontal edge?

Conditions

Texture



vs.



Orient. diff. $= \Delta\theta$
Colour diff. $= 0$

Stimuli

- 12×12 arrays of Gabors
- Gabor spatial frequency: 1 cycle/degree
- Gabors have fixed luminance contrast

Segmentation task: vertical or horizontal edge?

Conditions

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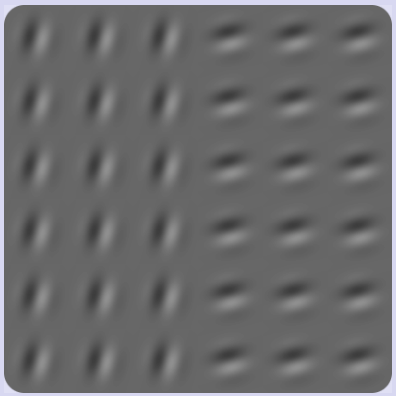

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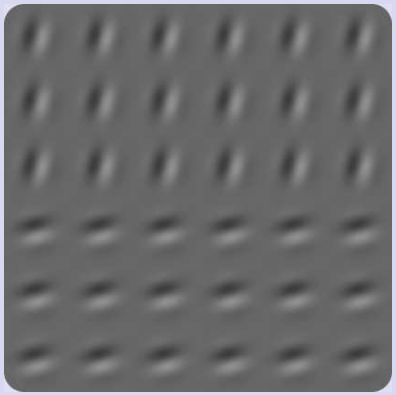

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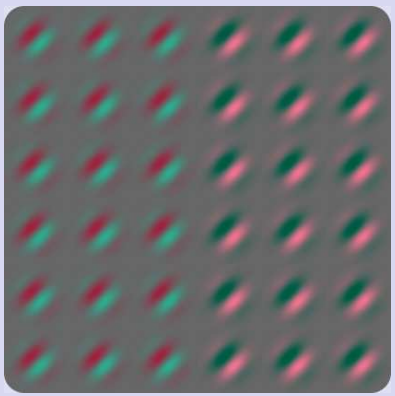

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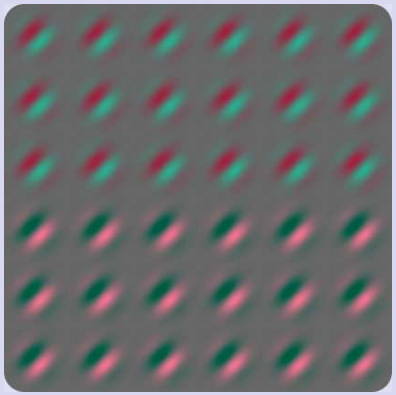

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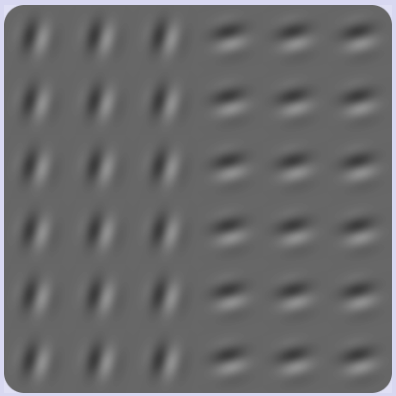

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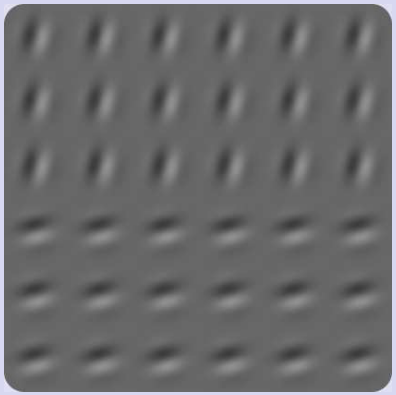

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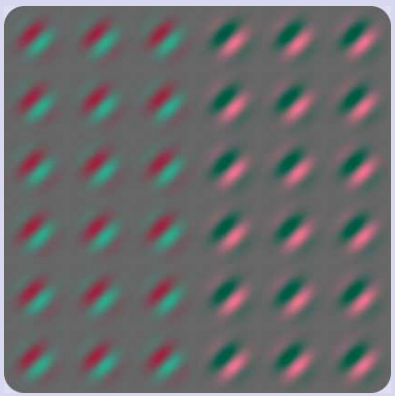

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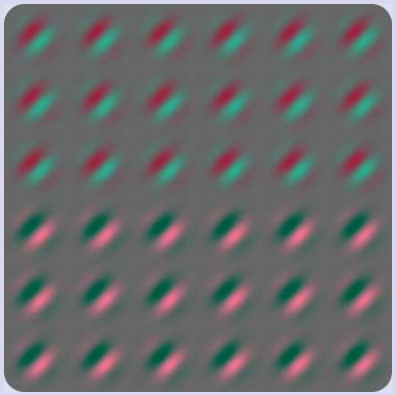

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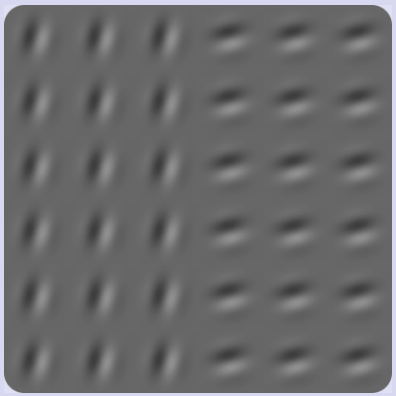

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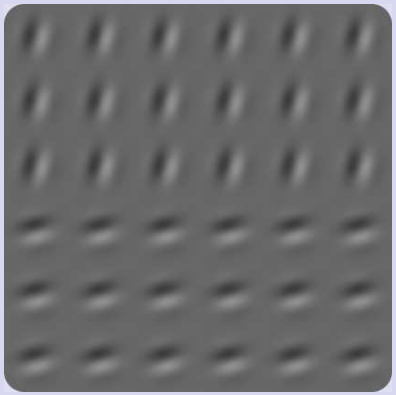

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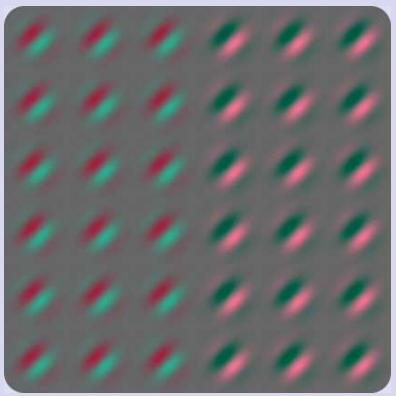

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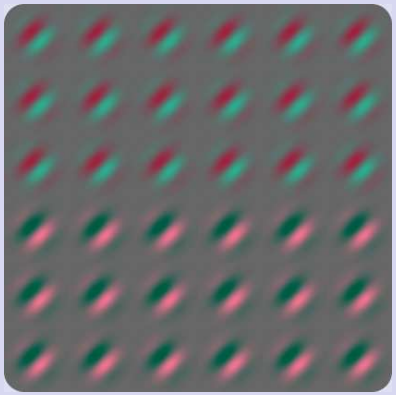

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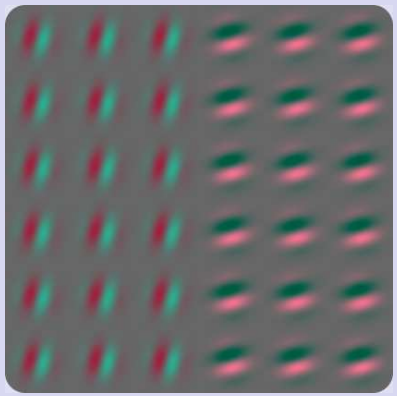

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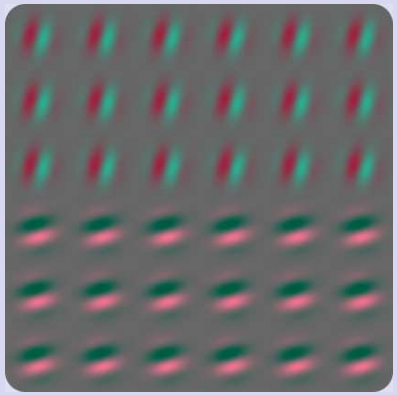

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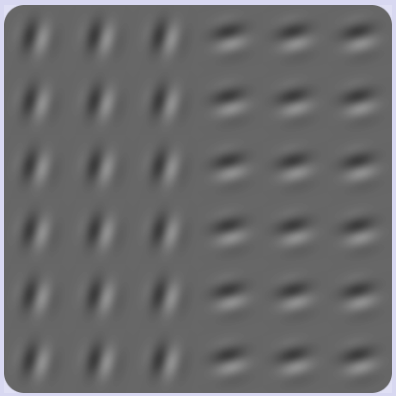

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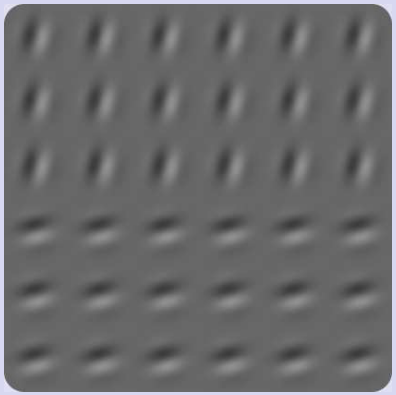

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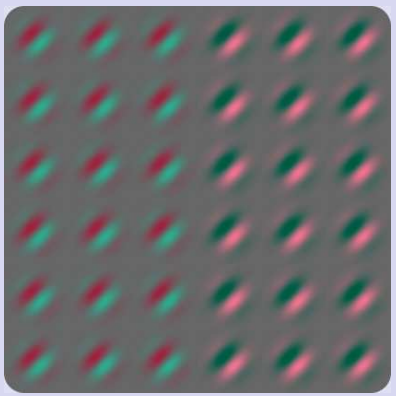

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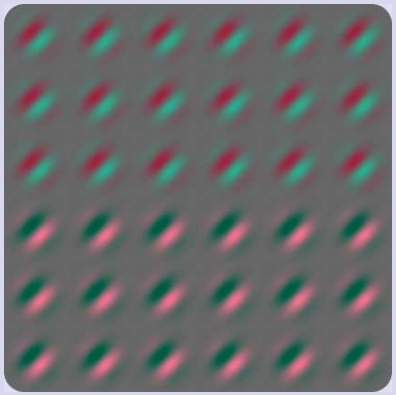

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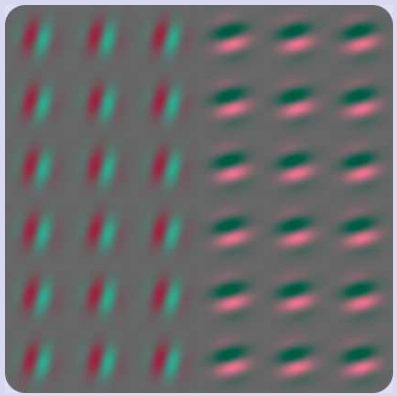

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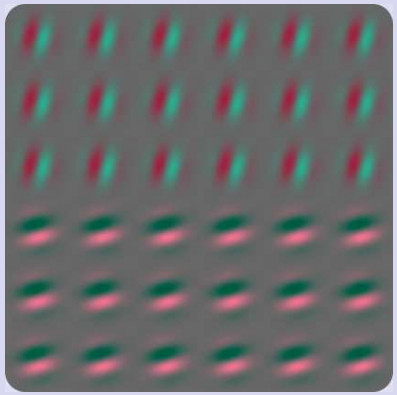

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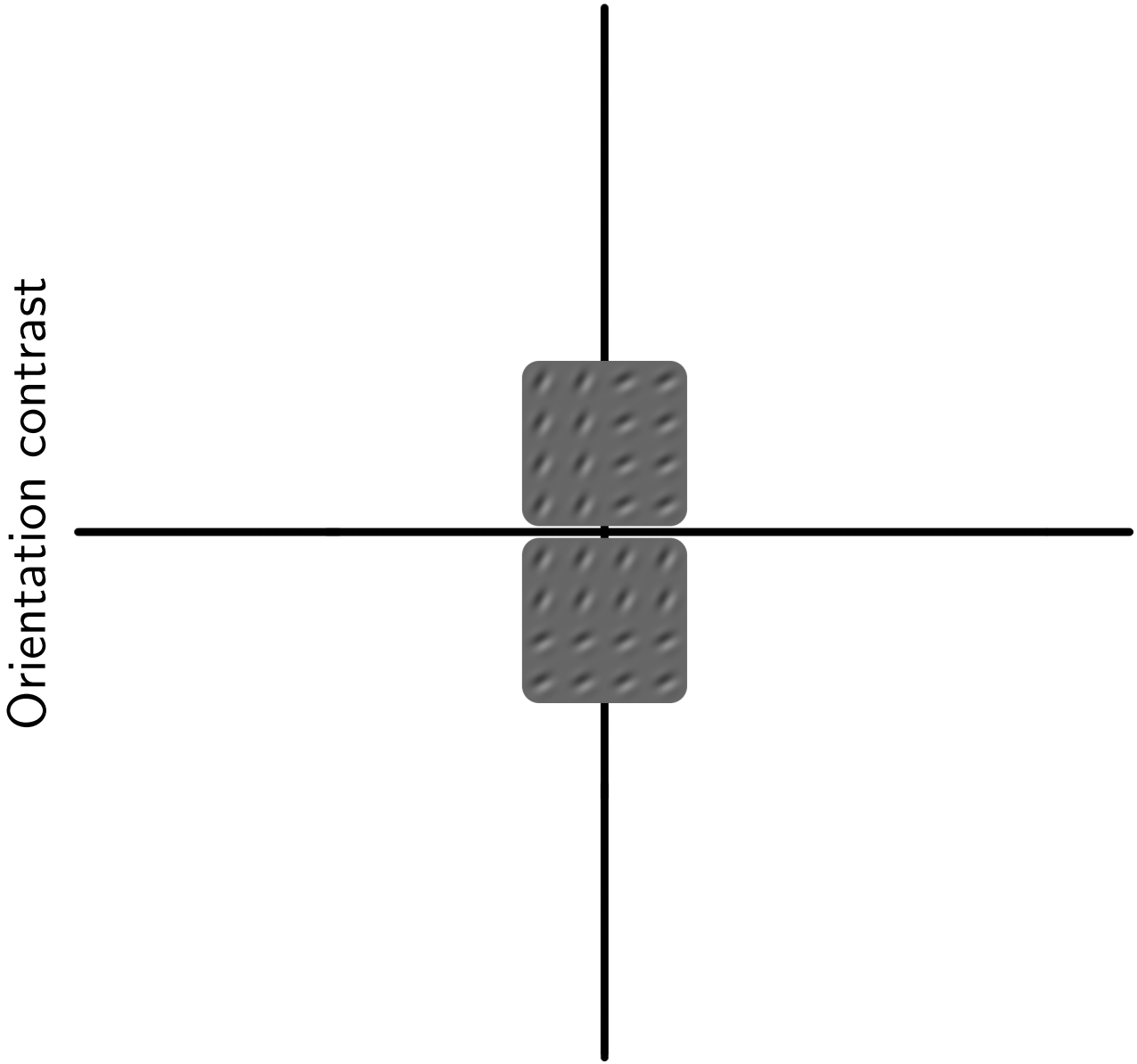
Procedure

- Single-interval design
- 250 ms presentation
- Blocked conditions
- Random stripe phase

Stimulus space: Texture condition



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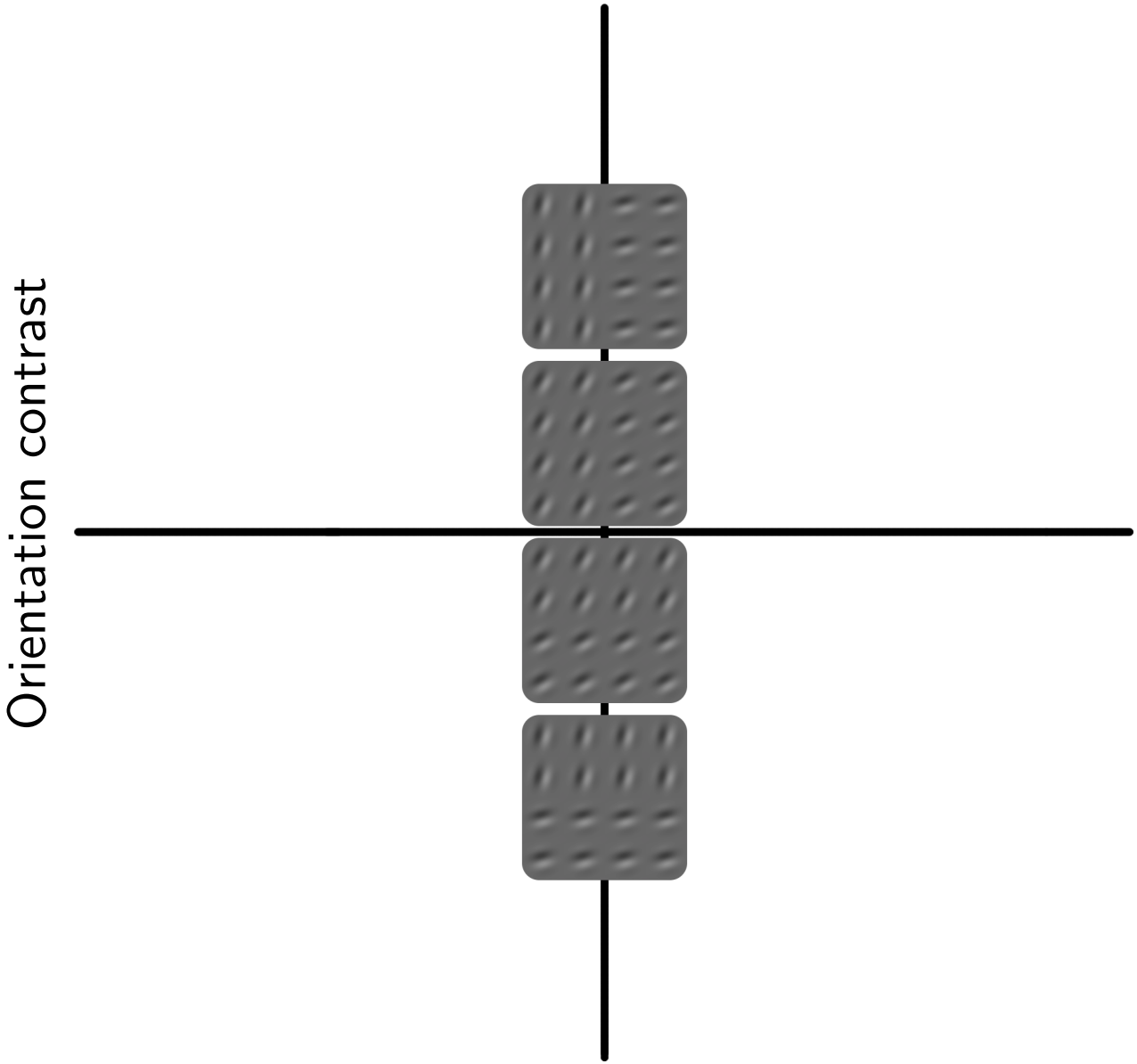

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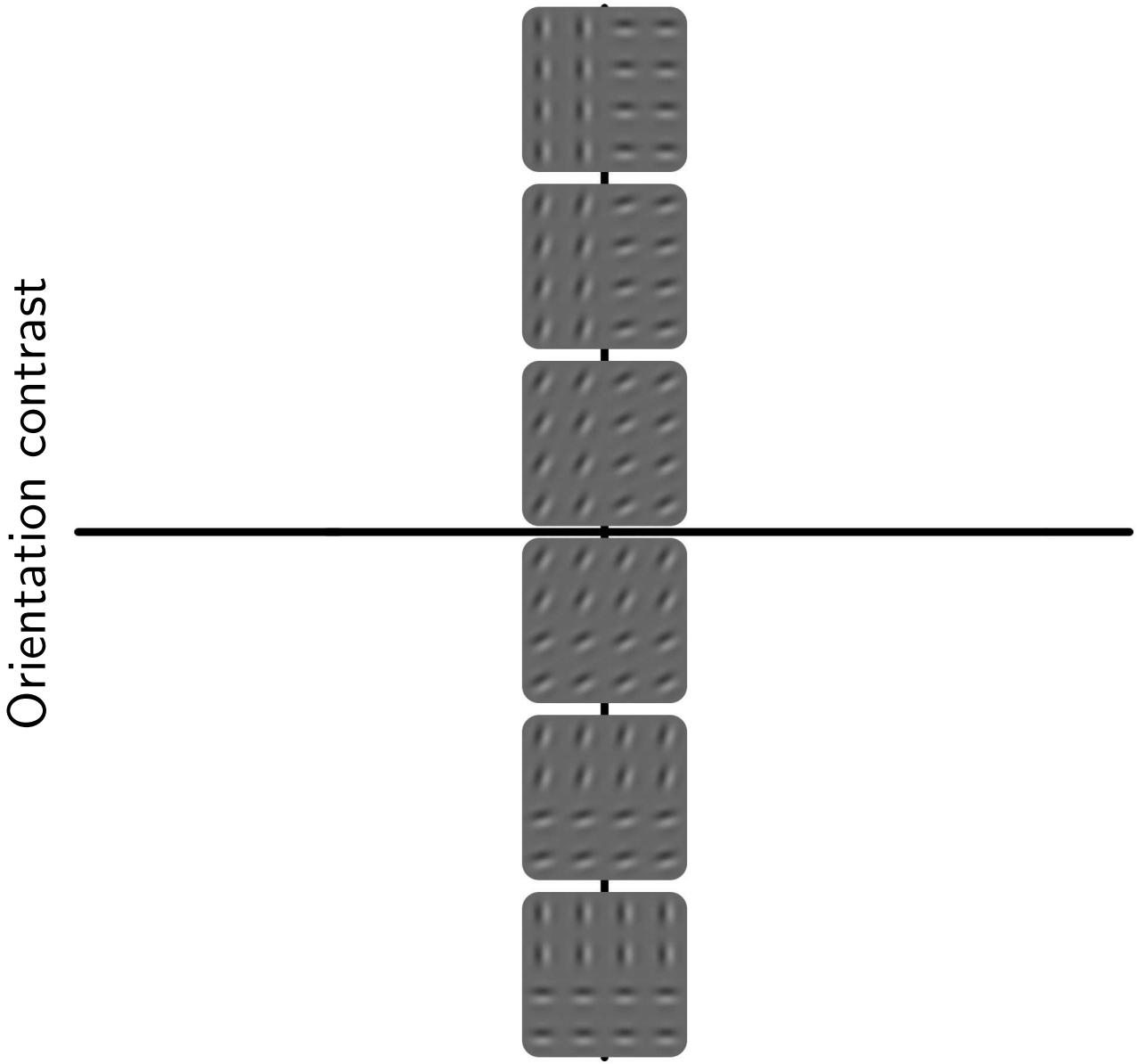
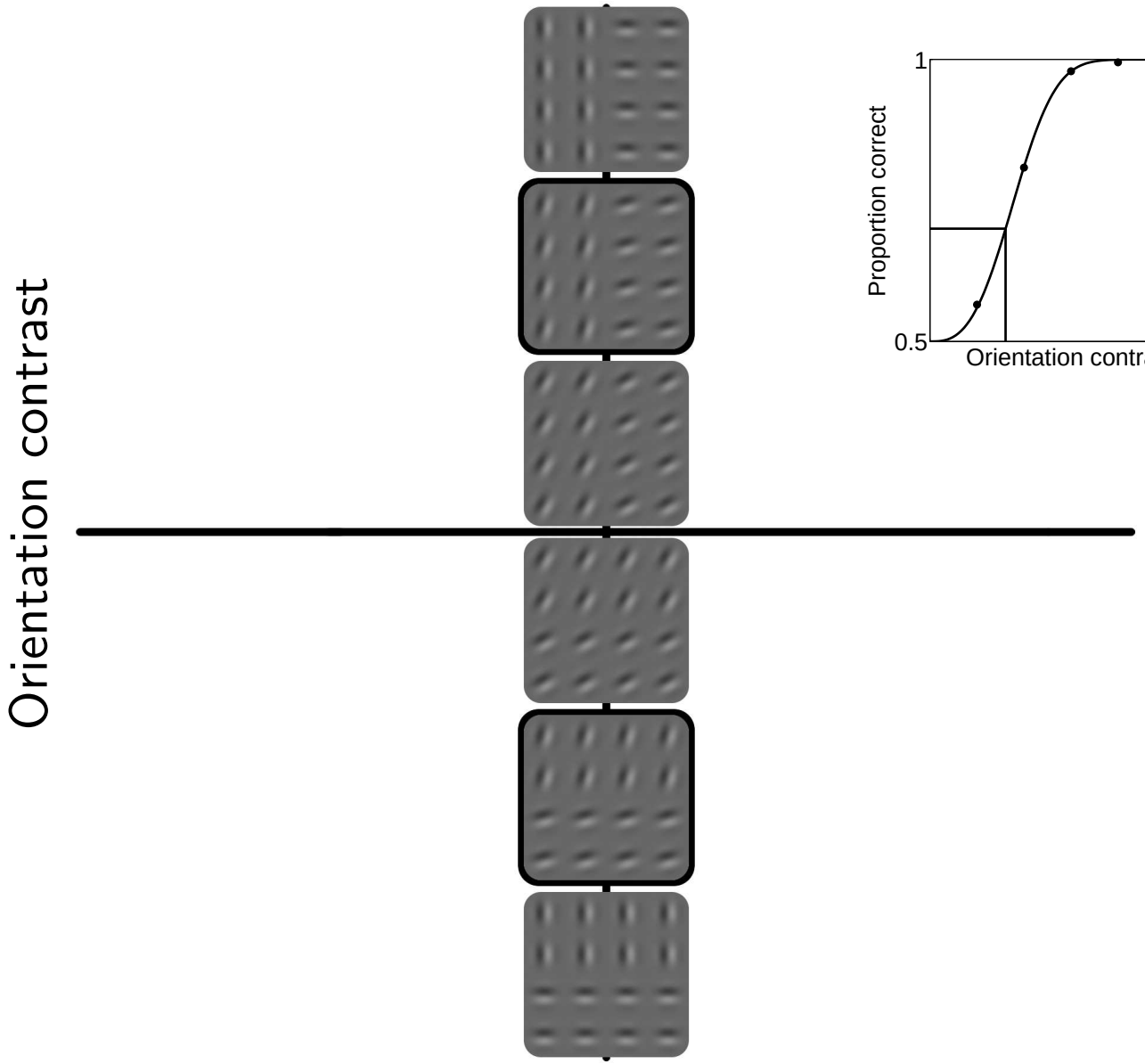


Stimulus space: Texture condition



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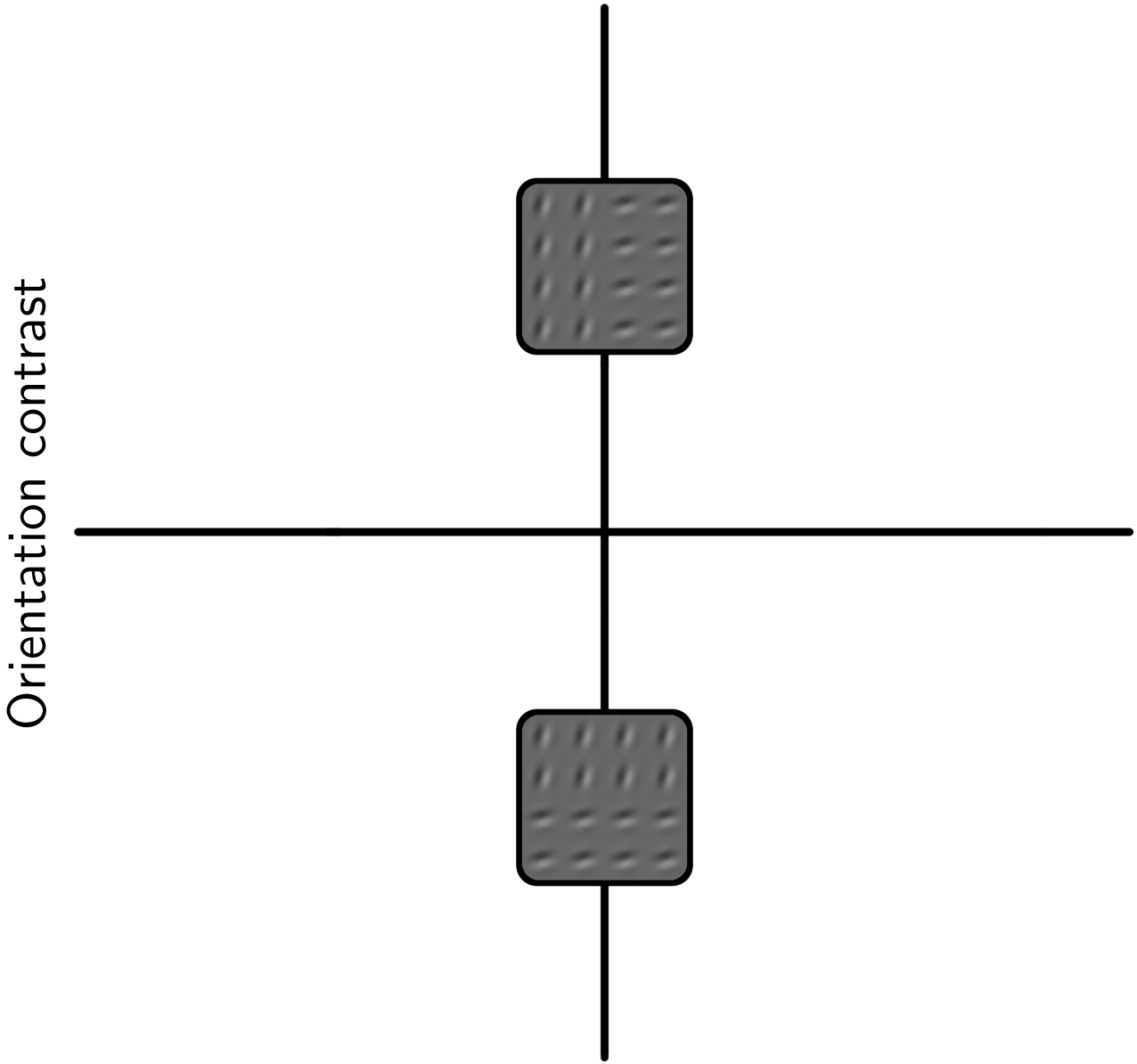
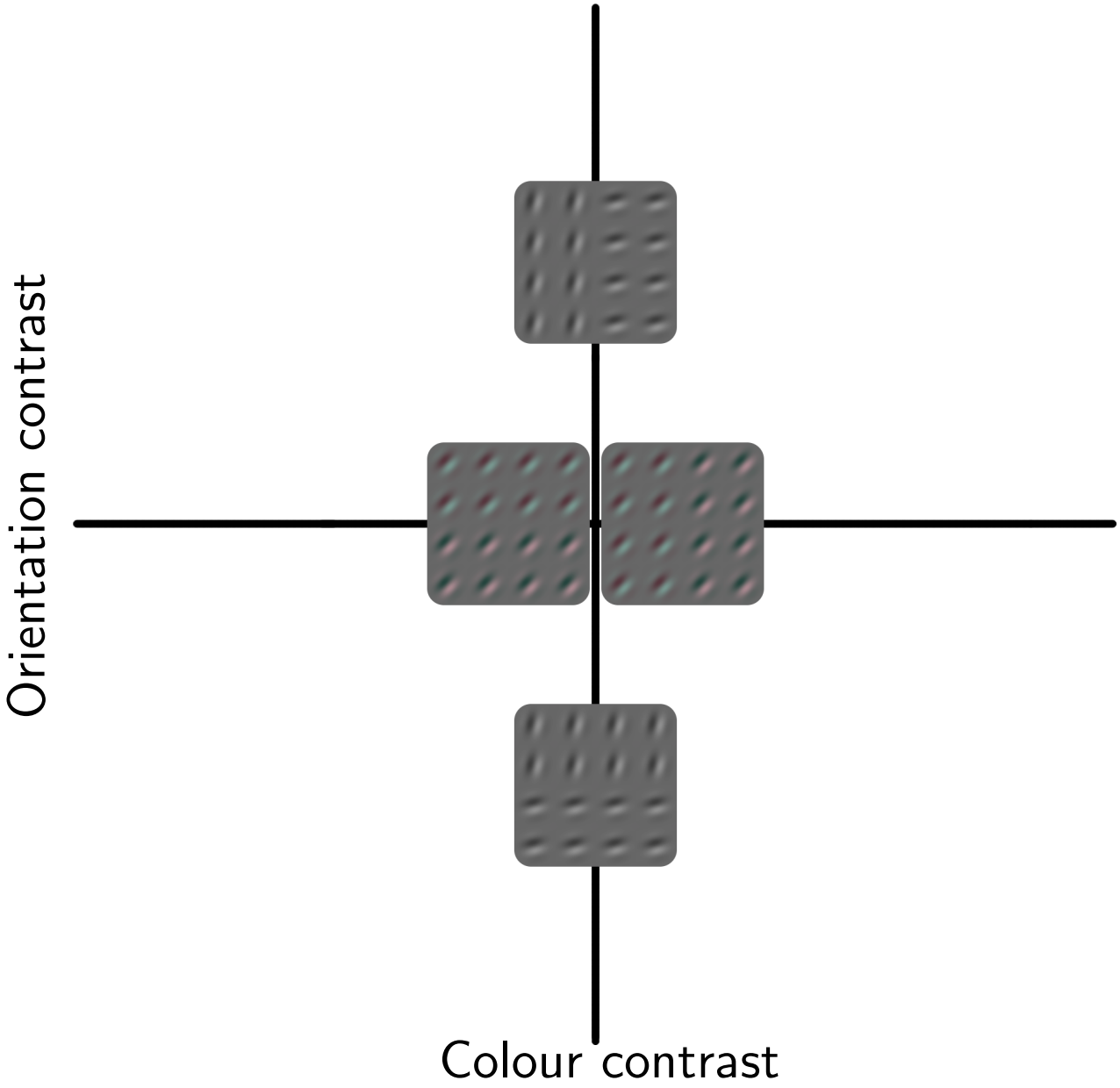
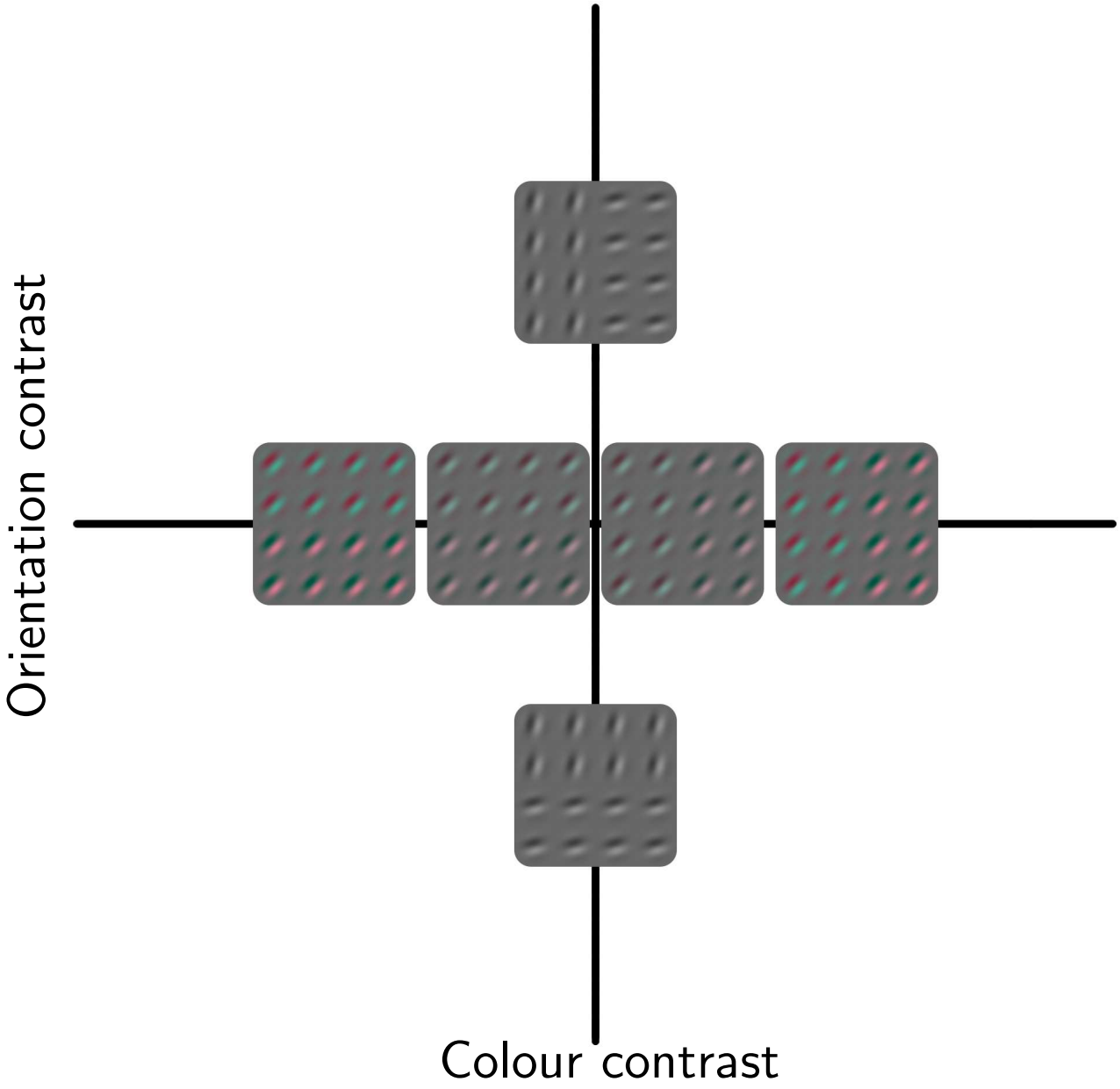


Stimulus space: Colour condition



Stimulus space: Colour condition



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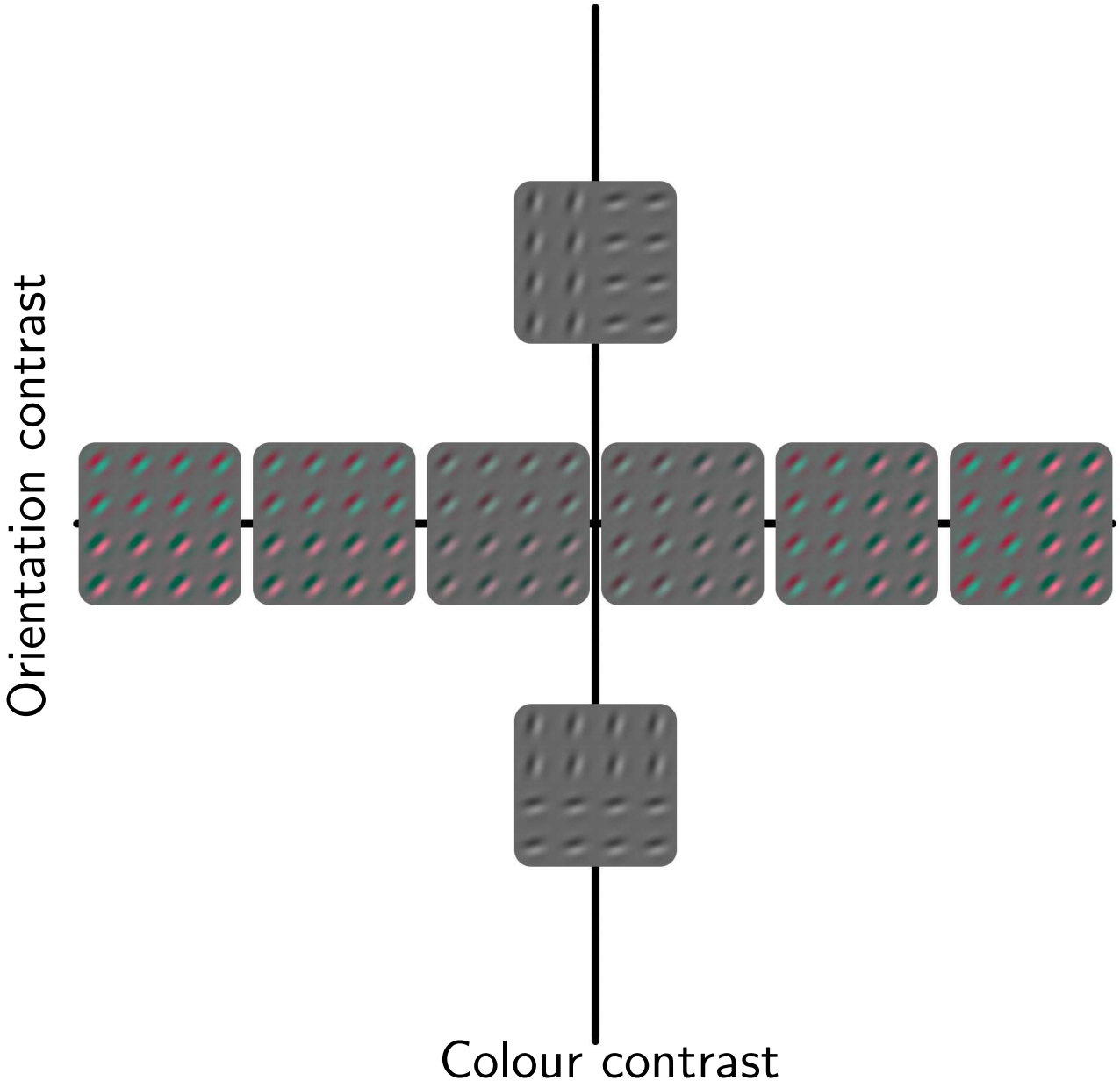

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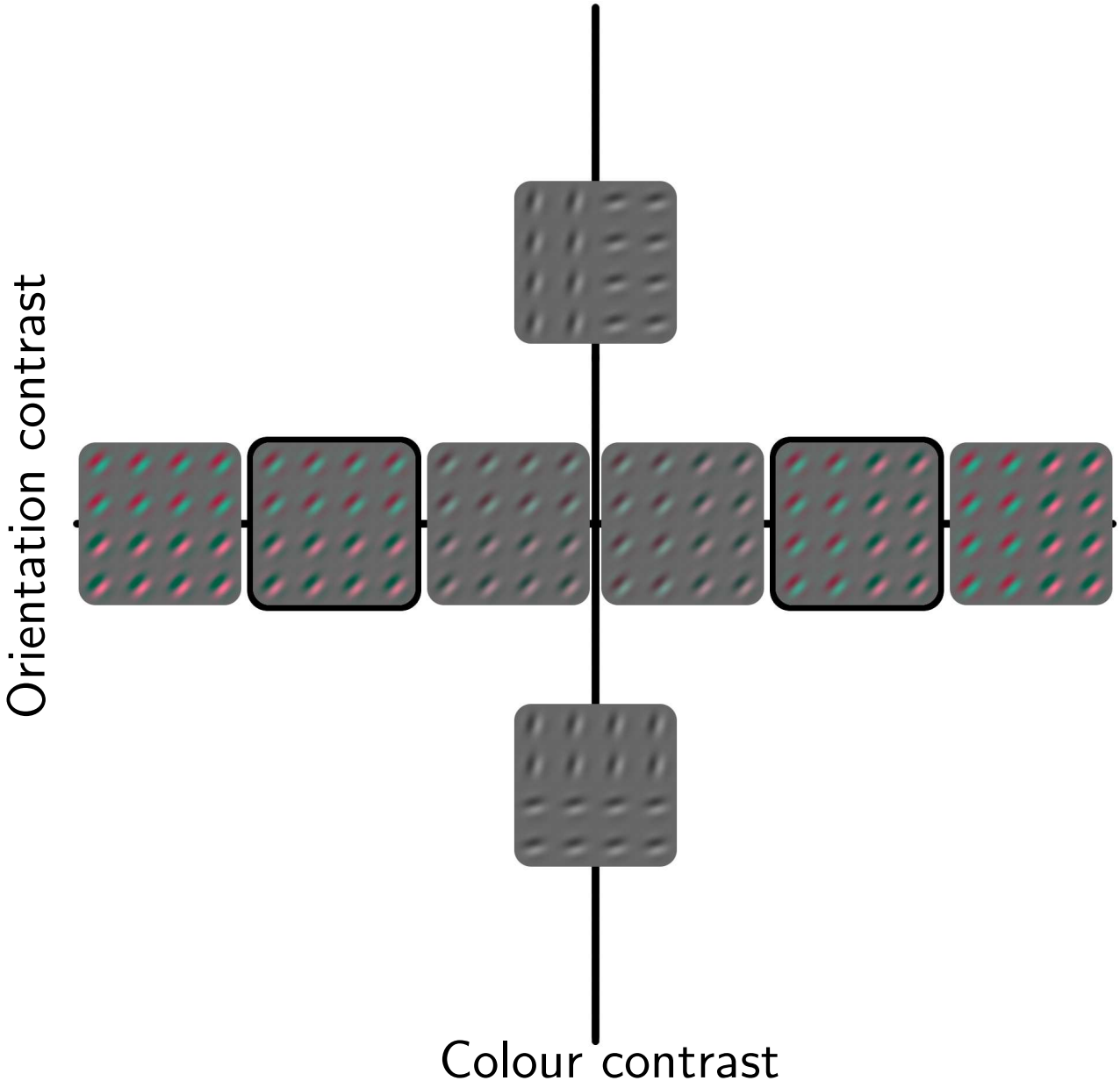
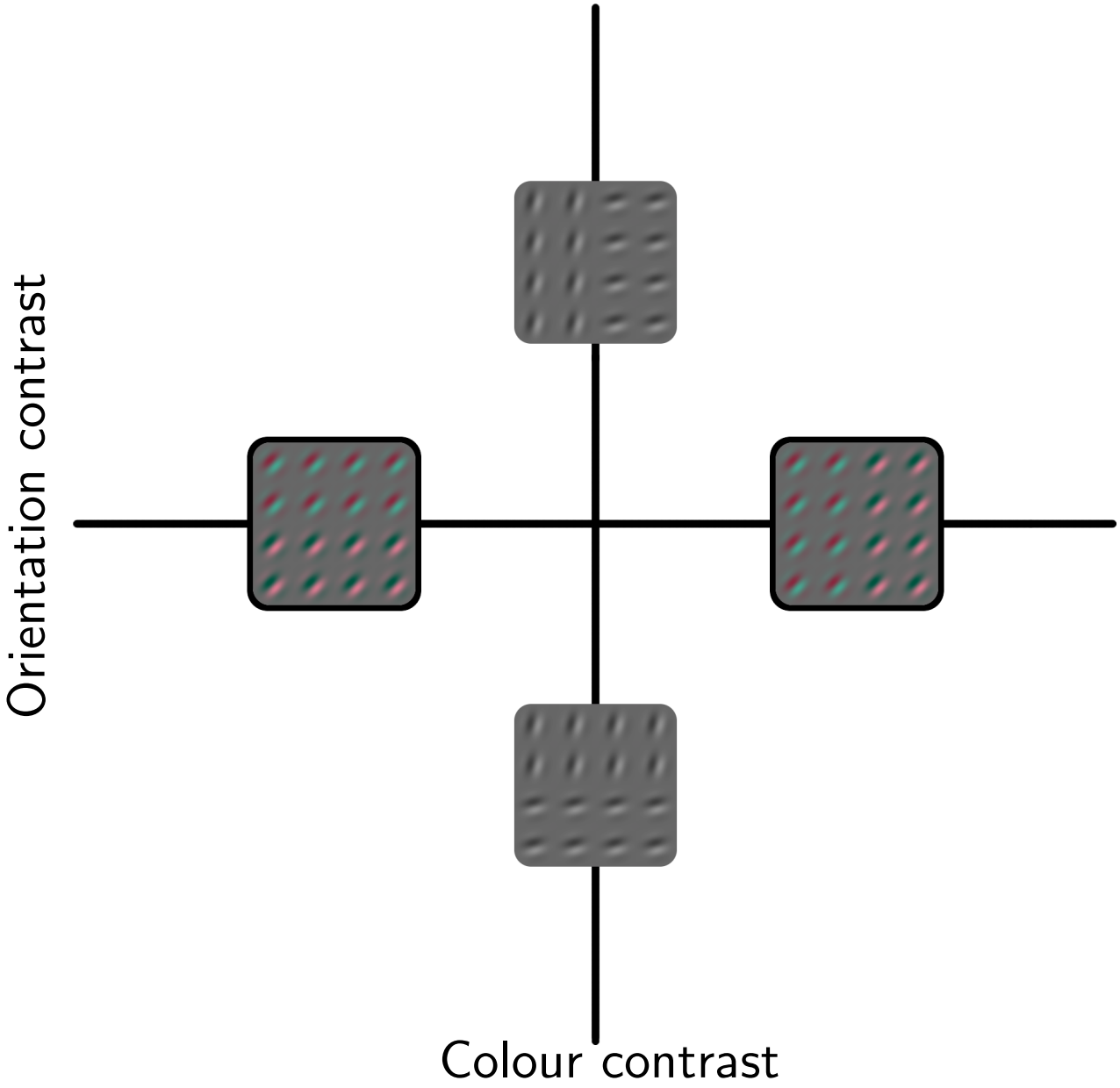
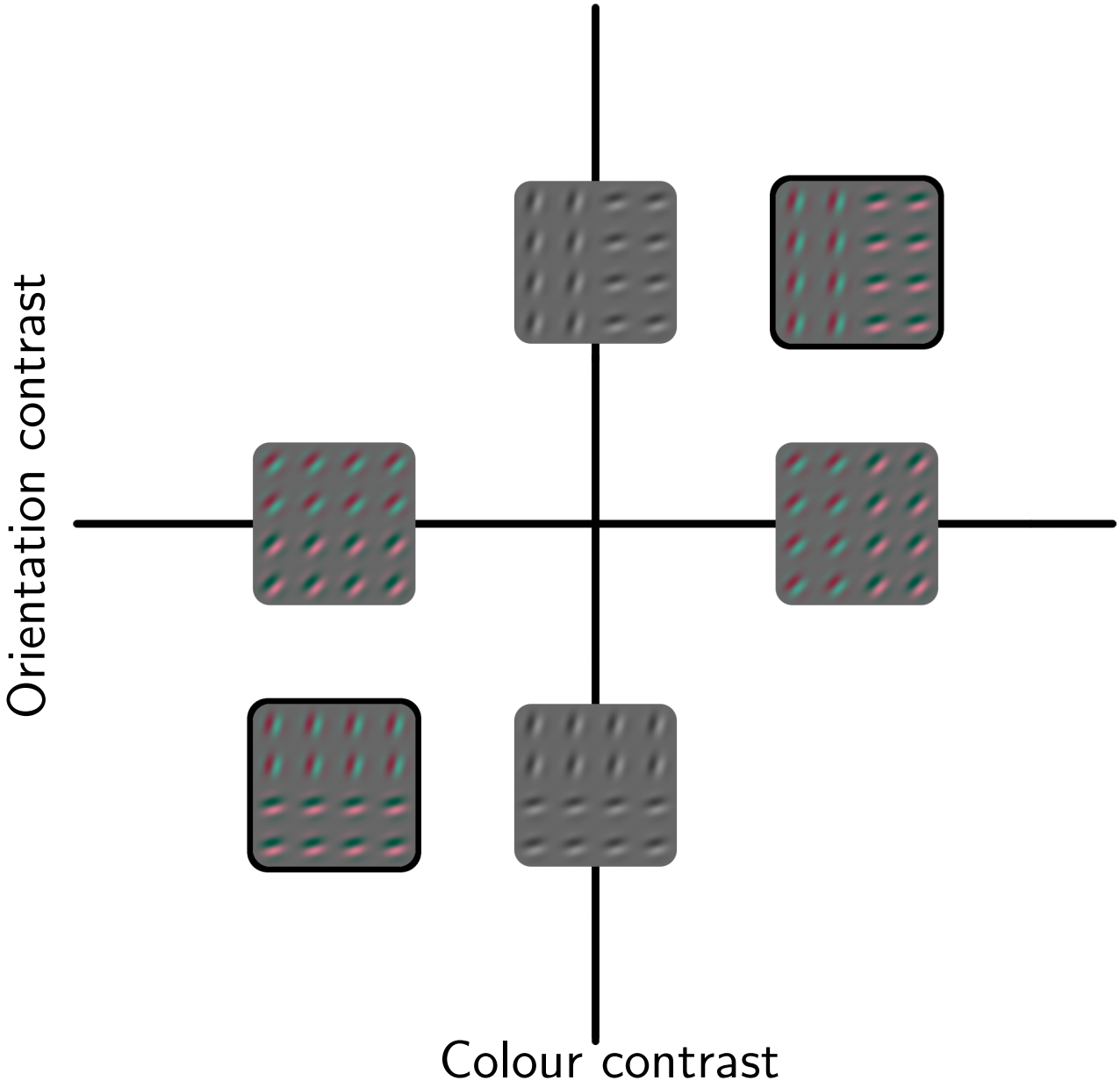


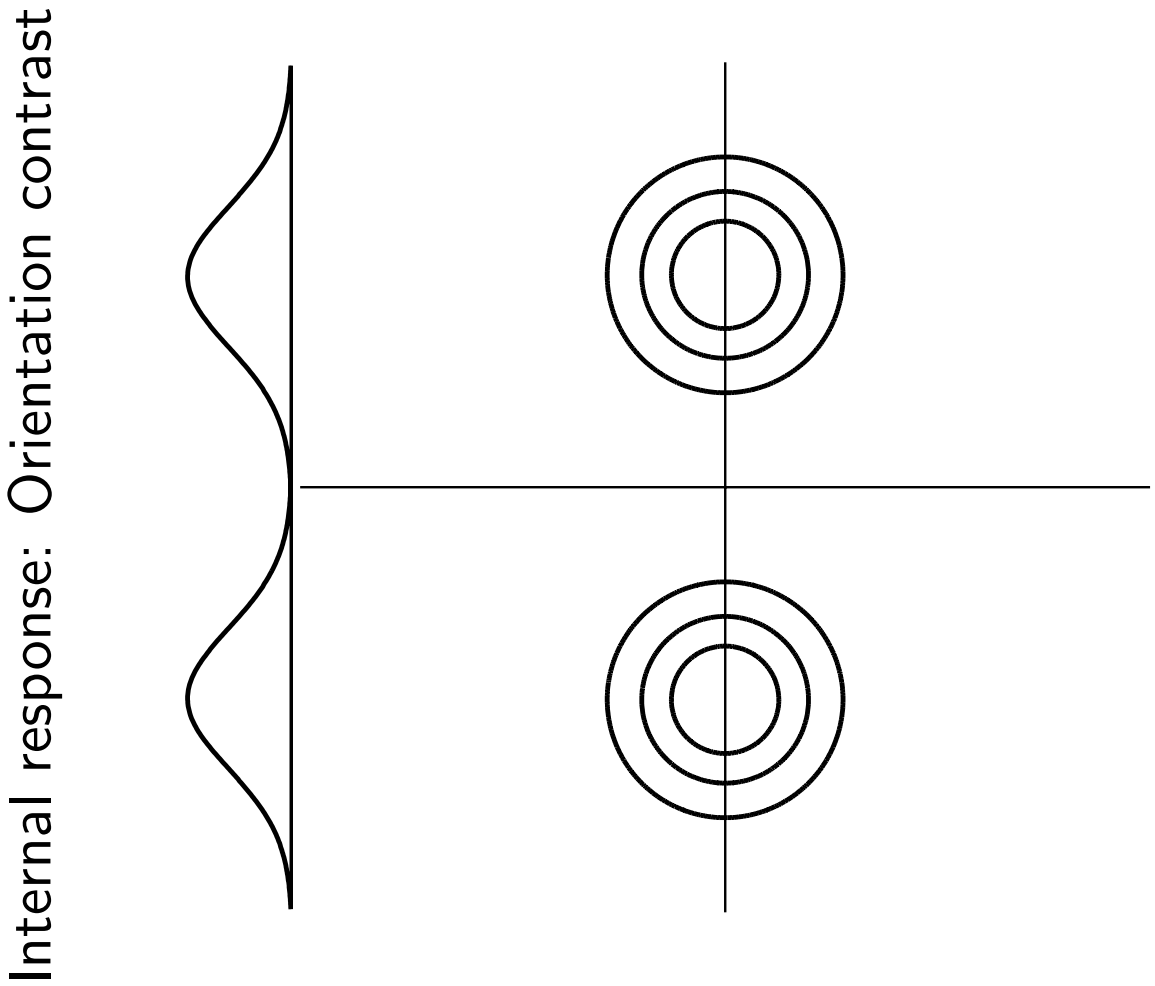
Stimulus space: Colour condition



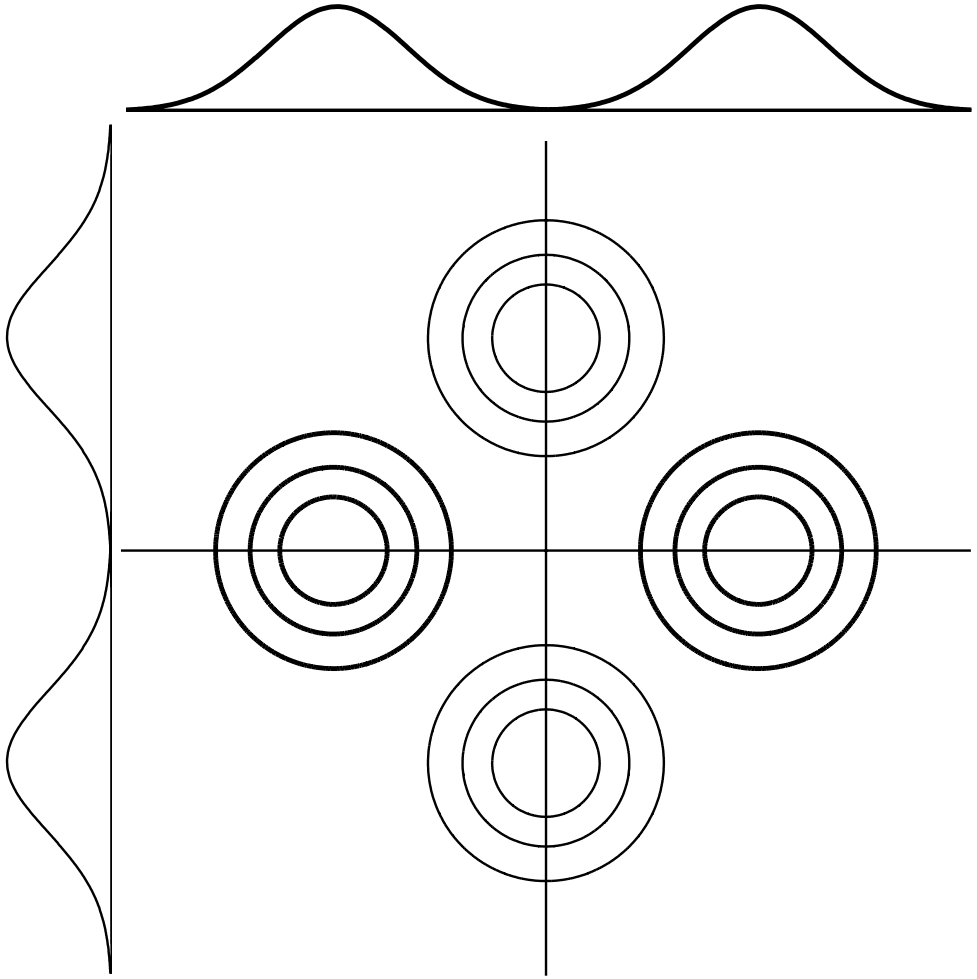
Stimulus space: Cue-combination condition



Decision space: Texture condition



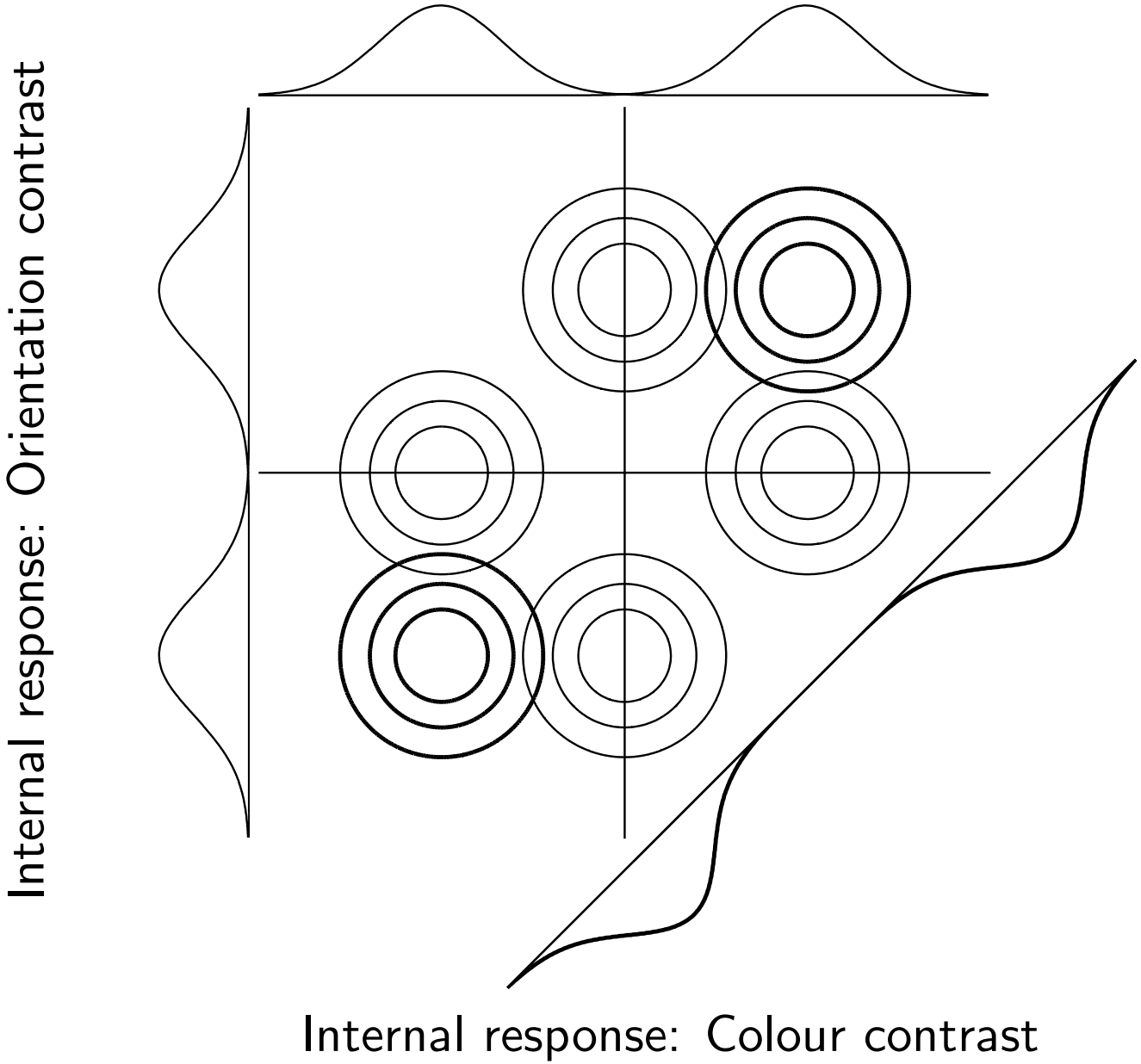
Decision space: Colour condition



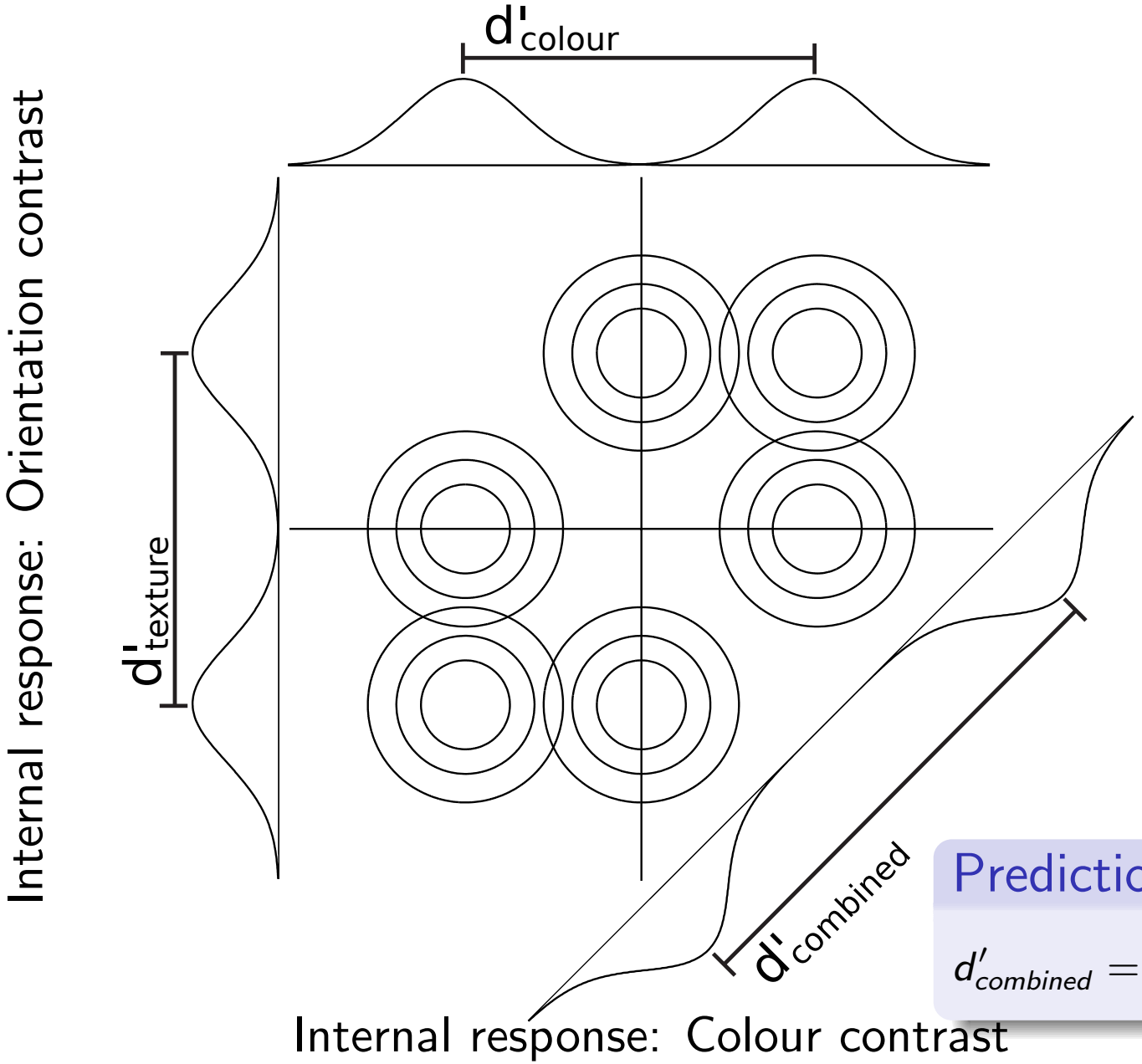
Internal response: Orientation contrast

Internal response: Colour contrast

Decision space: Cue-combination condition



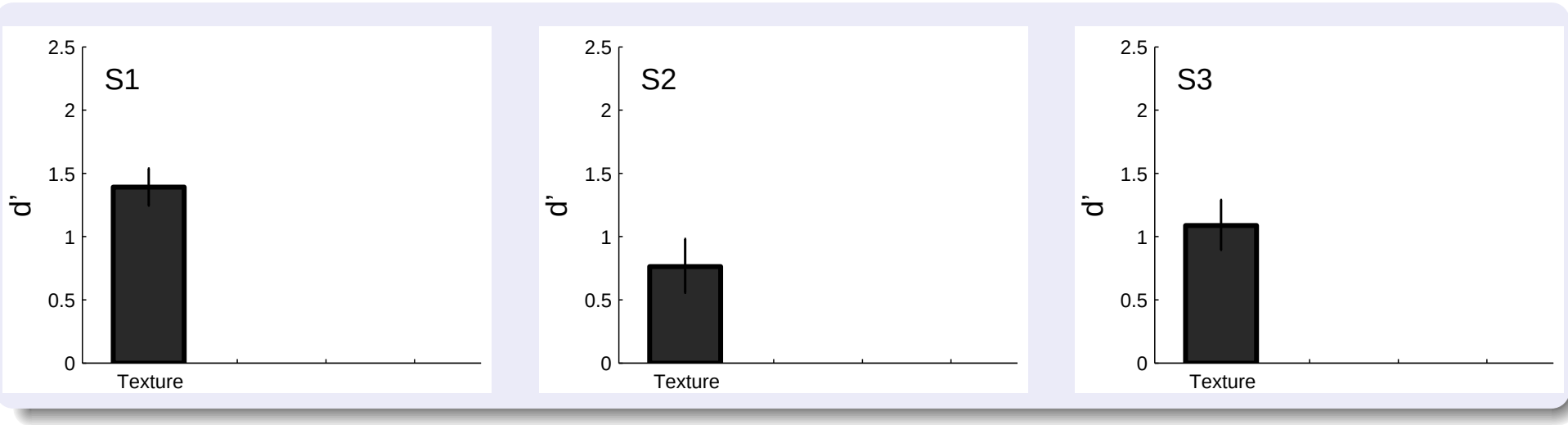
Decision space: Sensitivity



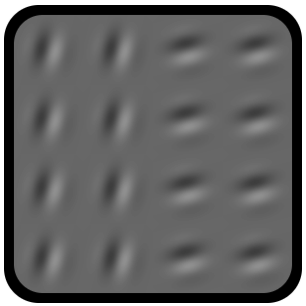
Prediction

$$d'_{combined} = \sqrt{d'^2_{texture} + d'^2_{colour}}$$

Results



Texture



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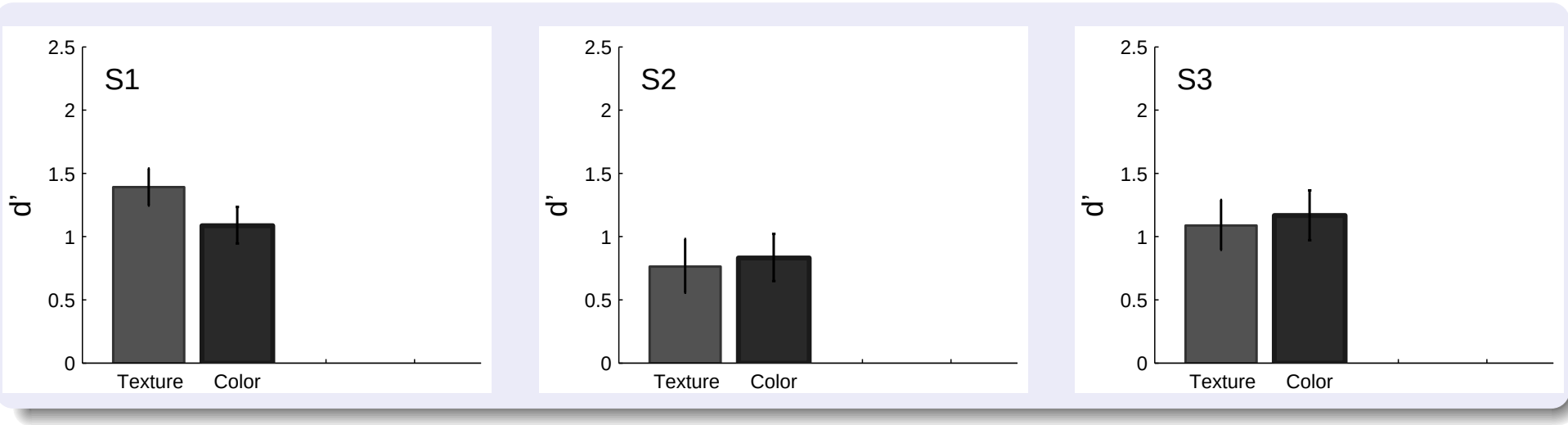

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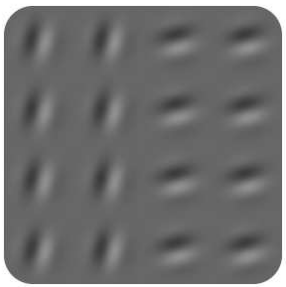
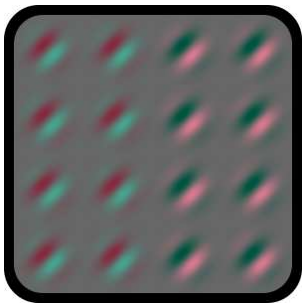


Colour



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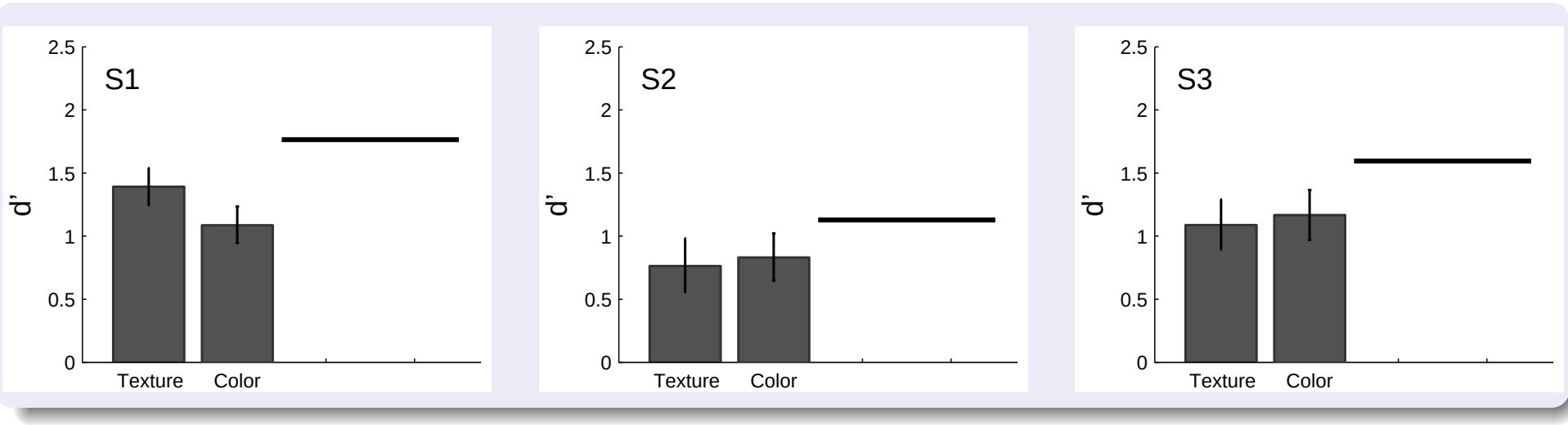

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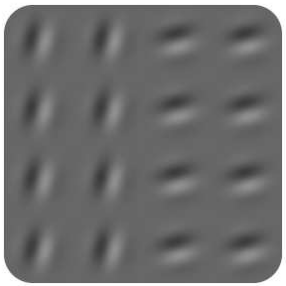
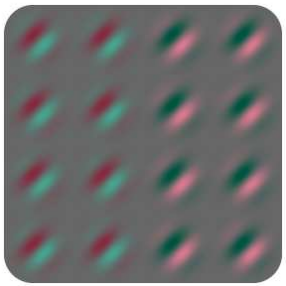
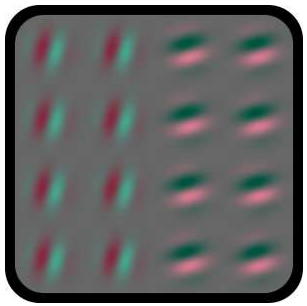


Colour



Combined



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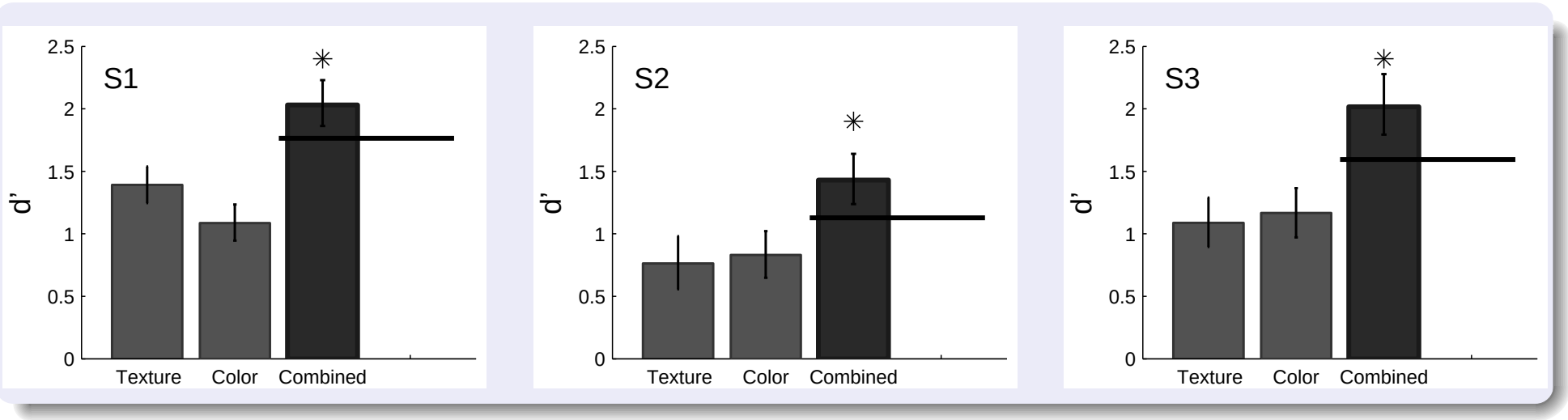
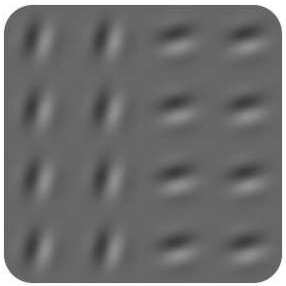
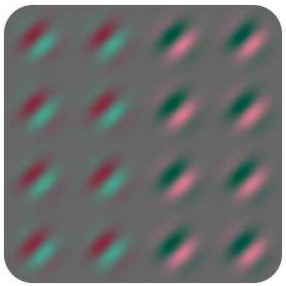


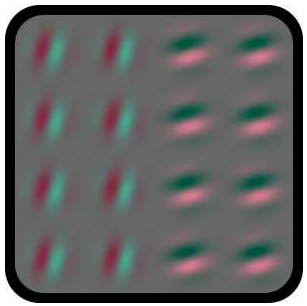
Texture



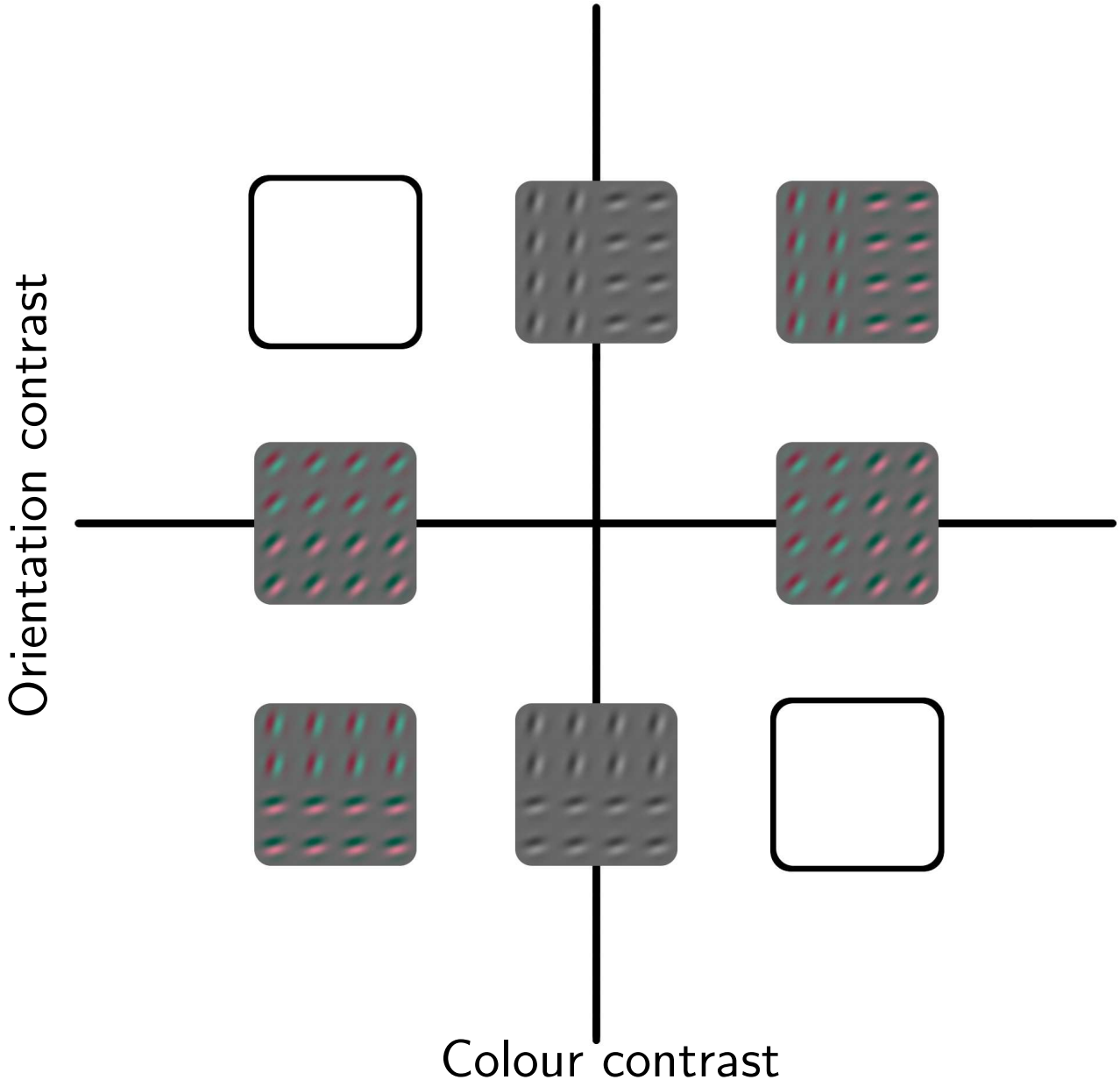
Colour



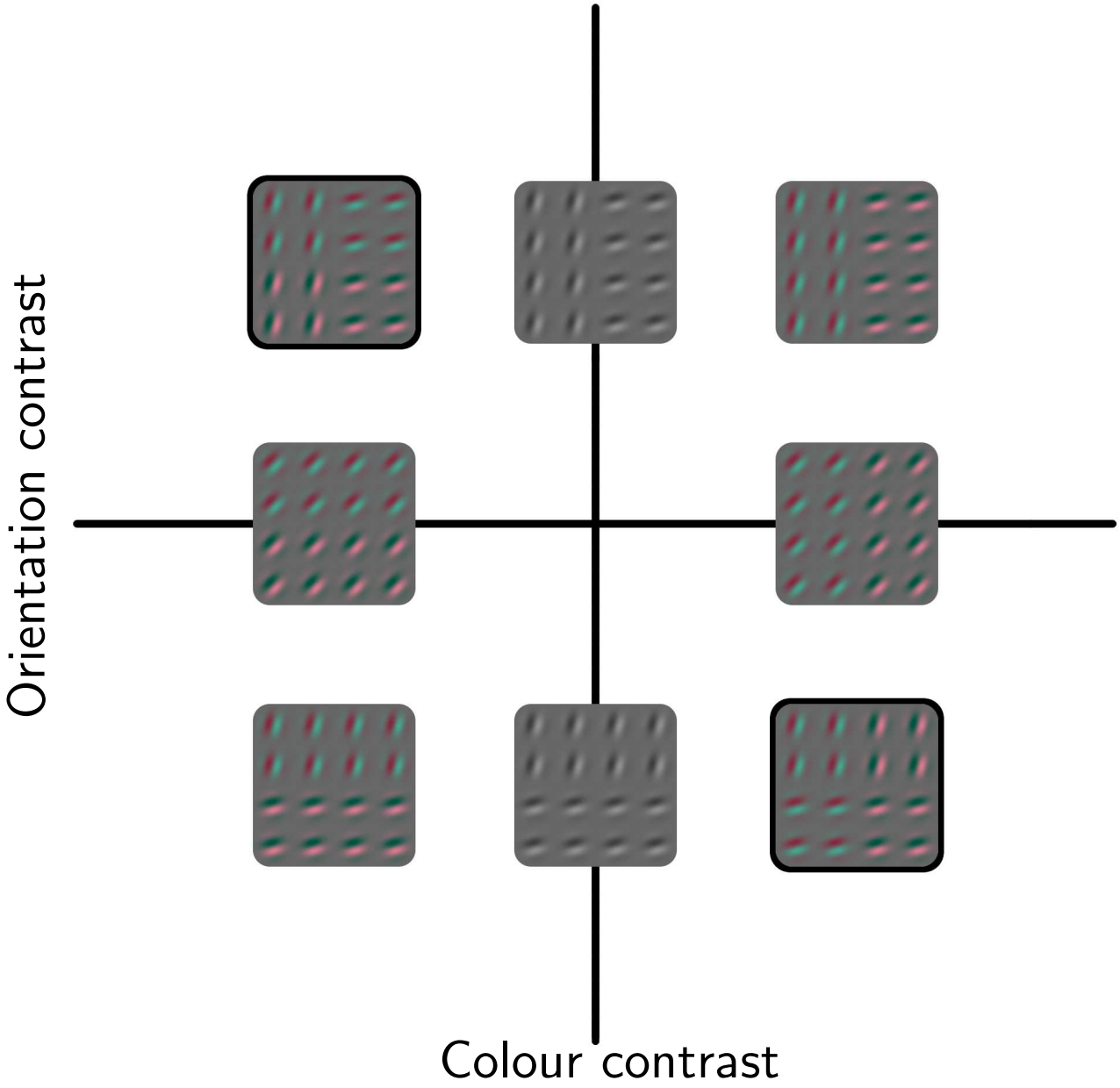
Combined



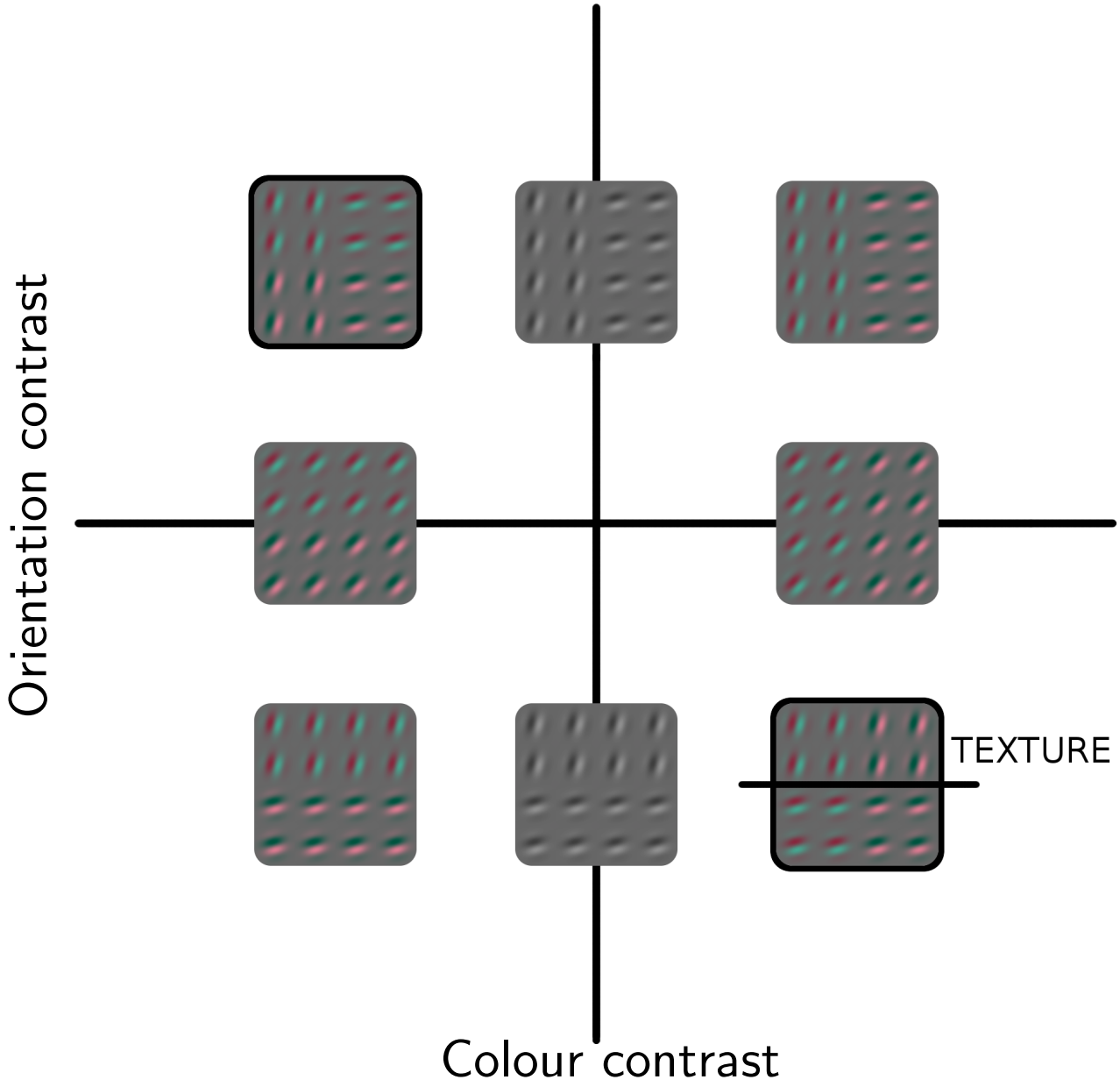
Stimulus space:



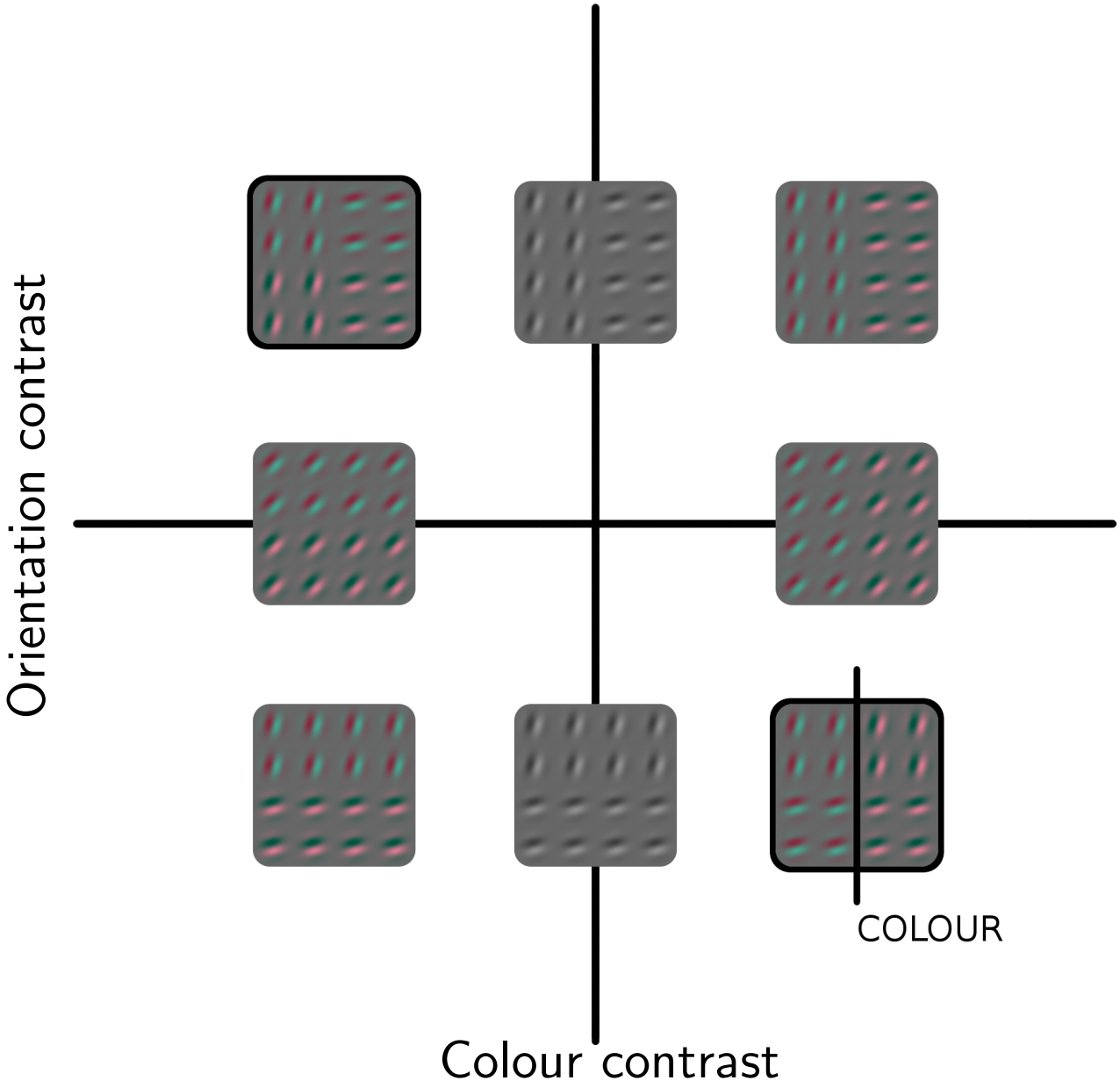
Stimulus space: Cue-conflict condition



Stimulus space: Cue-conflict condition

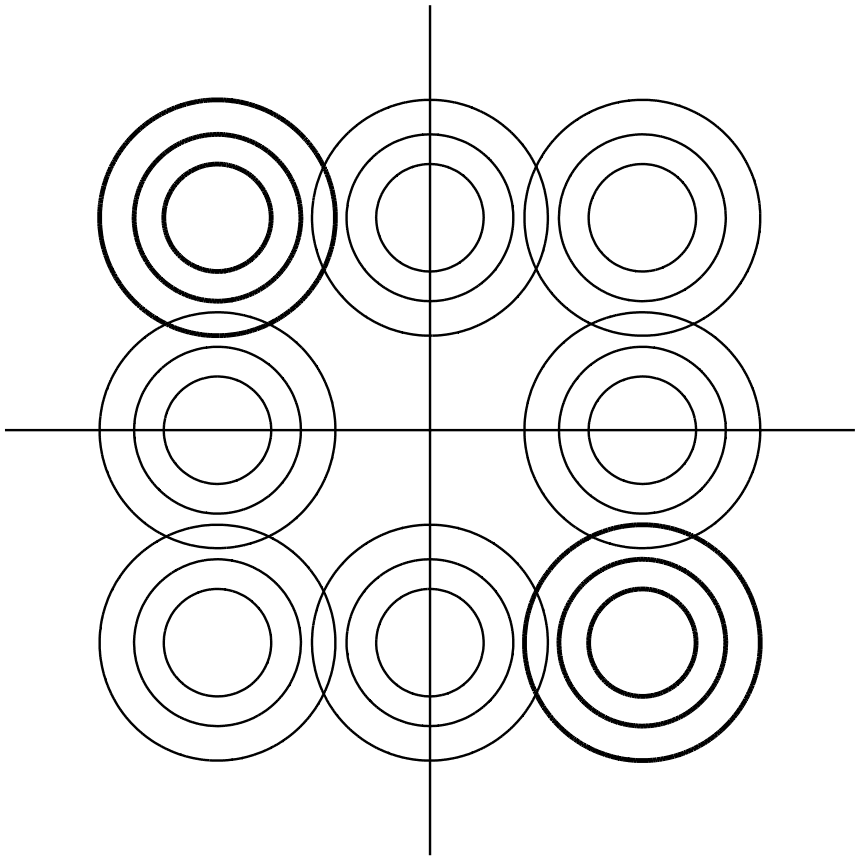


Stimulus space: Cue-conflict condition



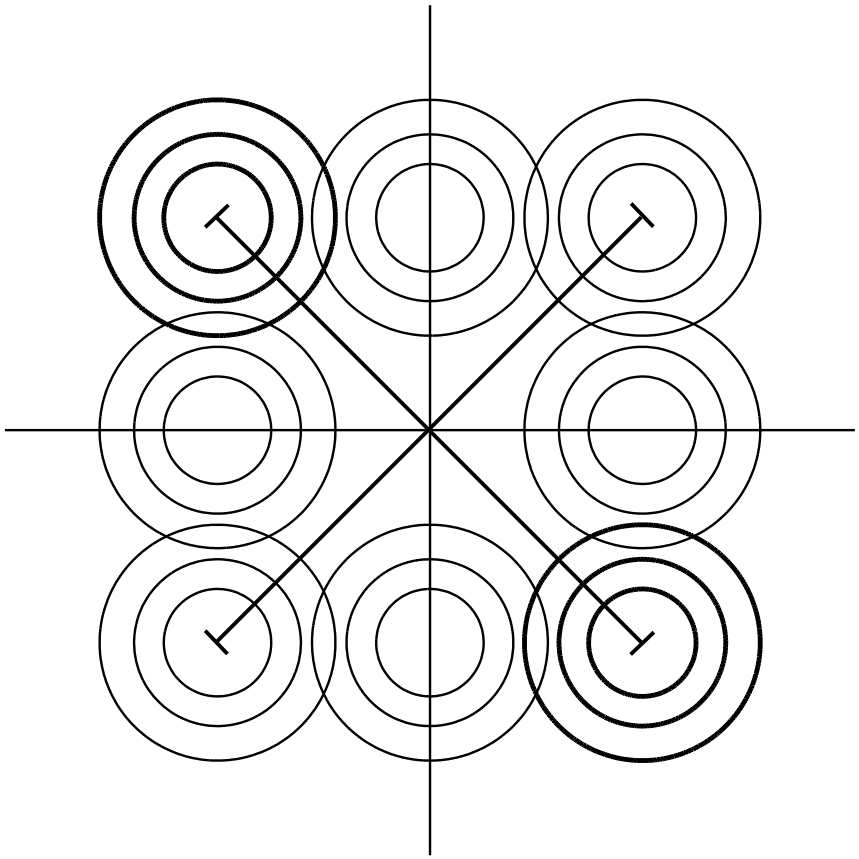
Decision space: Cue-conflict condition

Internal response: Orientation contrast



Internal response: Colour contrast

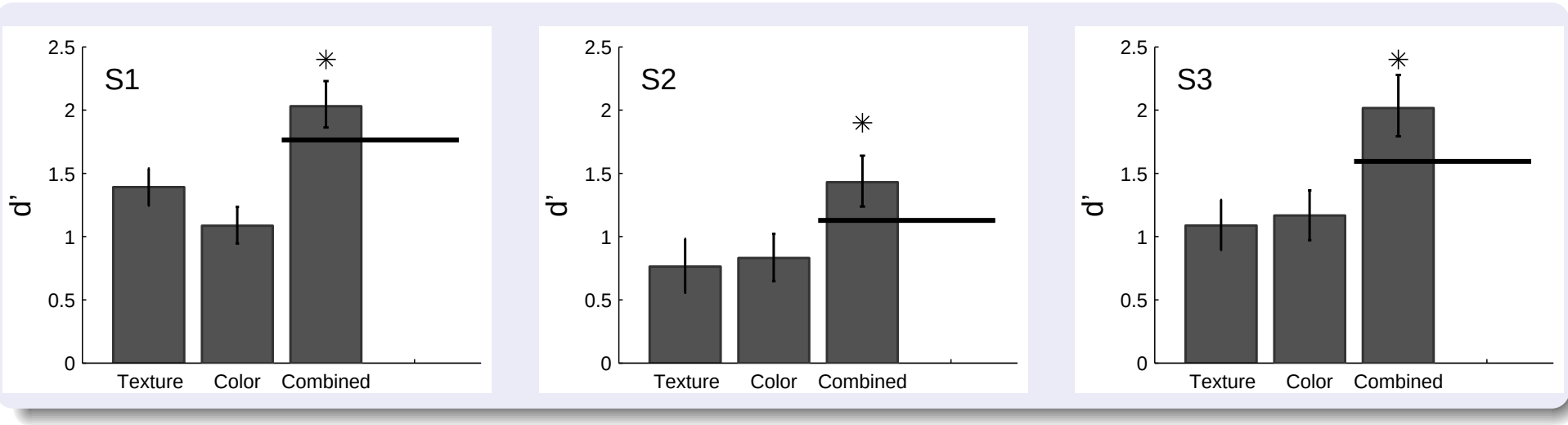
Decision space: Cue-conflict condition



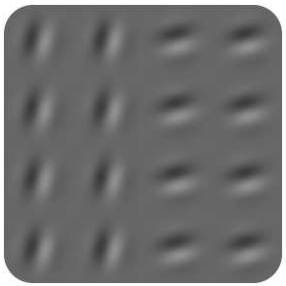
Internal response: Orientation contrast

Internal response: Colour contrast

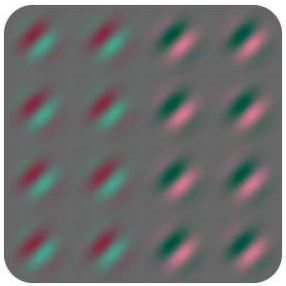
Results



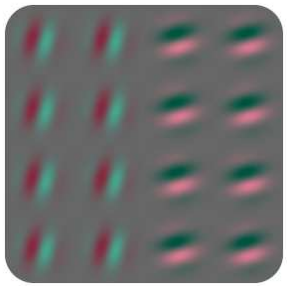
Texture



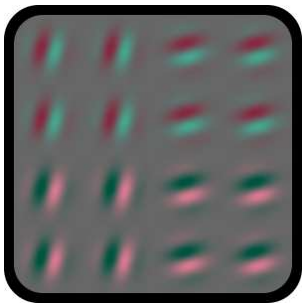
Colour



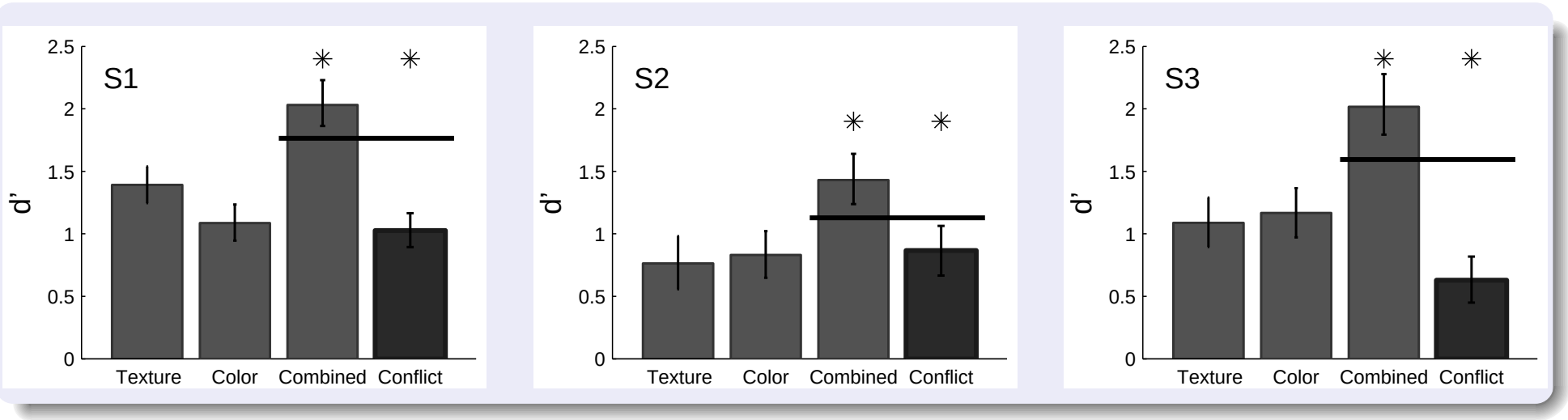
Combined



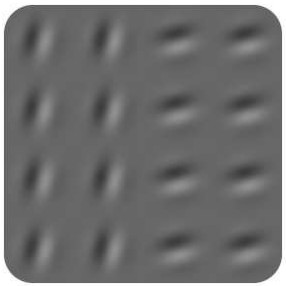
Conflict



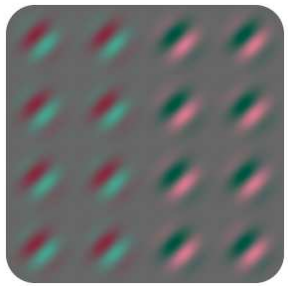
Results



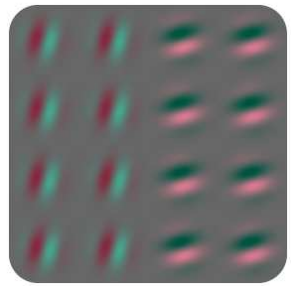
Texture



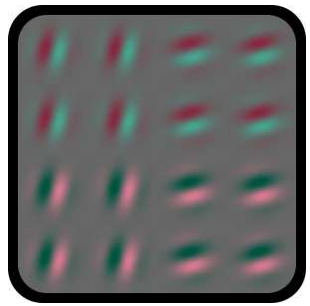
Colour



Combined



Conflict



Summary

1. Same information, different performance

$d'_{combined} > d'_{single\ cue} \geq d'_{conflict}$

- Although the cue-combination and cue-conflict stimuli had the same texture and colour differences.

$\Rightarrow$ Integration is possible only with spatially aligned cues.

Summary

1. Same information, different performance

$$d'_{combined} > d'_{single\ cue} \geq d'_{conflict}$$

- Although the cue-combination and cue-conflict stimuli had the same texture and colour differences.

$\Rightarrow$ Integration is possible only with spatially aligned cues.

2. Better cue-combination performance than predicted

$$d'_{combined} > \sqrt{d'^2_{texture} + d'^2_{colour}}$$

- Performance with combined cues is *better* than the best independent-processing prediction.

$\Rightarrow$ Texture and colour are not processed independently.

$\Rightarrow$ Cue-invariant segmentation

Thank you!

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