The nonlinearity in texture segregation is not rectification

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Background

The Filter Rectify Filter (FRF) model has been successfully applied to explain many aspects of second-order (or texture-defined) vision.

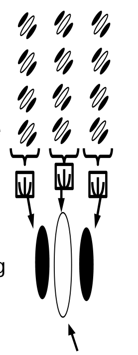
We examine the frequency bandwidth of the second-stage filter in two experiments:

Experiment 1: no evidence for frequency tuning

Experiment 2: frequency tuning consistent with previous estimates [1,2]

Both consistent with an additional nonlinearity that labels dominant texture

FRF model



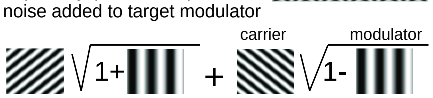
Second-stage filter

Stimuli

Orientation-modulated sine wave gratings

Vary target modulator amplitude

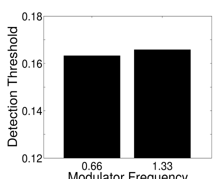
Exp 1: highpass or lowpass noise added to target modulator

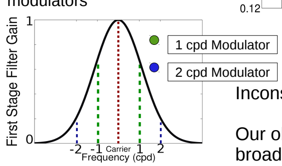


Effect of first-stage filtering on modulator

Modulator in second-order gratings manifests as distortion products around carrier.

Using a typical V1 channel as first-stage filter will attenuate higher-frequency modulators





Inconsistent with data

Our observer models use broad first-stage filters

Experiment 1: Critical-band-masking

Add lowpass or highpass noise to modulator (second-order noise)

Vary noise cutoff across blocks

Plaid noise, constant noise spectral density

"Highpass" noise actually 0 to carrier freq/2

Noise near the channel center should raise threshold

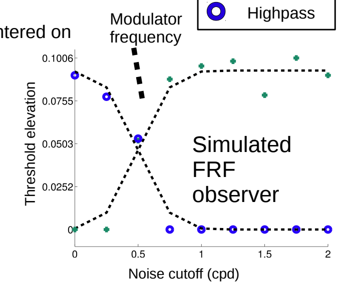
Channels should be centered on modulator

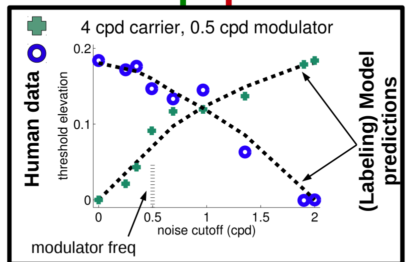
FRF model predicts S-shaped threshold elevation

Noise should not affect threshold outside of reasonable channel

Human data not S-shaped

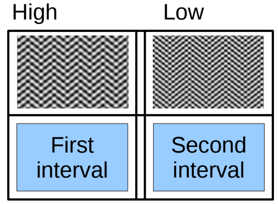
Noise elevates threshold regardless of frequency — no evidence for tuning





Experiment 2: Detection vs. discrimination

Task: 2x2 AFC



Detection and discrimination performance similar at threshold for very different modulator frequencies

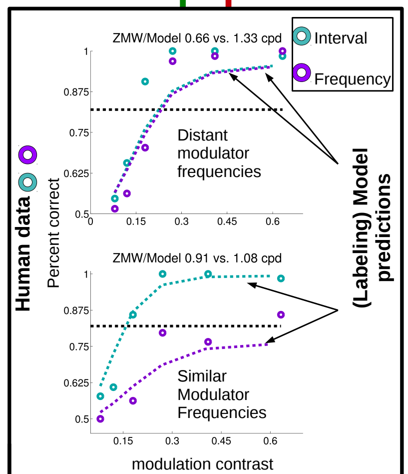
Implies independent mechanisms that are frequency tuned

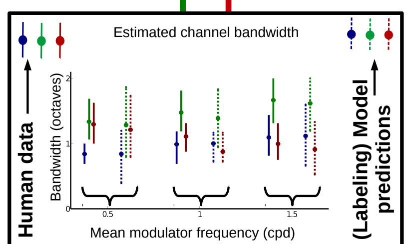
Labeled-lines paradigm for orientation-modulated gratings

Consistent with similar experiment on contrast modulated gratings [2]

We estimate channel bandwidths from data covering a variety of high/low frequency pairs

Suggests fixed width channels of 1-1.5 octave bandwidth





Orientation-labeling model

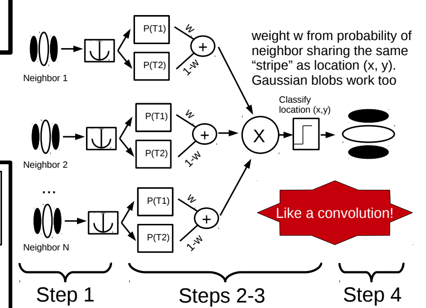
Some existing evidence points to extraction of dominant response as a nonlinearity in second-order vision [3, 4]. Our model:

1) Filter and rectify → texture energy image **E**(x, y)

2) Estimate distributions for textures T1 and T2 from **E** (we use Gaussian)

3) Label points T1 or T2 based on texture-energy responses **E**(x, y) in neighborhood around (x, y), assume independence of neighbors (naïve Bayes)

4) Apply second-stage filter to the orientation-labeled (binary) image to detect modulator



Experiment 1: No tuning for noise frequency

Experiment 2: Preserves tuning for frequency discrimination

Similar channel bandwidth estimates

Summary

Critical-band-masking data inconsistent with FRF given plausible second F

Detection vs. discrimination data consistent with previous bandwidth estimates

Nonlinearity that labels dominant texture accounts for both

References

[1] Landy, M. S. & Oruç, I. (2002). Properties of second-order spatial frequency channels. *Vis. Res.*

[2] Ellemberg, D., Allen, H. A. & Hess, R. F. (2006). Second-order spatial frequency and orientation channels in human vision. *Vis. Res.*

[3] Malik, J. & Perona, P. (1989). Preattentive texture discrimination with early visual mechanisms. *J. Opt. Soc. Am. A.*

[4] Motoyoshi, I. & Nishida, S. (2004). Cross-orientation summation in texture segregation. *Vis. Res.*