Pre-stimulus patterns of activity in early visual cortex bias stimulus perception

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Radboud University Nijmegen

Donders Institute for Brain, Cognition and Behaviour

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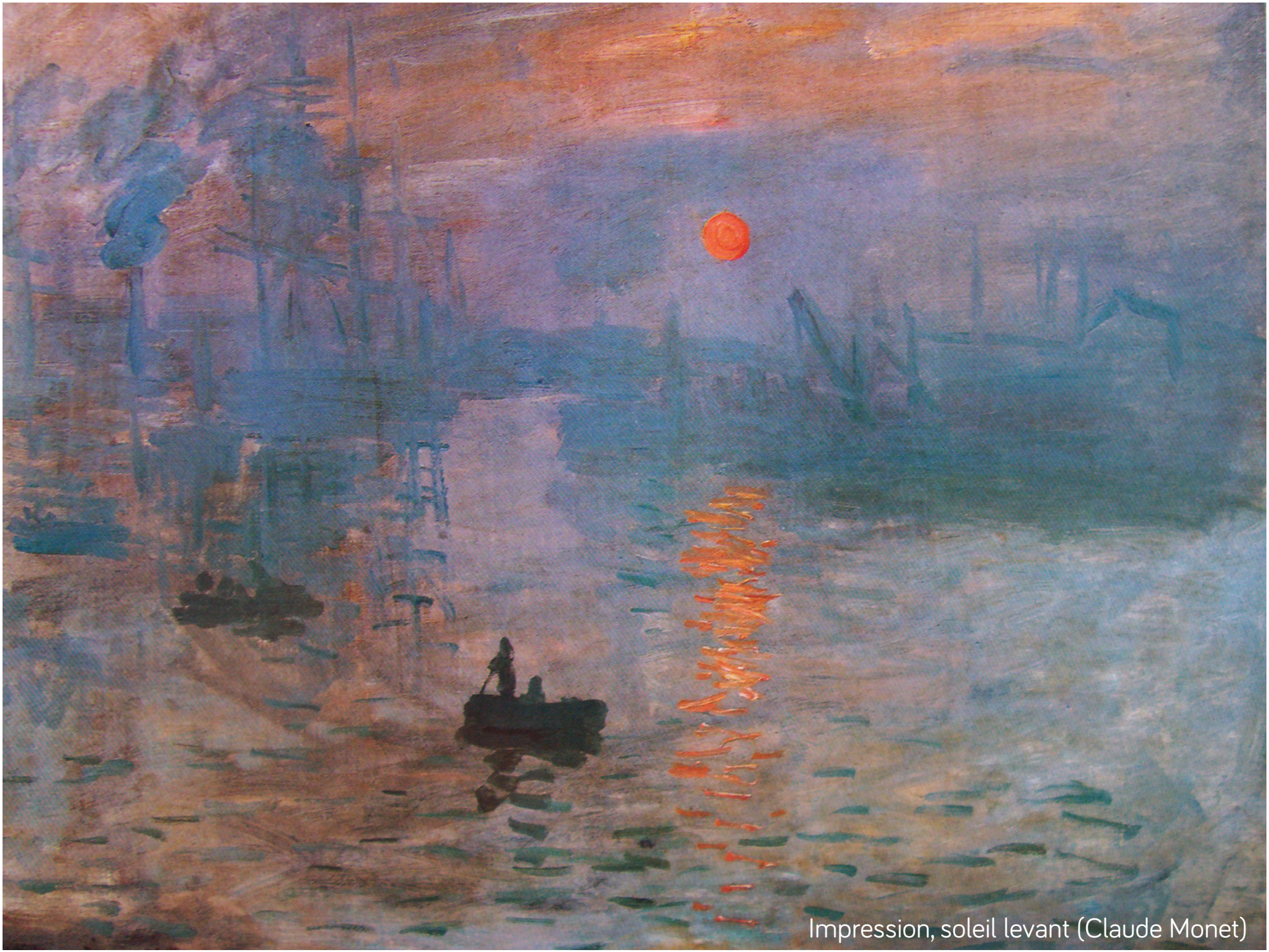
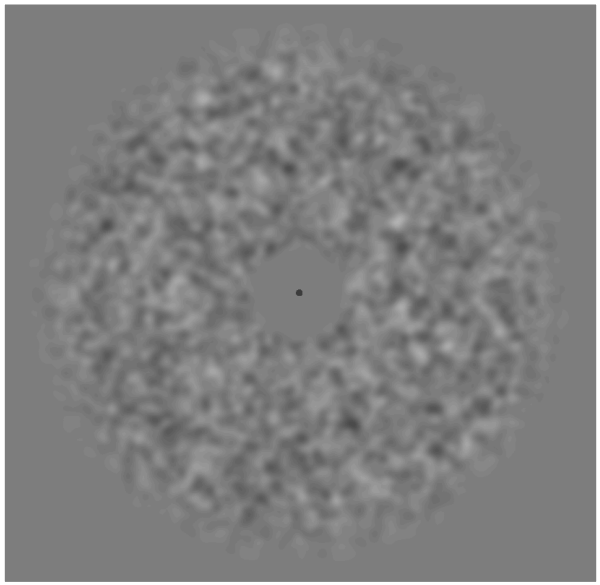
icon 12th International Conference on Cognitive Neuroscience



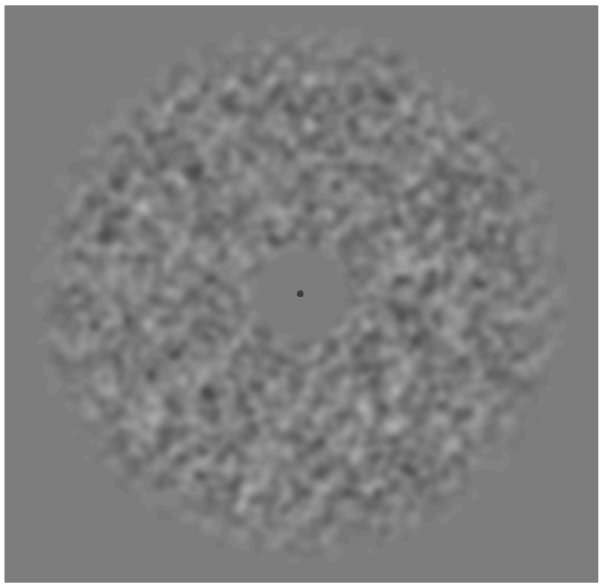
Impression, soleil levant (Claude Monet)

Signal-like fluctuations in noise can trigger (erroneous) stimulus detection

Noise:



Signal + noise:



(Wyart *et al.*, PNAS, 2012)

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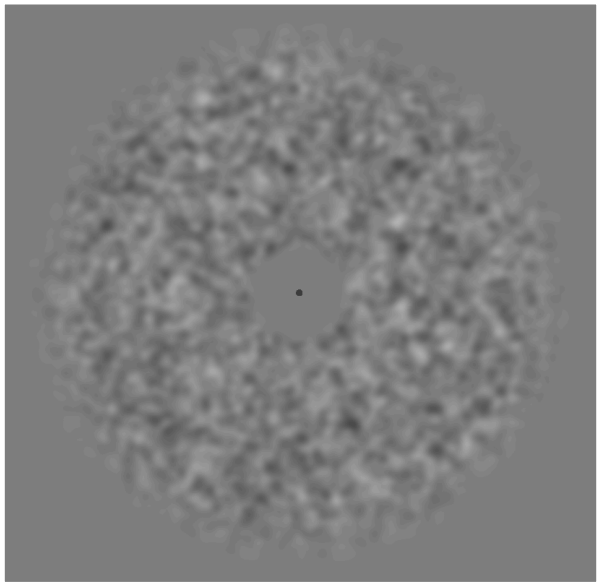

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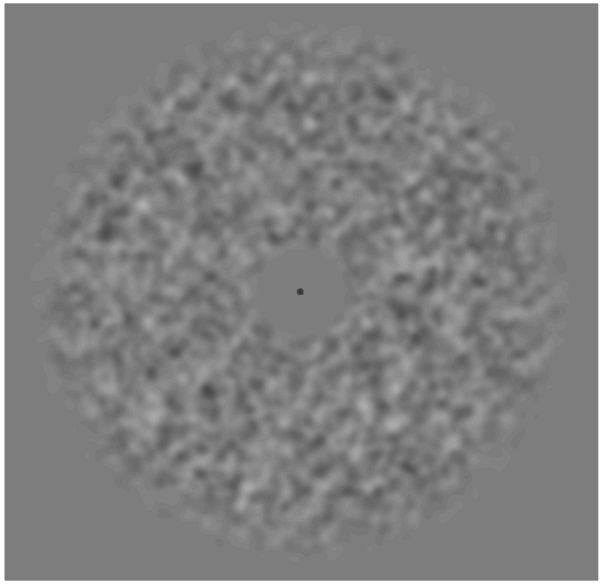

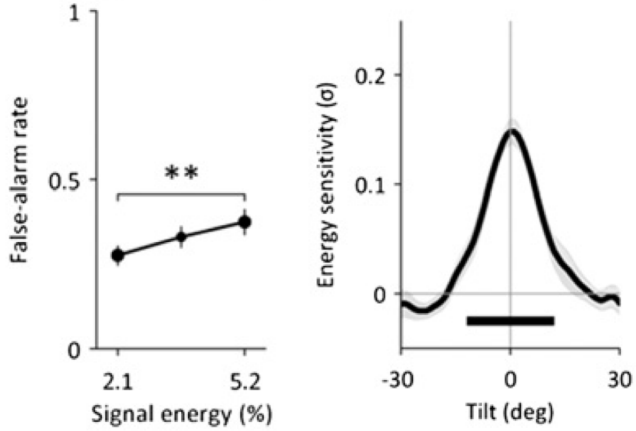

(Wyart *et al.*, PNAS, 2012)

- False Alarms occur mainly with high signal energy noise patches:
  - the visual system is sensitive to slight signal-like fluctuations in noise
  - False Alarms are genuine perceptual errors (*vs* pure strategic guesses)

Signal-like fluctuations in noise can trigger (erroneous) stimulus detection

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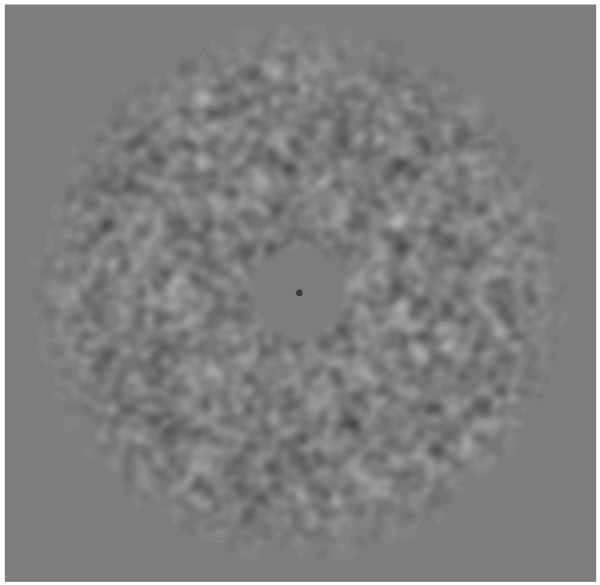

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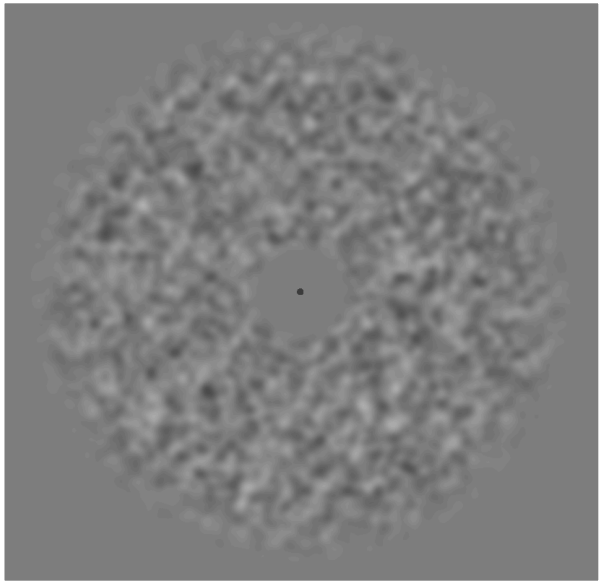
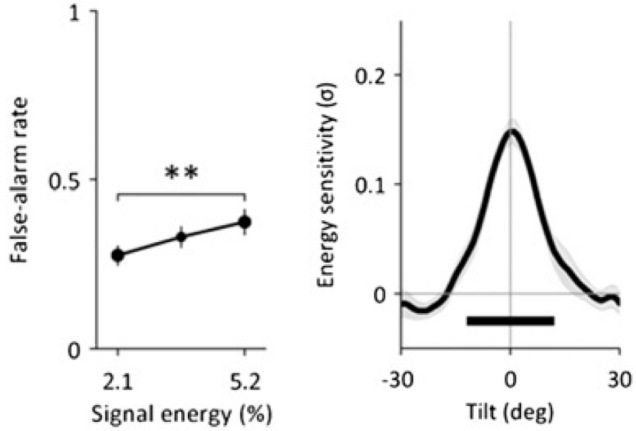
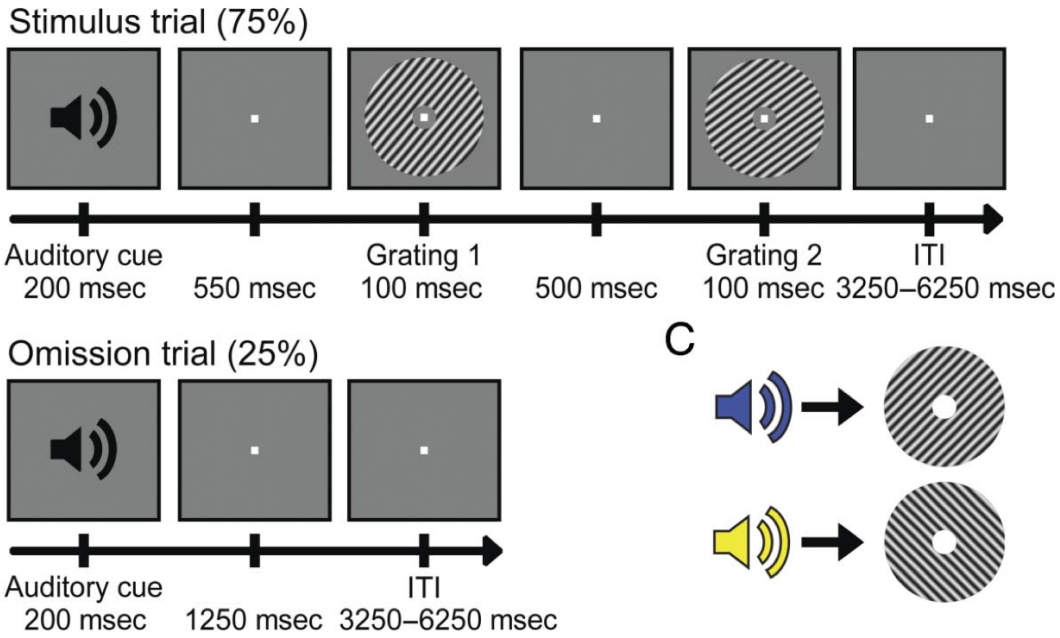




(Wyart *et al.*, PNAS, 2012)

- False Alarms occur mainly with high signal energy noise patches:
  - the visual system is sensitive to slight signal-like fluctuations in noise
  - False Alarms are genuine perceptual errors (*vs* pure strategic guesses)
- But False Alarms also arise with low signal energy noise patches:
  Endogenous orientation-specific fluctuations in neural activity ?

Expectations evoke stimulus templates in early visual cortex



(Kok *et al.*, J Cog Neuro, 2014)

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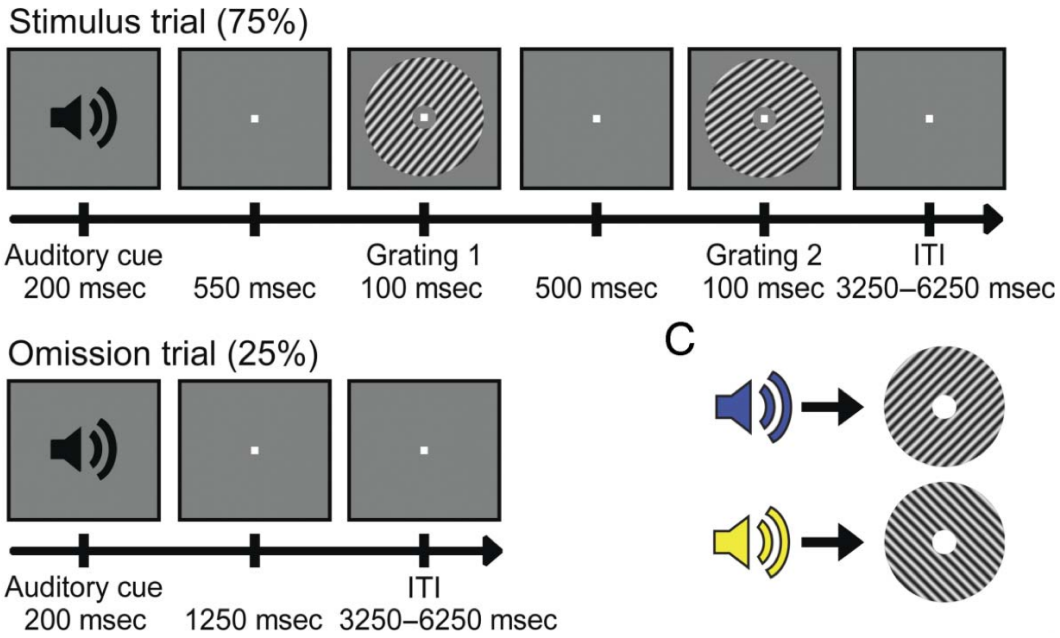

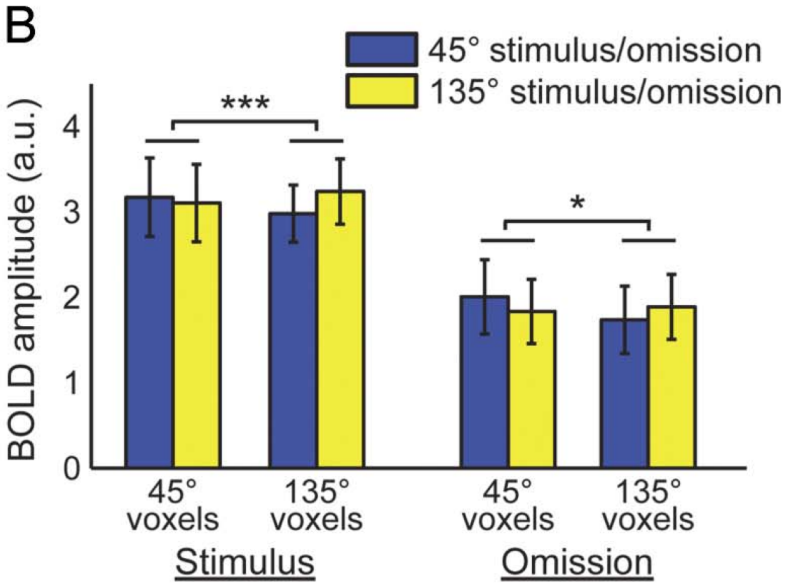

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- Perceptual expectations activate signal-selective units in early visual cortex when stimulus is absent

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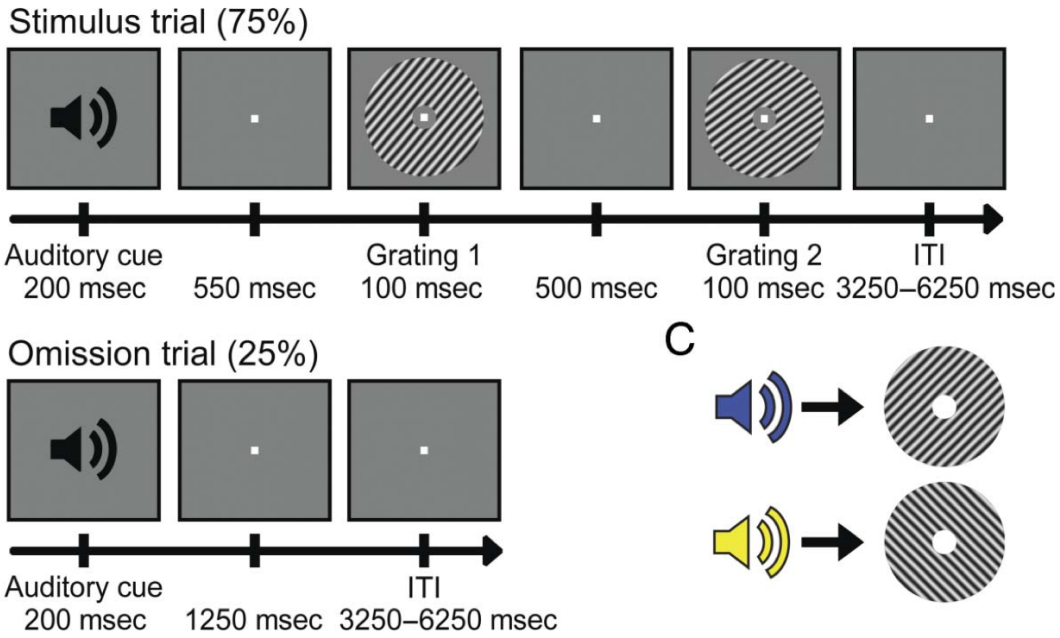
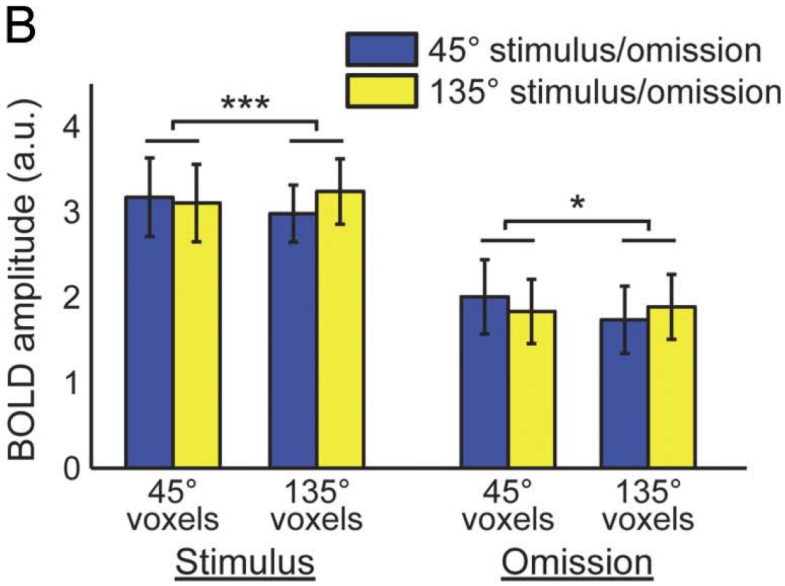




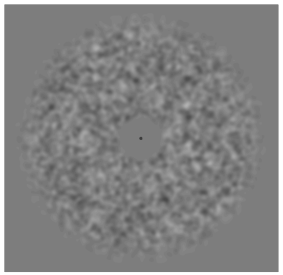
(Kok *et al.*, J Cog Neuro, 2014)

- Perceptual expectations activate signal-selective units in early visual cortex when stimulus is absent
- Could this signal fluctuate over time and favor False Alarms in a detection task?

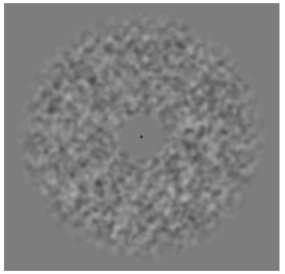
Hypothesis

- Detection task with gabors of a constant orientation:

Noise:



Noise + 45° gabor:



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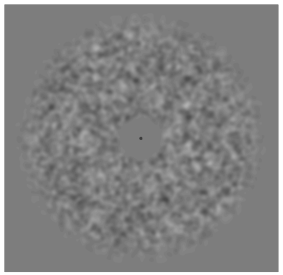

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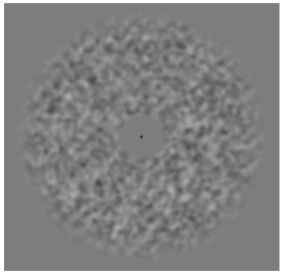

  - 'Expectation' signal in early visual cortex: increased activity in orientation-specific neurons (Kok et al., J Cog Neuro, 2014)

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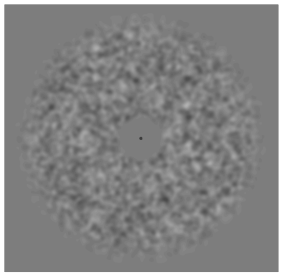

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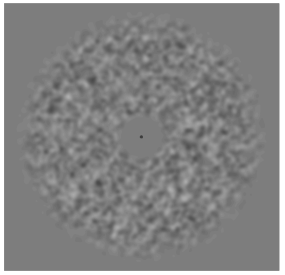

  - 'Expectation' signal in early visual cortex: increased activity in orientation-specific neurons (Kok et al., J Cog Neuro, 2014)
  - This 'expectation' signal would fluctuate over time,
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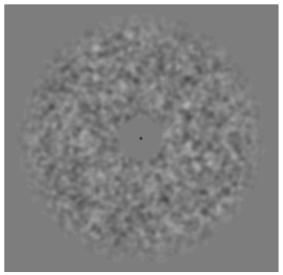

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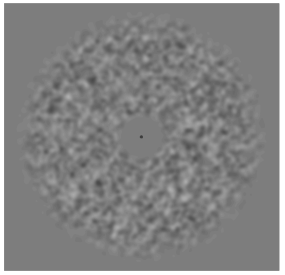

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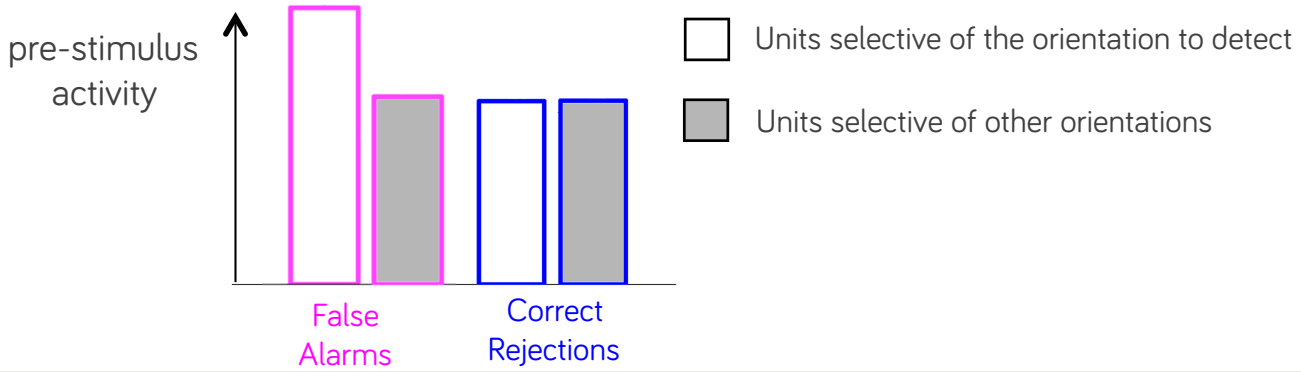
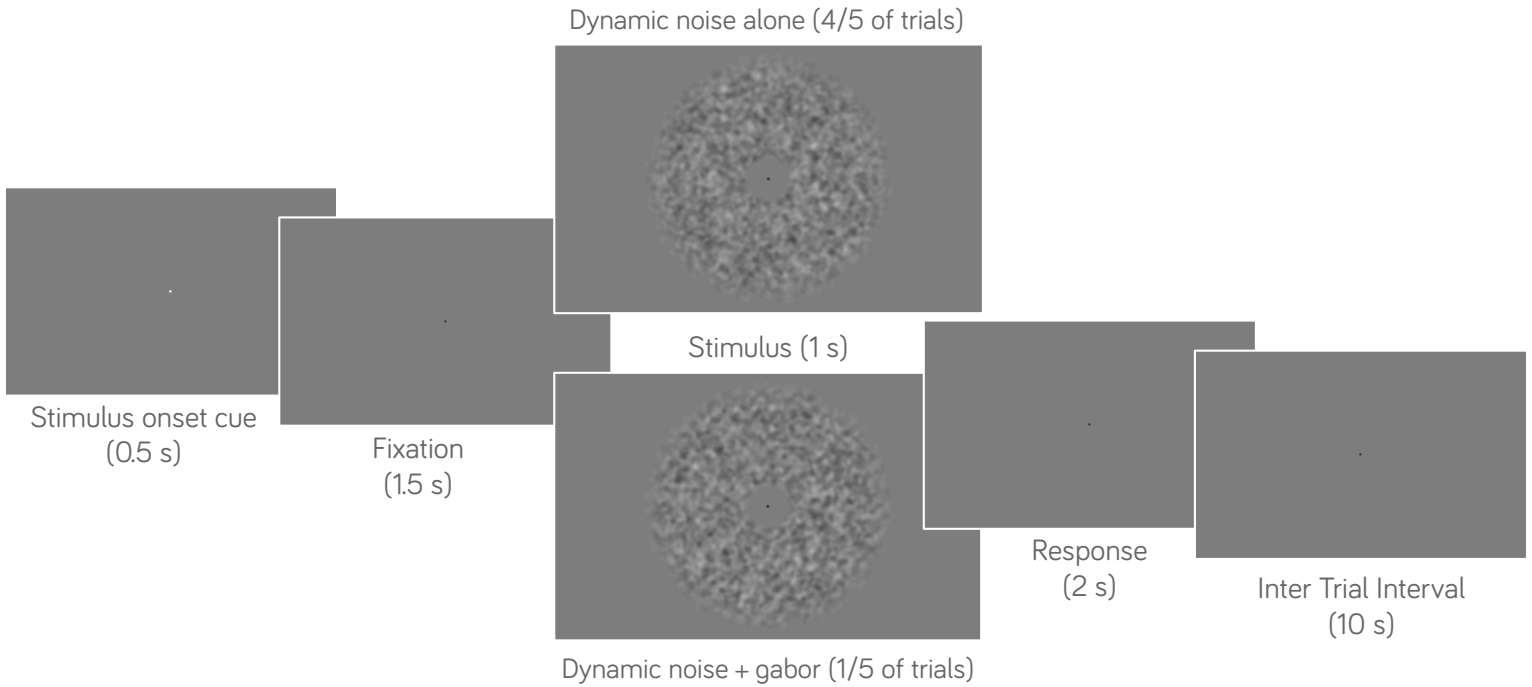


Paradigm

- Detection of a gabor patch embedded in gaussian white noise, at individual contrast threshold



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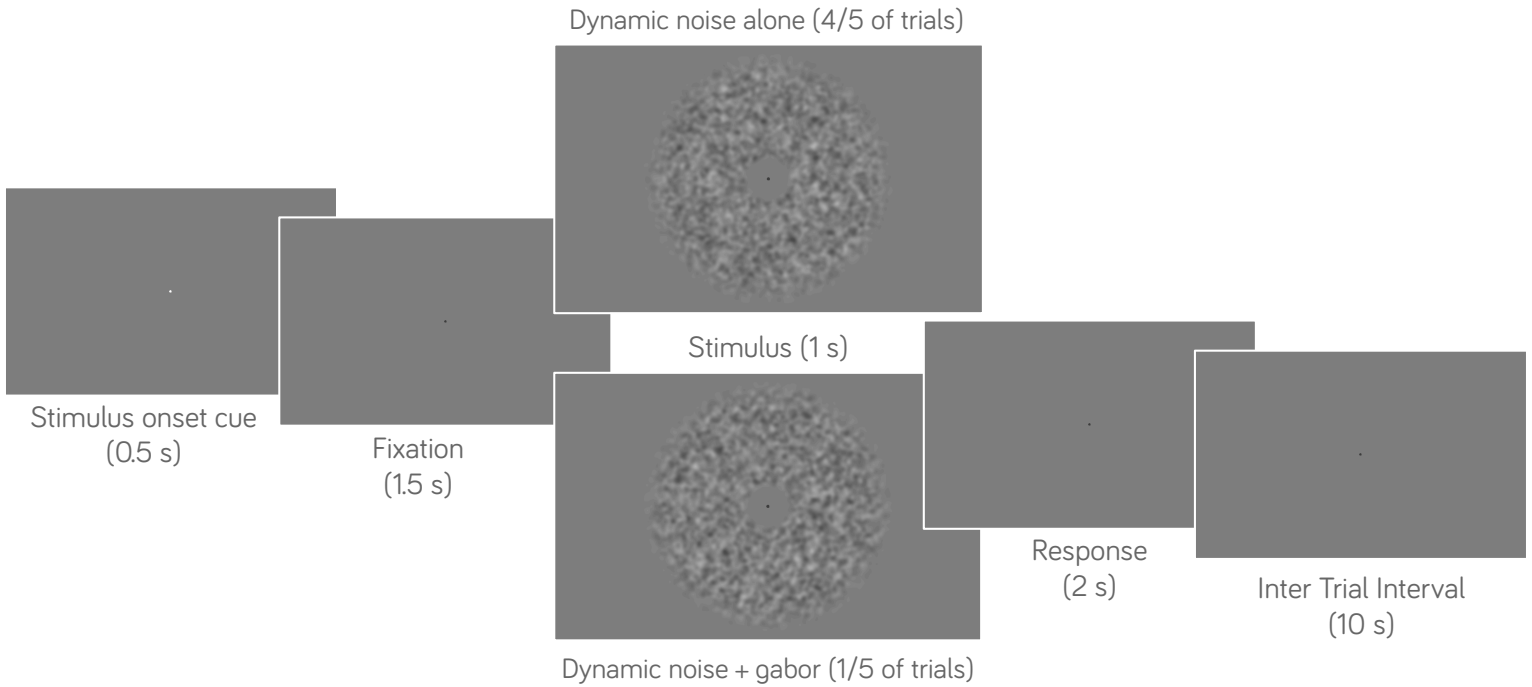
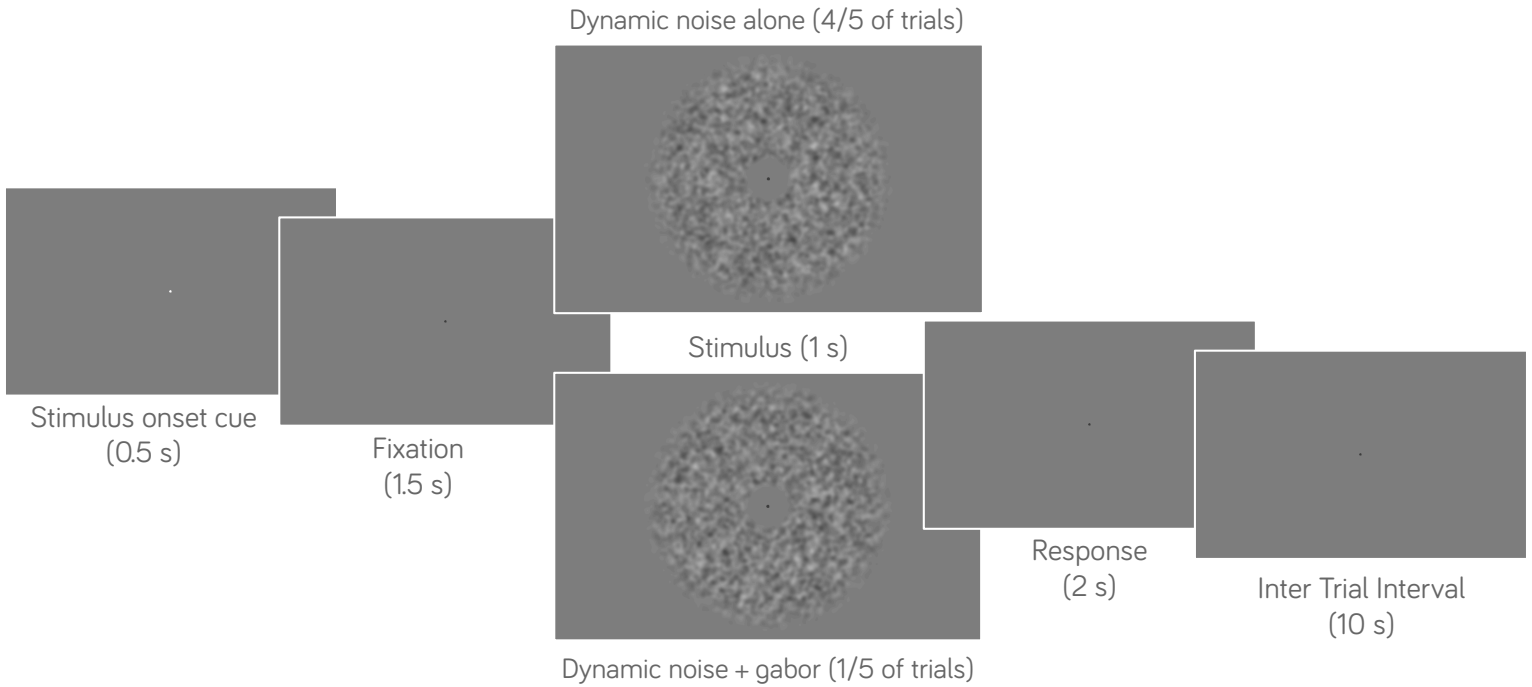
- Detection of a gabor patch embedded in gaussian white noise, at individual contrast threshold
- One single orientation in each run, 45° or 135°

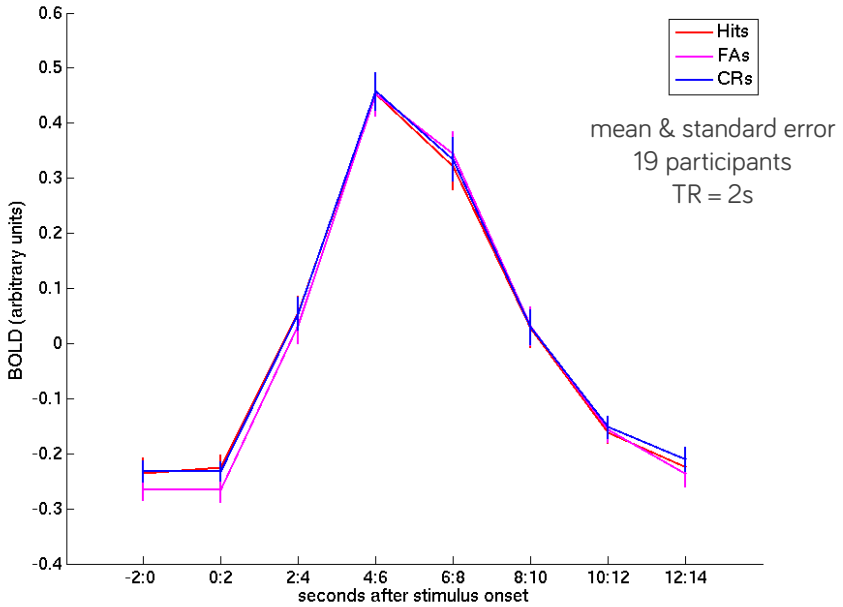


Paradigm

- Detection of a gabor patch embedded in gaussian white noise, at individual contrast threshold
- One single orientation in each run, 45° or 135°
- Dynamic noise: fixed set of 60 noise patches with low signal energy (< 2%) in a random sequence
  -> False Alarms cannot be caused by between-trials fluctuations in exogenous noise



Results : pre-stimulus activity in V1



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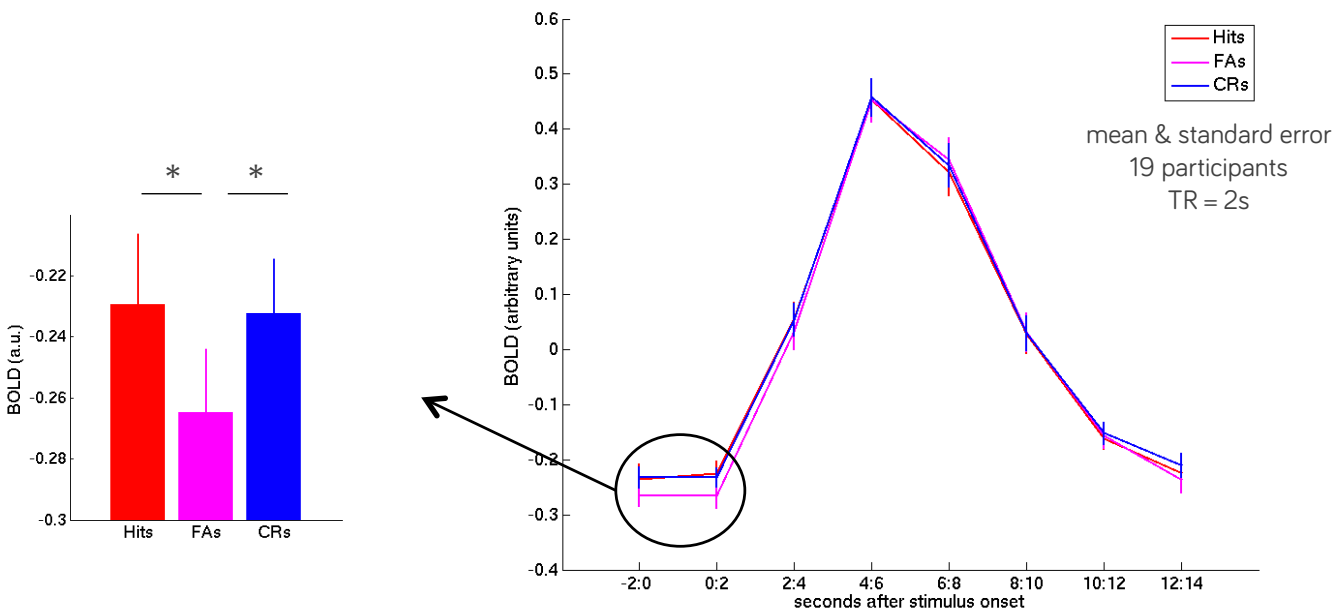

- Pre-stimulus activity is lower for False Alarms

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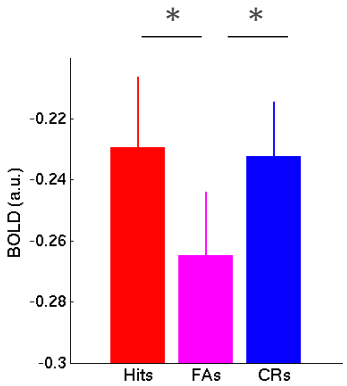

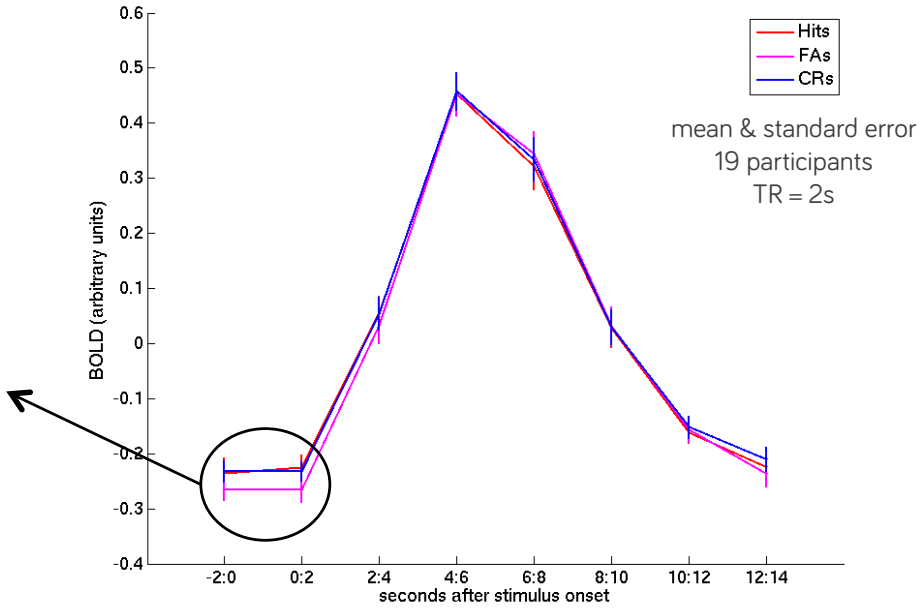

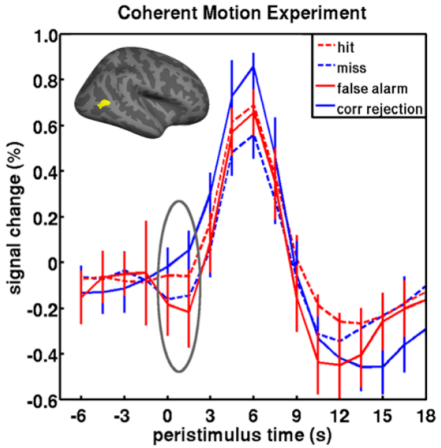

(Hesselmann *et al.*, 2010)

- Pre-stimulus activity is lower for False Alarms
- Consistent with previous work: lower pre-stimulus baseline before errors
  -> fluctuations in attention & precision of perceptual inference
  (cf Feldman & Friston, Front Human Neuro, 2010)

Results : pre-stimulus patterns of activity in V1 & signal detection

- Select 45° and 135°-selective voxels from independent localizer run

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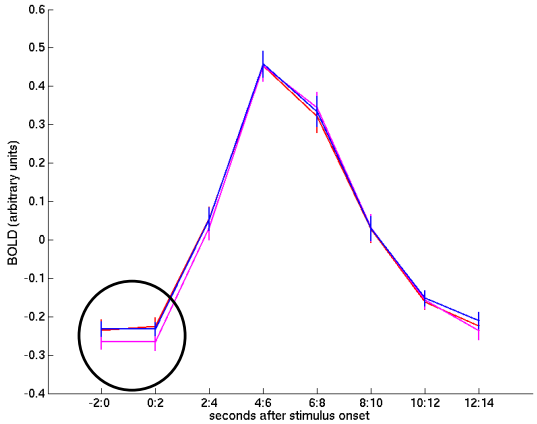

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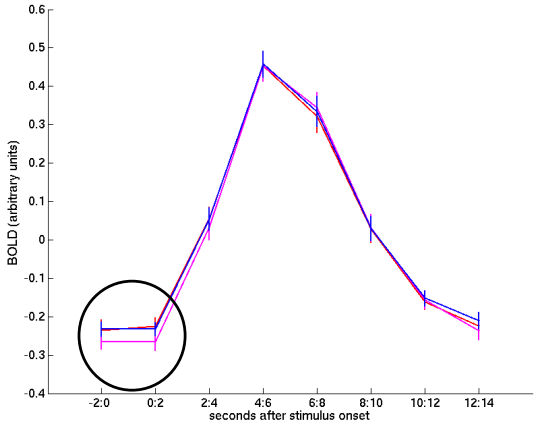

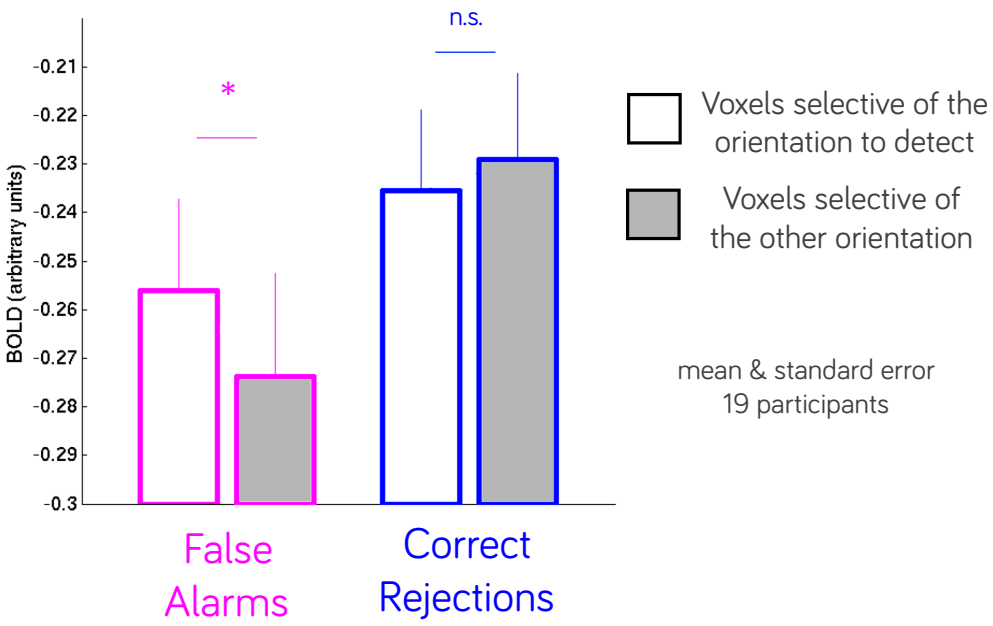

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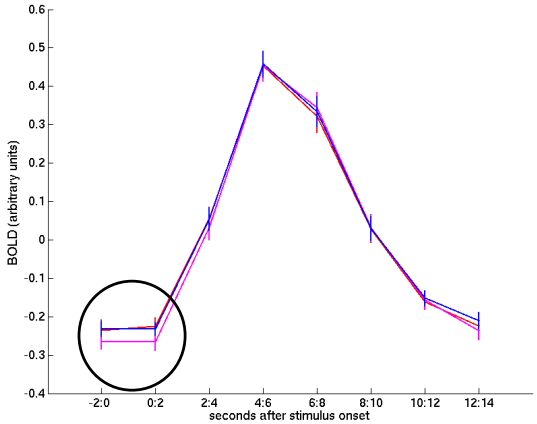

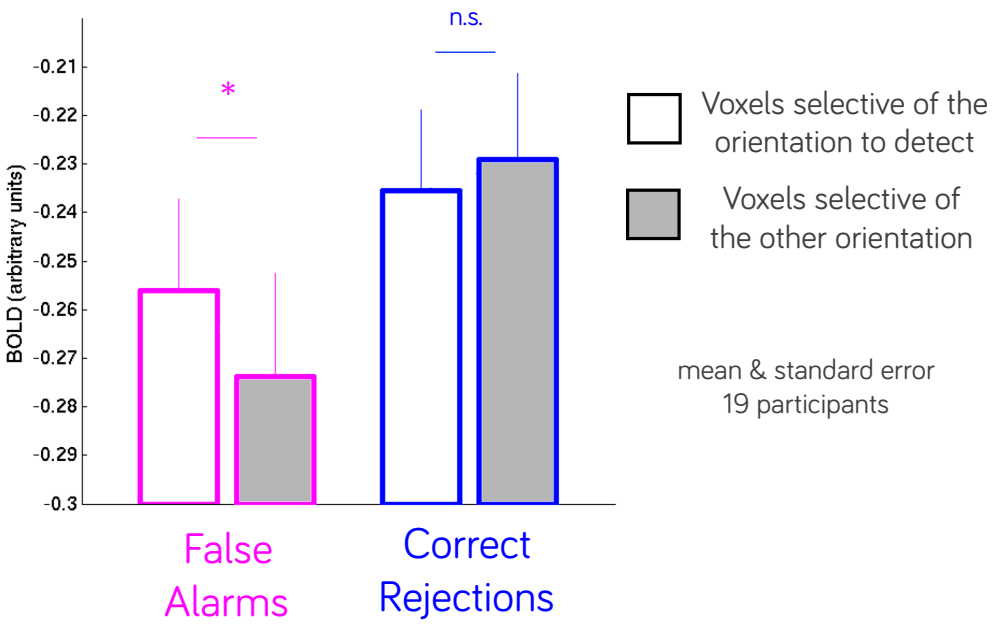

- Orientation-specific pattern of activity before False Alarms

Discussion

- It was previously shown that signal-like fluctuations in stimulus noise could favor False Alarms (Wyart et al., PNAS, 2012)

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- Consistent with computational modeling of behavioral data by Wyart *et al.*, which suggest increased baseline activity in signal-selective units before False Alarms
- Origin of the fluctuations in pre-stimulus patterns of activity:
  - 'perceptual expectations' signal (Kok *et al.*, J Cog Neuro, 2014)
  - mental imagery (Albers *et al.*, Current Biology, 2013)
  - feature-based attention
  - (random noise fluctuations)

Acknowledgements

- In the Netherlands :

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  - Floris de Lange
  - Peter Kok

- In France :

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  - Sid Kouider

Universiteit van Amsterdam

  - Tobias Donner

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  - Erik Meijs
  - Paul Gaalman
  - Thomas Meindertsma
  - & the PredAttors

Universiteit van Amsterdam

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- In France :

ENS École Normale Supérieure

LSCP :

  - Sid Kouider
  - Sylvain Charron
  - Romain Granchamp
  - & the Consciousness team

LNC :

  - Valentin Wyart

LPP :

  - Nathalie Serafin

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  - Floris de Lange
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  - Erik Meijs
  - Paul Gaalman
  - Thomas Meindertsma
  - & the PredAttors

Tomorrow:

10:30 am, room P6
On The Role Of Expectation In Visual Perception: A Top-Down View Of Early Visual Cortex

1:20 pm, room P8
Task Demands Modulate The Effects Of Perceptual Expectations In Early Visual Cortex

Universiteit van Amsterdam

  - Tobias Donner

- In France :

ENS École Normale Supérieure

LSCP :

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  - Romain Granchamp
  - & the Consciousness team

LNC :

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Thank you !

aureliane.pajani@ens.fr // @AurelianeP

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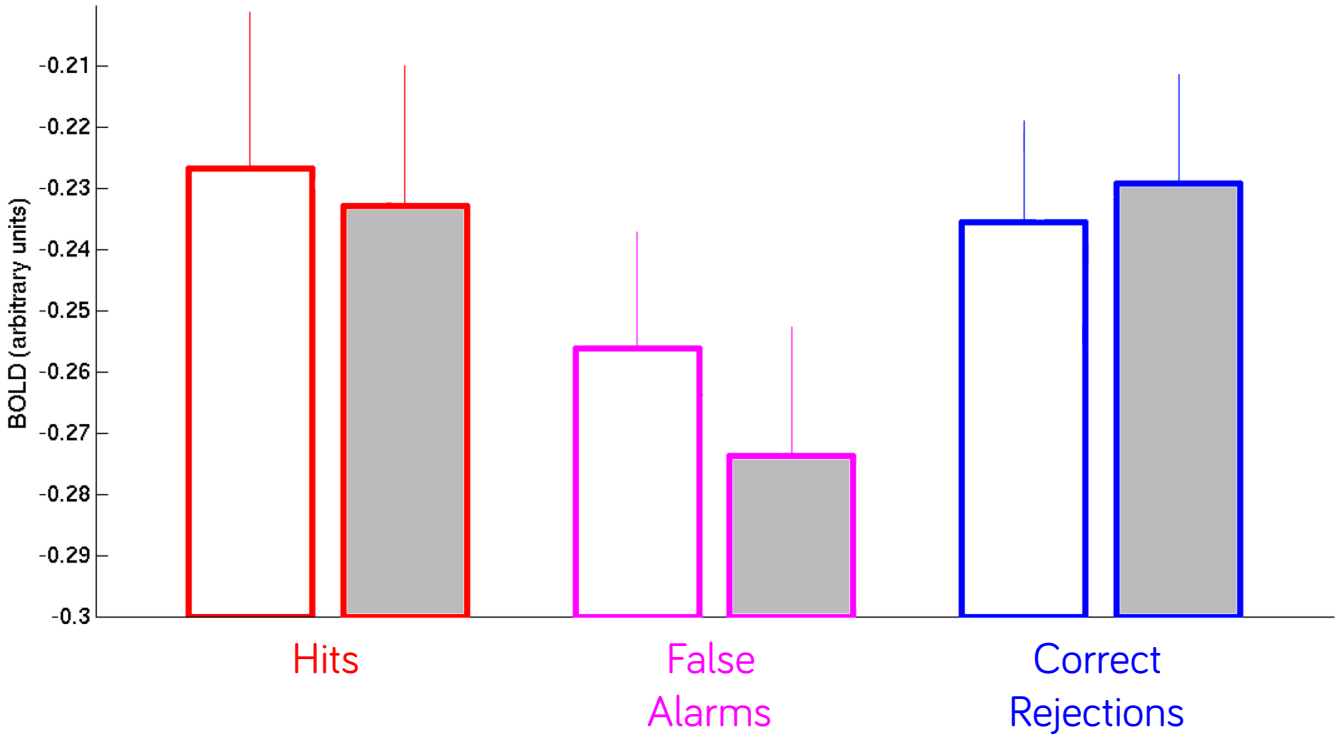
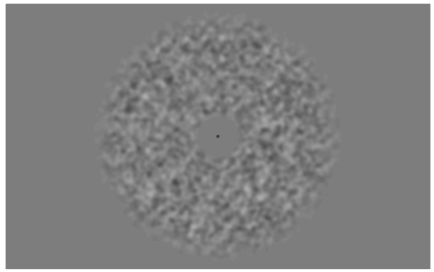


Paradigm: session structure

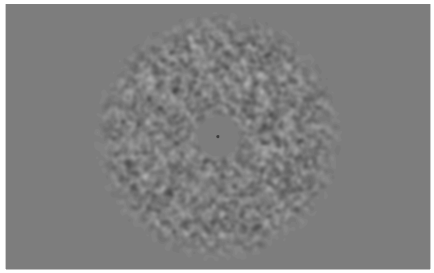
- One orientation in each run, 45° or 135°
  (order counterbalanced across participants)
- 1 run = 50 trials,
  grating present in 1/5 of the trials

Staircase
Run 1
Run 2



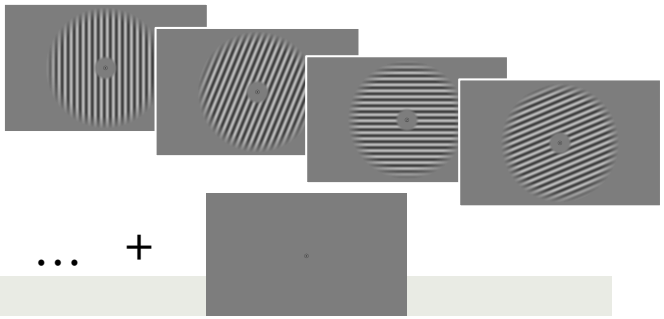
- Staircase for each orientation
  (QUEST, 70% correct)
- Localizer with high-contrast gabors
  (8 orientations + fixation)

Staircase
Run 3
Run 4



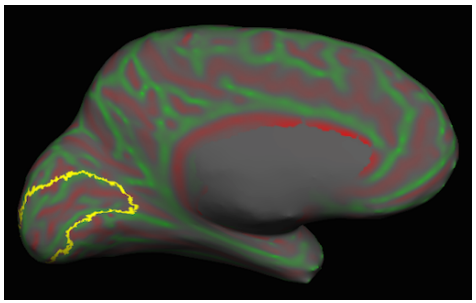
- 25 participants
  - 6 excluded (< 3 FAs for each orientation)
  = 19 participants

Localizer

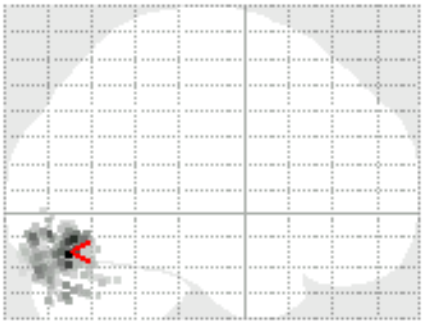


fMRI data processing

- Pre-processing:
  - SPM: Realign, Coregister
  - Matlab: filter, detrend, normalize



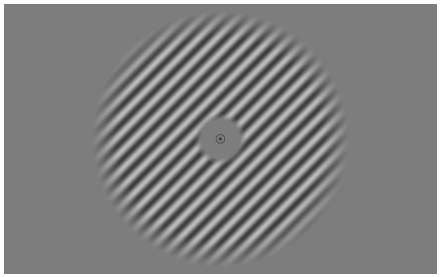
- Voxel selection:
  - Freesurfer: V1 masks from anatomical data
  - SPM: contrast ‘grating vs fixation’ during localizer

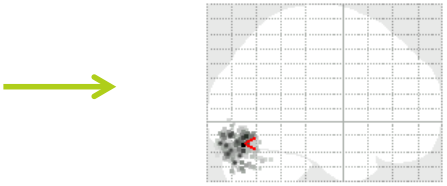


→ select the 500 voxels with highest positive T-values
= most ‘gabor-reponsive’ voxels in V1

Multivariate analysis

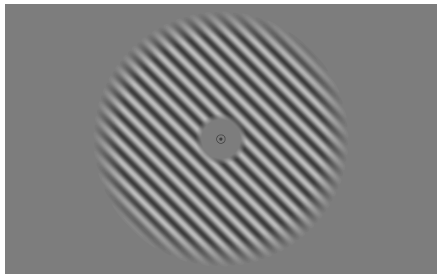
- Voxel population split: contrast '45° vs 135°' during independent localizer run
  (similar to Kok *et al.*, Journal of Cognitive Neuroscience, 2014)

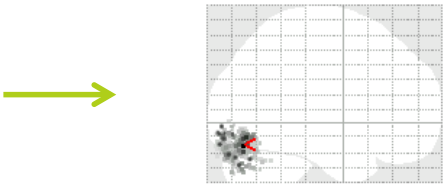




50 voxels with most *positive* T-value
= '45°-preferred' voxel population

vs





50 voxels with most *negative* T-value
= '135°-preferred' voxel population

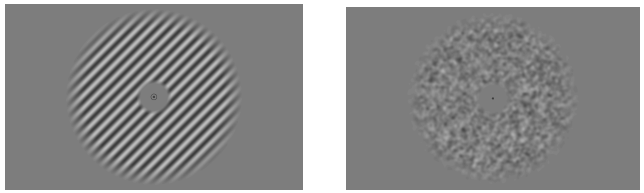
- Difference in BOLD signal in those 2 voxel populations between
  - preferred orientation blocks
  - non-preferred orientation blocks

Multivariate analysis

- Orientation specific signal =

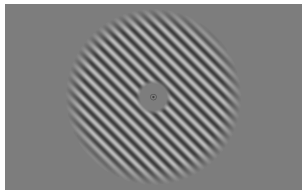
  BOLD response during runs of the preferred orientation

  - BOLD response during runs of the non-preferred orientation

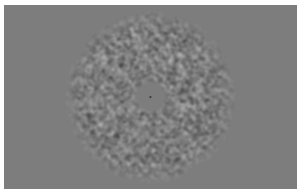


45° voxels

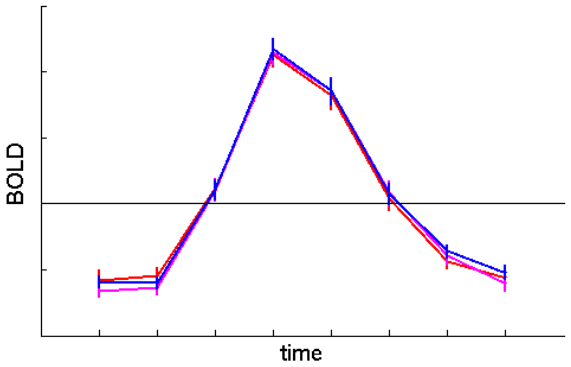
45° runs

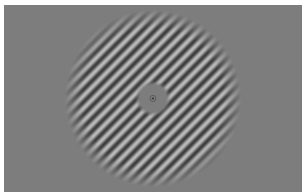


135° voxels

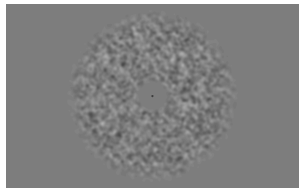


135° runs

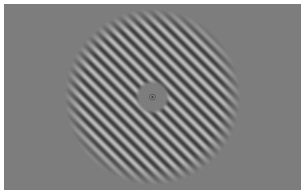




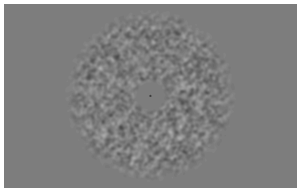
45° voxels



135° runs



135° voxels



45° runs