CNTRICS Constructs for Perception: Gain Control & Integration

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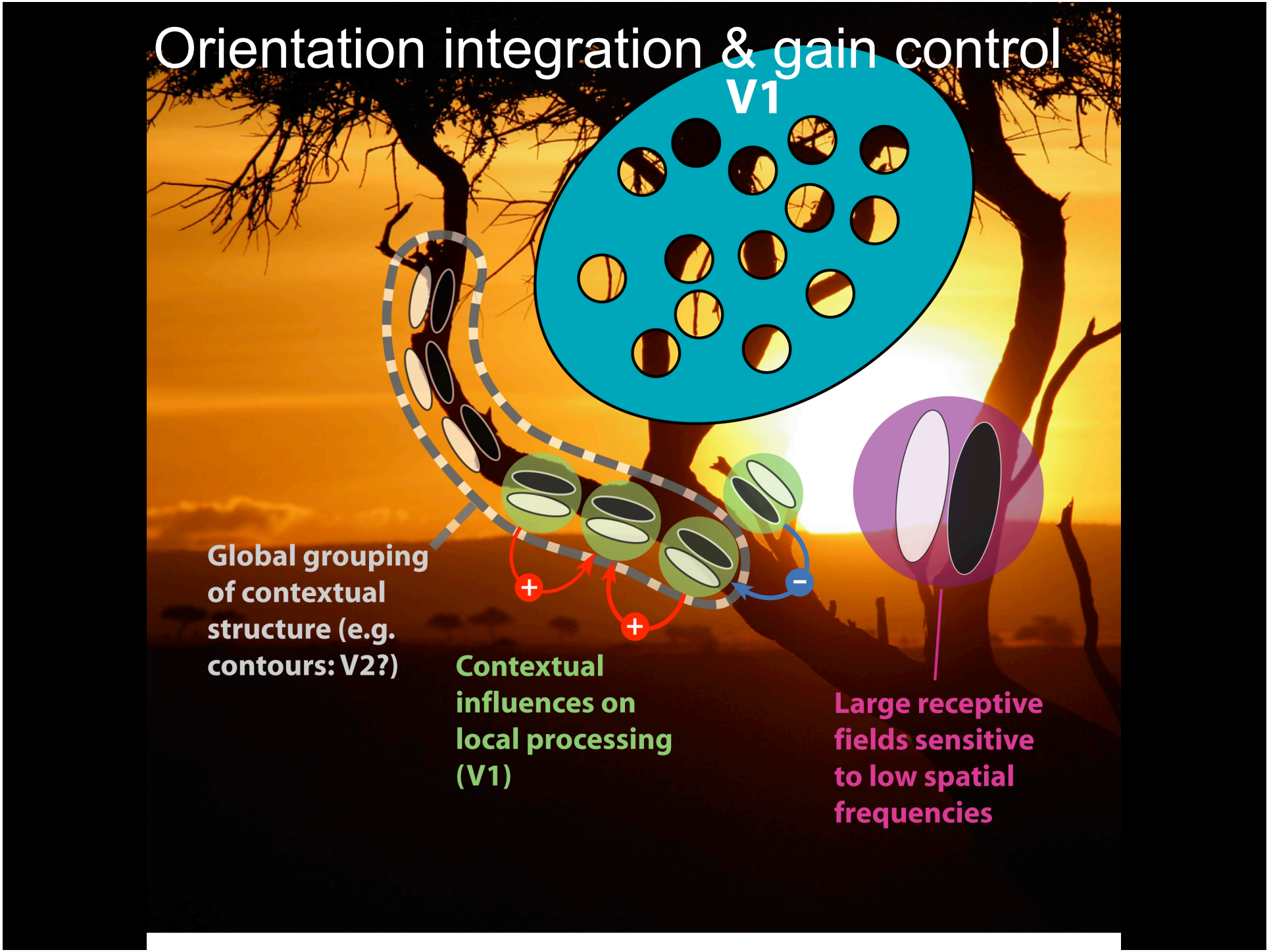
Overview

- The key requirement of perception is to identify functionally-significant information within a complex world
- This process is abnormal in (all stages of) SZ
- Constructs emphasise two components that could be failing:
  - **Gain control:** the use of context to effectively inhibit irrelevant features* (in order to optimise neural response-range). SZ ⇒ weak gain control
  - **Integration**: grouping *local* features* into useful *global* structures. SZ ⇒ inappropriate grouping
- I'll summarise constructs, illustrating each with candidate tasks

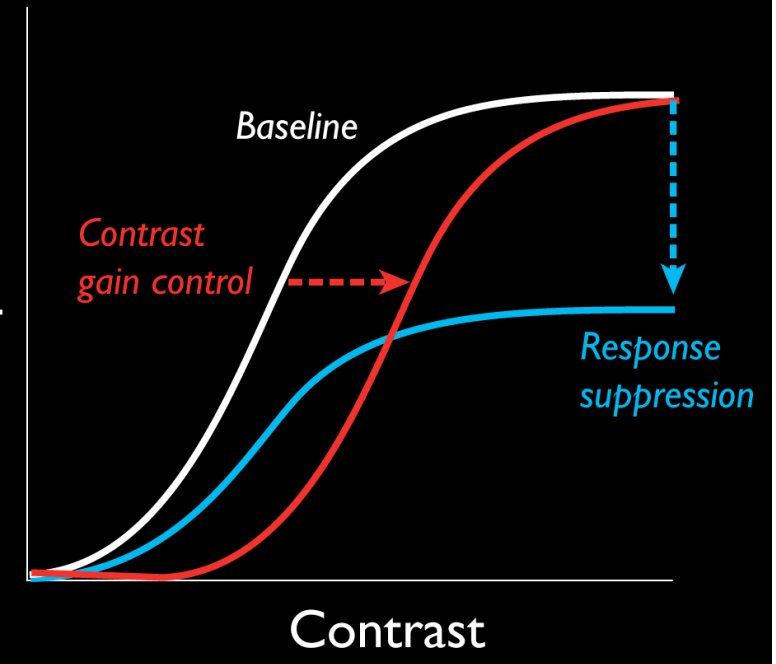
* Orientation, contrast, beeps

Orientation integration & gain control



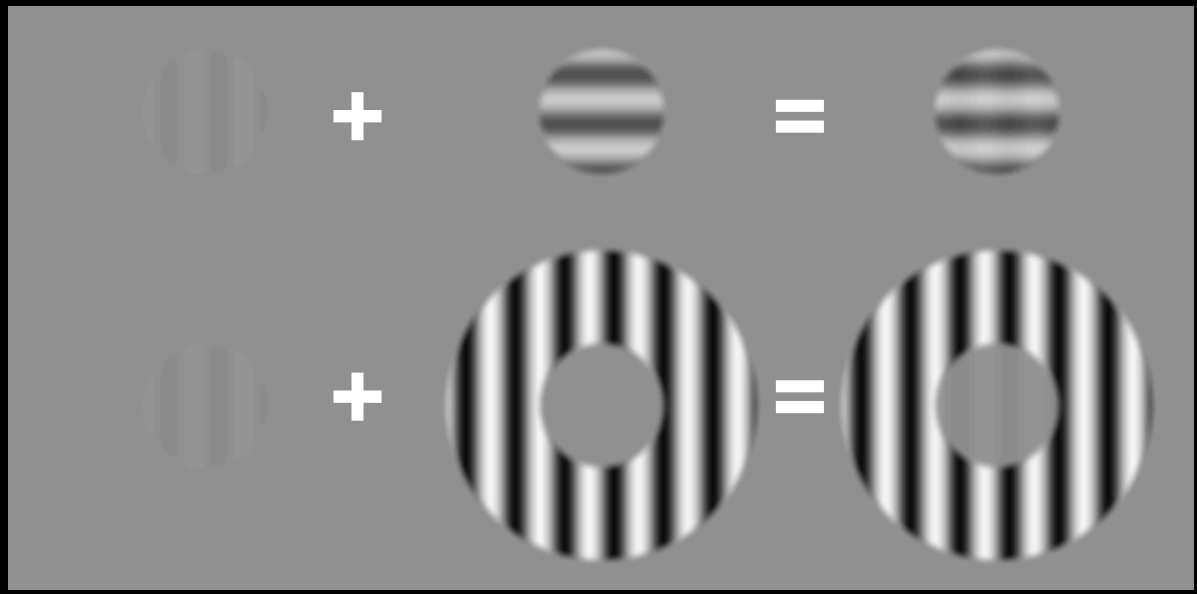
Mechanisms of gain control

- Serves to optimise a neuron's limited dynamic range
- Response-gain (e.g. divisive); surround
- Contrast-gain: masking
- Effected via connectivity & feedback
- NMDA involved.

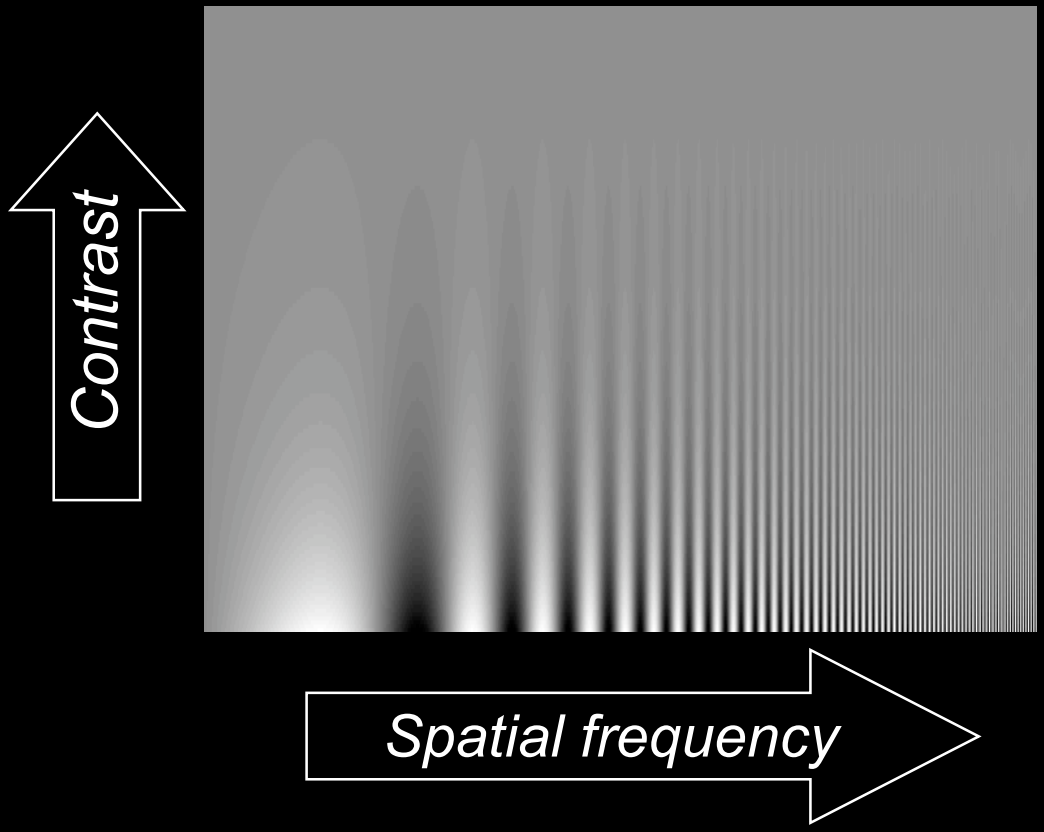


Masking

Surround suppression



Probing gain control: Contrast detection



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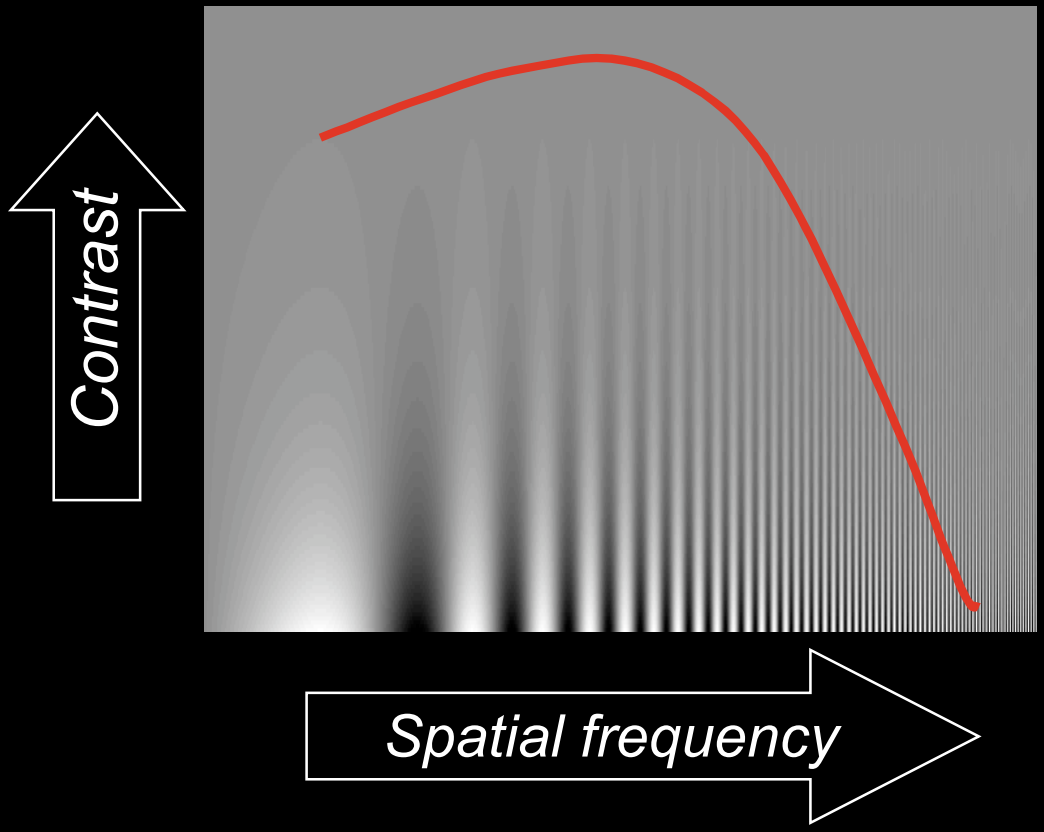
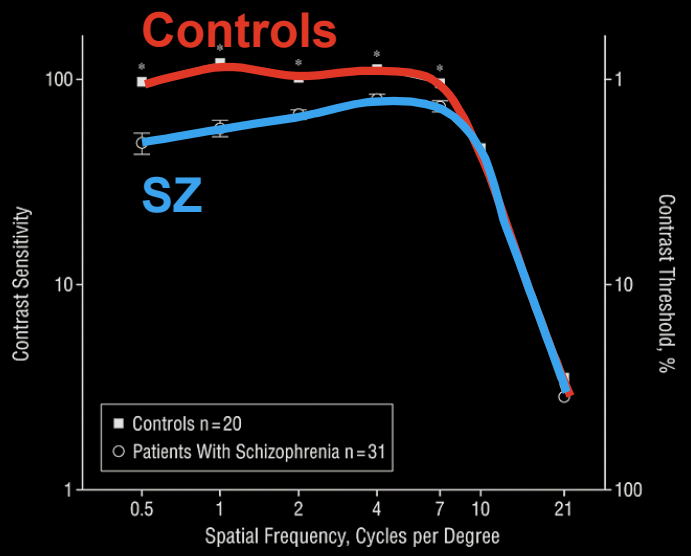
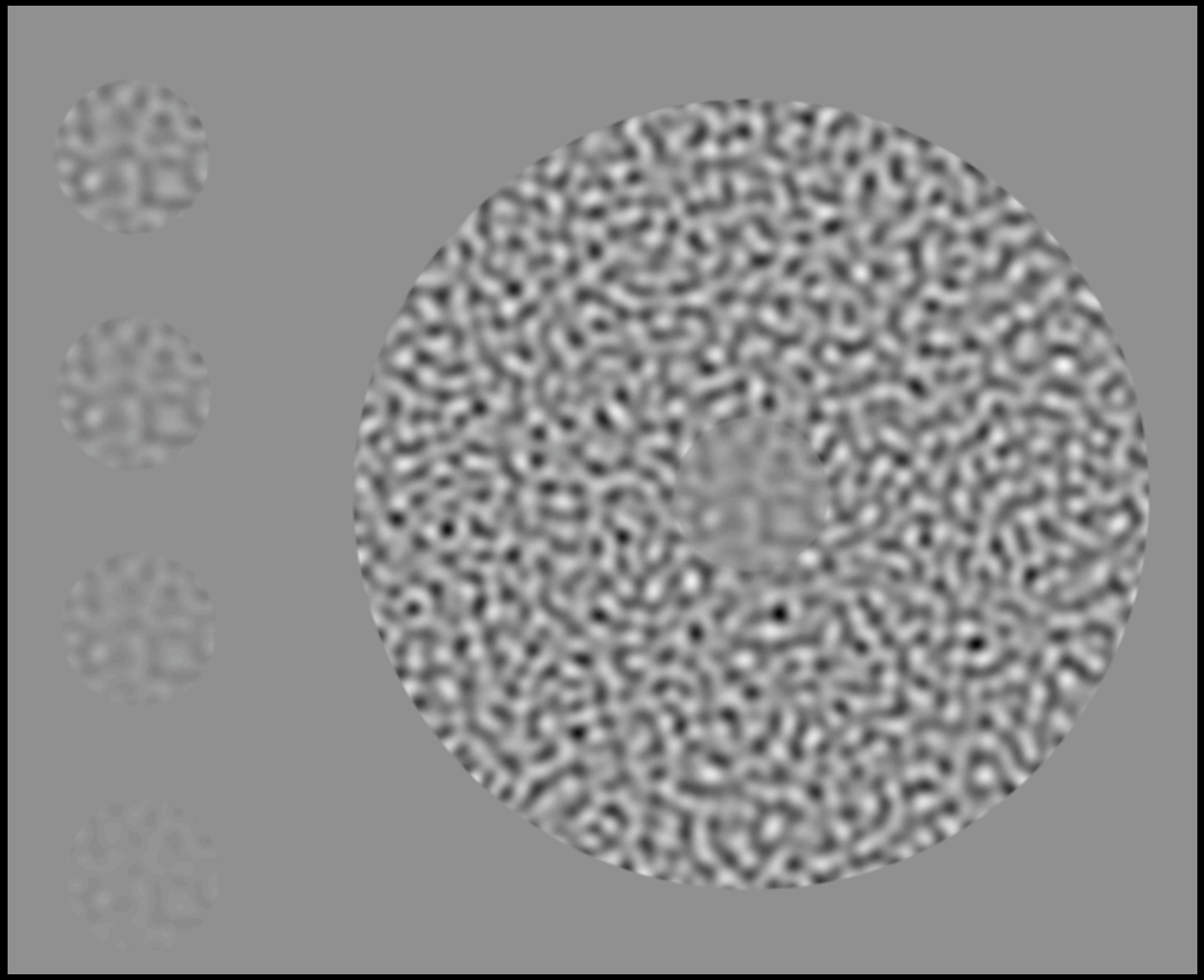




From Butler et al 2005

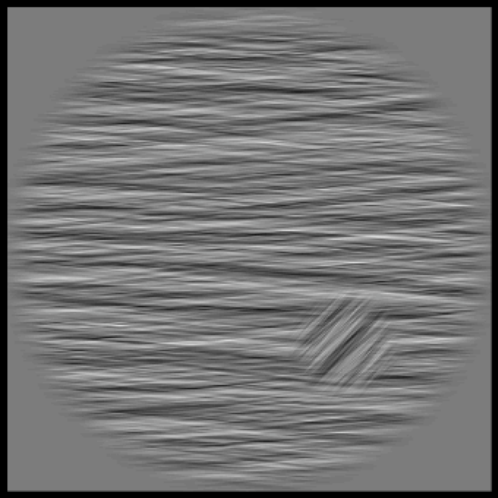
Probe with VEP or psychophysics

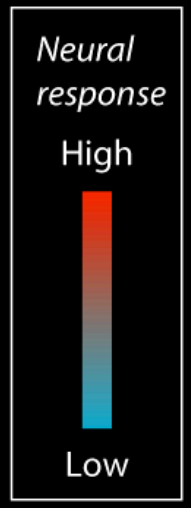
Probing gain control with “contrast-contrast”

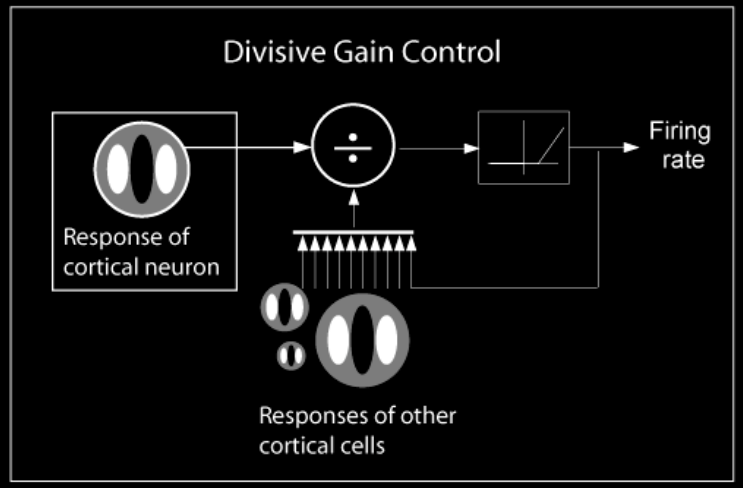


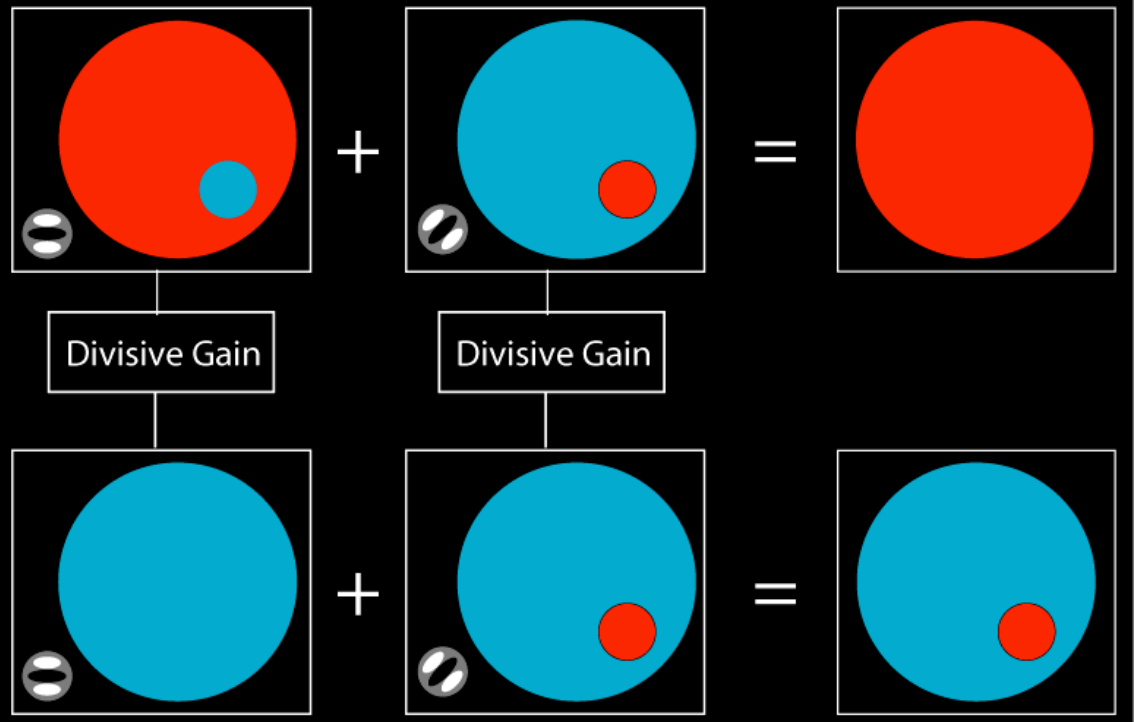
- Reduced gain control produces superior matching in SZ

Gain control & pop-out



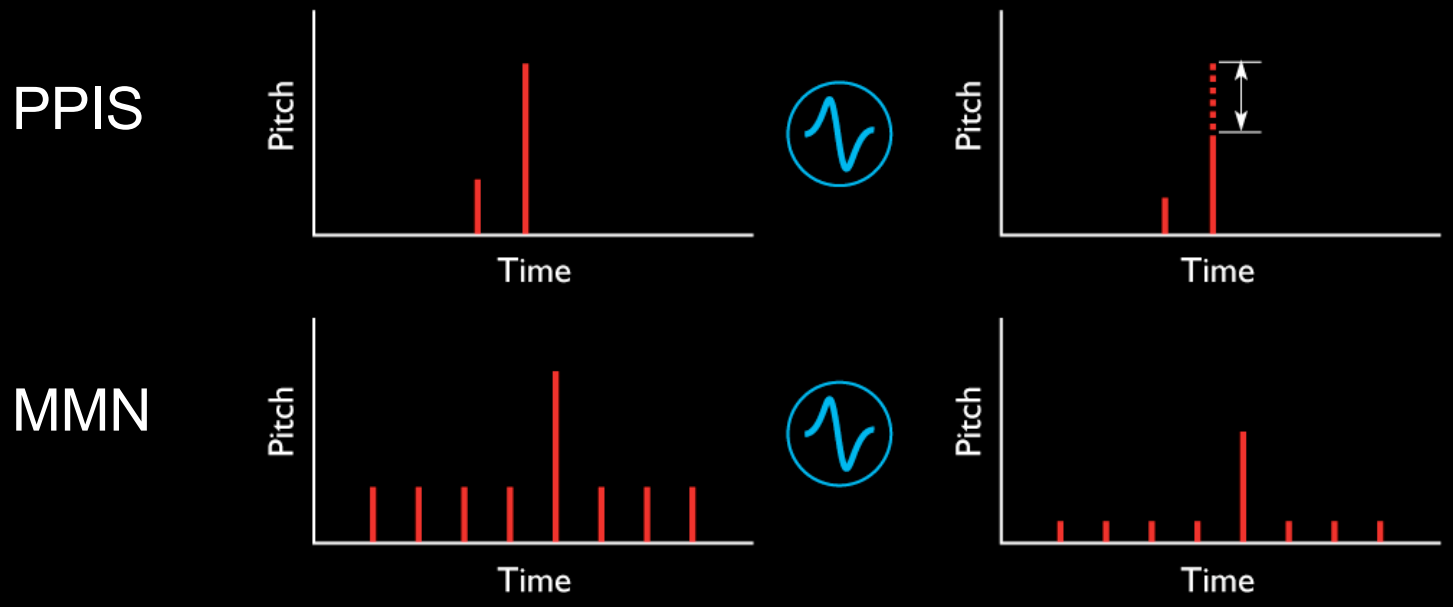






Probing gain control with auditory mismatch negativity (MMN) and prepulse inhibition of startle (PPIS)

- PPIS: reduced ERP for primed tones. Magnitude reduced in SZ.
- MMN: reduced ERP to “oddball” (pitch or duration-defined) tone within a regular sequence.

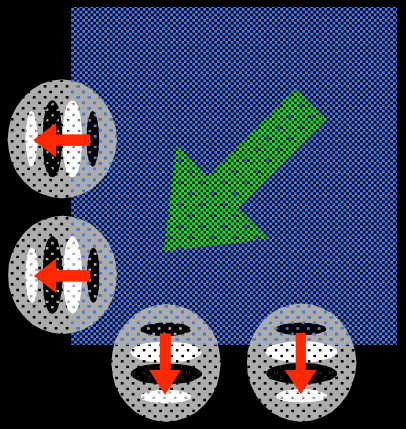


Integration

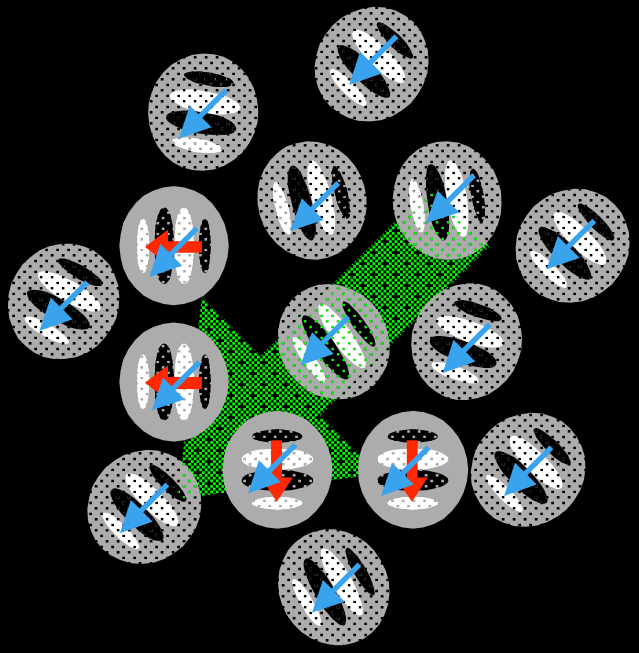
- Visual cortical representation is a mosaic of receptive fields
  $\Rightarrow$ grouping required to signal complex global structure
- Specific mechanisms not well understood but involve:
  - Later areas (form: Line (V1) $\rightarrow$ Corner (V2) $\rightarrow$ Shape (V4) $\rightarrow$ Faces (IT))
  - Feedback
  - Synchronisation of activity(?)
  - Long-range horizontal connections (anatomy?)

Motion integration

Motion is signaled by direction selective cells in V1 then pooled by MT neurons with larger receptive fields. Why?

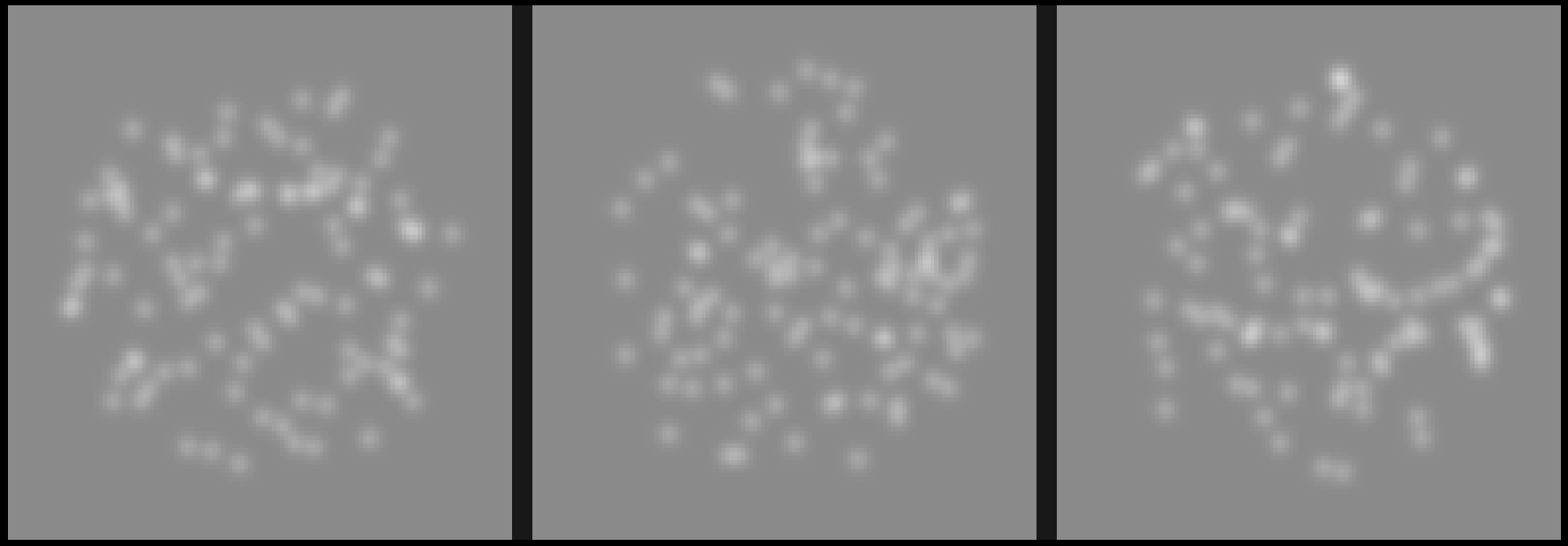


The aperture problem



MT collector unit

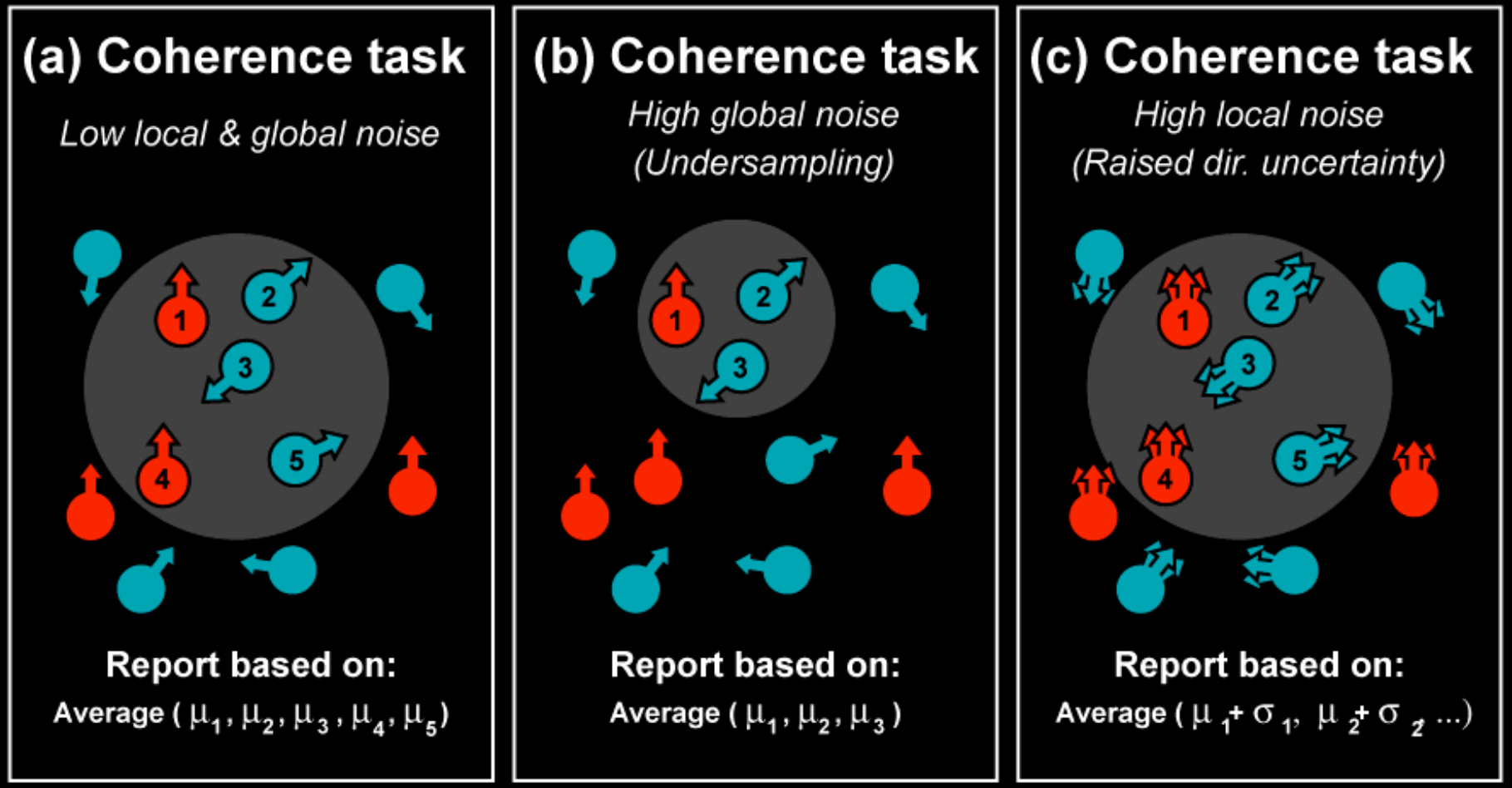
Probing motion integration with motion coherence



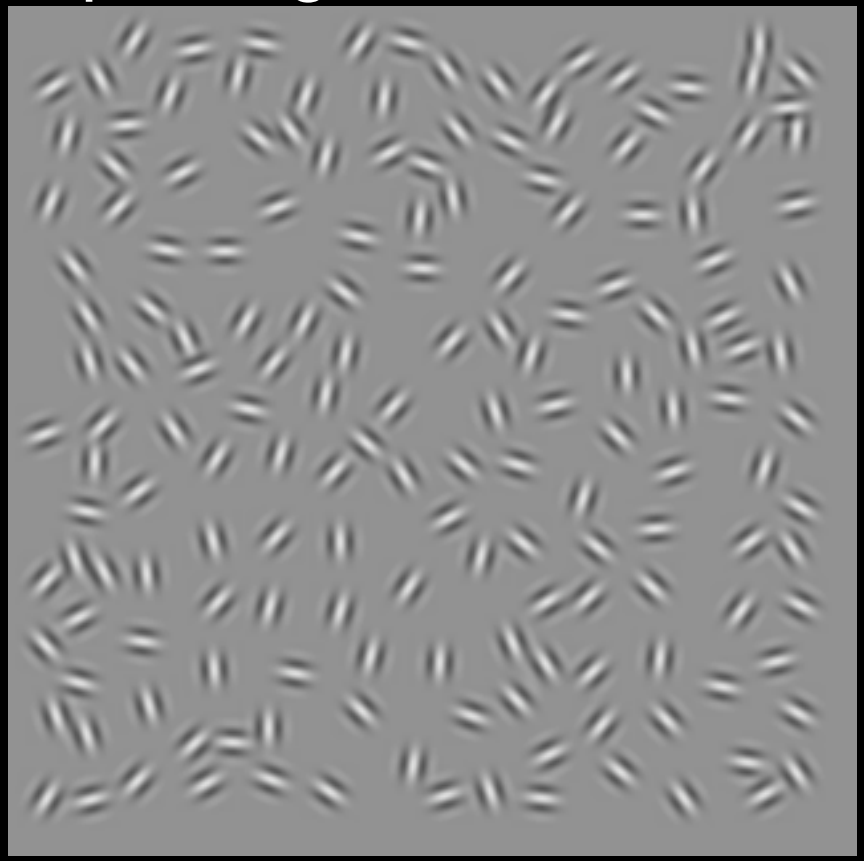
100% *25%* *10%*

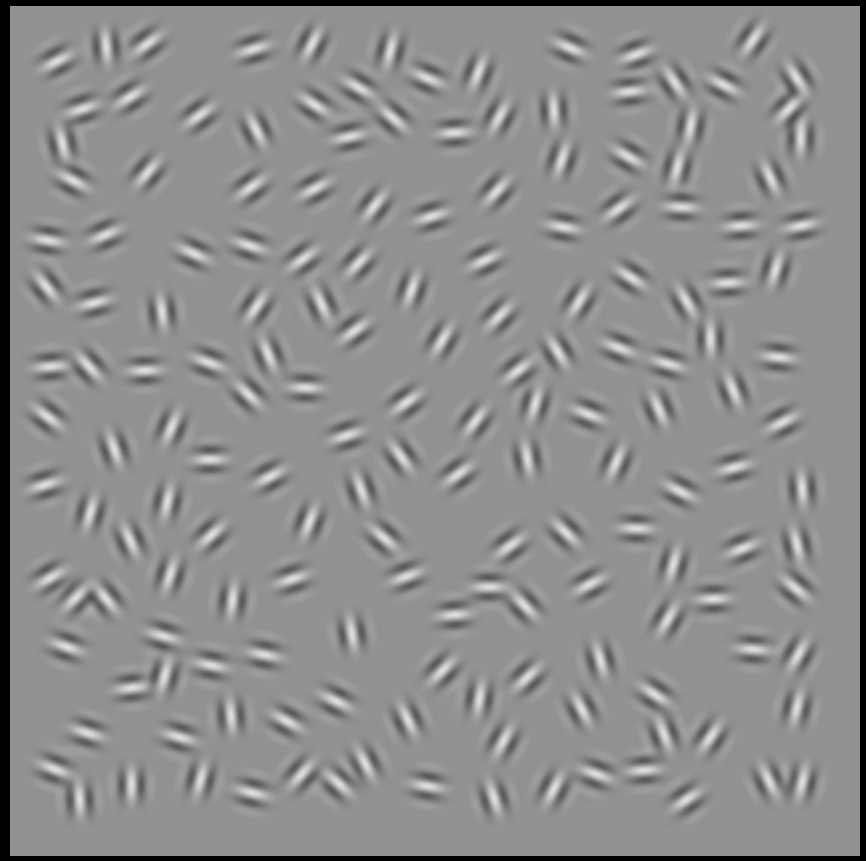
- Report “up or down?”
- Widely used but does poor performance ⇒ global deficit?

Motion coherence: Local or global motion limit?



Probing form integration with a “path” paradigm





Task: “which image contains an extended contour?”
Proposal is that people with SZ “over-integrate”

Probing over-integration in the auditory domain

- The “babble” task (Hoffman *et al* 2007)
- Play multiple overlaid voices, observers report longest sentences heard (longer in SZ)
- Over-integration (of word-like structure) or failing gain-control (of non-word structure)

Conclusions

- Perceptual gain control and integration deficits are established and quantifiable
- Important because higher-level deficits could in part be attributable to lower level perceptual effects