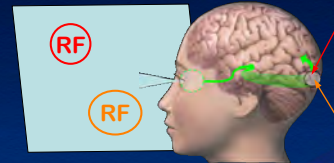


Center-surround interactions in visual motion perception

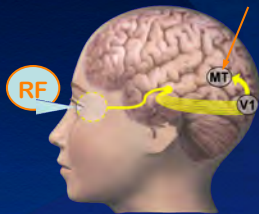
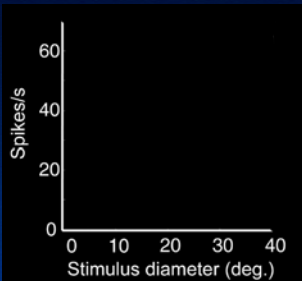


Center for Visual Science
Brain and Cognitive Sciences
Ophthalmology

Center-surround receptive field interactions



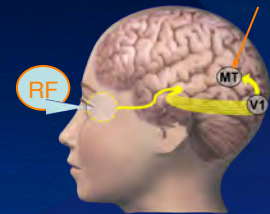
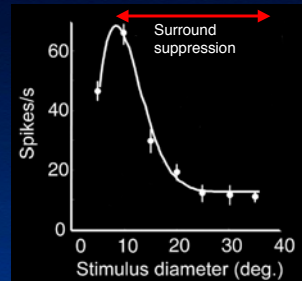
Center-surround receptive field interactions



Suppressive center-surround interactions in cortical area MT



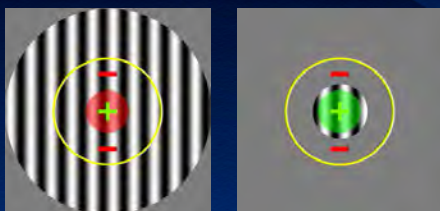
Center-surround receptive field interactions



Suppressive center-surround interactions in cortical area MT



Center-surround suppression in motion processing



++++ < ++++++

Monkey & Human: V1, MT, MST & superior colliculus
Cat: area 17, PMLS & superior colliculus
Frog, toad & pigeon: tectum
Salamander & rabbit: retina

Tadin & Lappin, 2005



Motivating Question?

Given the ubiquity and importance of center-surround suppression ...
...can we observe **perceptual correlates** of this neural mechanism?



Better -----> Worse

Effect of size on motion perception

Established result: **Bigger is better**

Lappin & Bell, 1976; Anderson & Burr, 1987, 1991; Frederickksen et al., 1997; Watson & Turano, 1995...



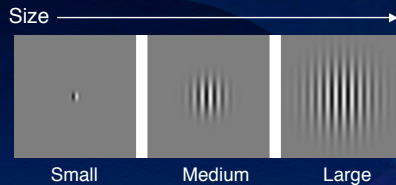
But...

spatial integration by neurons can change depending on stimulus conditions

Levitt & Lund, 1997; Sceniak et al, 1999; Dragoi & Sur, 2000; Cavanaugh et al, 2002; Pack et al., 2005...

Measurement of motion perception at suprathreshold contrasts

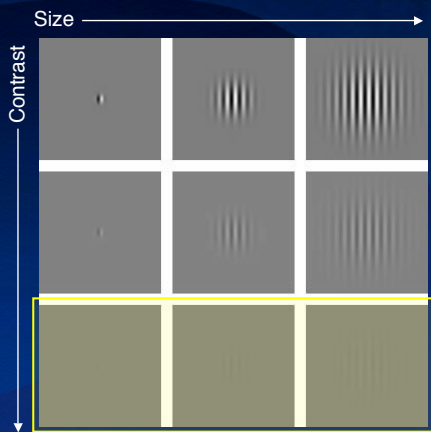
Moving stimulus (Gabor patch)



Dependent variable: presentation time

Measurement of motion perception at suprathreshold contrasts

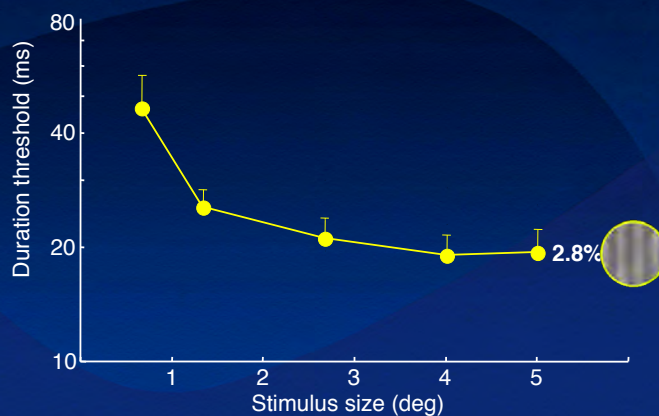
Moving stimulus (Gabor patch)



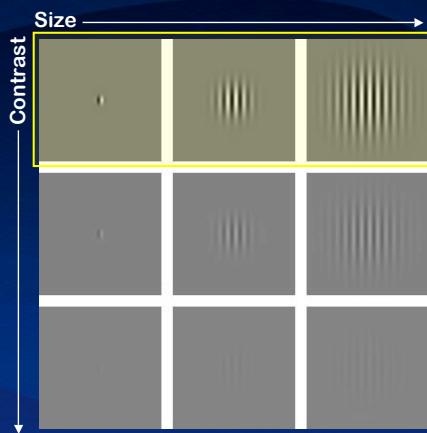
Dependent variable: presentation time

Task: LEFT vs. RIGHT discrimination

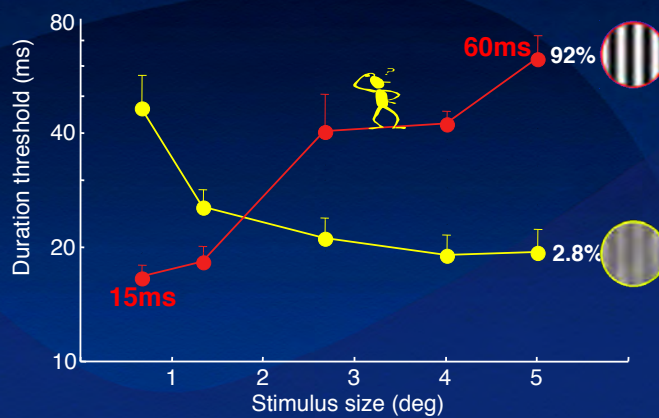
Spatial summation



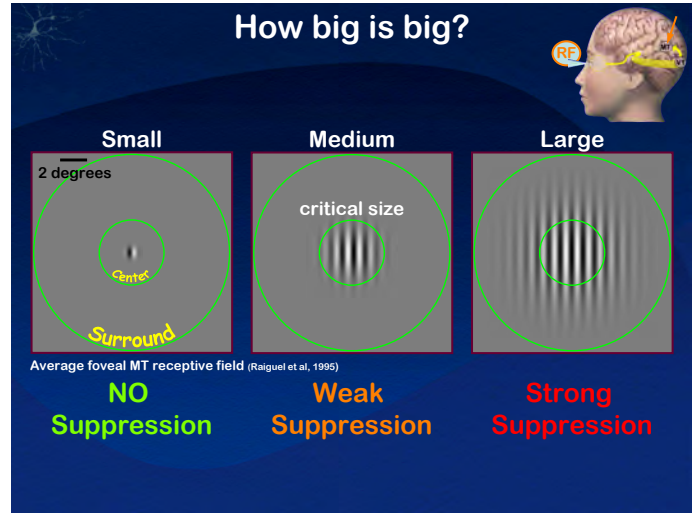
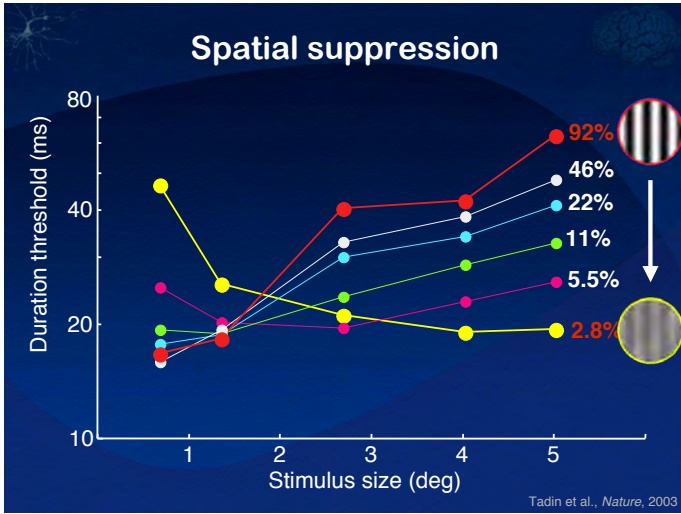
Tadin et al., Nature, 2003



Spatial suppression

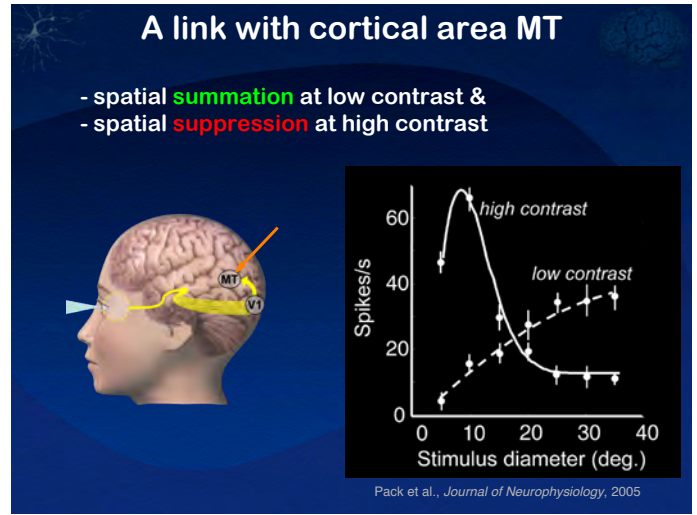


Tadin et al., Nature, 2003



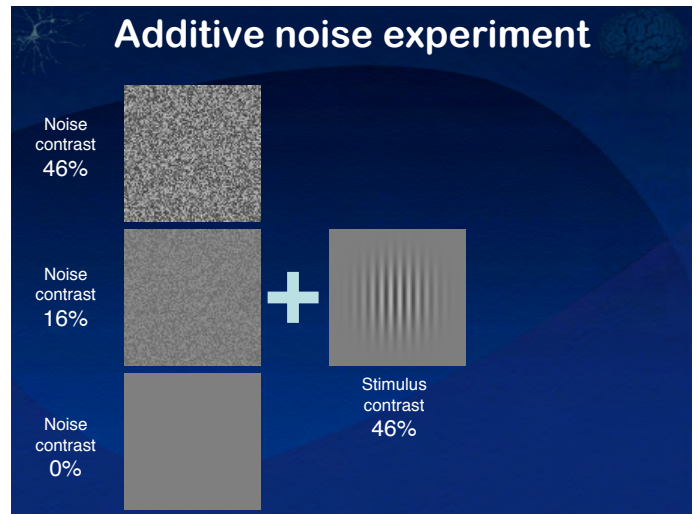
Main finding

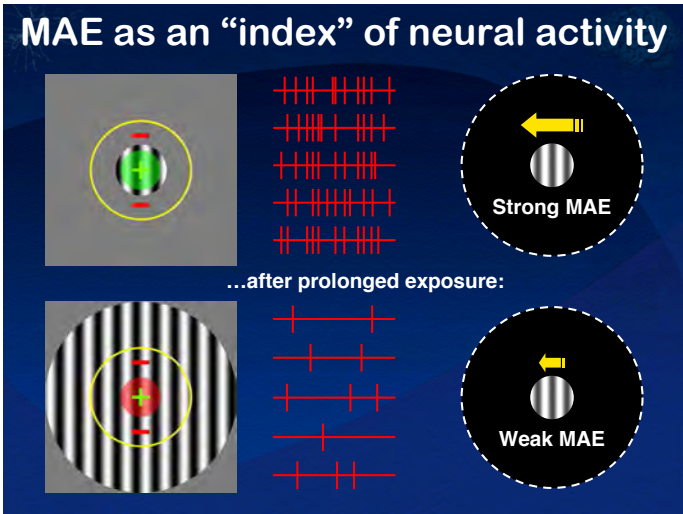
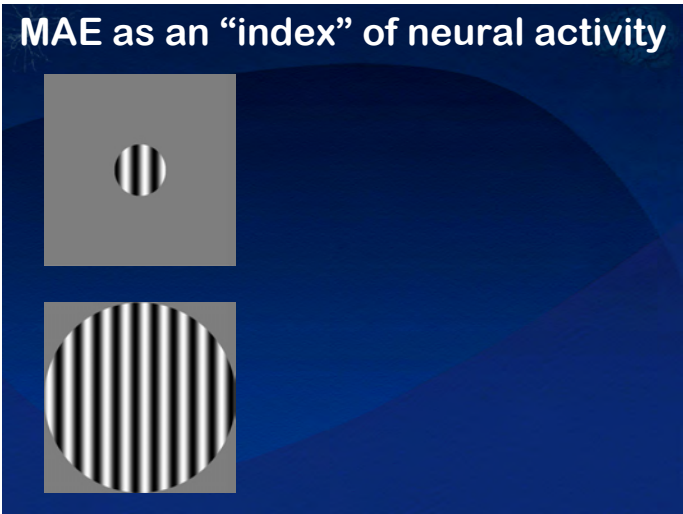
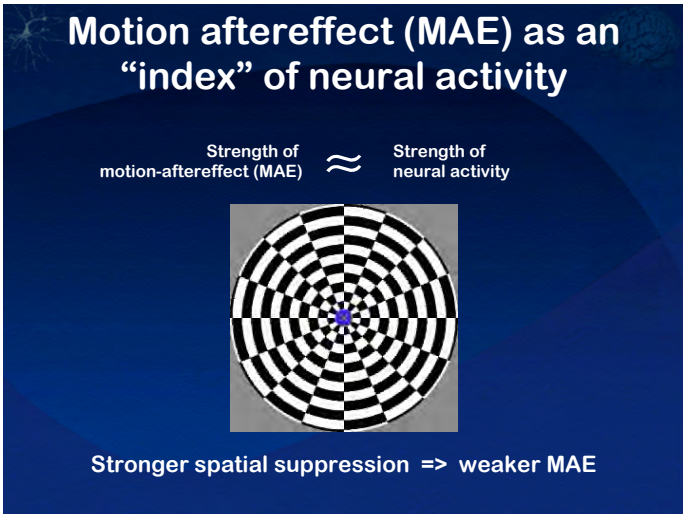
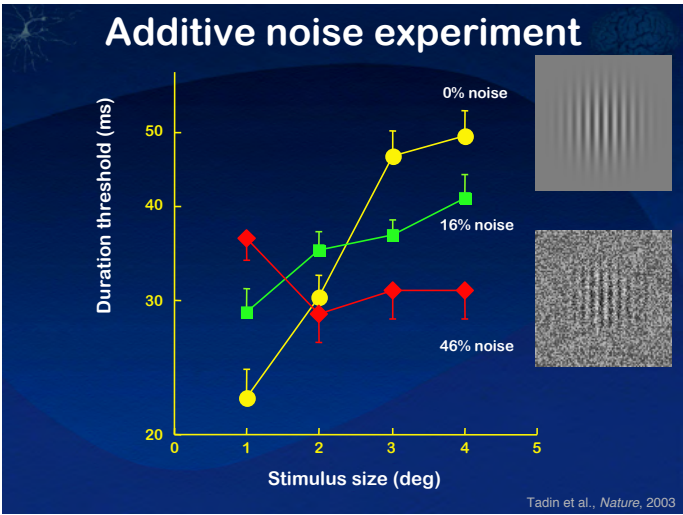
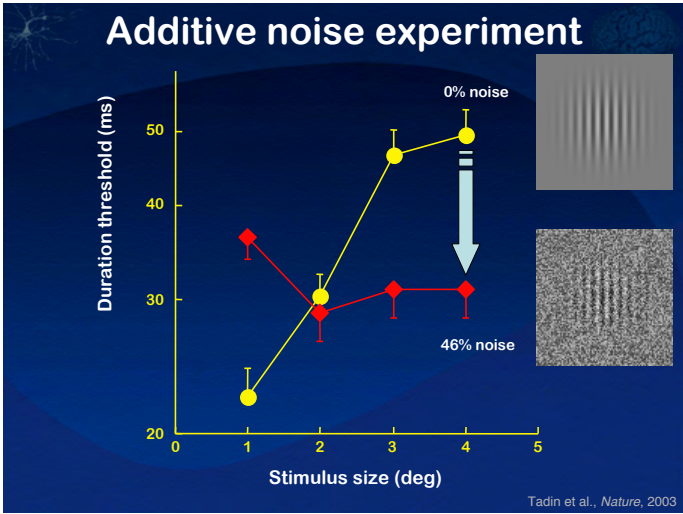
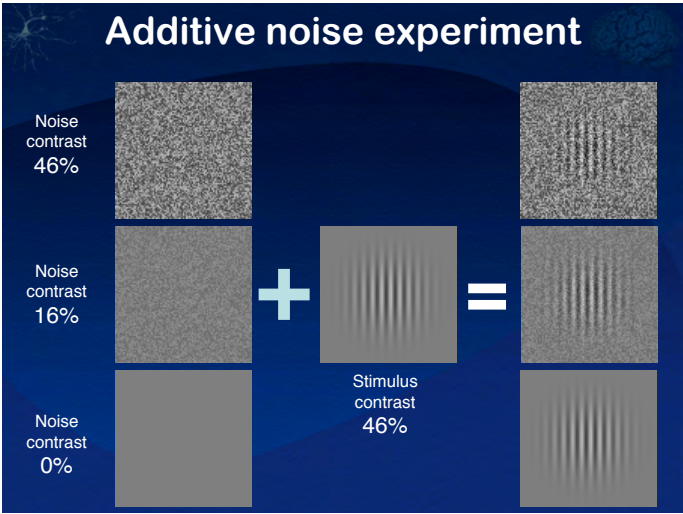
- spatial **summation** at low contrast &
- spatial **suppression** at high contrast

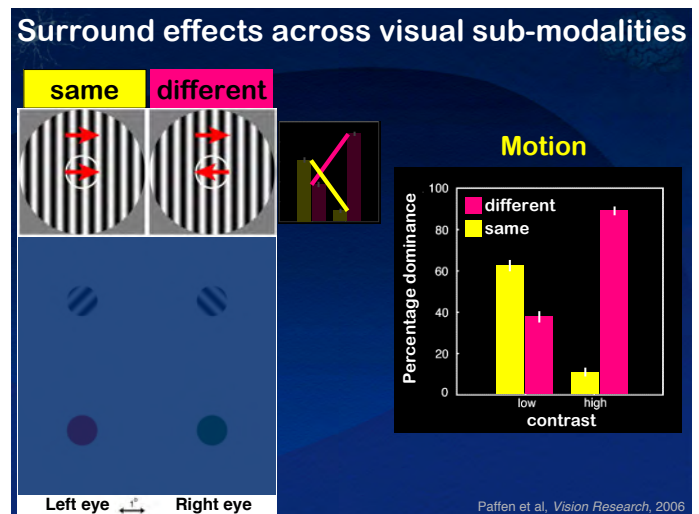
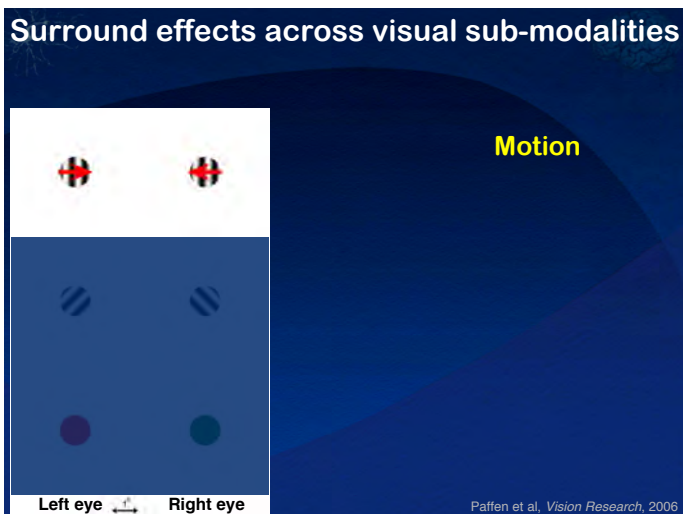
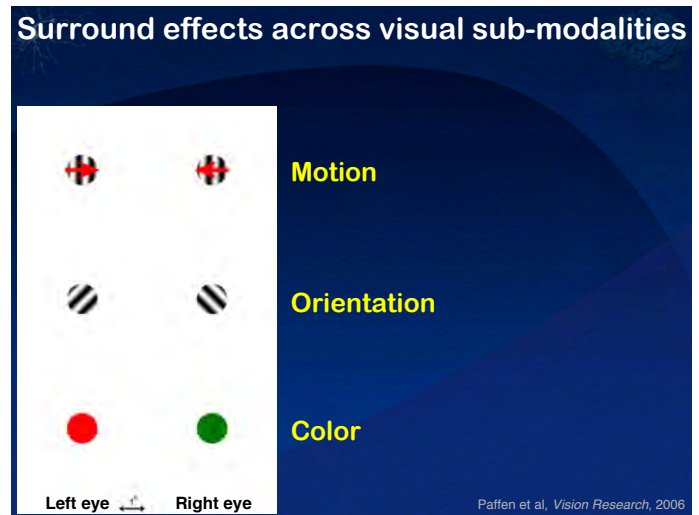
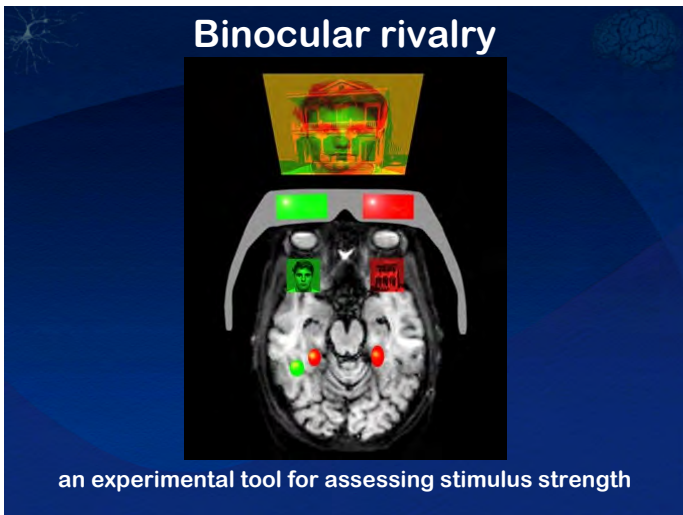
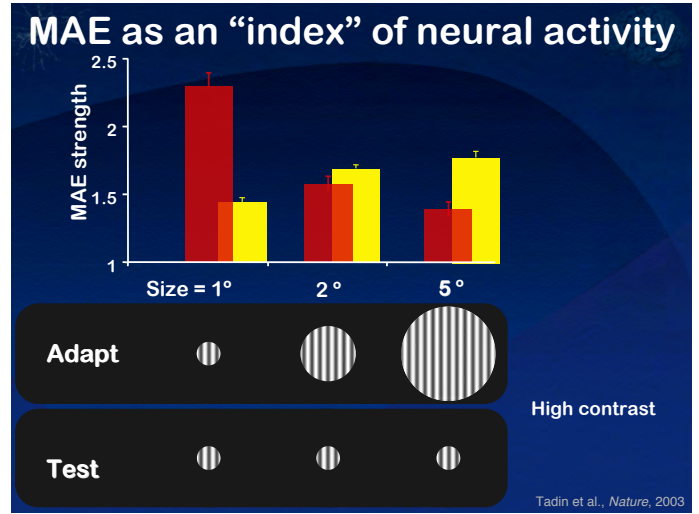
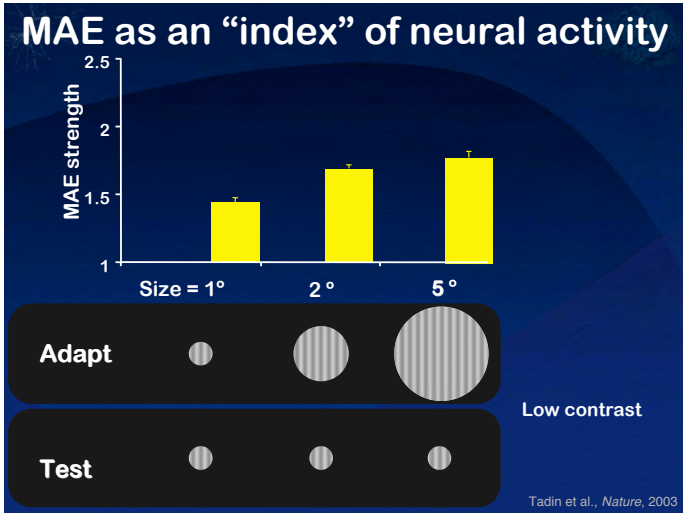


Center-surround interactions in visual motion perception

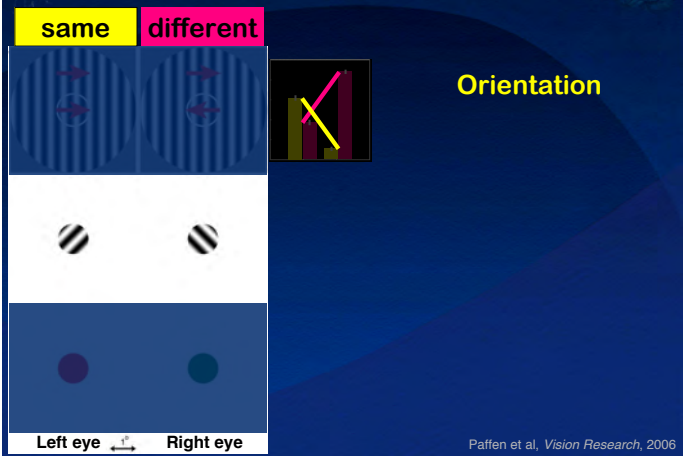
1. Background & Initial findings
2. How general are these results?
3. What happens if center-surround mechanisms are impaired?
4. Functional role of center-surround interactions
5. Conclusion



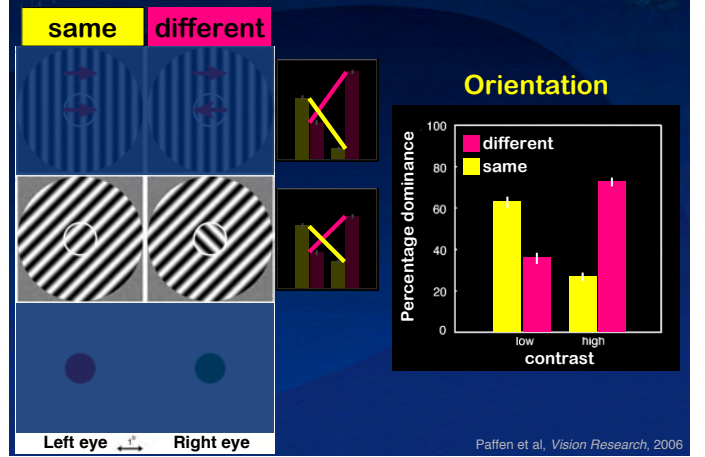




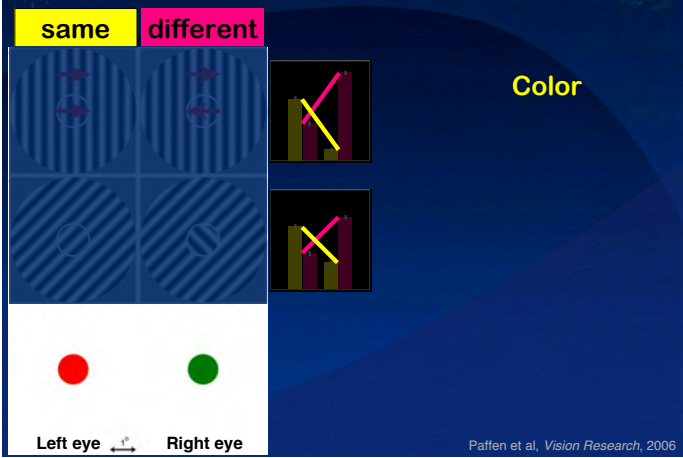
Surround effects across visual sub-modalities



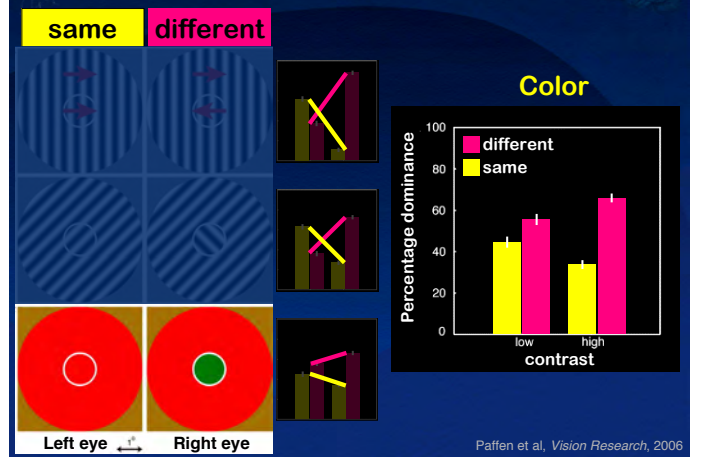
Surround effects across visual sub-modalities



Surround effects across visual sub-modalities



Surround effects across visual sub-modalities



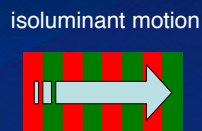
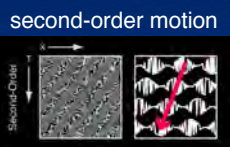
Replication and extension

Findings generalize to a variety of stimuli



Findings generalize to a variety of methods: reaction times, RF modeling, reverse correlation

Findings do NOT generalize to

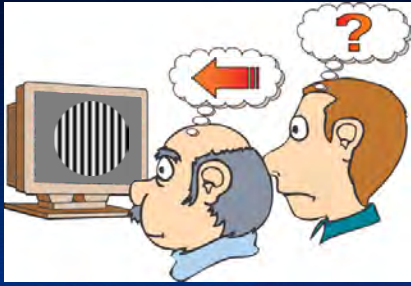


Tadin et al., 2003; 2005; 2006; 2007; Glasser & Tadin, 2011

Center-surround interactions in visual motion perception

1. Background & Initial findings
2. How general are these results?
3. What happens if center-surround mechanisms are impaired?
4. Functional role of center-surround interactions
5. Conclusion

Can this mechanism become impaired?

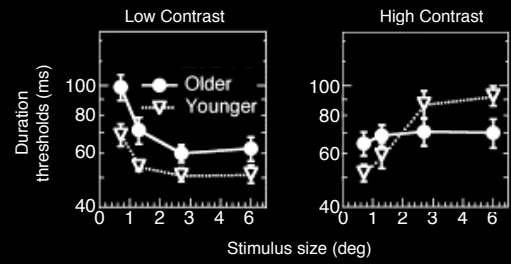


"Impaired" performance Typical performance

Spatial suppression in aging

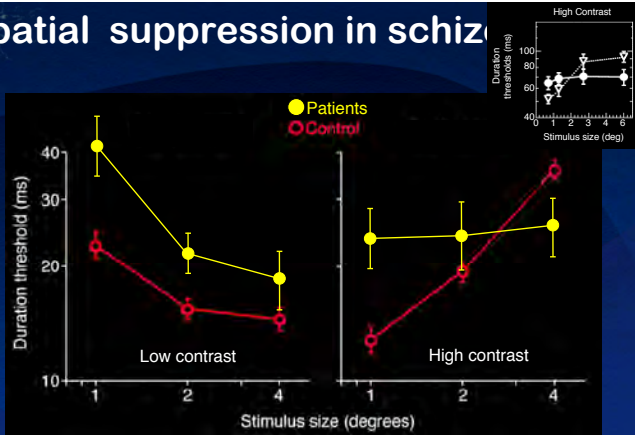
Efficacy of cortical inhibition reduces with age (Leventhal et al., *Science*, 2003).

What could be the resulting effects on spatial suppression mechanisms?

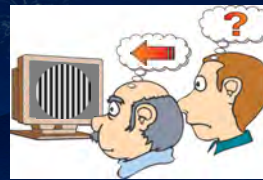


Betts et al., *Neuron*, 2005

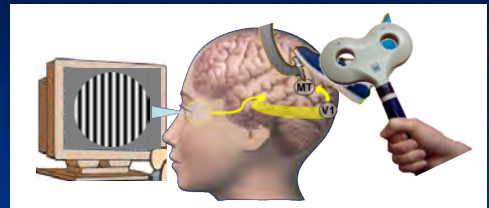
Spatial suppression in schiz



Tadin et al., *Journal of Neuroscience*, 2006

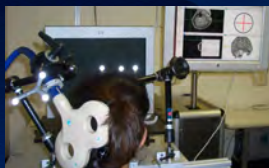


Can we replicate these "impairments" in typical subjects?



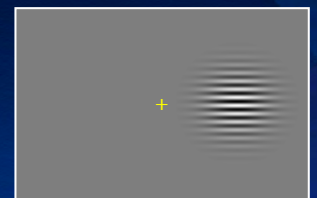
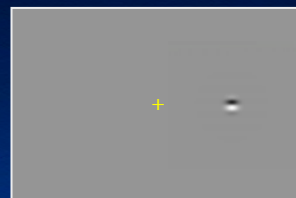
Does disrupting MT weaken the strength of spatial suppression?

Using TMS to produce "virtual lesions"



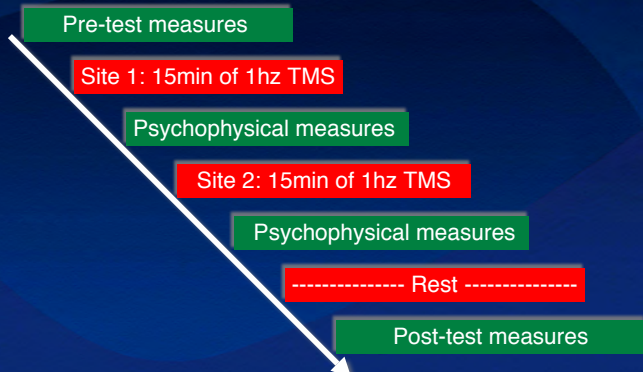
Behavioral task

Stimulus: Briefly presented vertically drifting Gabor (small & large)
Measurement: Duration thresholds



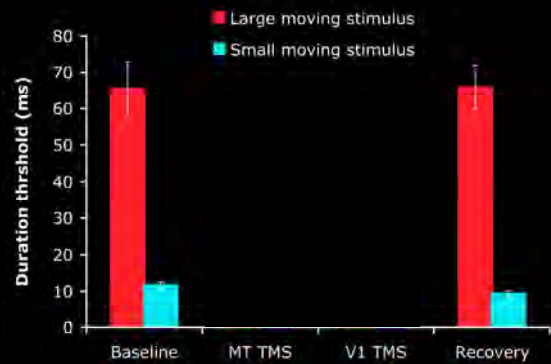
Tadin et al., *J Neuroscience*, 2011

Experimental Paradigm



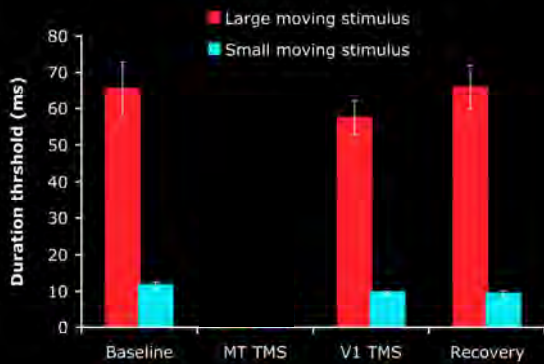
Tadin et al., *Journal of Neuroscience*, 2010

Effects of TMS on center-surround suppression



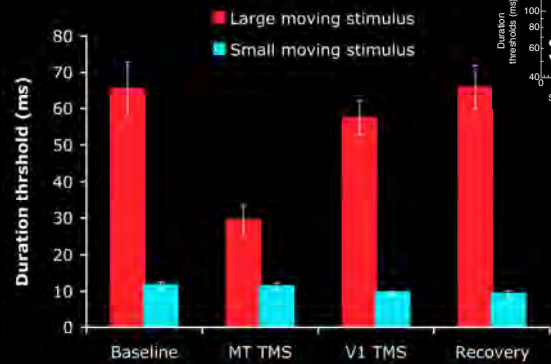
Tadin et al., *J Neuroscience*, 2011

Effects of TMS on center-surround suppression



Tadin et al., *J Neuroscience*, 2011

Effects of TMS on center-surround suppression



Tadin et al., *J Neuroscience*, 2011

TMS experiment conclusions

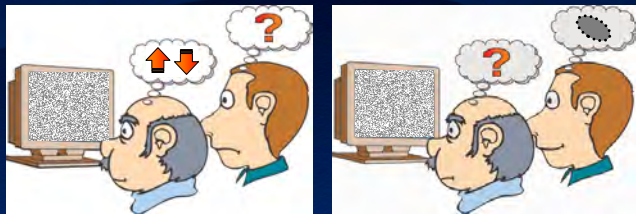
- Reduced excitability of MT yields **improvements** in motion discriminations of large, high-contrast moving stimuli
 - result specific to MT & stimuli presented in the contralateral visual field
- The observed **reduction in spatial suppression** is comparable in magnitude to the abnormally weakened spatial suppression found in special populations

Tadin et al., *J Neuroscience*, 2011

Center-surround interactions in visual motion perception

- Background & Initial findings
- How general are these results?
- What happens if center-surround mechanisms are impaired?
- Functional role of center-surround interactions
- Conclusion

Functional consequences?



Elderly & Schizophrenia

Enhanced integration of large moving objects

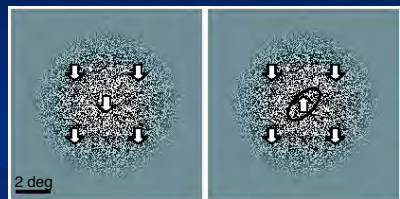
Impaired figure-ground segmentation

Spatial suppression --> motion segregation



Motion task

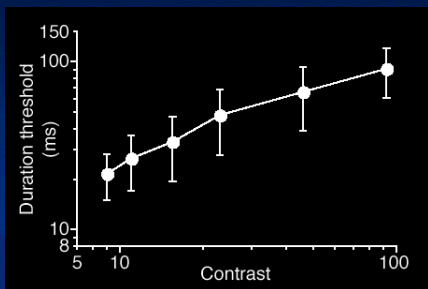
Figure-ground task



UP vs. DOWN

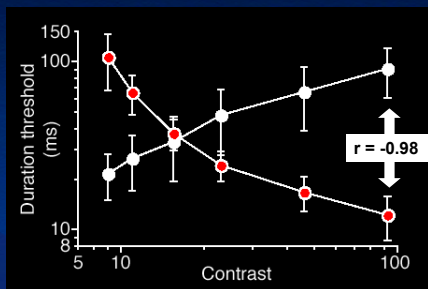
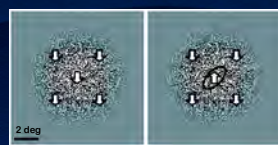
VS.

Spatial suppression --> motion segregation



Motion task

Spatial suppression --> motion segregation

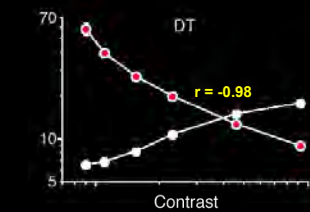
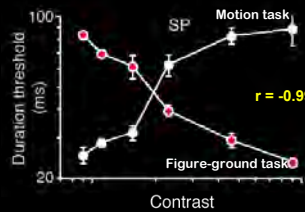


Motion task

Figure-ground task

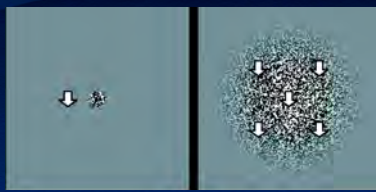
$r = -0.98$

Individual variability



Spatial suppression --> motion segregation

Exploiting individual variability:



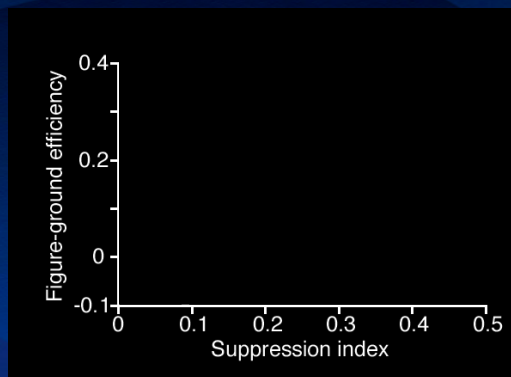
Suppression index



Figure-ground efficiency

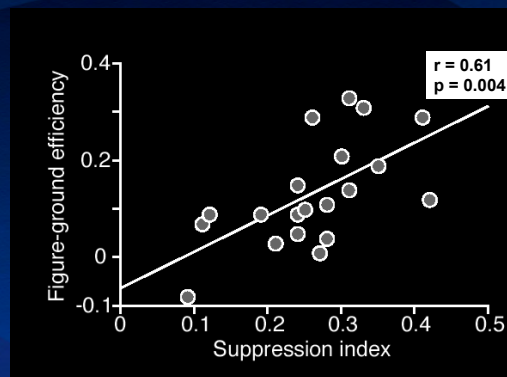
Spatial suppression --> motion segregation

Exploiting individual variability:



Spatial suppression --> motion segregation

Exploiting individual variability:



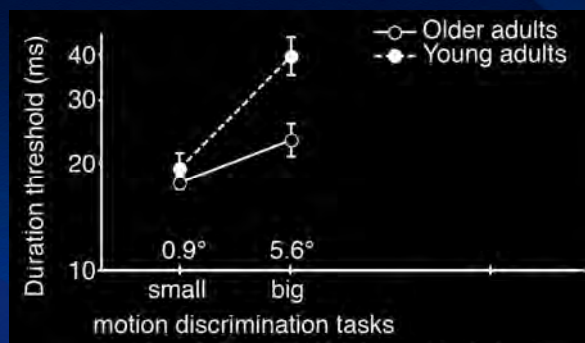
Spatial suppression --> motion segregation

Exploiting individual variability:



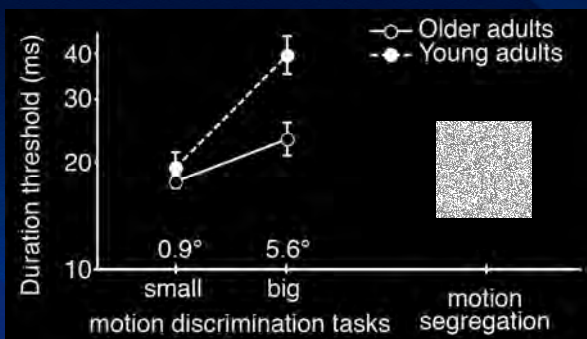
Spatial suppression --> motion segregation

Exploiting individual variability:



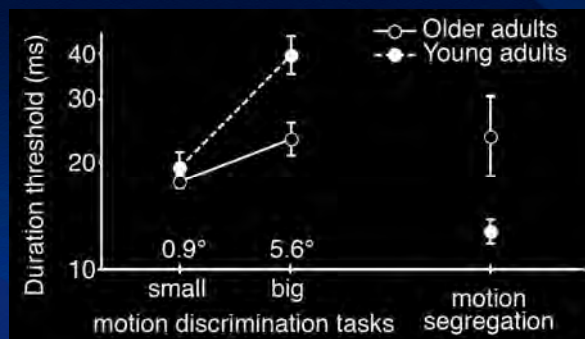
Spatial suppression --> motion segregation

Exploiting individual variability:



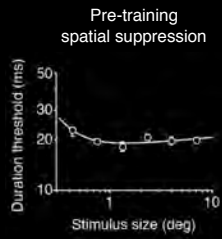
Spatial suppression --> motion segregation

Exploiting individual variability:



Spatial suppression --> motion segregation

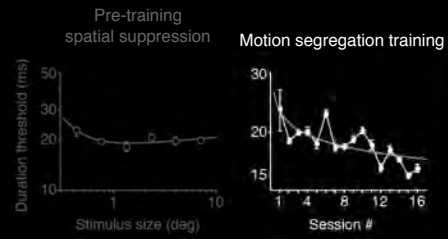
Can we train spatial suppression?



An older adult subject
Age 71

Spatial suppression --> motion segregation

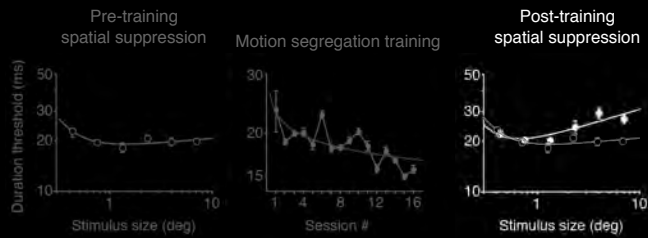
Can we train spatial suppression?



An older adult subject
Age 71

Spatial suppression --> motion segregation

Can we train spatial suppression?



An older adult subject
Age 71

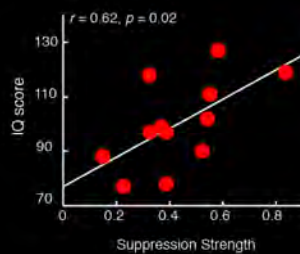
Conclusions

1. Behavioral evidence for a fundamental neural mechanism: **spatial suppression**
2. Support for a functional link between: **spatial suppression & motion segregation**

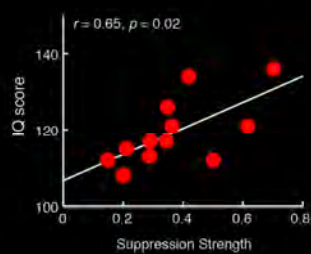


Food for thought?

Spatial suppression strongly predicts IQ scores!



WASI



WAIS - IV