Spatio-temporal regularity in mapping sequences sharpens* population receptive field estimates

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*** At least for short stimulus cycles**

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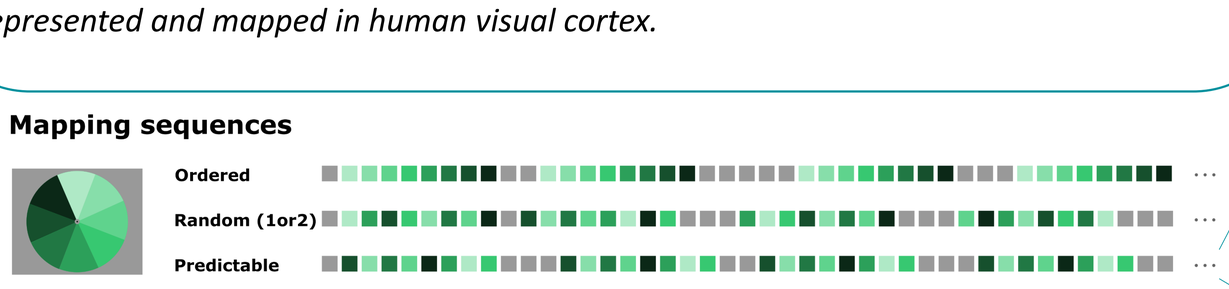
Background and goals

Typically, visual mapping studies employ ordered stimulus sequences - such as rotating wedges, contracting and expanding rings, or sweeping bars - to span the visual field (1-4, but 5-6).

Despite the importance of expectations in perception, visual mapping studies have mostly overlooked the influence of spatial predictability of visual stimuli in mapping estimates.

*We employed functional MRI and the **population receptive field (pRF)** mapping approach (3) to estimate the **polar angle preference and the width of the tuning function of voxels in early visual cortex** (pRFs modelled as a von Mises distribution). Comparing parameter estimates obtained with different mapping sequences (ordered, random, predictable), we explored whether expectations and spatio-temporal regularities modulate how stimuli are represented and mapped in human visual cortex.*

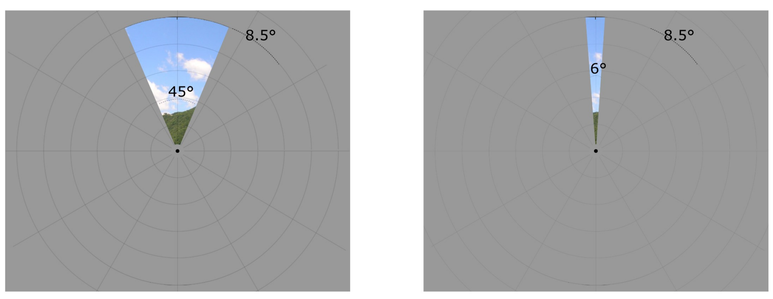
Mapping sequences



2 sessions. 6 runs per condition (3 in each session).

Methods

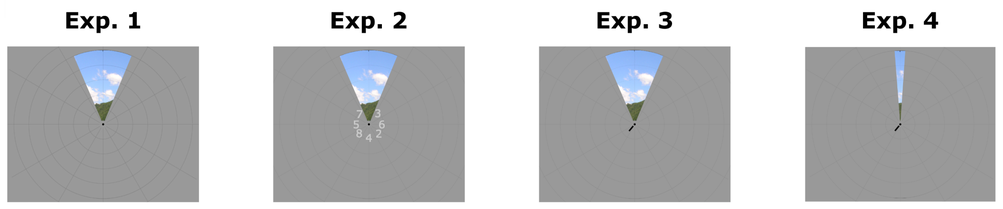
Mapping stimulus



Stimuls duration: 1s
Full cycle: 8s

Stimuls duration: 1s
Full cycle: 36s

Predictable condition: location cues across experiments



6 unique sequences were learned before the mapping exp.

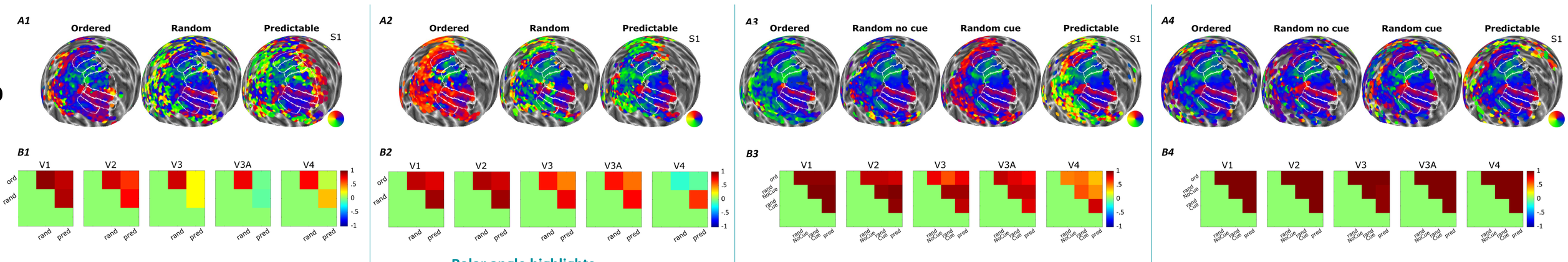
Low-contrast numbers indicated the sequence of wedge locations.

A cue appearing 200ms before the next wedge indicated the location of the upcoming stimulus.

Results

Exp. 1 N=5 | Exp. 2 N=5 | Exp. 3 N=4 | Exp. 4 N=4

Polar angle

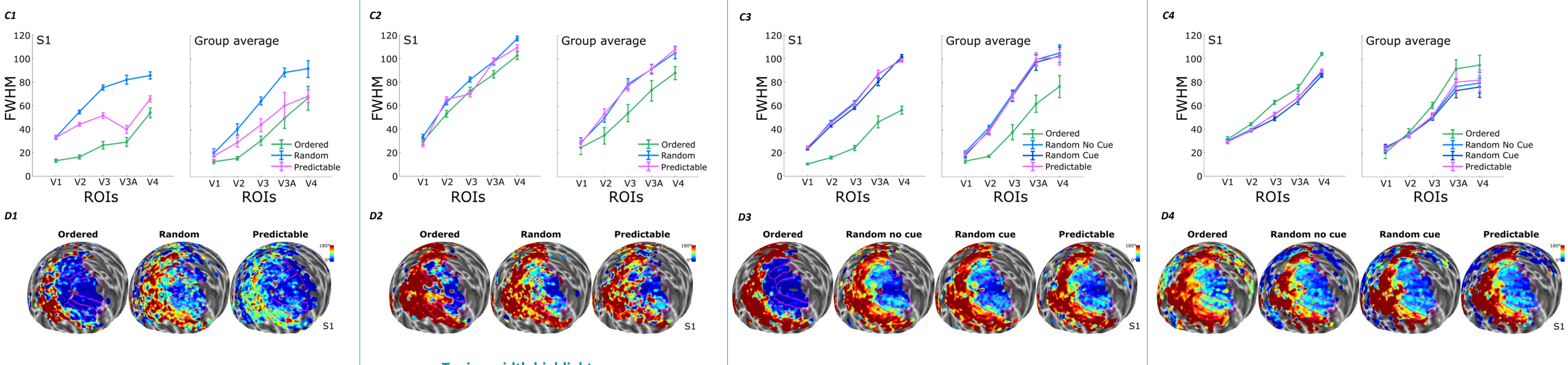


(A1-A4) Polar angle maps for different mapping conditions for the same (left) hemisphere of one participant (S1).
(B1-B4) Pearson correlation matrices of polar angle estimates between mapping conditions (group mean).

Polar angle highlights

- **Spatio-temporal regularities in mapping sequences do not systematically bias spatial location estimates in early visual areas.**
- **Increase in spatial resolution (smaller wedge size) and increase in cycle duration improves polar map consistency across conditions (Exp. 1-3 vs Exp. 4).**

Tuning width

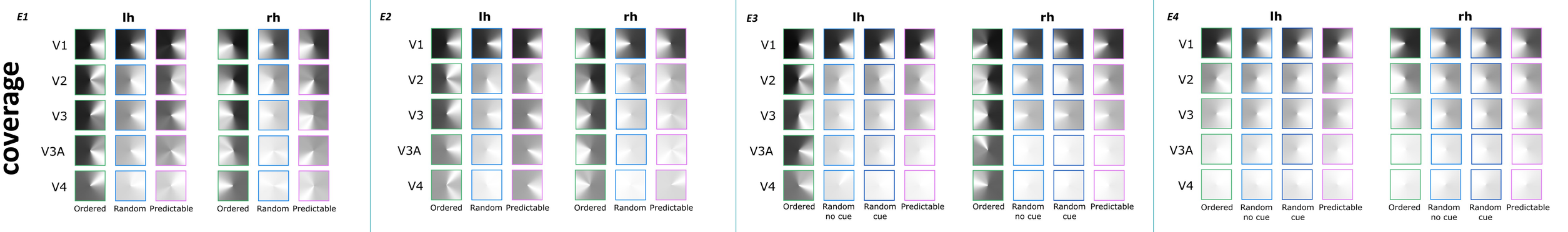


(C1-C4) Individual and group average Full-Width Half-Maximum (FWHM) estimates.
(D1-D4) FWHM maps for the same (left) hemisphere of one participant (S1).

Tuning width highlights

- **The spatial-location predictability does not systematically influence the width of polar angle tuning functions (FWHM of predictable sequence < FWHM of random sequence in Exp. 1 but not Exp. 2-4).**
- **The length of the mapping cycle biases FWHM for ordered mapping stimuli in opposite directions (FWHM of ordered sequence < FWHM of random/predictable sequence in Exp. 1-3, and > in Exp. 4).**

Visual field coverage

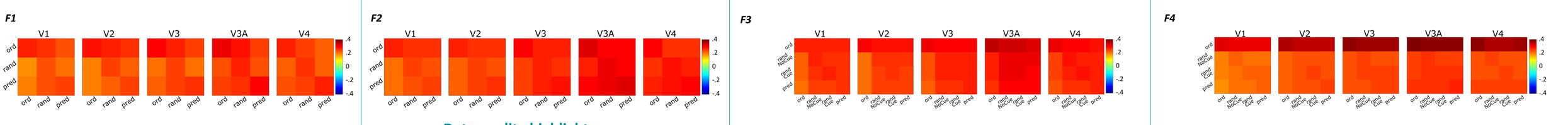


(E1-E4) Visual field coverage maps for Exp. 1-4. Visual field maps are computed using polar angle and sigma (each map is normalized for max value). Data pooled across participants.

Visual field coverage highlights

- **The visual field coverage maps are highly consistent across conditions in Exp.4, reflecting more consistent polar angle and FWHM estimates with a longer cycle duration.**

Data Quality



(F1-F4) Pearson correlation matrix between measured time series and responses predicted based on pRF parameters estimated in each of the experimental conditions (group mean).

Data quality highlights

- **The comparison of predicted and observed BOLD responses suggests that different mapping sequences provide comparable parameter estimates, even though the estimated goodness of fit is the highest for the ordered sequences (in particular in Exp. 4).**

References: [1] Engel et al. *Nature* 1994; [2] Sereno et al. *Science* 1995; [3] Dumoulin & Wandell *Neuroimage* (2008); [4] van Dijk et al. *Neuroimage* (2016); [5] Vanni et al. *Neuroimage* (2005); [6] Binda et al. *Journal of Vision* (2013);

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