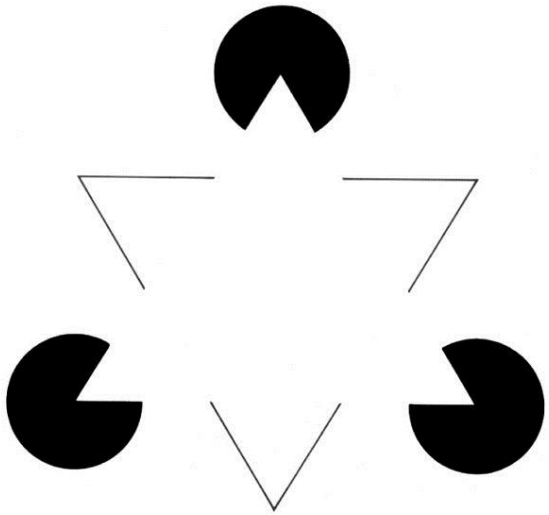
Donders Institute
for Brain, Cognition and Behaviour

On the role of expectation in visual perception: A top-down view of early visual cortex

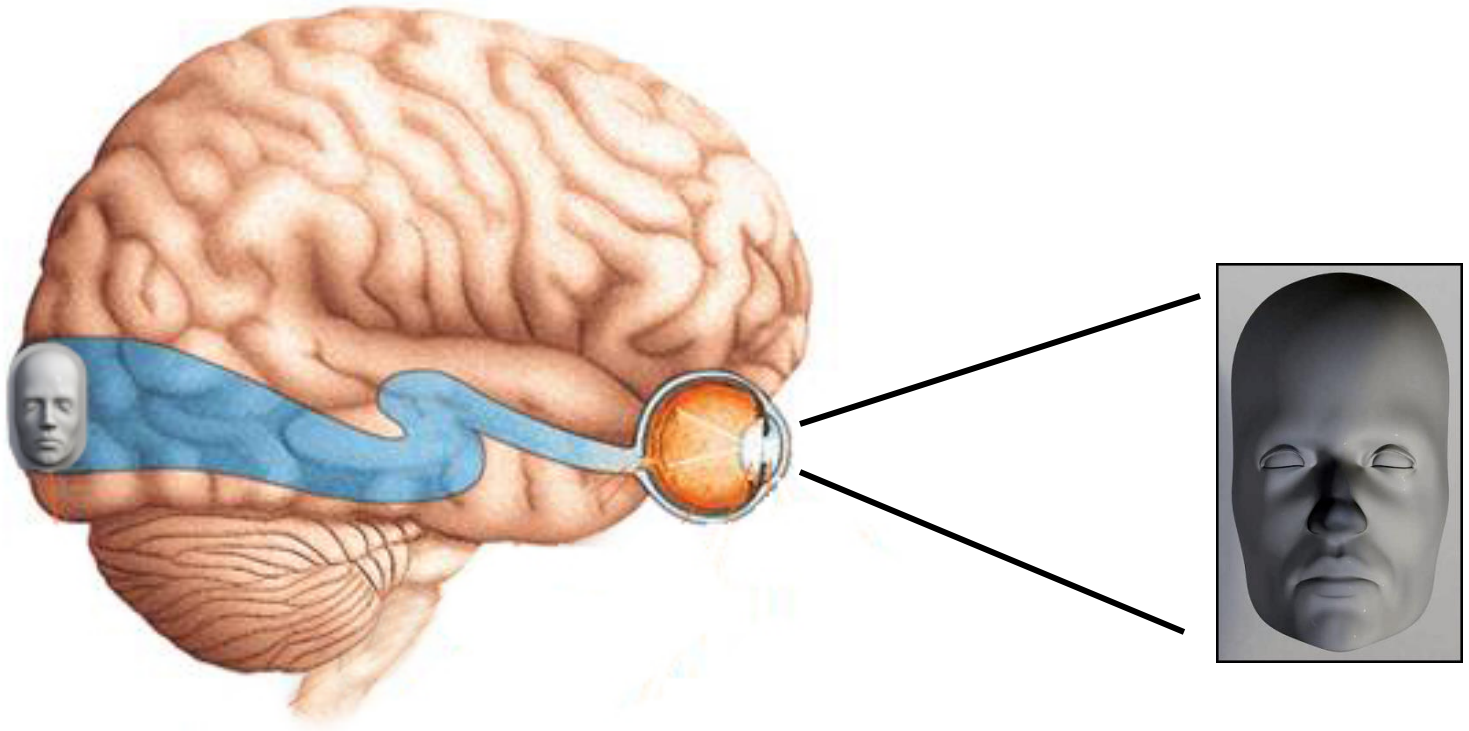


Peter Kok

ICON 2014, Brisbane
31-07-2014

Radboud University Nijmegen

PRIOR KNOWLEDGE INFLUENCES PERCEPTION



- Perception as inference: hypothesis testing.

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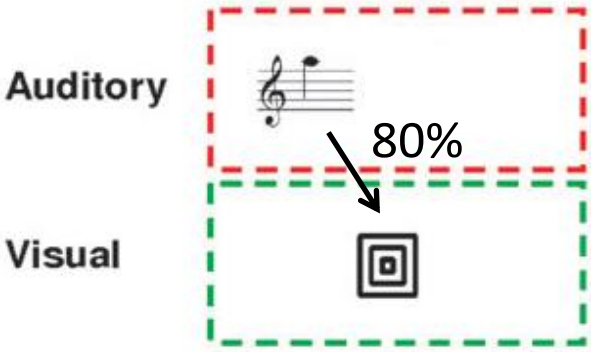
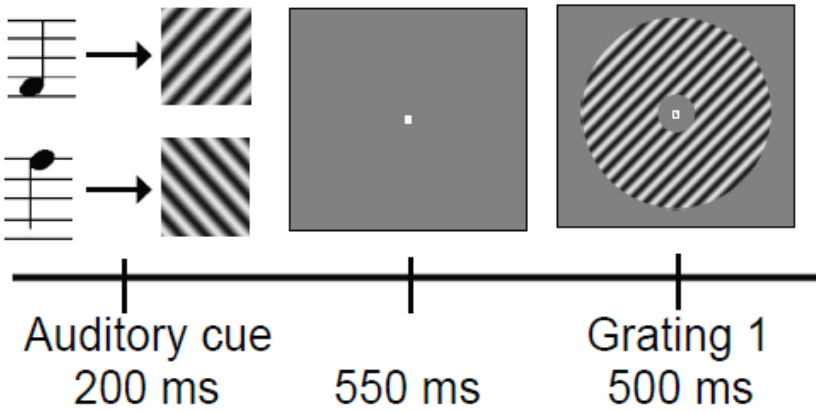
- Valid prior hypothesis -> reduced sensory response.

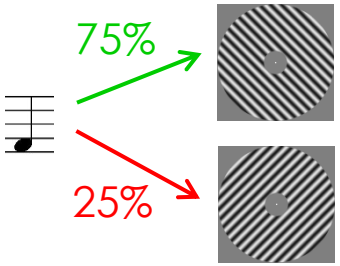


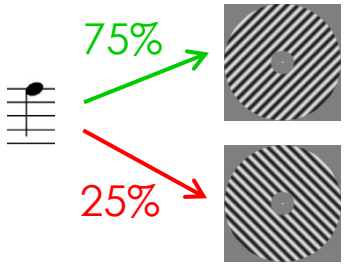
Den Ouden *CerCor* 2009

- Perception as inference: hypothesis testing.
- Valid prior hypothesis -> reduced sensory response.
  - Reduced representation in early sensory regions?
  - Improved representation, but reduced noise (prediction error)?

Kok, Jehee & De Lange *Neuron* 2012



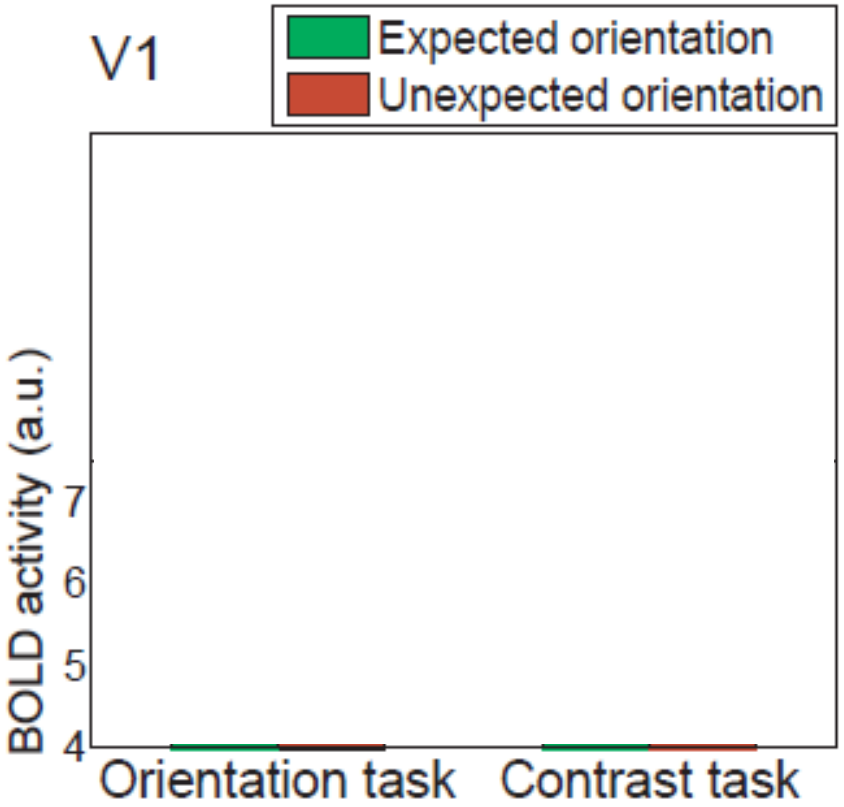




- Orientation task: is the second grating rotated clockwise or anti-clockwise wrt the first?
- Contrast task: does the second grating have lower or higher contrast than the first?

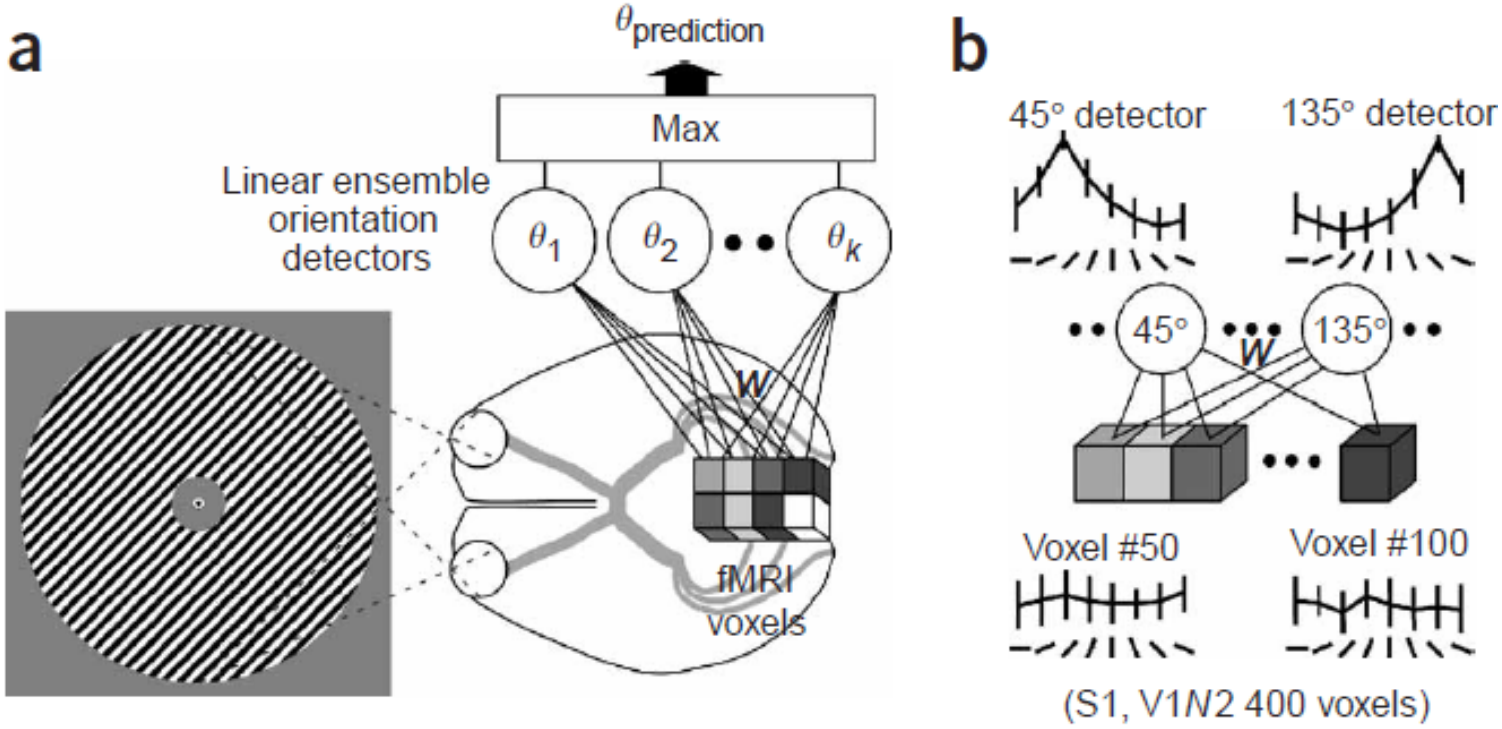
Kok, Jehee & De Lange *Neuron* 2012

- Activity in V1 is reduced for gratings with expected orientation.
- This reduction is equally strong for the orientation and contrast tasks.



Kok, Jehee & De Lange *Neuron* 2012

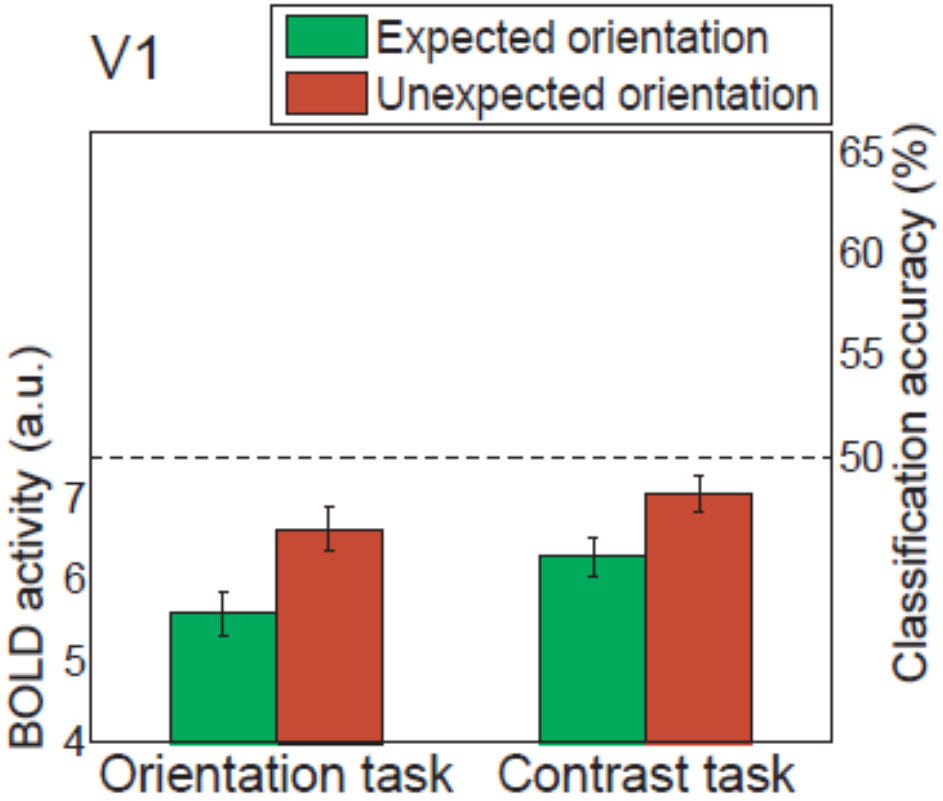
- Multivariate pattern analyses (MVPA) can classify the perceived orientation from the pattern of BOLD activity in V1.



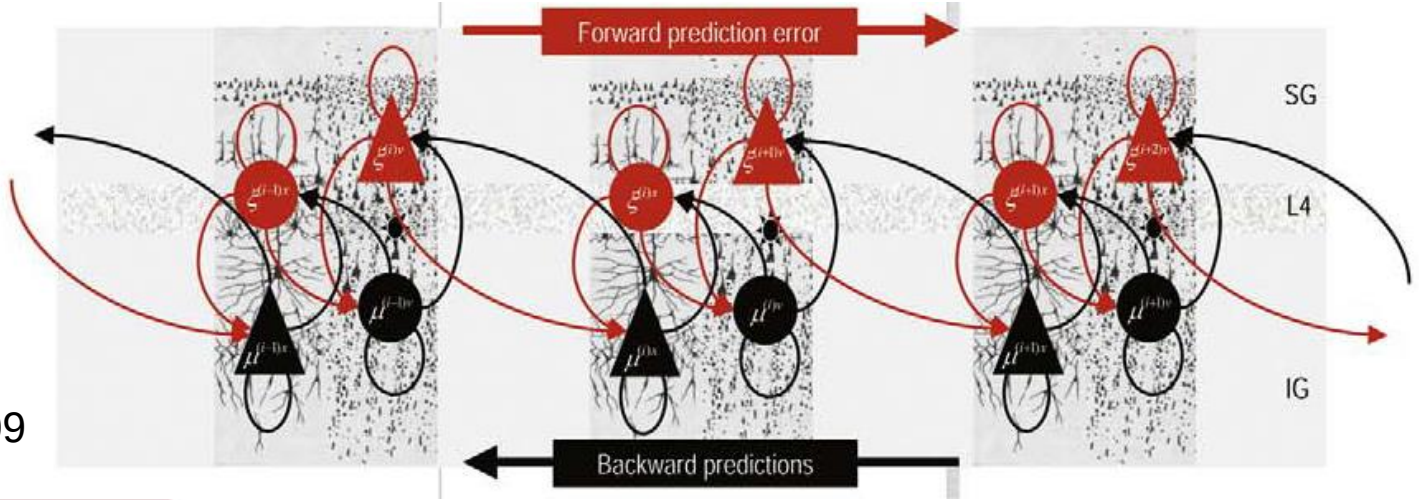
Kamitani & Tong *Nat Neurosci* 2005

Kok, Jehee & De Lange *Neuron* 2012

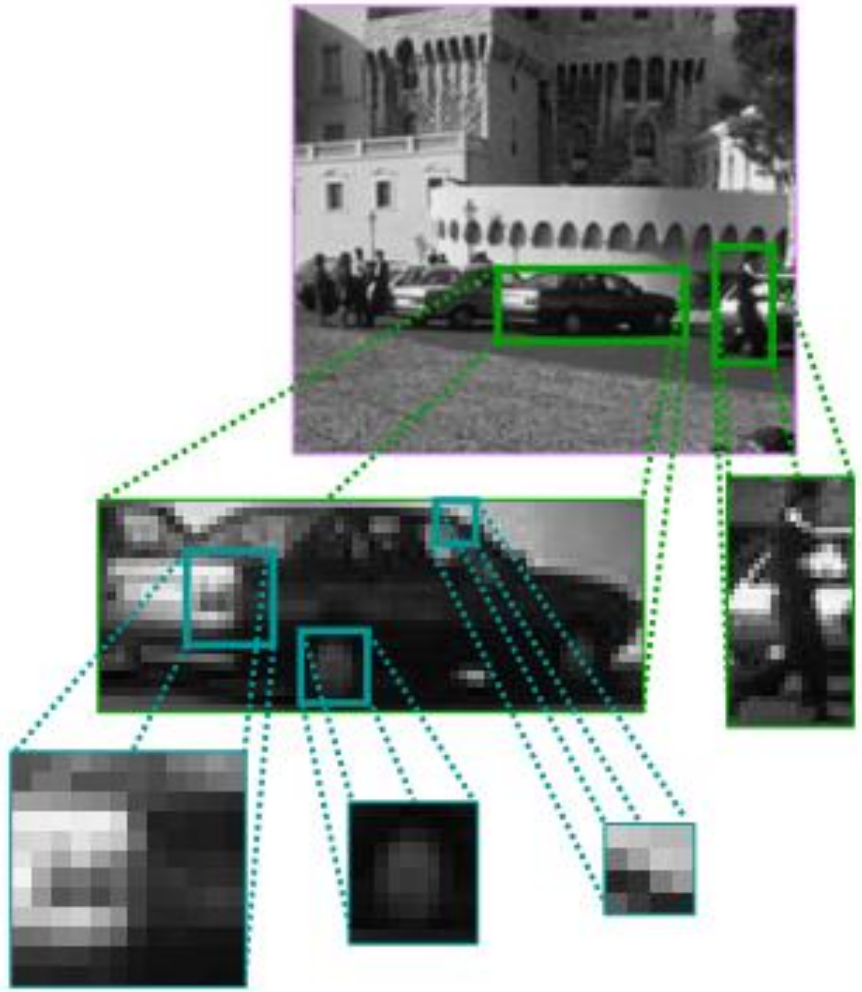
- Orientation information in V1 is increased when orientation is expected.
- This increase is equally strong for the orientation and contrast tasks.

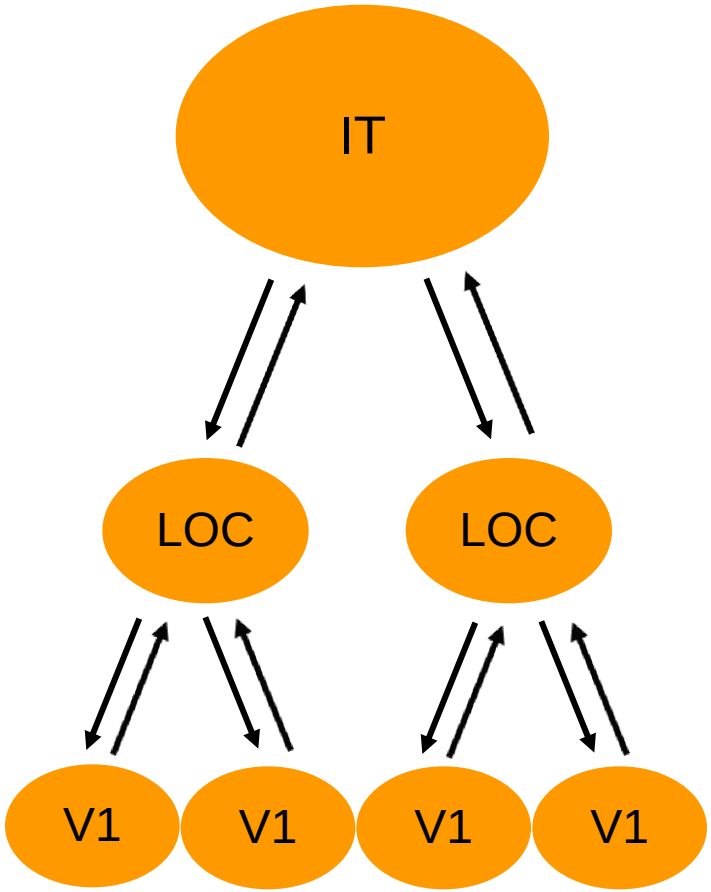


- Valid prior hypothesis -> reduced sensory response, but improved representation.
- In line with predictive coding theories: reduced prediction error (Rao & Ballard 1999, Friston 2005).



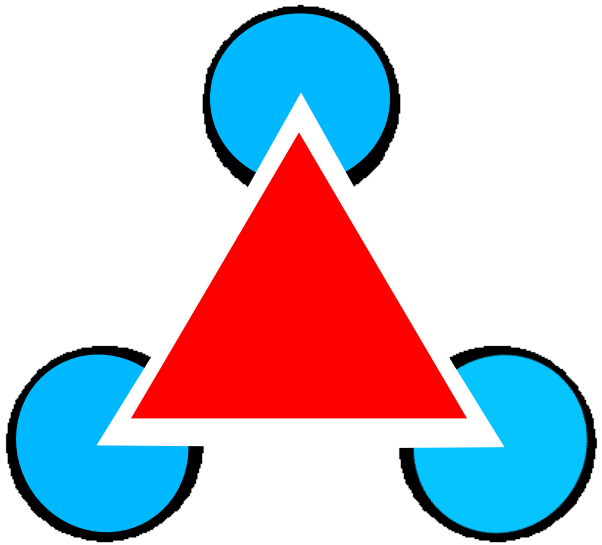
Friston 2009



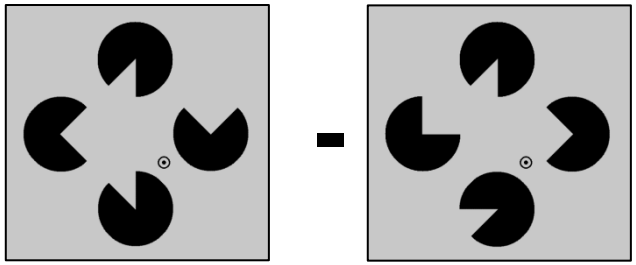


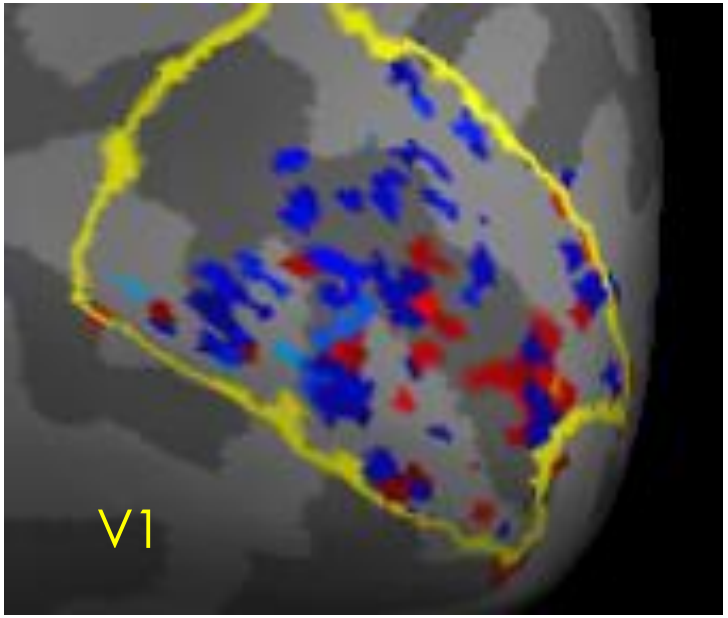
cf Lee & Mumford 2003, Ahissar & Hochstein 2004

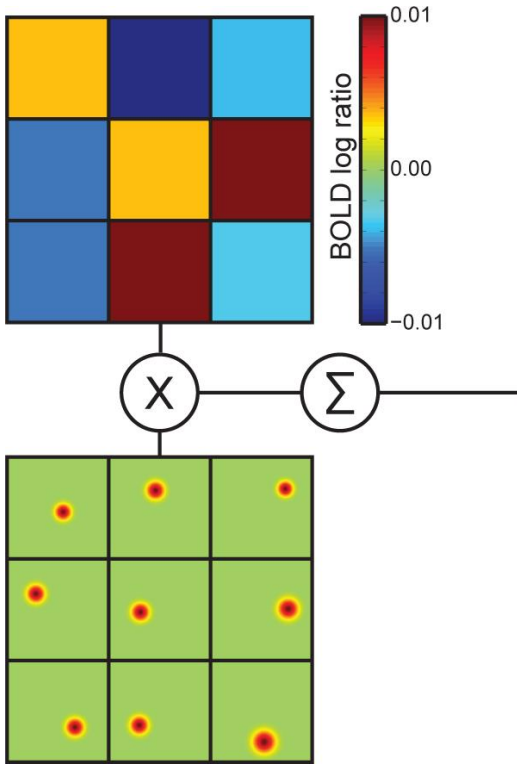
- Hypothesis: the effect of top-down predictions depends on the (mis)match with the bottom-up input; the prediction error.
  Rao & Ballard 1999, Friston 2005
  - Excitation of unexpected (absence of) signals
  - Inhibition of expected signals



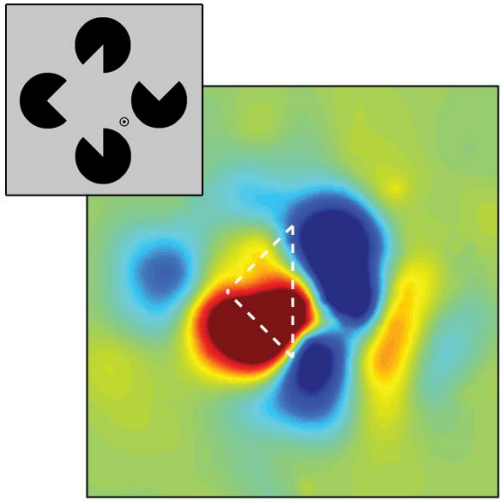
Kok & De Lange *CurBio* 2014







Kok & De Lange *CurBio* 2014



N=20

Kok & De Lange *CurBio* 2014

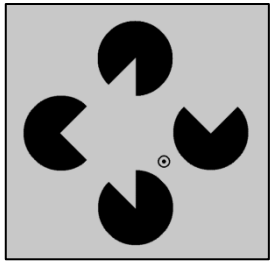
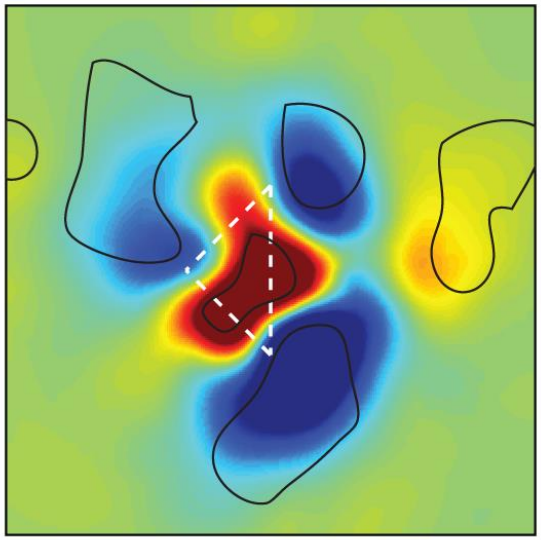
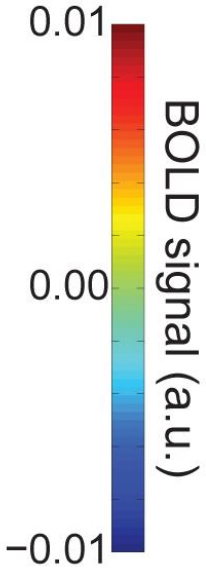


Figure task



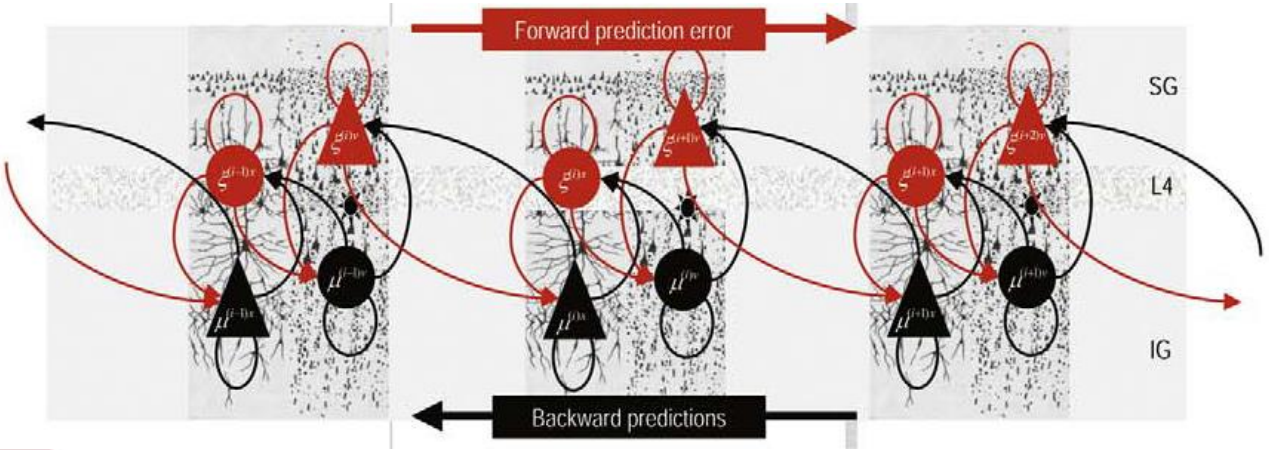


- Excitation of unexpected (absence of) signals.
- Inhibition of expected signals.

N=20

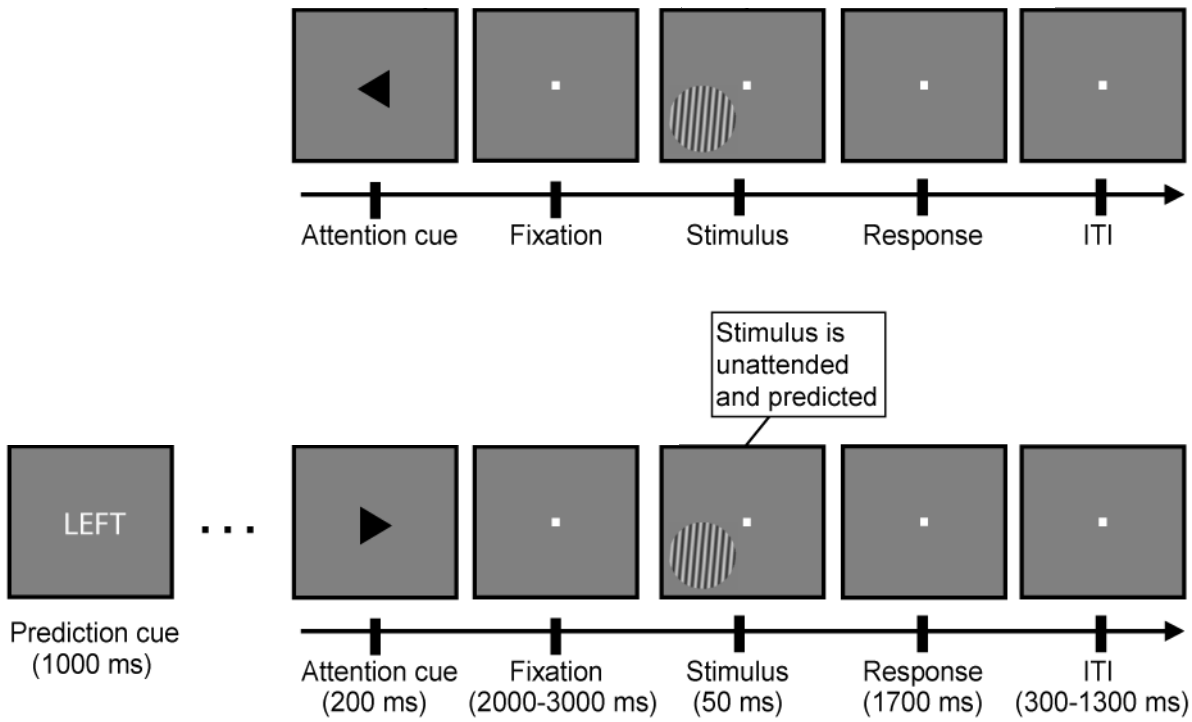
PREDICTION AND ATTENTION INTERACT

- So far, I've discussed effects of expectation that seem independent of attention.
- These effects are in line with predictive coding theories.
- Attention boosts sensory signals.
- In predictive coding, the sensory signal is the prediction error: input – prediction.
- So, attention boosts prediction errors (Feldman & Friston 2010).



Friston 2009

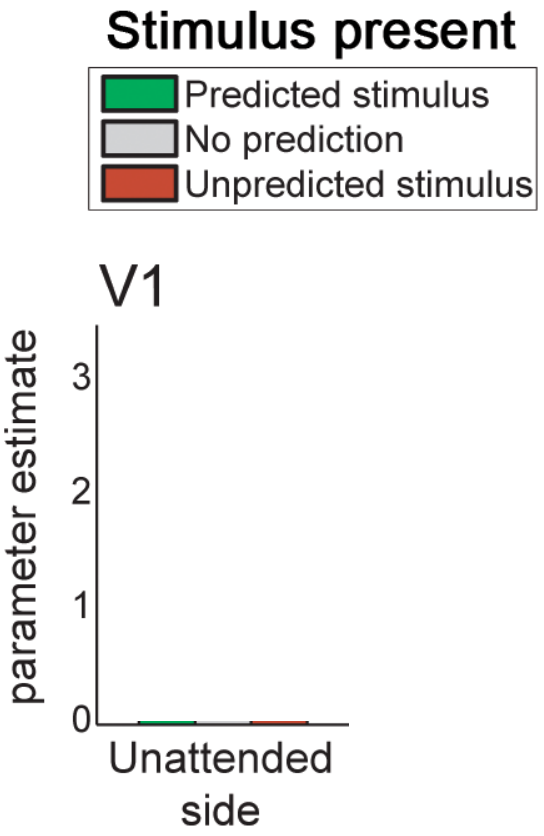
Kok, Rahnev et al. *CerCor* 2012



Prediction cue ⟶ likelihood

Attention cue ⟶ task-relevance

Kok, Rahnev et al. *CerCor* 2012



- Attention reverses prediction suppression.
- Consistent with attention boosting PE at the predicted location.

- Top-down predictions modulate processing in early sensory regions.
- Suggests that brain performs hierarchical perceptual inference (Lee & Mumford 2003).
- Dependent on (mis)match with bottom-up input, in line with predictive coding theories (Rao & Ballard 1999, Friston 2005).
- Prediction and attention interact in a way that is consistent with casting attention as boosting (the precision of) prediction errors (Feldman & Friston, 2010).
  - For more on the task dependence of effects of expectation, see talk by Elexa St. John-Saaltink this afternoon.

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NWO

JAMES S. MCDONNELL FOUNDATION

www: www.predatt.com

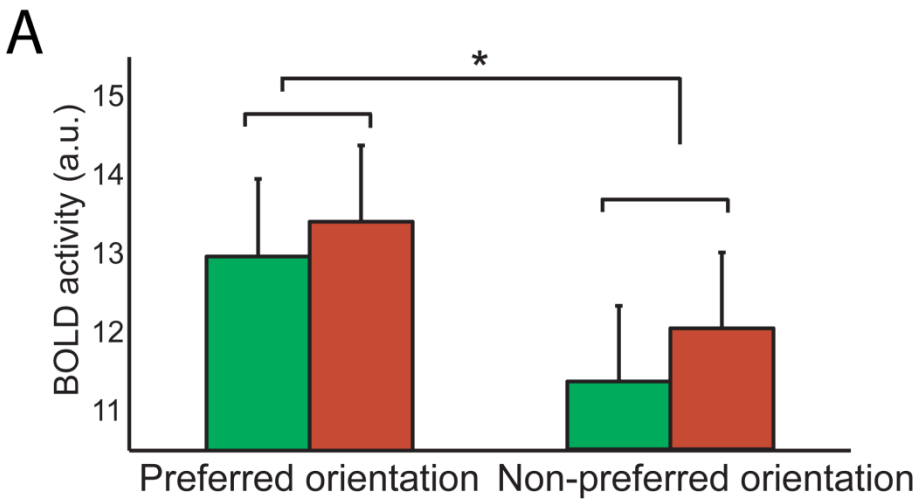
Elexa St. John-Saaltink
OP6 – Attention, 1 PM

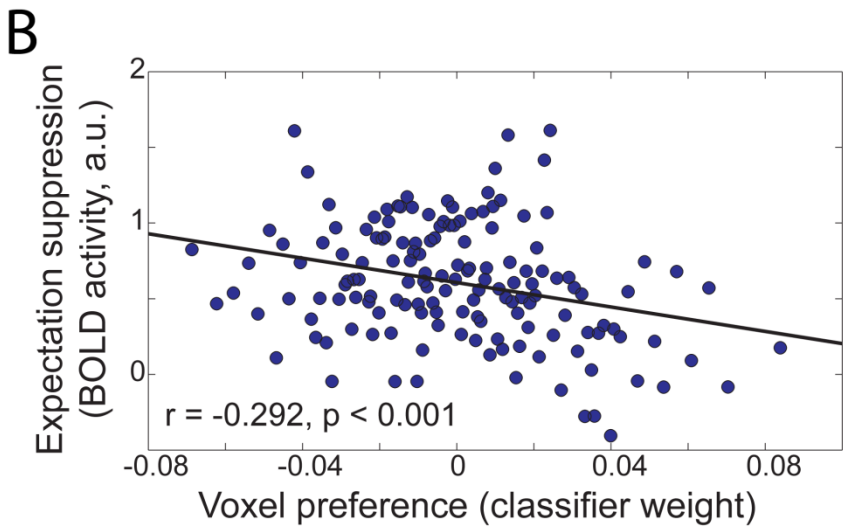
Task demands modulate the effects of perceptual expectations in early visual cortex

EXTRA SLIDES

Kok *Neuron* 2012

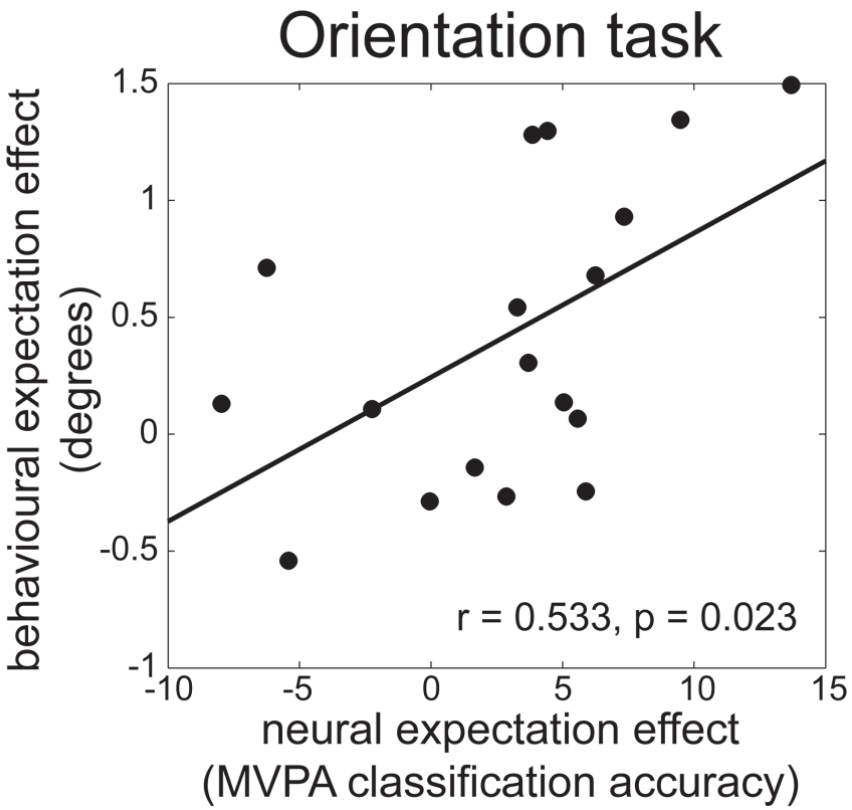
- Further evidence for 'sharpening': the expectation-induced reduction in BOLD amplitude is larger in voxels non-selective for the current orientation.





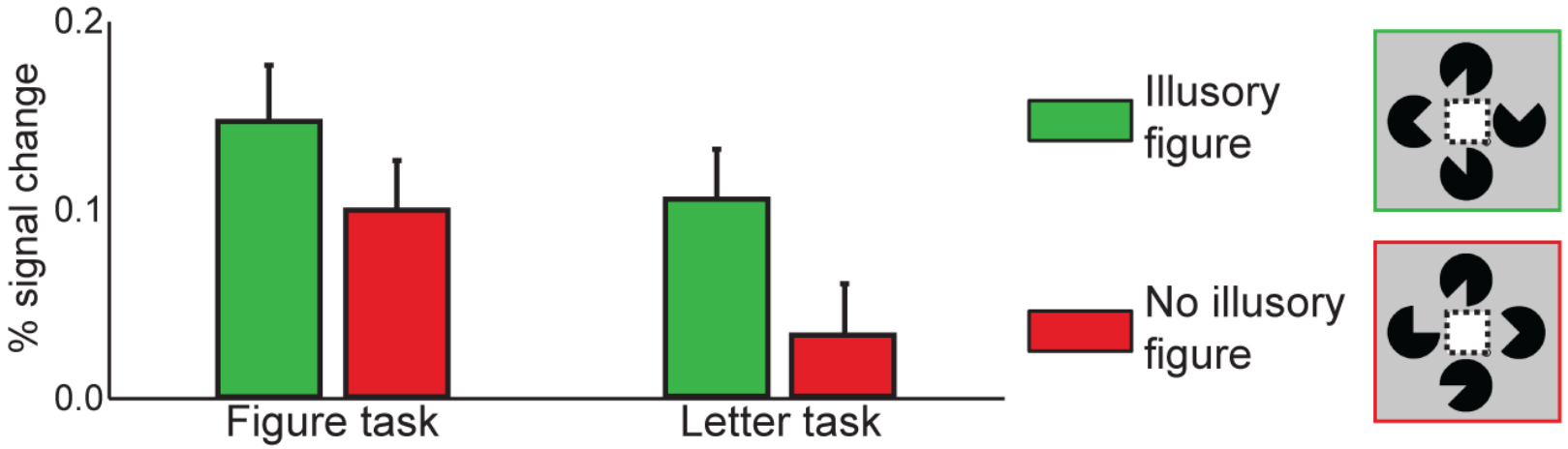
Kok *Neuron* 2012

- Effects of expectation on behaviour and classification accuracy (in V1) are correlated.



SIMULTANEOUS UP- AND DOWN-REGULATIONS IN V1

Kok & De Lange *CurBio* 2014



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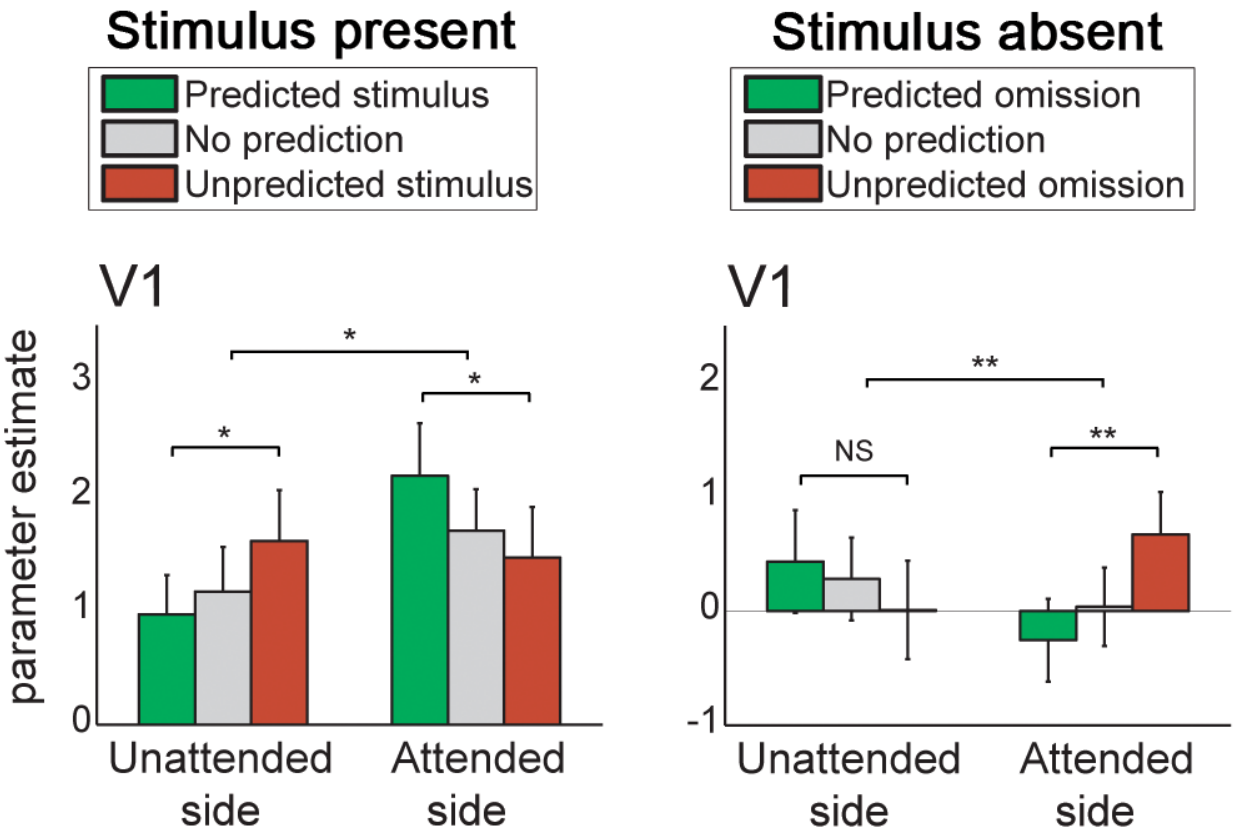
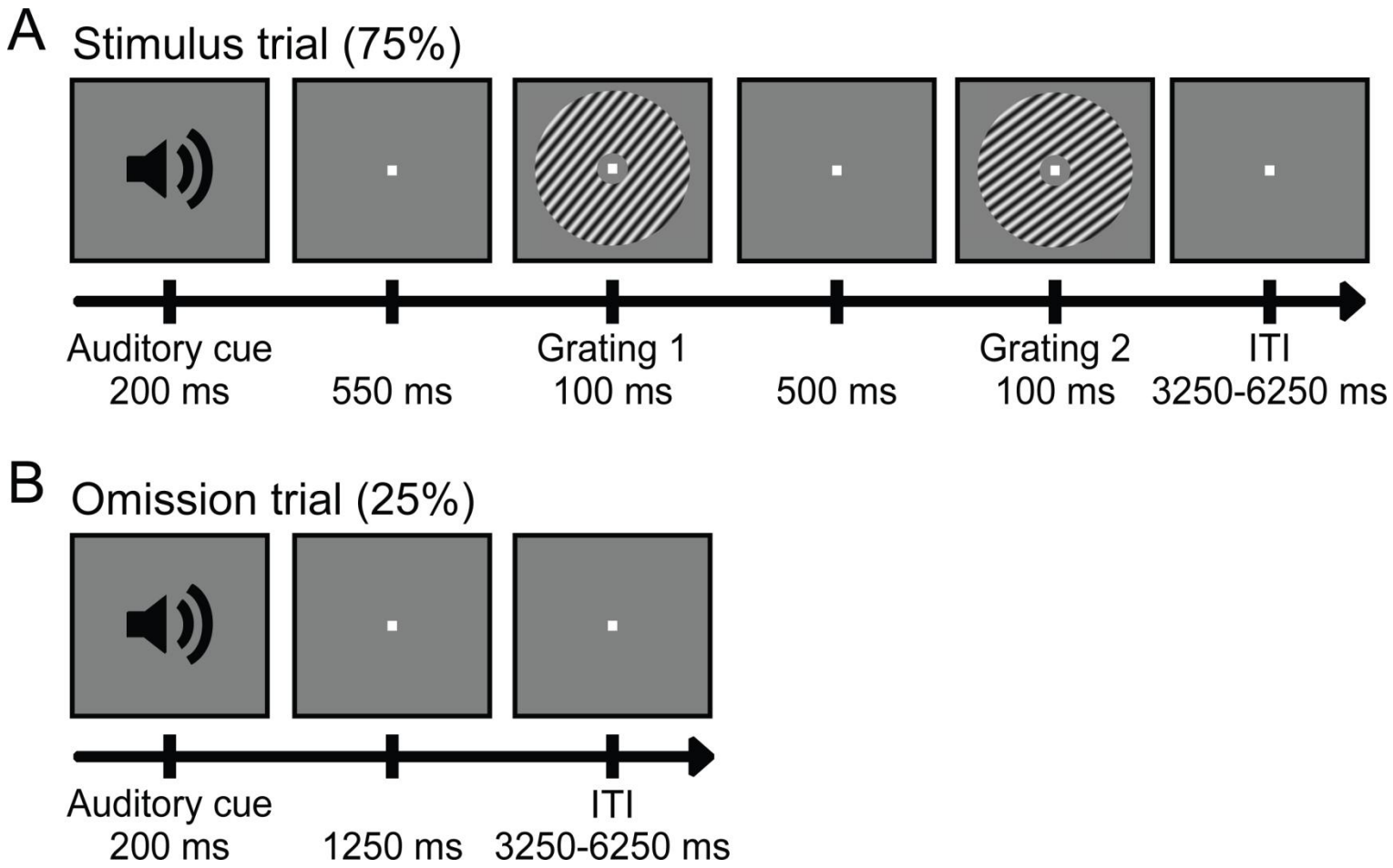
Kok *CerCor* 2012



Kok *JoCN* 2014



Kok *JoCN* 2014

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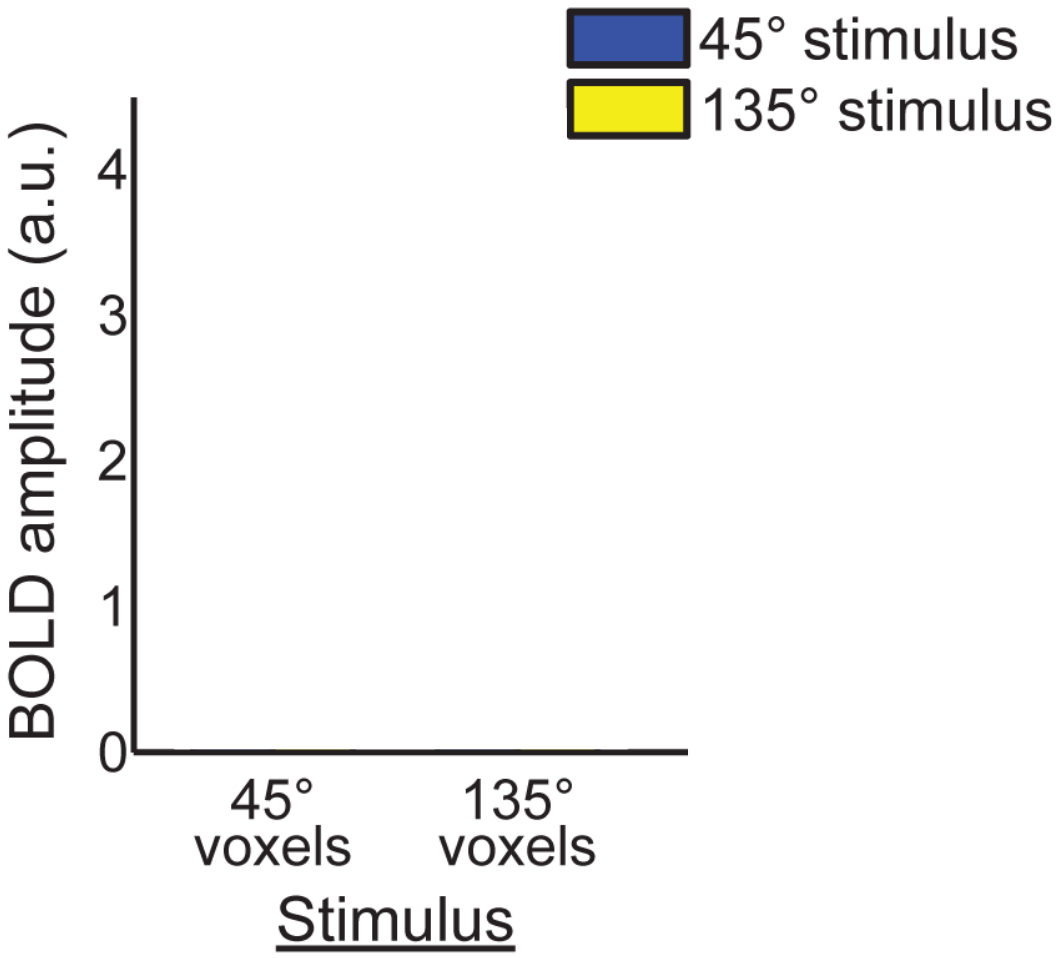

Kok, Rahnev et al. *CerCor* 2012