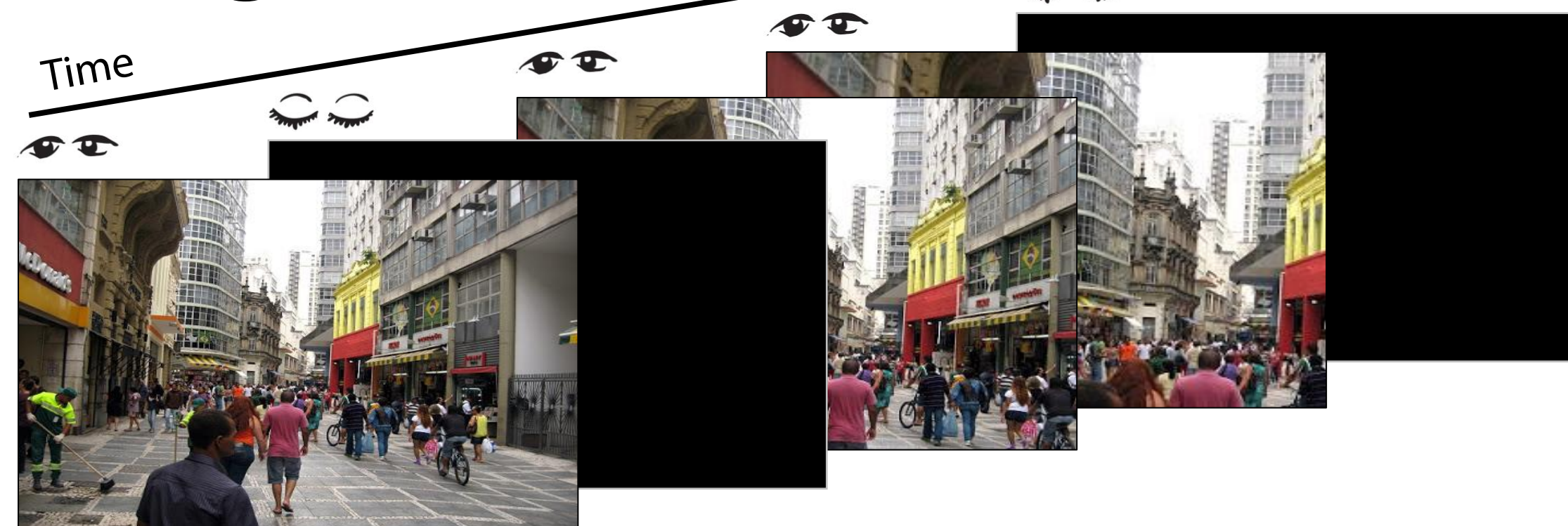# The effect of holding multi-feature ensemble in visual working memory on perception

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Backgrounds

Time

The visual scene consists of multi-feature objects scattered across spatial dimension (i.e., pedestrians and buildings), and it is temporally discontinuous and discrete (i.e., frequent eye movements and blinks).
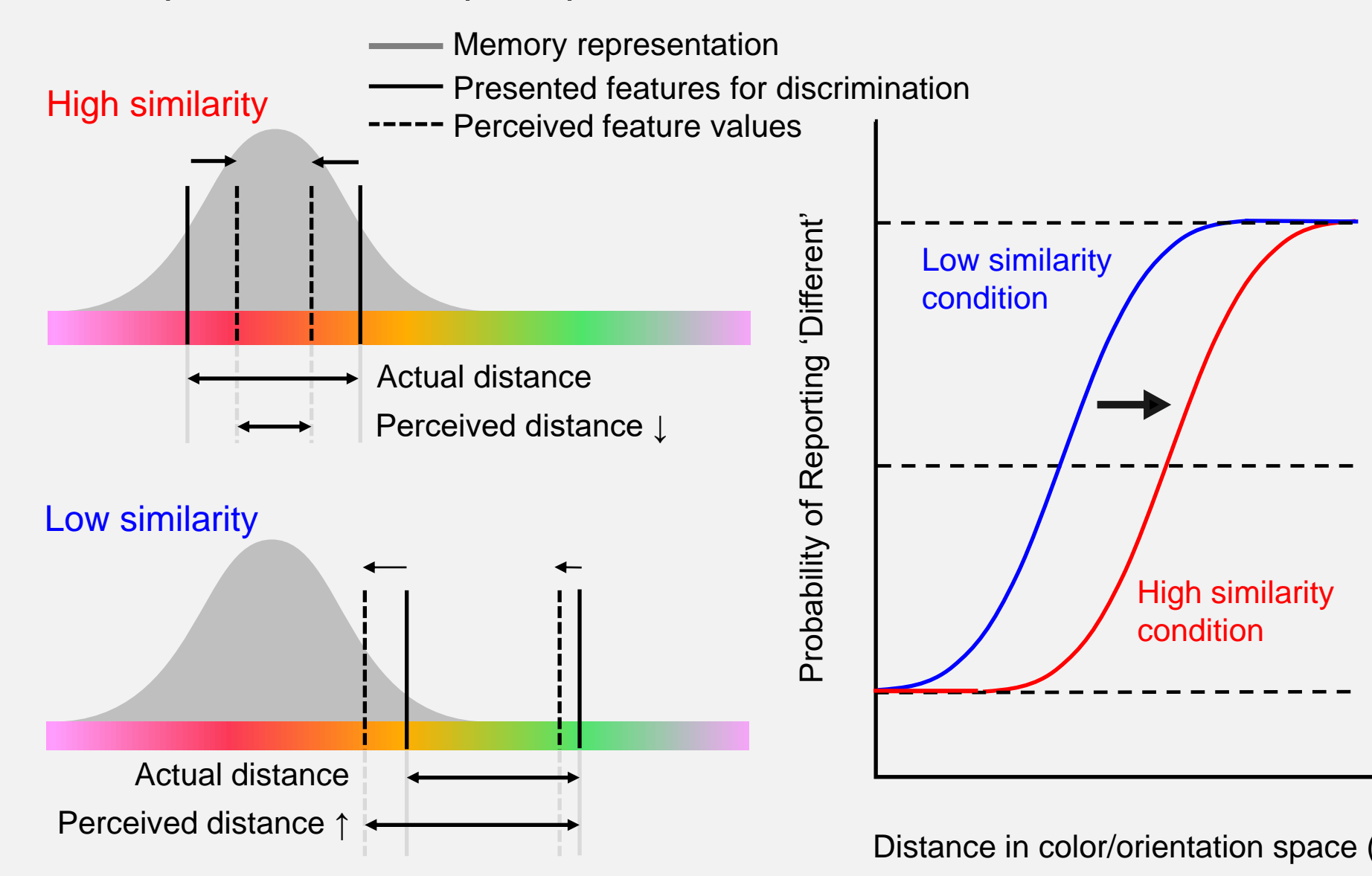
- The visual system can simultaneously extract ensemble representations (summary statistics) of features[1].

- Recent visual experience held in visual working memory (VWM) interacts with subsequent perceptual experience[2], which enables stable visual experience out of temporally discrete visual information.

Research Question

Would multi-feature ensemble representations interact with subsequent perception, regardless of task relevance (EXP 1) or attentional focus (EXP 2)?

SENSORY RECRUITMENT ACCOUNT ON THE INTERACTION BETWEEN VWM AND PERCEPTION

- The similarity between VWM and perception pulls the perception towards the VWM contents, because of shared neural resources in early visual cortex[2,3].

- When two discrimination stimuli is around the VWM contents (high similarity), the perceptual attraction increases the discrimination threshold of the two stimuli.

- The discirimination threshold difference between the high similarity and the low similarity conditions implies the influence of vwm representation on perception[2].
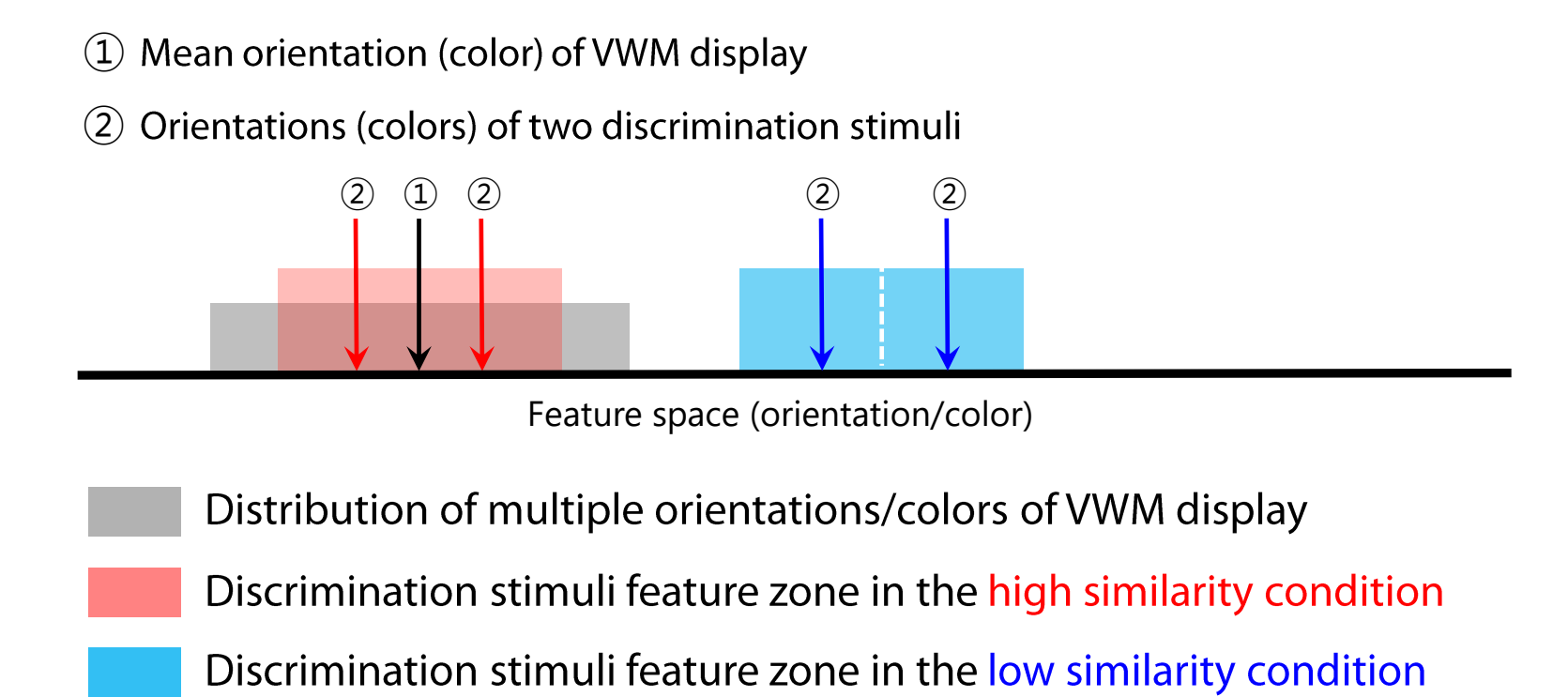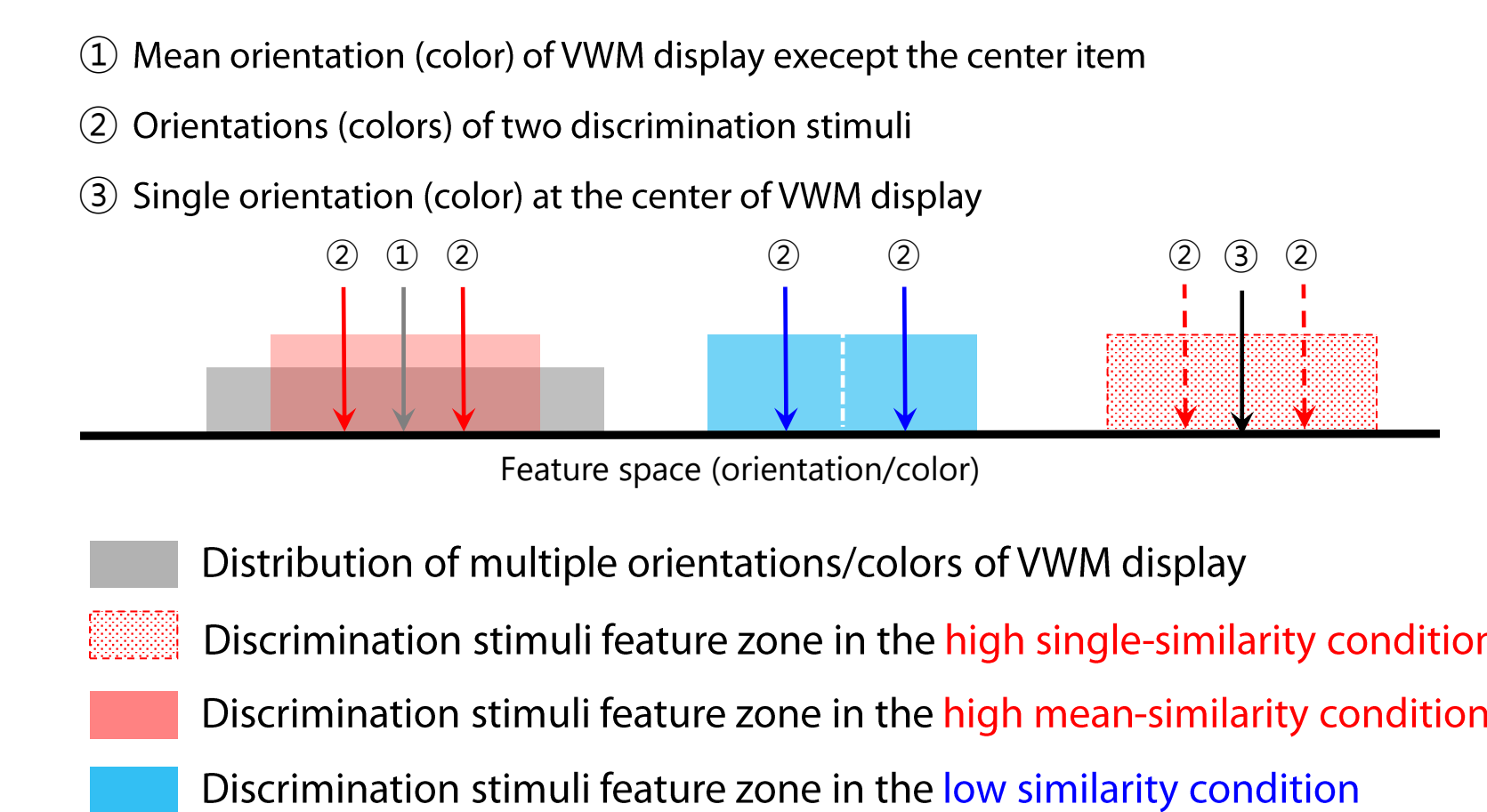

Procedures and Design
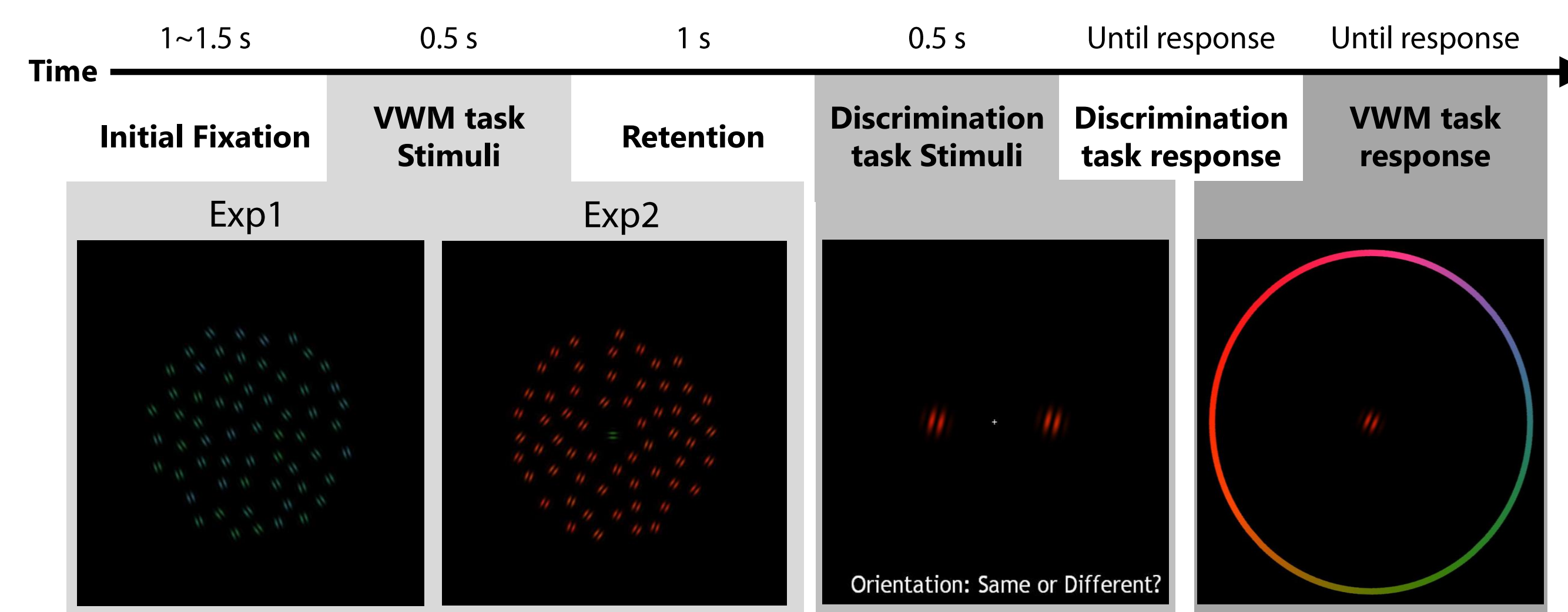
|	EXP 1	EXP 2
VWM task	"Remember the mean orientation (color) of multiple Gabor patches"	"Remember the orientation (color) of a single Gabor patch at the center."
Discrimination task	"Respond whether the two stimuli have same orientation (color)"	
VWM-Discrimination task conditions (Between-subject)	Two task-relevant feature (orientation/color) × two tasks (VWM/discrimination task)	
	Orientation-Orientation (OO) Color-Orientation (CO) Color-Color (CC) Orientation-Color (OC)	Orientation-Orientation (OO) Color-Orientation (CO)
VWM-Discrimination feature similarity conditions (Within-subject)	High similarity condition Low similarity condition	High single-similarity condition High mean-similarity condition Low similarity condition

Exp1

① Mean orientation (color) of VWM display
② Orientations (colors) of two discrimination stimuli

Exp2

① Mean orientation (color) of VWM display except the center item
② Orientations (colors) of two discrimination stimuli
③ Single orientation (color) at the center of VWM display

Experiment 1

Ensemble representation of two feature dimensions were encoded and modulated subsequent perception regardless of task relevance.

The effect of orientation ensemble on orientation discrimination
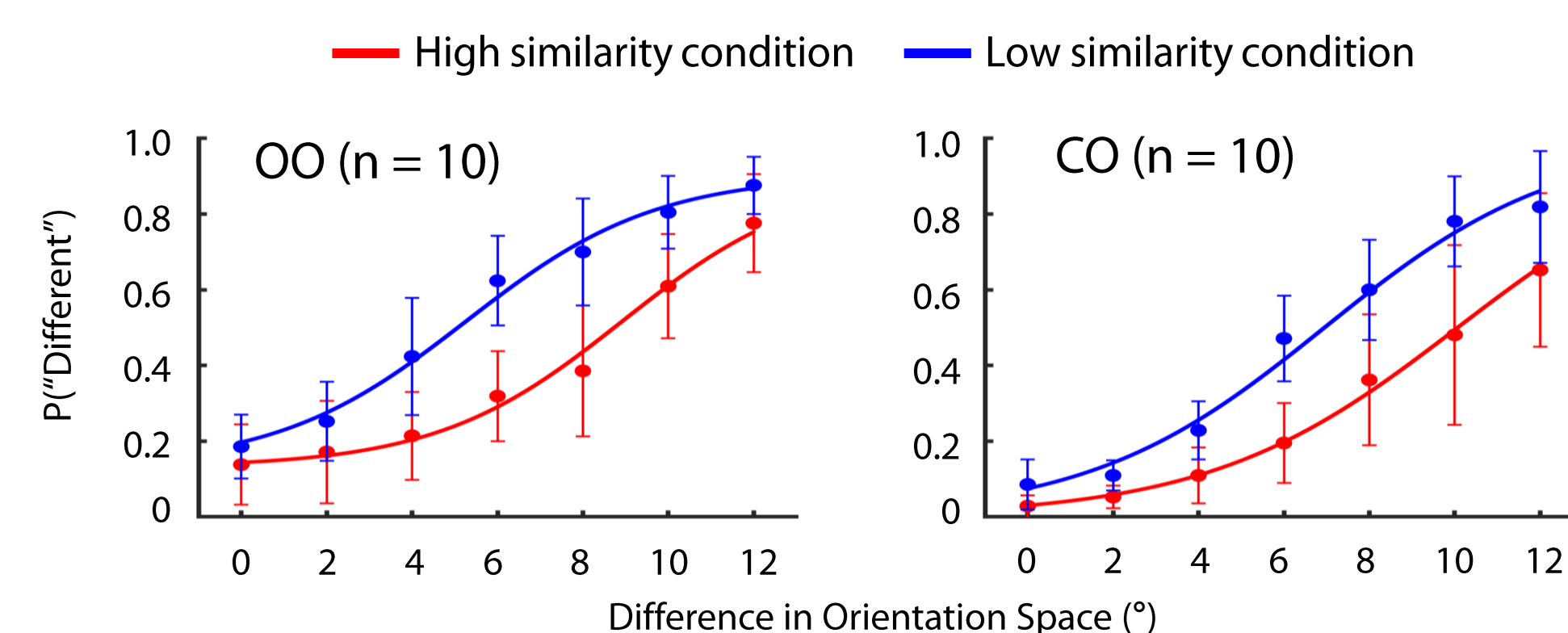
The discrimination threshold increased in the high similarity condition compared to the low similarity condition, both when the the VWM feature was relevant (OO) or irrelevant (CO).

### The effect of color ensemble on color discrimination
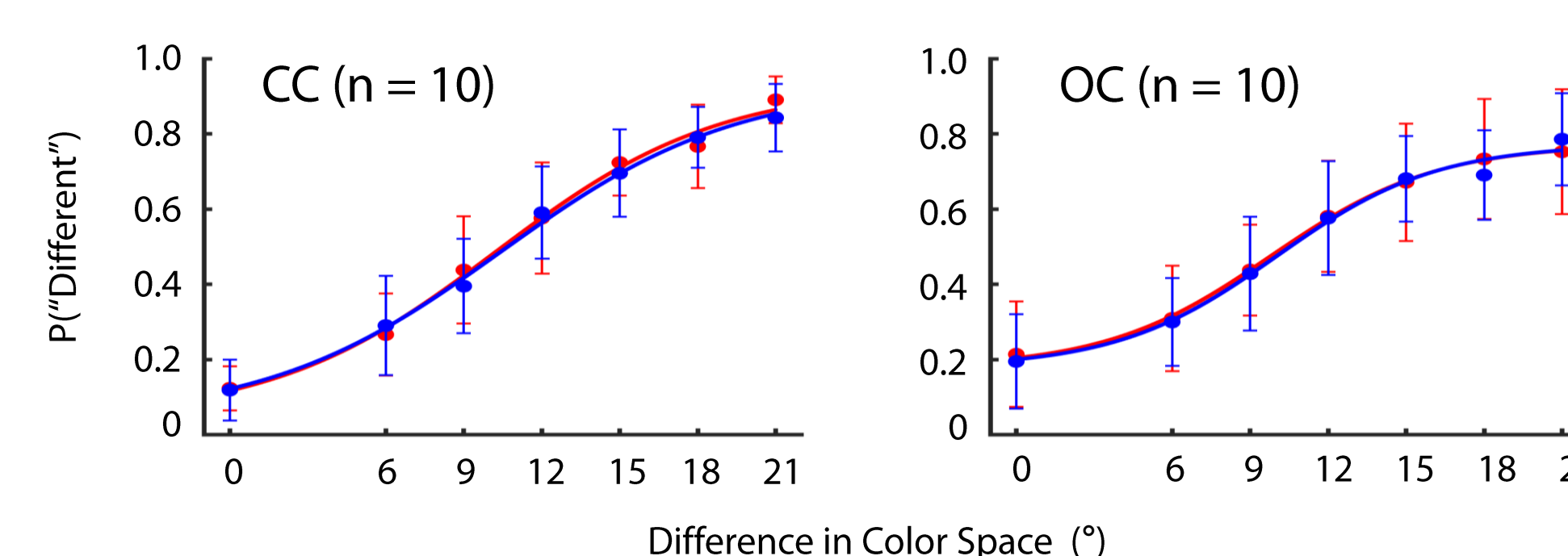
No difference in the discrimination thresholds between the two conditions reveals that the mean color did not affect subsequent color discriminability regardless of task relevance.

VWM task results showed that ensemble representation held in visual working memory was biased toward perception. Please contact us if you need further details.

THE INFLUENCE OF CATEGORICAL COLOR PERCEPTION

- Some ensemble colors were perceived as two different colors because of categorical color perception, and this could have obscured the effect of color ensemble on perception.

- To investigate this, we performed color rating task by asking observers to decide whether certain distribution of colors appeared as a single peak or not.
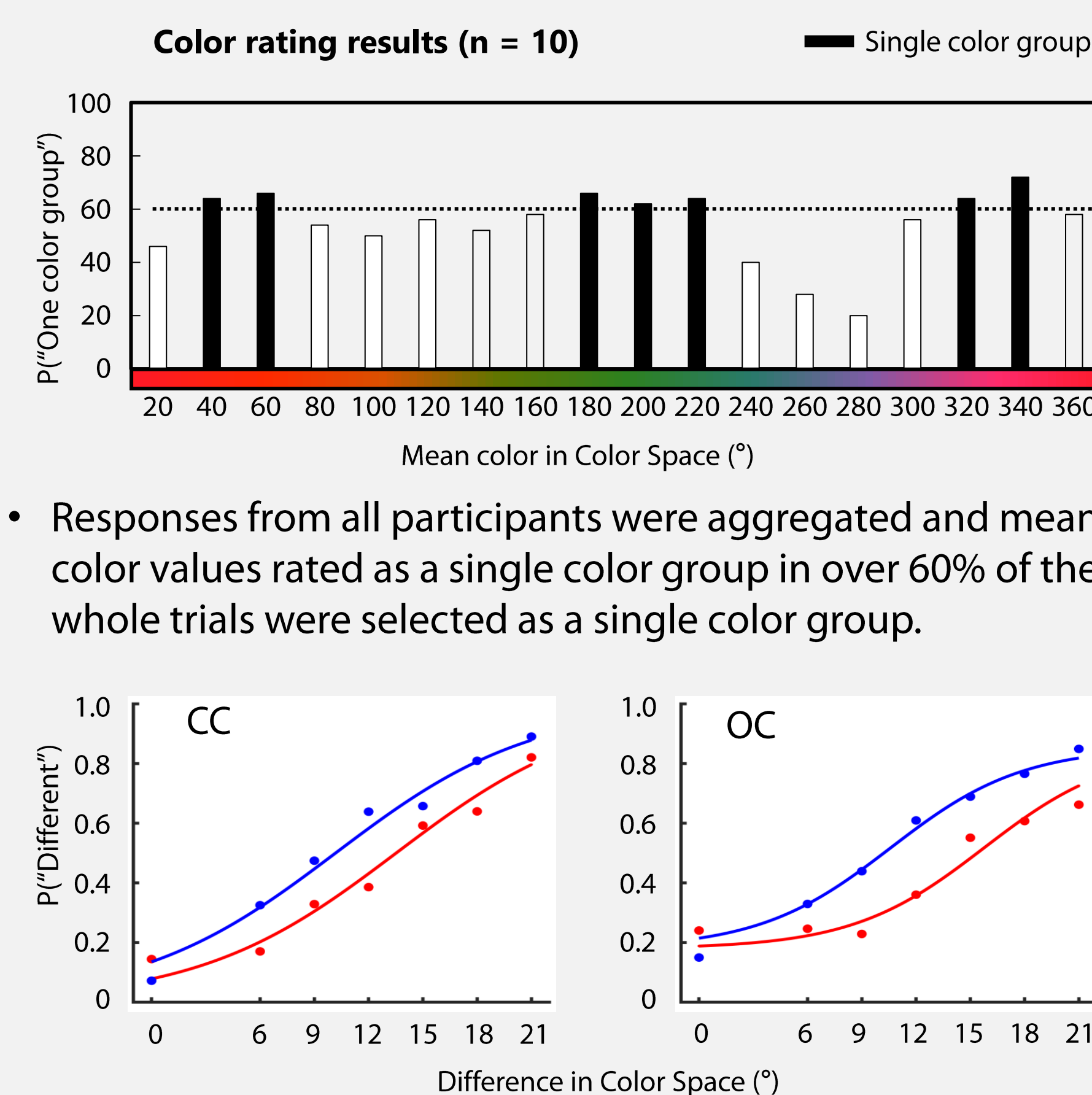

- Responses from all participants were aggregated and mean color values rated as a single color group in over 60% of the whole trials were selected as a single color group.

- Additional analysis on color discrimination including only single color group trials revealed that color ensemble also affected subsequent color perception.

Experiment 2

Multi-feature ensemble representations of surrounding objects affected subsequent perception despite task instruction to focus on a single item.

The effect of single/ensemble orientation on orientation discrimination
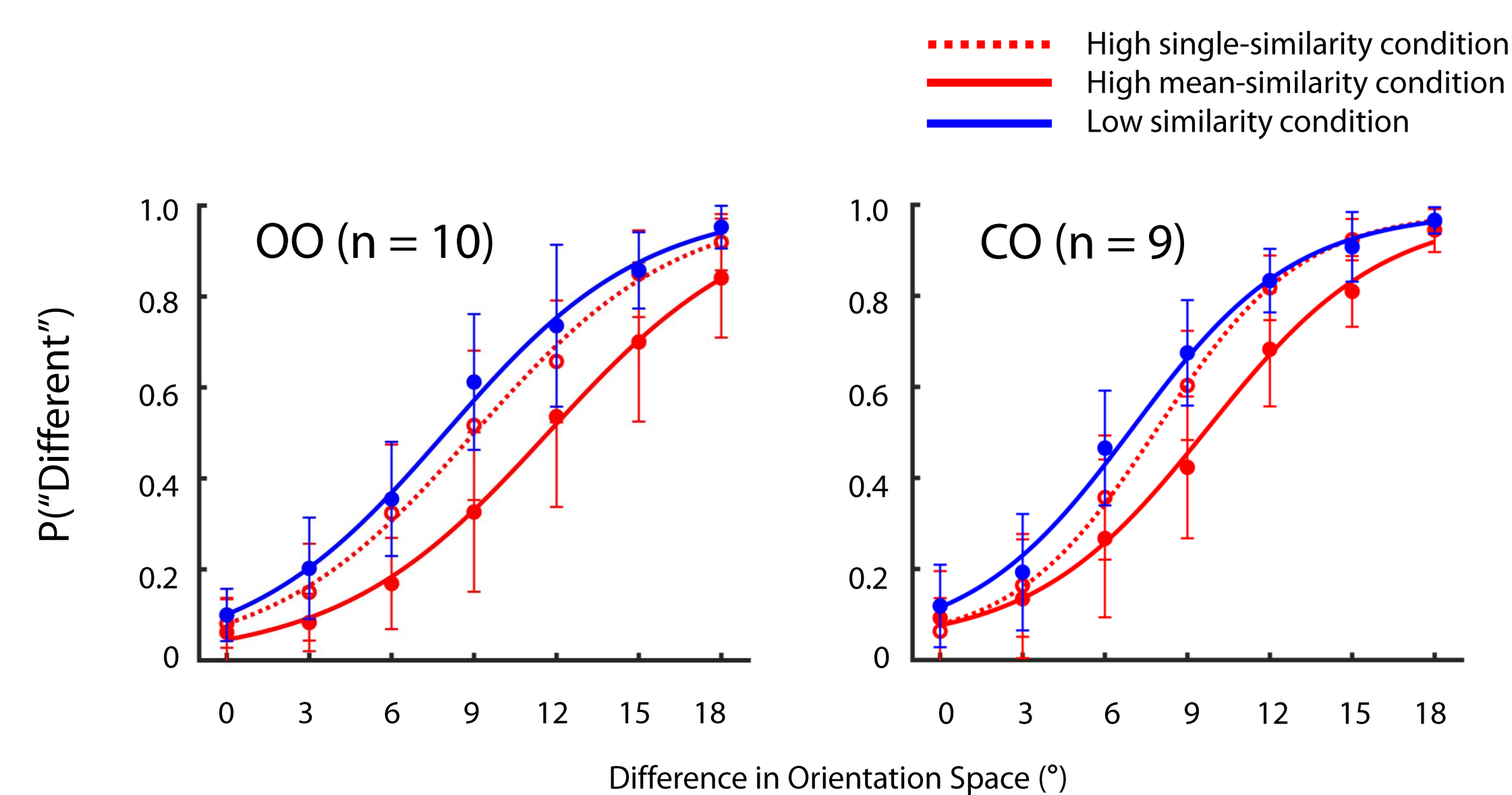
Increased discrimination threshold in the high single-similarity condition indicates that the orientation of the single Gabor patch interacted with subsequent perception, both when the VWM feature was relevant (OO) or irrelevant (CO).

Increased discrimination threshold in the high mean-similarity condition indicates that the multi-feature ensemble representation of surrounding objects are obligatorily processed and affected subsequent perception
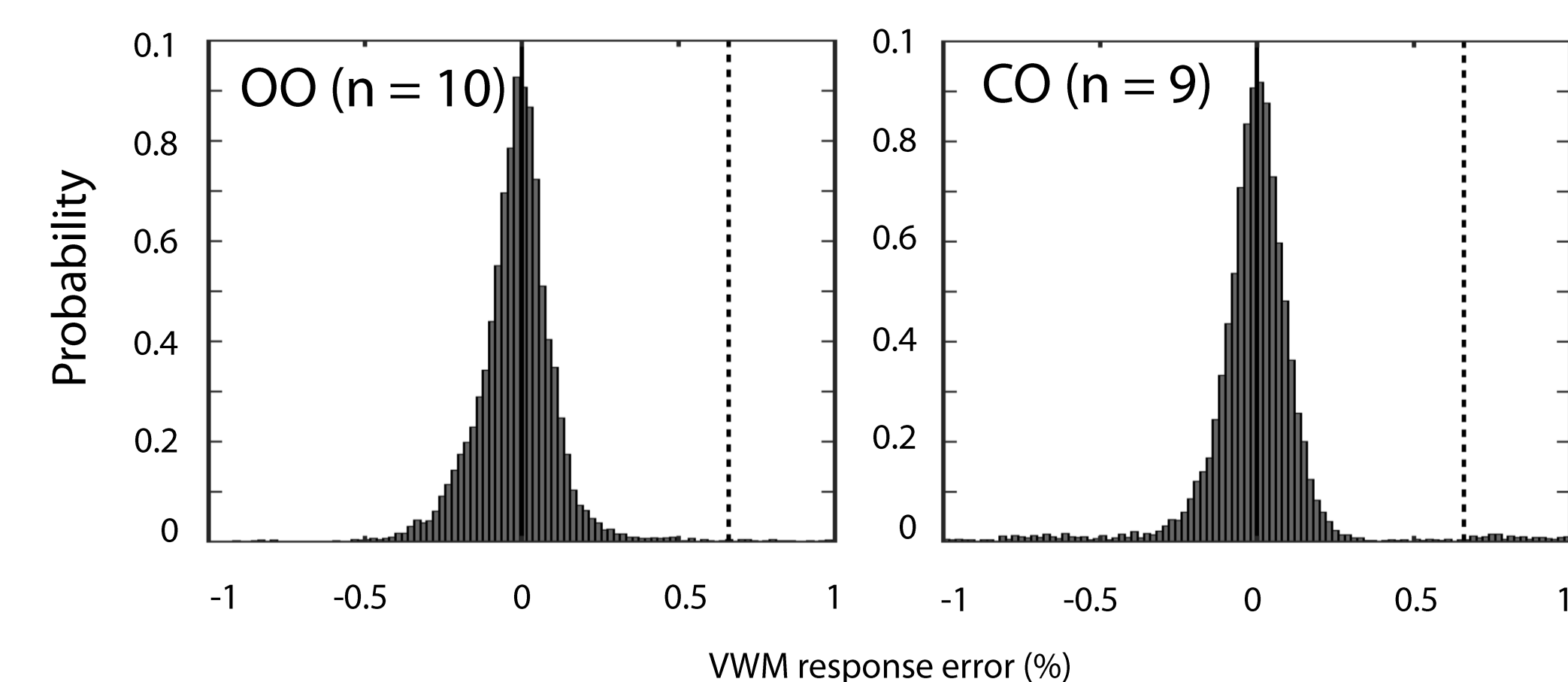
The VWM error distributions, pooled across participants, for the OO and CO condition showed that participants encoded and reported the orientation or color of a single Gabor patch (black solid line) instead of multiple Gabor patches (black dotted line).

Conclusions

- Regardless of task relevance, summary statistics of multiple features are simultaneously encoded and persist over time to interact with subsequent perceptual experience.

- Even when asked to focus on single object, multi-feature ensemble representations of the surrounding objects modulated subsequent perception.

- These explain how visual system encodes ensemble representations from complex scene and retains them in VWM for stable visual experience.

References

1. Kristjánsson, A. (2006). Simultaneous priming along multiple feature dimensions in a visual search task. Vision research, 46(16), 2554-2570.
2. Teng, C., & Kravitz, D. J. (2019). Visual working memory directly alters perception. Nature human behavior.
3. D'Esposito, M., & Postle, B. R. (2015). The cognitive neuroscience of working memory. Annual review of psychology.