



Donders Institute
for Brain, Cognition and Behaviour

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

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ICON, July 31st, 2014

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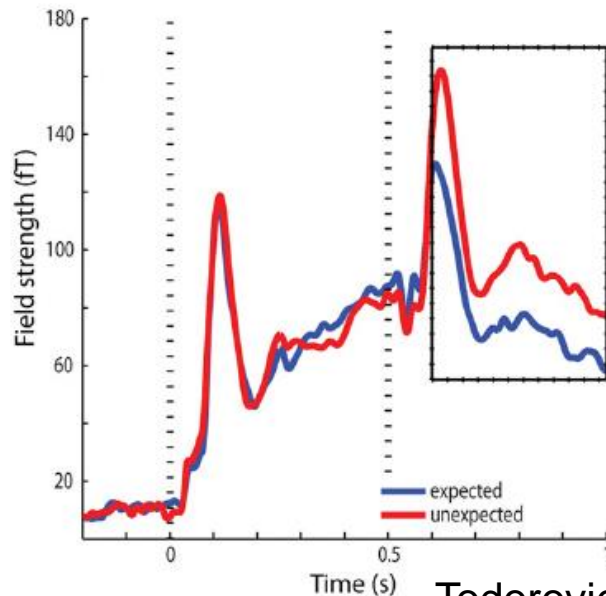
Expectations in perception

Expectations shape what we perceive

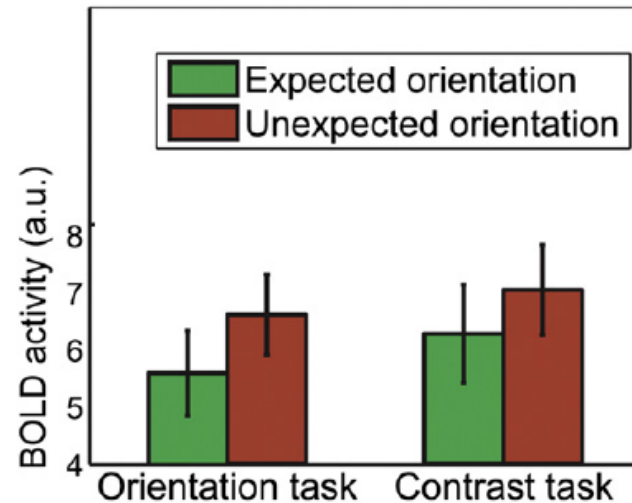
...and how our brains process sensory input.



V1



Todorovic et al., 2011



Kok et al., 2012
Oliva & Torralba, 2007



Is expectation suppression automatic?

- Larsson & Smith (2012): No expectation suppression when attention is diverted.
- However, expectation suppression:
 - During passive viewing (Alink et al., 2010);
 - When task irrelevant (Den Ouden et al., 2009).

Hypothesis: Expectation suppression depends on which processing resources are available.

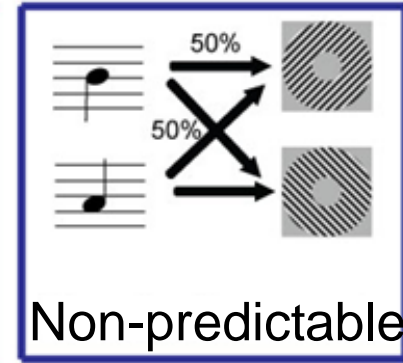
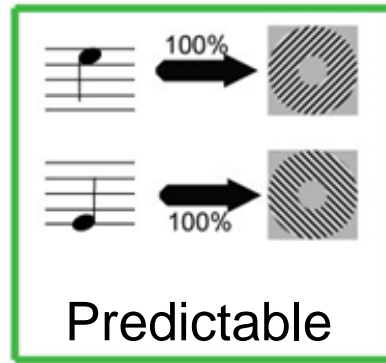
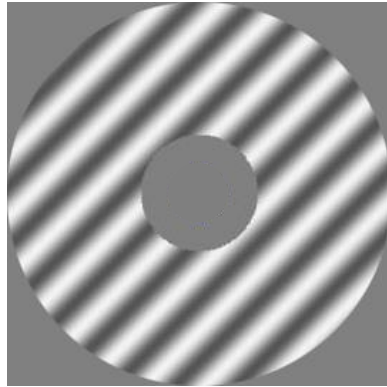




Divert attention away from predictable stimuli to a task at fixation; compare a perceptual load to a working memory (WM) load.

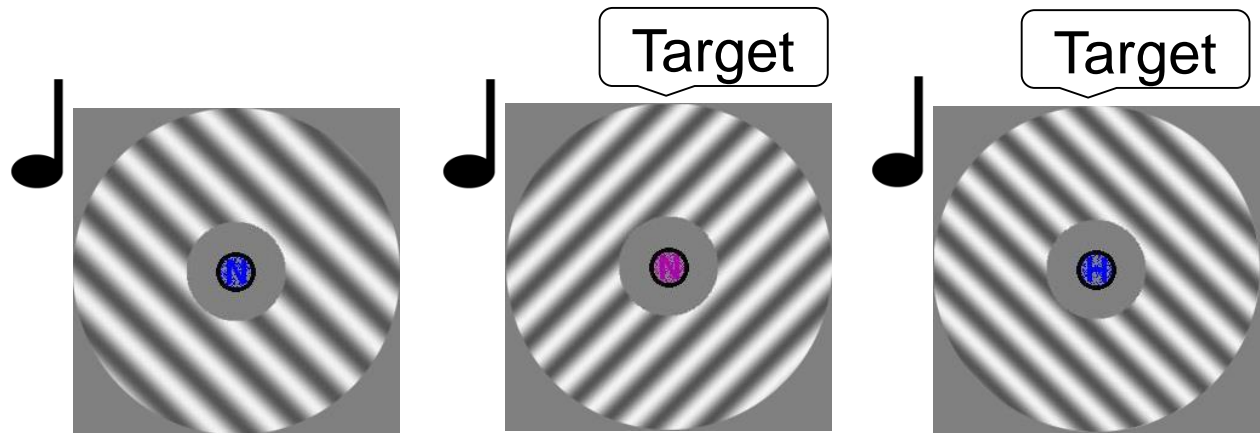
- If expectation does not require attention, there should still be an expectation effect.
- If expectation is dependent on either perceptual or WM resources, task and expectation will interact.



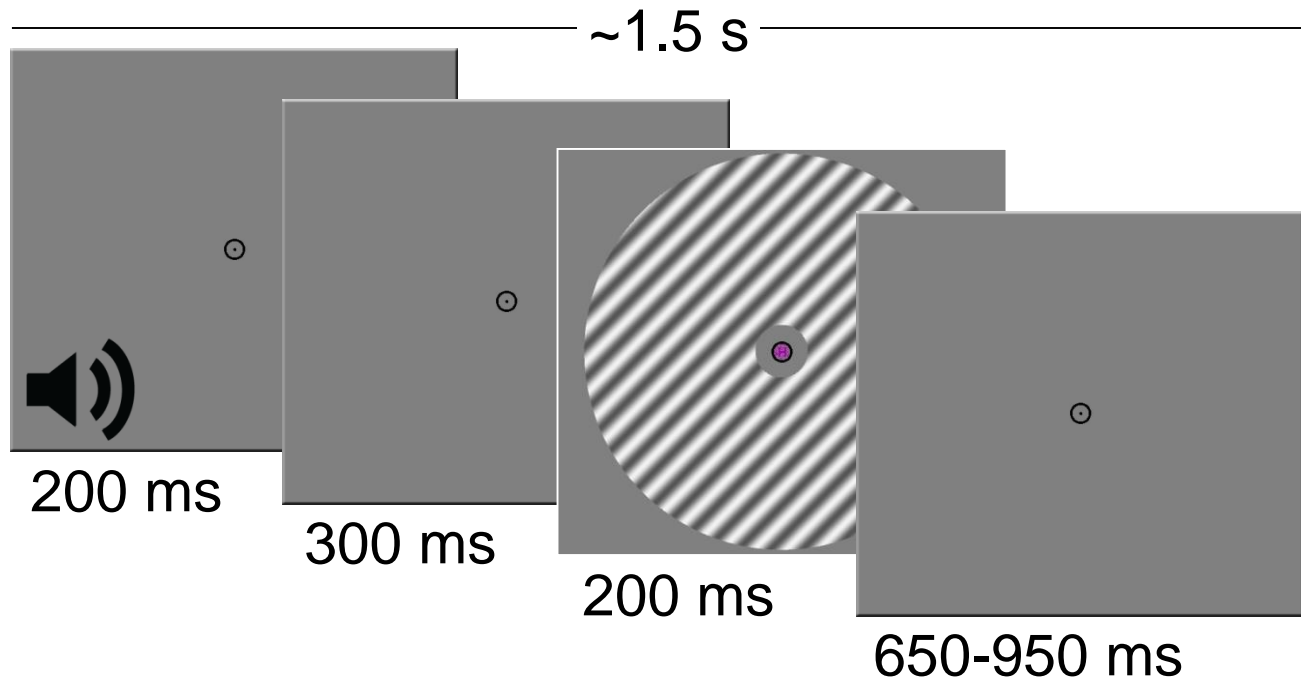


Perceptual load:
WM load:

1-back on noisy letters
2-back on colours



Experimental paradigm



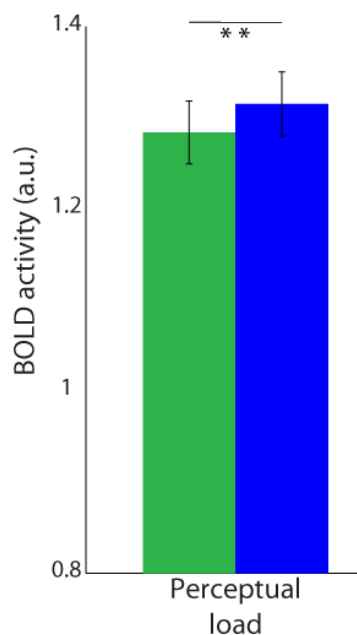
- Cue-predictability blocked (12 trials, 18 s)
- One task per run (5.4 m, 18 blocks)



Neural effects in early visual cortex

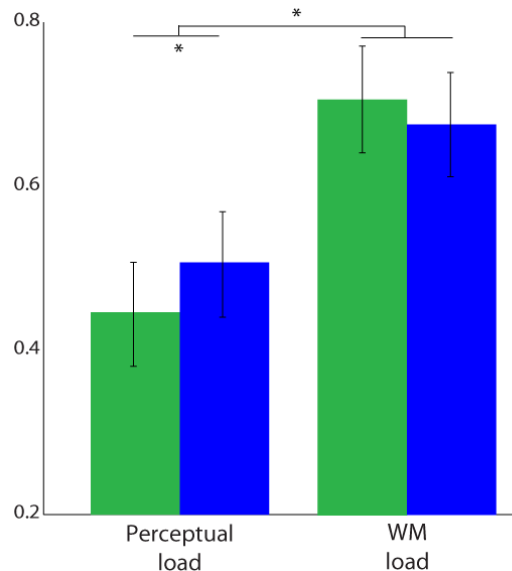
- Expectation suppression during perceptual task ($p=0.0079$).
- Interaction with task: WM load abolishes expectation effect ($p=0.040$).

V1

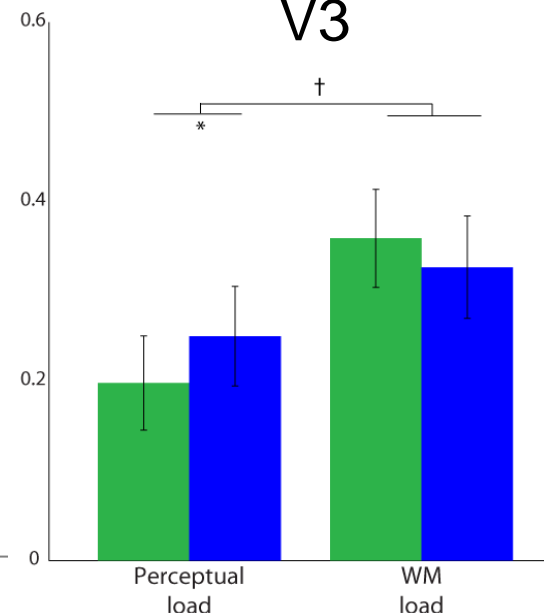


■ Predictable
■ Non-predictable

V2



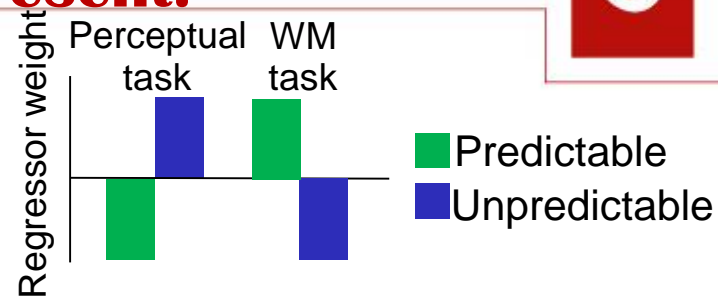
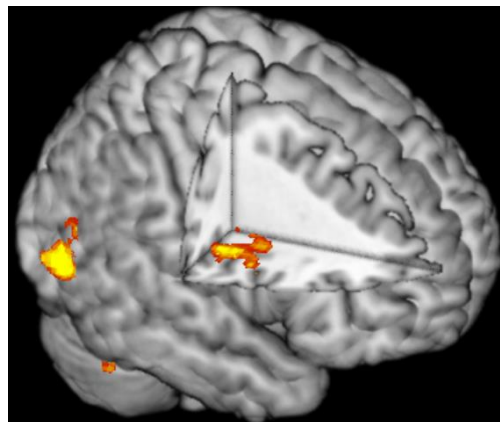
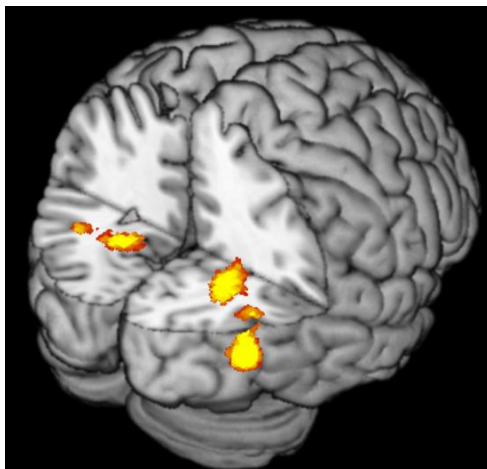
V3



N=33



Where else is this interaction present?



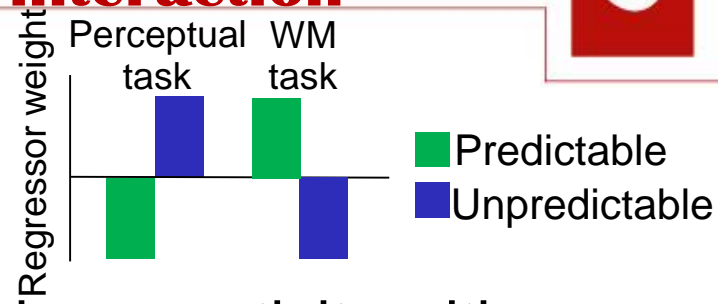
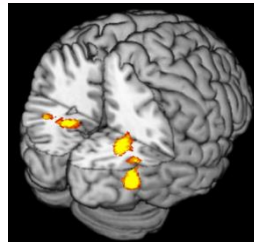
- **Bilateral cuneus** (Right: $p < 0.001$ FWE_{clust} ; Left: $p = 0.013$ FWE_{clust})
Preparatory attentional states (Macalusco et al., 2003);
Associative recognition memory (Yonelinas et al., 2001).
- **Right insula** ($p = 0.014$ FWE_{clust})
Expectation violations (Casey et al., 2000);
Response scales with unpredictability (Huettel et al., 2005; Turk-Browne et al., 2010).





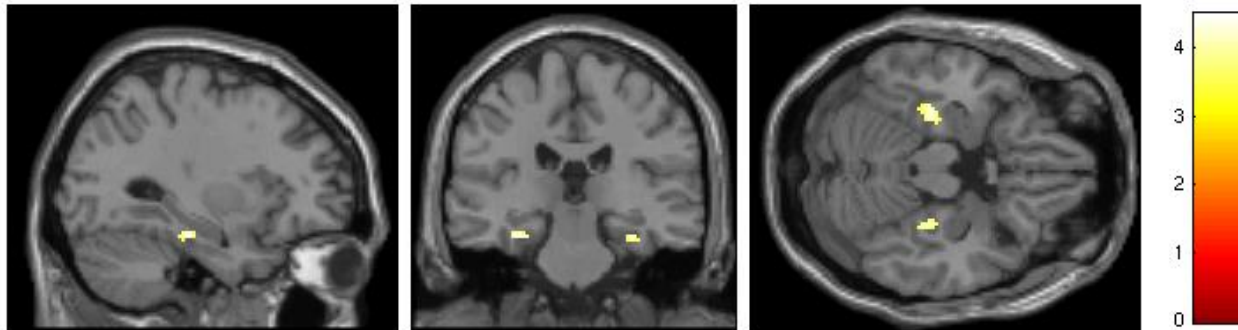
Connectivity changes mirroring interaction

Seed: Bilateral cuneus



Where in the brain is there increased connectivity with these regions as function of predictability, specifically for the task where the expectation cue has an effect?

- Hippocampus (Left SVC: $p=0.033$; Right SVC: $p=0.057$)



Sensitive to predictability in the environment (Harrison et al., 2006; Strange et al., 2005; Turk-Browne et al., 2010);
Involved in associative learning and memory (Chua et al., 2007).





Conclusions

- Predictable stimuli do not need to be attended in order to be suppressed by expectation.
- However, this effect is task dependent → requires WM resources.
 - Expectations evoke stimulus-specific representations in primary visual cortex (Kok et al., 2014).
 - WM required to bring online stimulus templates?
- Explanation for the discrepancies in the literature:
 - Critically, Larsson & Smith (2012) used a WM task.
- Insula & hippocampus are candidate regions for signalling perceptual uncertainty.
- Combined with Yi et al. (2004), further evidence that expectation suppression (ES) & repetition suppression (RS) are distinct mechanisms:

	ES	RS
Percept. load	✓	✗
WM load	✗	✓



Affiliations



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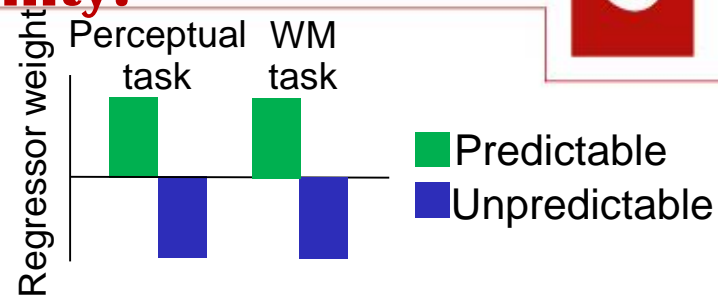
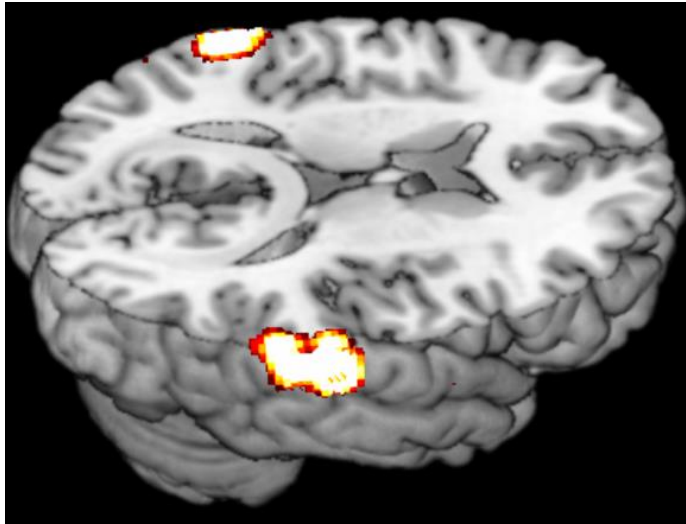
Peter Kok



Christian Utzerath



Areas that respond to predictability?



- Superior temporal gyrus (STG) (Right: $p < 0.001$ FWE_{clust} ; Left: $p < 0.001$ FWE_{clust})
Predictable stimulus sequences (Berns et al., 2001);
and timing (Lewis & Miall, 2003).
Often, but not exclusively, auditory stimuli.

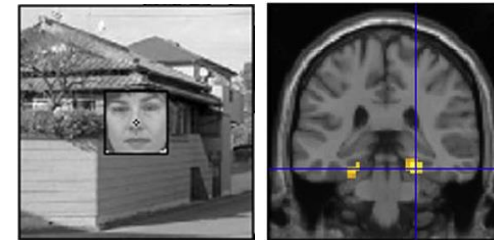
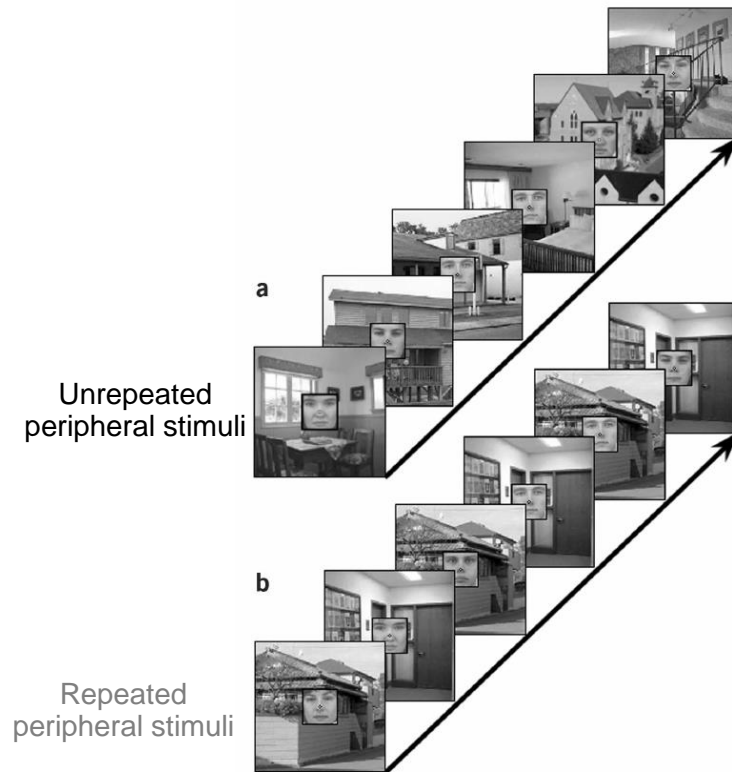


Yi et al., Nature Neuroscience 2004

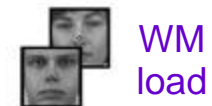
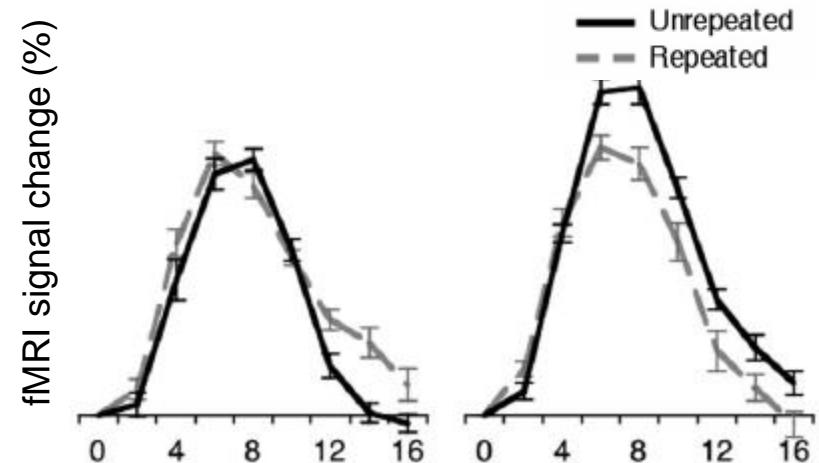


- Tasks at fixation with perceptual or WM load, measured neural activity to the surround (repeats vs. non-repeats).

Perceptual load: 1-back on noisy faces
WM load: 2-back on faces (no noise)



Neural response to peripheral stimulus



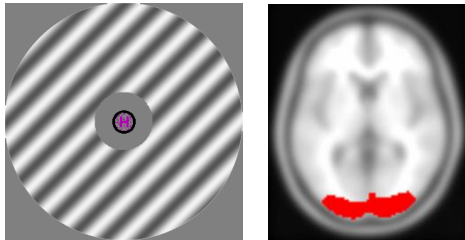
Yi et al., Nature Neuroscience 2004



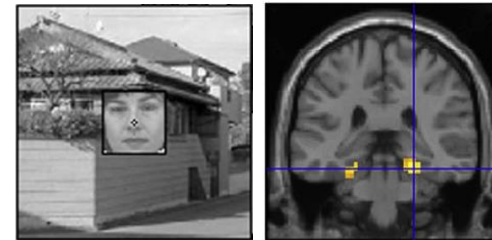
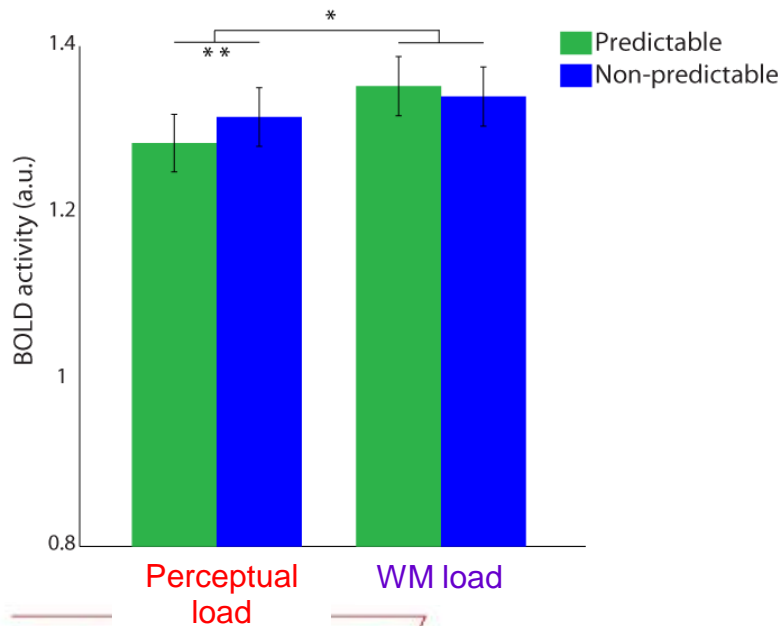
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V1



Neural response to peripheral stimulus

