Opera House
Monday 3:00 — 5:00 PM

Visual Psychophysics & Physiological Optics

Early Vision and High-Level Visual Perception - Special Minisymposium

MODERATOR: Angela M Brown

PGM#	TIME	AUTHORS
1034	3:00	Graham
1035	3:30	Bergen
1036	4:00	Sperling
1037	4:30	Nakayama, He, Shimojo

1034 — 3:00

LOW-LEVEL VISUAL PROCESSES IN PERCEIVED REGION SEGREGATION ((N. Graham)) Department of Psychology, Columbia University, New York City, NY, 10027, U.S.A.

We have studied perceived segregation between regions containing "textures" composed of the same two element types but in checkerboard vs. striped arrangements. The +'s and -'s in the sketch might represent squares of different sizes and contrasts (e.g., Sutter, Beck, and Graham, 1989) or Gabor patches of different spatial frequencies and orientations (e.g., Graham, Sutter, and Venkatesan, 1993), etc. While these patterns were originally introduced to study relatively high-level linking processes (Beck, Prazdny and Rosenfeld 1983), many if not all of our results can be explained by low-level processes.

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These low-level processes include simple spatial-frequency and orientation-selective channels (linear, first-order, Fourier processes) plus at least two kinds of nonlinearities. One kind of nonlinearity may be modelled by complex channels (second-order, non-Fourier processes) where each complex channel consists of two linear-filtering stages separated by a rectification-type nonlinearity. The second kind of nonlinearity -- which is dramatically compressive even at contrasts below 25% -- may be modelled either as a relatively-local nonlinearity preceding the simple and complex channels, or as inhibitory interaction (normalization) among the channels themselves.

In this context, I will briefly discuss some problems encountered using visual stimuli at suprathreshold contrasts: non-replications, individual differences, and learning effects. These problems may have a perfectly respectable source -- observers may be able, once patterns are substantially above contrast threshold, to perform in quite different ways experimental tasks which seem to be identical or very similar. Thus, a satisfactory explanation of observers' supra-threshold behavior may require greater consideration of high-level processes than that sufficient to explain near-threshold behavior (Graham, *Visual Pattern Analyzers*, 1989).

Supported by NEI grant EY08459 *Proprietary interest: None*

1035 — 3:30

TEXTURE PERCEPTION: FILTERS, NON-LINEARITIES AND STATISTICS ((J.R. Bergen)) David Sarnoff Research Center, Princeton, USA

Visual texture perception has been thought for many years to be a possible link between low-level visual processes that are studied using physiological and psychophysical methods and higher-order processes with more direct perceptual manifestations. Texture is a kind of simplified visual quality in which many of the details of spatial structure and exact arrangement of parts are not significant. Instead, more general visual characteristics, such as variability, granularity, streakiness and so forth, determine textural properties.

There have been two major approaches to formulating theories of texture perception. The first is based on image statistics. In this view, textures are treated as random spatial processes with specified spatial correlation properties. One difficulty with this approach is that explicit description of complex spatial statistics is awkward. The second approach treats texture as a random scattering of some set of small local features. In this case, it is the structure of these local features that captures the spatial correlation properties of the texture. One difficulty with this approach is that it is hard to know how to define local features that are appropriate and can be extracted reliably from natural images.

The statistical and feature-based approaches can be united into a single framework in which the central description is the set of histograms or first-order statistics of the output of a set of local spatial measurements. On the basis of this description, it is possible to synthesize textures matching given examples in the sense that their filter output histograms are matched. This allows a direct test of the sufficiency of a hypothesized local spatial representation.

1036 — 4:00

SECOND-ORDER PERCEPTION

(George Sperling) University of California, Irvine, CA 92717.

An ideal way to detect a pattern is make a template of the pattern, correlate the input with the template, and output a detection response when the correlation exceeds a threshold. This basically is the linear-filter-plus-theshold approach that has worked so well to explain psychophysical phenomena, a regime referred to as first-order perception. However, as soon as there is uncertainty in location, size, shape, orientation, shading, or any other characteristic, both the ideal statistical and actual human detection problems are enormously more complex. For some cases in which the ideal solution is known, it involves highly nonlinear combinations of elementary features. **Method.** An enormously useful tool new tool for the study of such complex perceptual processes is the use of stimulus patterns that cannot detected by a linear-filter-plus threshold mechanism.[1] Second-order perception refers to the ability to perceive structure in in such patterns. The essential ingredient in human 2nd-order perception seems to be full-wave rectification (e.g., absolute value or squaring) of the outputs of "texture grabbers".[2] What is surprising is that such highly nonlinear rectification processes seem both to be pervasive and to occur extremely early in perception. Demonstrations of 2nd-order phenomena will illustrate: lateral inhibition specific to spatial frequency, Mach bands, 2nd-order sinewave motion stimuli, and examples of texture perception. However, 2nd-order motion does not seem to support useful structure-from-motion computations (the kinetic depth effect). Significant 2nd-order spatial interactions and motion computations occur monocularly (before binocular combination) as well as interocularly. Whereas 2nd-order stimuli, by their nature, are less information-dense than first-order stimuli, the statisical efficiency with which they are detected can rival that of first-order stimuli. **Conclusion.** The universitality, primitiveness, and efficiency of second-order perceptual phenomena suggests that feature extraction and rectification are basic computations in visual perception that occur at the earliest processing levels.

[1] Chubb, C. and Sperling, G. (1988). *J. Opt. Soc. Amer. A, 5*, 1986-2006;
[2] Chubb, C. & Sperling, G. (1991). *J. Math. Psychol., 35*, 411-442

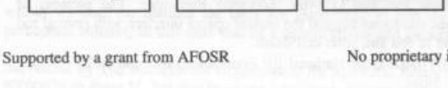
Supported by AFOSR Life Sciences, Visual Information Processing Program.

1037 — 4:30

Visual surface representation: an intermediate stage between early filtering and object recognition. ((Ken Nakayama and Zijiang He)), Harvard University; ((Shinsuke Shimojo)), University of Tokyo

We divide this presentation into two sections. First, in a series of visual tasks traditionally thought to be mediated by early visual filtering, we show a strong dependence of higher order factors, primarily organization at a surface representation level. Thus motion perception, visual search, and visual texture segregation are shown to be critically determined by perceived surface layout, not by the presumed outputs of cortical filters. This suggests that one must either consider surface representation to be implemented earlier in the visual pathway than had been previously supposed and/or that so-called rapid visual processes are implemented later.

Second, we have attempted to understand the mechanism of surface formation itself. Again, rather than appealing to early filtering, we propose local interactions among visual modules which are highly constrained by real world inverse optics rules. This includes local T-junctions, binocular disparity and half occlusions, border ownership, and the evaluation of the Metelli transparency conditions. Many of these can in part be understood in terms of the generic sampling assumption. The visual system assumes that it is not viewing the scene from a privileged vantage point.



Supported by a grant from AFOSR No proprietary interest