Masking reveals channels for second-order letters B79

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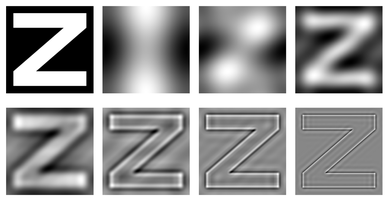
Introduction

Information is available for letter identification in many frequency bands.

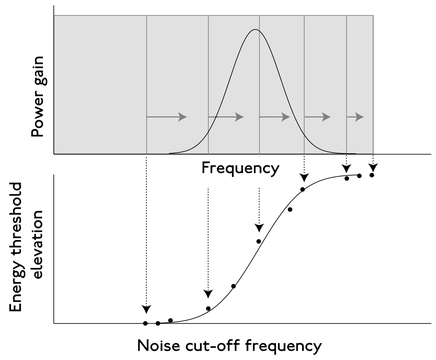


Yet observers typically use only a 1.5-octave -wide channel for letter identification.[1,2]

Critical-band masking

How can one estimate the channel used by observers to identify letters?

Answer: Critical-band masking.

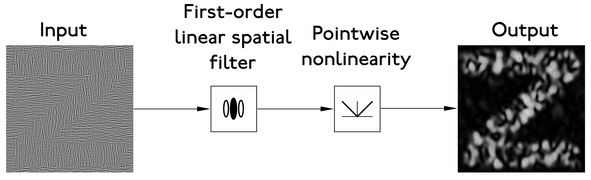


As low-pass masking noise cut-off is increased, more signal energy is required for threshold letter identification performance.

Derivative of threshold elevation = channel's power gain

Second-order letters

What about texture-defined letters?



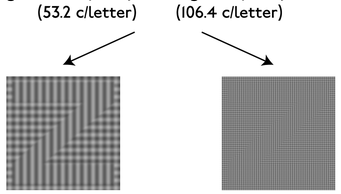
A linear filter and subsequent nonlinearity demodulate the stimulus. What second-order channel is used to identify the letter?

Methods

Stimuli: 5 letters in Sloan font: D N R S Z

Carrier: Sine-wave grating, Low frequency and High frequency

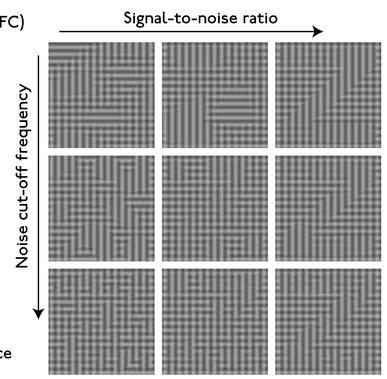
Examples:



Task:
Letter identification (5AFC)

Noise:
Second-order, low- and high-pass filtered Gaussian white noise

Conditions:
14 noise conditions (6 cut-off frequencies of high- and low-pass noise, plus no noise and white noise)

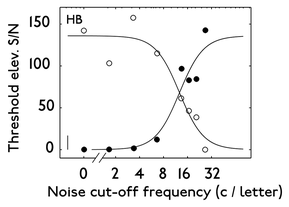


Viewing distance:
Standard viewing distance was 87 cm. In addition, half, double and triple the standard viewing distances were also used.

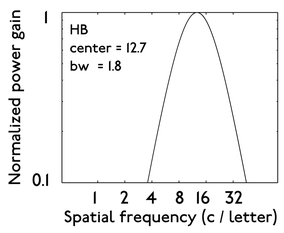
Results

Here are the threshold elevation curves.

Lower carrier frequency



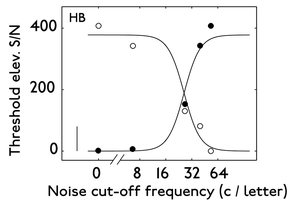
A single sigmoid fits both the high- and low-pass data.



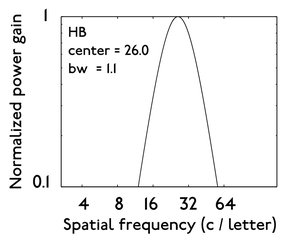
Average channel frequency is 15.2 +/- 1.1 c/letter. Bandwidth is 1.4 +/- 0.6 octaves

Scale invariance holds.

Higher carrier frequency



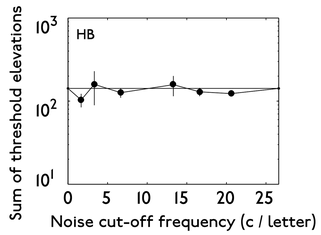
Average channel frequency is 30.9 +/- 1.1 c/letter. Bandwidth is 1.2 +/- 0.4 octaves



Channel frequency is proportional to carrier frequency.

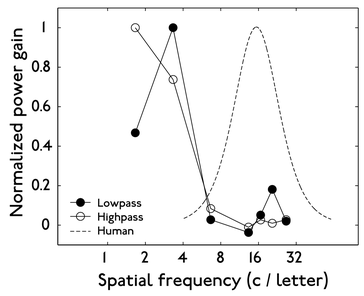
Channel switching

This analysis assumes a fixed channel is used as noise bandwidth is increased. If observers switched channels to avoid the noise, then the sum of threshold elevation for low- and high-pass noise should be less than that for white noise.



Subjects do not switch channels to avoid noise.

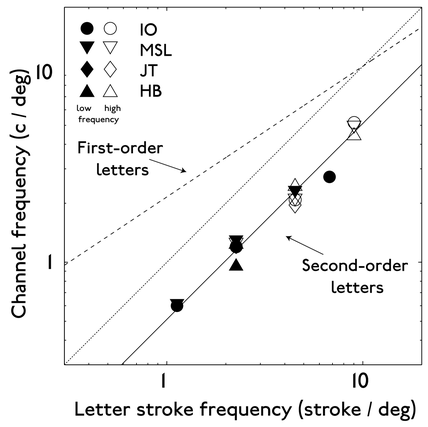
Model results



Might the human channel be a trivial consequence of the stimulus? No. A demodulate-and-template-match model uses an entirely different part of the spectrum.

Discussion

Stroke frequency: Majaj et al. (2002) defined stroke frequency as the number of strokes in a horizontal cut through a letter at mid-height divided by the letter width in degrees averaged over the alphabet. We modify this to incorporate carrier frequency into stroke frequency.



Stroke frequency determines the second-order letter channel.

Second-order letter channels are lower frequency than first-order.

Conclusions

1. No channel switching.
2. Scale invariance holds.
3. Channel depends solely on stroke frequency.

References
1. Solomon, J. A. & Pelli, D. G. (1994). The visual filter mediating letter identification. Nature (London), 369, 395-397.
2. Majaj, N. J., Pelli, D. G., Kurshan, P. & Palomares, M. (2002). The role of spatial frequency channels in letter identification. Vis. Res., 25, 239-252.

Acknowledgements
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Oruc, I., Landy, M. S., & Pelli, D. G. Masking reveals channels for second-order letters. Vision Sciences Society, Sarasota, Florida, May 6-11, 2005.

http://bar.psych.ubc.ca/PDF/vss2005