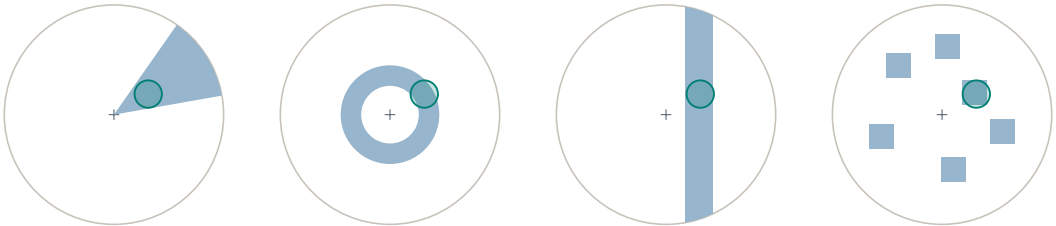
POPYLAR PRF WORKSHOP · COIMBRA · THURSDAY 5 NOVEMBER 2026

DESIGNING PRF EXPERIMENTS

From retinotopic maps to informative tests of neural computation

Tomas Knapen

WHAT MAKES A GOOD DESIGN?



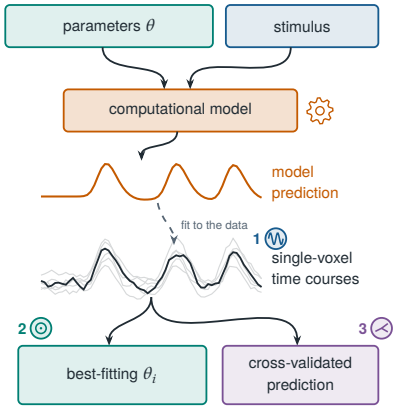
- Many apertures make a recognisable map; which one is better depends on what we want to learn.

A SHORT HISTORY OF APERTURES



- Each family spreads information differently over position, time and extent *(Benson et al. 2018; Alvarez et al. 2015; Chang et al. 2025; Kay et al. 2013)*.

THREE KINDS OF SUCCESS



1 Maps

polar angle, eccentricity, preferred frequency

→ retinotopic and tonotopic maps



2 Estimation

Sampling: where, and how big?

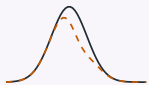
→ spatial pRF parameters: position and size



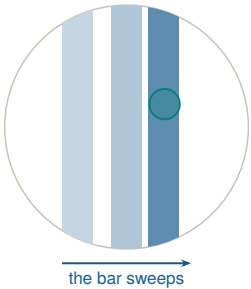
3 Discrimination

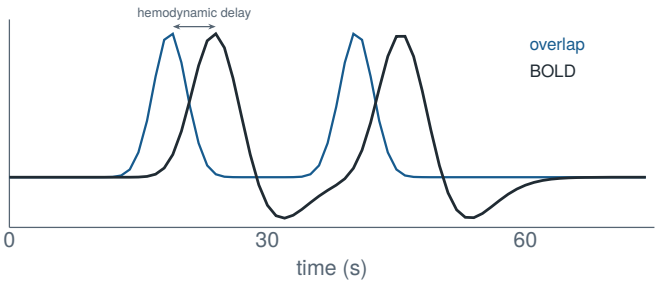
end-to-end computational 'process' model

→ compare parameters and models



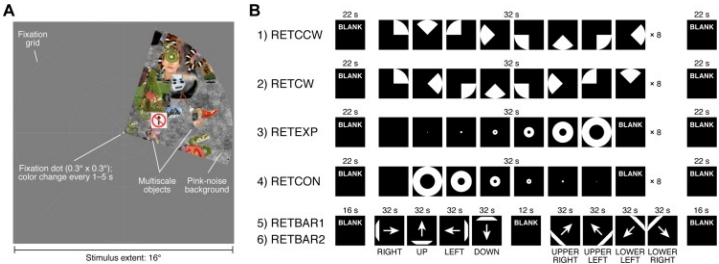
FIRST, A CLEAN RESPONSE





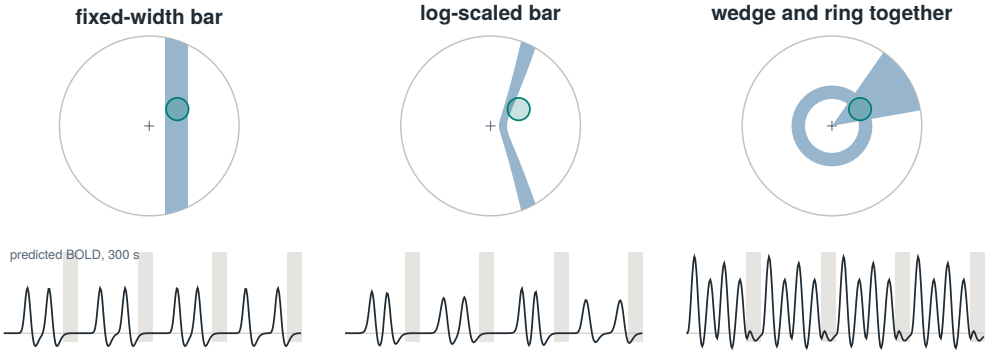
- A predictable sweep visits every position and modulates the BOLD signal strongly.

A WORKED PROTOCOL: HCP 7T



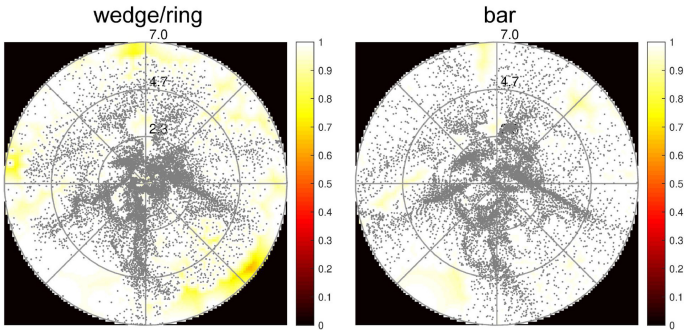
- Six runs of 300 s: wedges and rings in both directions and two bar runs; an object texture as the carrier, chosen to drive higher visual areas; a fixation-dot colour-change task *(Benson et al. 2018)*.

MORE RESPONSES PER MINUTE?



- The aperture changes how often a field is driven and what comes out *(Alvarez et al. 2015)*.

SAME CORTEX, OTHER COVERAGE

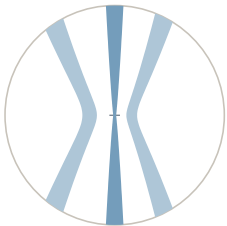


- Wedges and rings put more pRF centres within 2° and gave much smaller sizes than bars, in the same participants *(Linhardt et al. 2021)*.

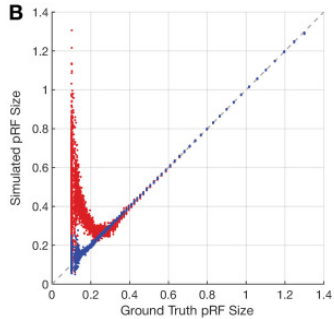
DESIGN FOR ACCURACY



fixed-width bar

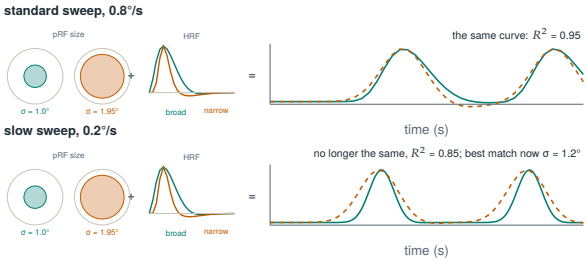


log-warped bar



- Against ground truth, the fixed bar overestimated fields smaller than 0.2°; the warped bar matched them *(Chang et al. 2025)*.

PRF SIZE V HRF SHAPE?



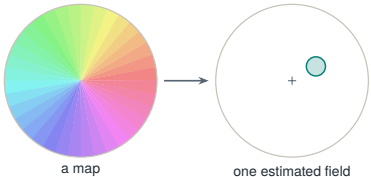
- A fast sweep cannot tell a wide pRF from a broad HRF: a wrong HRF biases the size.
- Slower or randomized sweeps weaken the dependency, at a cost *(Lerma-Usabiaga et al. 2020)*.

PRF EXPERIMENTER KNOW-HOW

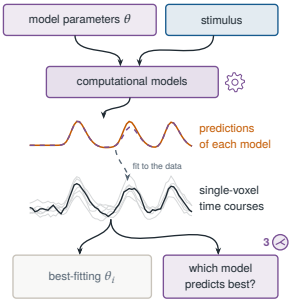
choice	what it can buy	cost or caution
bars, wedges, rings, or both	bars: repetitions for averaging; wedges and rings: strong response, coverage	wedges and rings cannot be averaged; bars make fixation harder
bar width, speed, warping	ensure prolonged stimulation for the target pRFs; warping may help near fixation	scan time, response strength, visual-field coverage
checkerboard or richer carrier	contrast drives early cortex; object textures drive higher areas	the carrier selects which populations respond
ordered or random; blanks	periodic or random sampling; blanks: a baseline for size and surround	HRF bias; lower temporal contrast; duty cycle
fixation task, eye tracking	compliance; eye position gives the true retinal input	a correct colour-change task is not stable gaze
extent, repeats, analysis	enough extent, both directions; repeats increase SNR and allow cross-validation	scan time; the model interacts with display boundaries

- Choices depend on your question; we are here to share know-how.

A MAP IS NOT A COMPUTATION



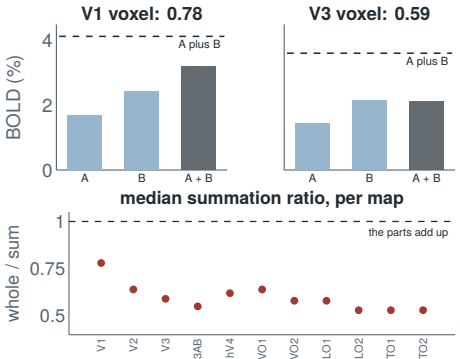
- ? Do inputs add?
- ? Can context suppress?
- ? Does timing matter?



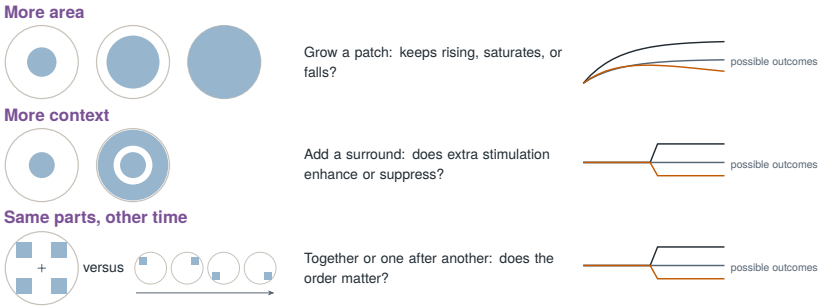
- To use pRFs for computational neuroscience, compare models.

COMPUTATIONAL EXAMPLE: DO INPUTS ADD?



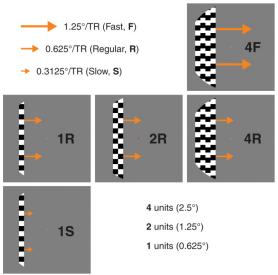


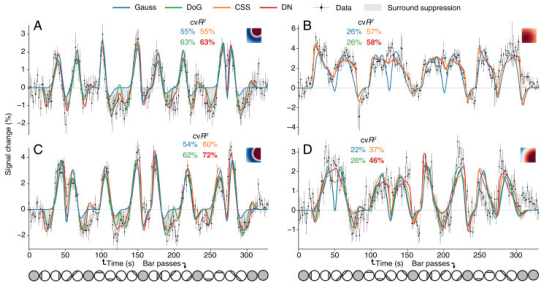
OTHER QUESTIONS TO ASK



- Test your model of the response by tailoring your stimuli *(Zuiderbaan et al. 2012; Aqil et al. 2021; Kupers et al. 2024)*.

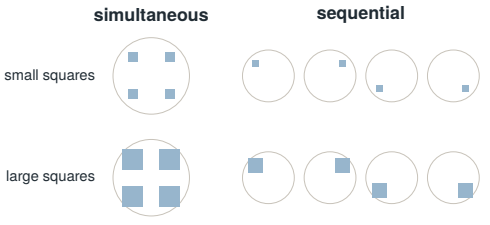
RICHER BARS, RICHER RESPONSES

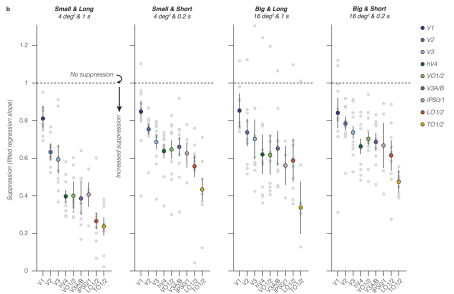




- Time courses show suppression and compression; extra conditions test generality *(Aqil et al. 2021)*.

CHANGE WHEN, NOT JUST WHERE





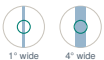
- Together or in sequence: little difference in V1, more suppression higher up *(Kupers et al. 2024)*.

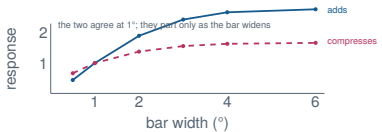
THE ELEMENT DECIDES THE DESIGN

model element: compression

design: **several bar widths**

one width cannot tell them apart

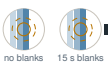


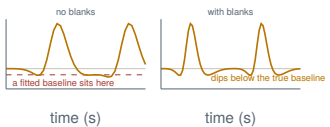


model element: suppressive surround

design: **long blanks**

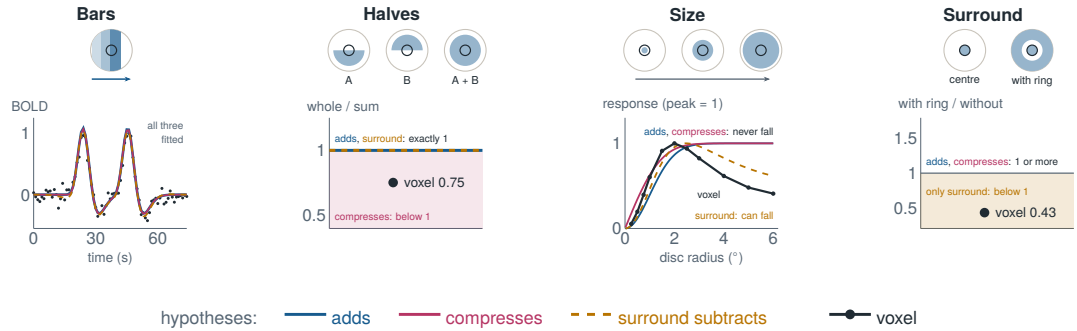
blanks give the baseline the dips are measured against





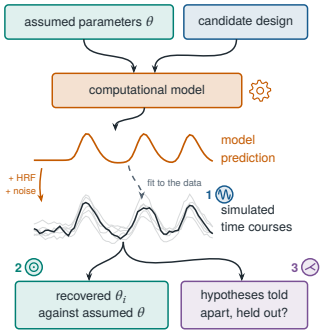
- The element decides the stimulus: widths for compression, blanks for a surround.
- The best design is not always apparent; next: how to find it.

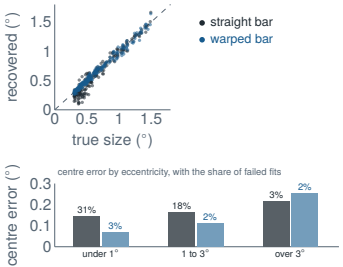
DESIGNS THAT ADJUDICATE: A GALLERY



- Designs that test what each one forbids rule out all three; the halves rule out adds and surround subtracts, the growing disc and the ring rule out adds and compresses.

SIMULATE BEFORE SCANNING





- With assumed parameters, a design can be optimized before scanning.

DESIGN FOR THE QUESTION

objective and target	experienced-practitioner start	question to simulate
1 **maps** retinotopic and tonotopic maps	the target visual regions; a carrier that drives them; a reliable wedge, ring or bar protocol	enough response and coverage in those regions, in the time available?
2 **estimation** spatial pRF parameters: position and size	the target regions and their expected pRF sizes; calibrated geometry; bar width and speed matched to those sizes	lowest bias and spread for centre and size?
3 **discrimination** compare parameters and models	contrasts between inputs on which the candidate models disagree	can the models be told apart, under real noise?

- First decide what you want to learn; then design the stimulus.

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