Bandwidths of Cigars and Doughnuts in higher-level spatial vision
Lynn A. Olzak and Patrick J. Hibbeler
Miami University of Ohio

Introduction

Olzak and Thomas (1999) described two spatial vision pathways in early-to-midlevel cortical vi-
sion based on two Fourier dimensions, orientation and spatial frequency. Each sum over pools of
early tuned mechanisms, first to form a gain control pool and then a different pool in which re-
sponses are summed together. One pathway provides information about the orientation of edges
and lines, and is broadband with respect to spatial frequency but narrowly tuned for orientation
(cigars). The other provides information about the textural grain, or 2-D spatial frequency content of
textures, and is broadband with respect to orientation but narrowly tuned for spatial frequency
(doughnuts). The current study is focused on measuring the bandwidths of two of the processes
believed to be involved in both pathways: normalizing pools (gain control pools) and summing cir-
cuits.

Observers
• One graduate: 10 undergraduates, all normal or corrected to normal. Not all observers parti-
cipated in all conditions

Methods

Task
• Discriminate between two sinusoidal patterns on the basis of either slight differences in orienta-
tion or spatial frequency

Conditions
• Control (simple 3 cpd vertical sinewave)
• Masking to isolate gain control pool
• Two cues—very together
• Two-cue—very in opposition

Procedures
• Blocks of 80 trials, intermingling the two stimuli to be discriminated
• Five repetitions at each orientation difference
• On any trial, one stimulus appeared for 500 ms, followed by a 500 ms response period
• Signal detection rating scale (1-6) certainty as to whether stimulus A or B had been presented
• Calculate daily d’, average over 5 replications of each condition

Experiments
• Isolate Cigars with orientation judgments. Mask and second cue initially vertical at 15 cpd.
• Change orientation of second component in different sessions to measure orientation bandwidth
• Isolate Doughnuts with spatial frequency judgments. Mask and second component initially or-
thogonal (horizontal) at 3 cpd. Change spatial frequency of second component to measure spatial
frequency bandwidth of doughnut pathway.

Results

Doughnuts
The gain control pool associated with doughnut mechanisms is very broad with respect to spatial
frequency. Fitted Gaussians on data averaged over all observers yielded a half height full bandwidth
of 2.3 octaves. Asymmetries were noted in the data of some observers. Summing circuits were
quite narrow, with a half height, full bandwidth of 0.35 octaves.

Cigars
The gain control pool associated with cigar mechanisms is very broad with respect to spatial fre-
quency. Fitted Gaussians on data averaged over all observers yielded a full bandwidth, half height
of 116°. Summing circuits, however, were very narrow, with a half height, full bandwidth of 2°.

Discussion

Assuming that there is a single gain control pool underlying both orientation and spatial frequency judgments, then the pool associated with fine spatial discriminations is broadband with
respect to both dimensions. This is consistent with previous estimates and models based on detection tasks (Foley, 1984; Watson & Solomon, 1997). The summing circuit results involved in
these fine spatial discriminations, however, were surprising. The range over which the circuits operate is exceedingly narrow, especially relative to first-stage filters. While broadband
mechanisms are capable of making fine discriminations (e.g. color), a mechanism designed to average spatial frequency in a texture or orientation information in an edge would be best
expected by increasing the likelihood that the information came from the same surface or edge. One way of doing this is to narrow bandwidth with respect to the dimension the mechanism is
summing over.

References

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Acknowledgments

This research was supported by NIH grant EY13953 to LAG. Special thanks to Amanda Boos, Amanda Due, Christine Beener, Chad Becchle, Erika Hadley, Courtney Hammond, Chris Harris, Megan O’Sullivan, Caroline Scacca and Abhay Sokal for their participa-
tion.