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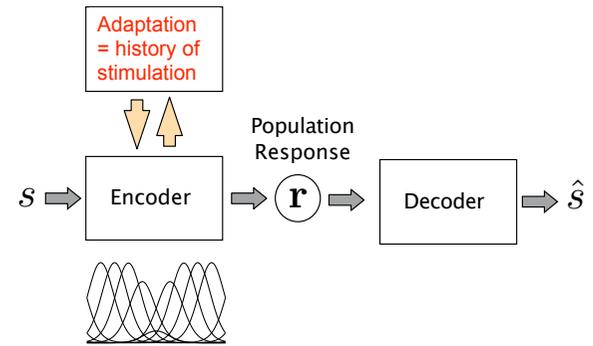
## Adaptation

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Further reading: A. Kohn, Visual adaptation: physiology, mechanisms, and functional benefits, J Neurophysiol, 2007.

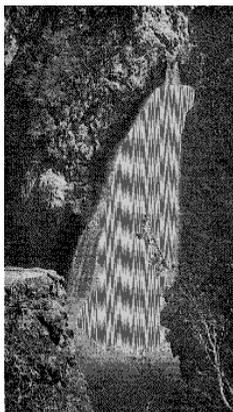
## When neurons and perception change (2)

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## Motion After-Effect



### The Waterfall Illusion

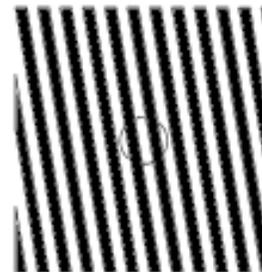
known to the Ancient Greeks, but the first modern report of it is often attributed to Robert Addams (1834), who observed the effect while viewing a waterfall at Foyers in Scotland.

similarly [http://www.michaelbach.de/ot/mot\\_adapt/index.html](http://www.michaelbach.de/ot/mot_adapt/index.html)

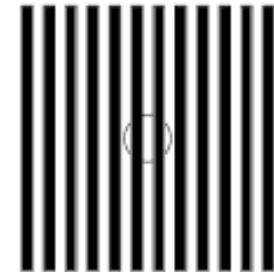
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## Orientation After-Effect

Look at the circle for 30 sec

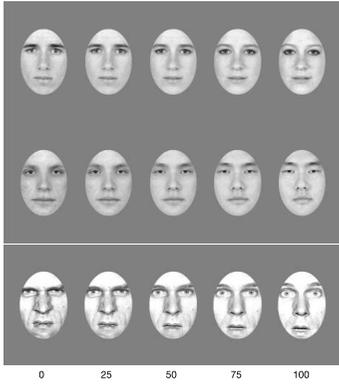


Then this one



The "Tilt after-effect"

## Face after-effects



**Figure 1** Examples of face pairs for the dimensions of gender (top row), ethnicity (middle row), or expression (bottom row). Morph arrays consisted of 100 images spanning the two original faces, which were assigned a value of 0 or 100. The morph level (for example, 25, 50, or 75) therefore corresponded to how far along the sequence the image fell between the two originals. Category boundaries corresponded to the image level chosen as the neutral point within the morph sequence.

After viewing male faces, subsequent faces look more female.  
 After viewing caucasian faces, subsequent faces look more asian.  
 thin/fat  
 etc..

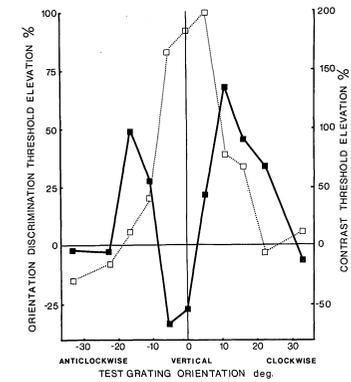
Webster, Nature, 2004

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## Visual Adaptation: Psychophysics

Visual adaptation leads to:

- ❖ detection tasks: **higher detection thresholds**



**Fig. 3.** Postadaptation threshold elevations for orientation discrimination (continuous line) and for contrast detection (dotted line). The adapting grating was vertical (0 on abscissa).

The more similar the test to the adaptor, the higher the increase in detection threshold

[Regan and Beverley, 1985]

## Visual Adaptation: Psychophysics

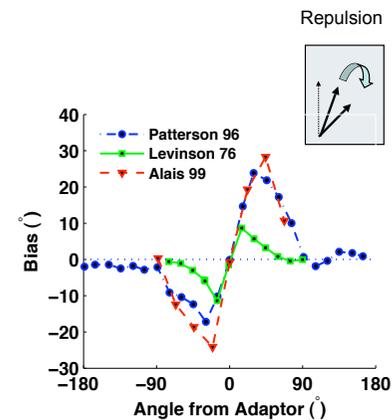
Visual adaptation leads to:

- ❖ detection tasks: **higher detection thresholds**
- ❖ estimation tasks : **strong biases** (mainly repulsion)

## Visual Adaptation: Psychophysics

Visual adaptation leads to:

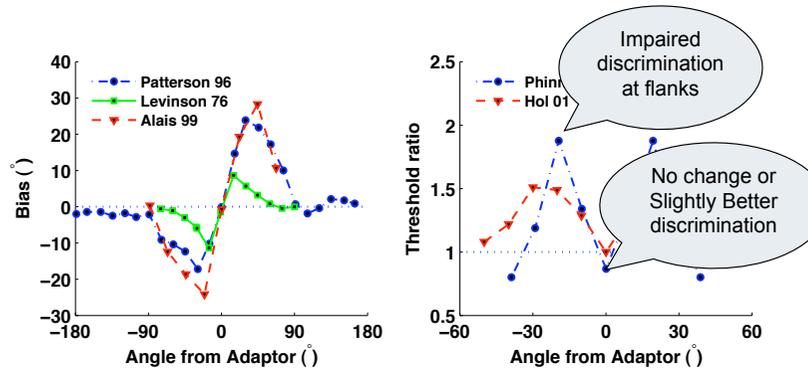
- ❖ detection tasks: **higher detection thresholds**
- ❖ estimation tasks : **strong biases** (mainly repulsion)



## Visual Adaptation: Psychophysics

Visual adaptation leads to:

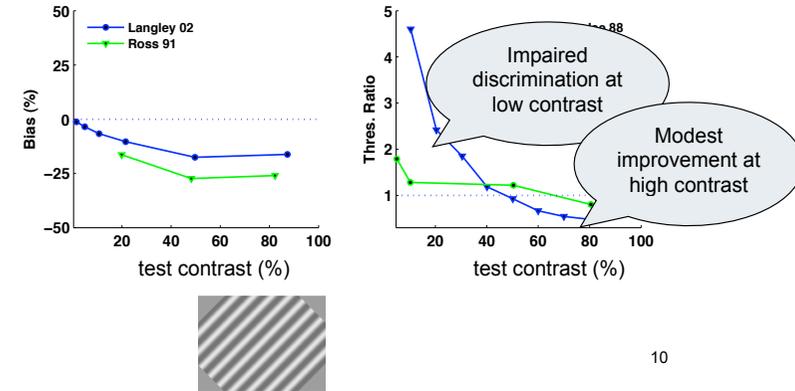
- ♦ detection tasks: **higher detection thresholds**
- ♦ estimation tasks: **strong biases** (mainly repulsion)
- ♦ discrimination tasks: **changes in discrimination thresholds**.



## High Contrast Adaptation

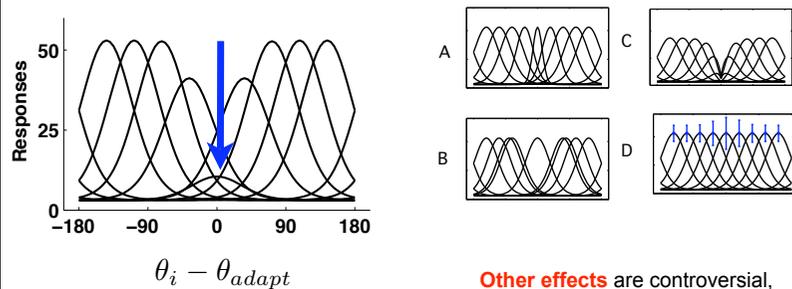
Adaptation to 100% contrast :

- ♦ reduces **apparent contrast** for all test contrasts
- ♦ changes **discrimination threshold**



## Visual Adaptation: Physiology

♦ For motion direction, orientation, ... (bell-shaped tuning curves)



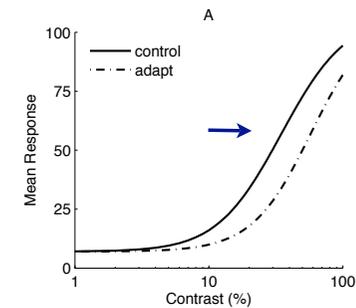
**Mainly a Gain change**

[Van Wezel & Britten 2002, Krekelberg et al. 2006]

**Other effects** are controversial, dependent on time scale and area: shifts in preferred orientation, changes in width, changes in variability. [Kohn & Movshon 2004, Dragoi et al, 2000]

## Neural basis of Contrast adaptation

♦ For sigmoidal response curve: Mainly a shift towards the adaptor

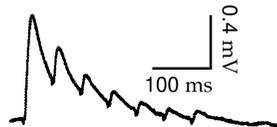


## Mechanisms

Question: Cellular mechanism ? Network effect? Still debated.

- Intracellular recordings in cat V1 show that contrast adaptation leads to a large **hyperpolarization** of the membrane potential (Carandini & Ferster, 1997), which is at least partly due to **cellular mechanisms** (activation of sodium-gated potassium channels, Sanchez-Vives et al 2000).

- **Synaptic depression** (Chung et al 2002), due to depletion of vesicles from presynaptic terminal. Thalamo-cortical synapses only? cortico-cortical?



## Temporal scales

- Duration matters.
- Some effects appear after **very short durations**, e.g. 300 msec, specially at **higher processing stages**.
- To a first approximation, adaptation effects appear **qualitatively similar** on a wide range of time scales with more prolonged exposure resulting in stronger effects [Kohn, 2007]

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## Functional role ?

- ❖ reduce metabolic costs.
- ❖ **improves coding (discriminability) of most frequent conditions?**  
= re-center tuning around prevailing stimulus conditions?
- ❖ luminance adaption leads to increase in discrimination to match prevailing conditions, perceptual benefits of other types of adaptation are unclear (weak enhancements in discriminability)
- ❖ **improves detectability or discriminability of novel or rare stimuli?**
- ❖ weak evidence for improvement of detectability or discriminability for novel stimuli.

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## Conclusion

- ❖ Adaptation is a form of **plasticity**, common feature of cortical responses, on multiple time scales.
- ❖ Adaptation causes significant **changes in perception**
- ❖ Adaptation is used as a tool to study underlying representations (**'the psychologist's microelectrode'**), e.g. nowadays, specificity and invariance in fMRI.
- ❖ **biophysical mechanisms** are still murky
- ❖ **locus of adaptation** often unclear.
- ❖ An appealing hypothesis is that adaptation serves **efficient coding**, to match the response properties of our sensory systems to prevailing environment.
- ❖ A better understanding of the relationship between neural responses and perception will help validate this assumption.