Foveated metamers of the early visual system

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See poster 53.425 for plenoptic, a python package for synthesizing your own metamers (and more)

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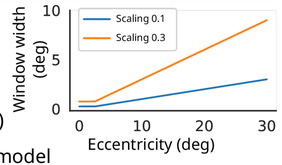
What information are humans insensitive to in the periphery?

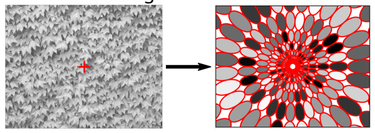
- Develop foveated models of human perception.
- Synthesize metamers for these models (c.f., 1, 2).
- Use psychophysics to find **critical scaling**: largest window size where model metamers become human metamers

Pooling models

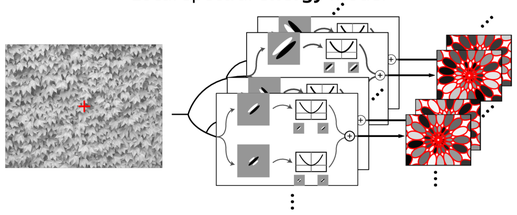
- Models compute statistics in Gaussian pooling windows across image.
- Pooling windows' width grows linearly with eccentricity.
- One free parameter: **scaling** (slope)



Local average **luminance** model

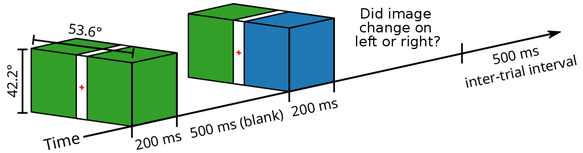


Local spectral **energy** model



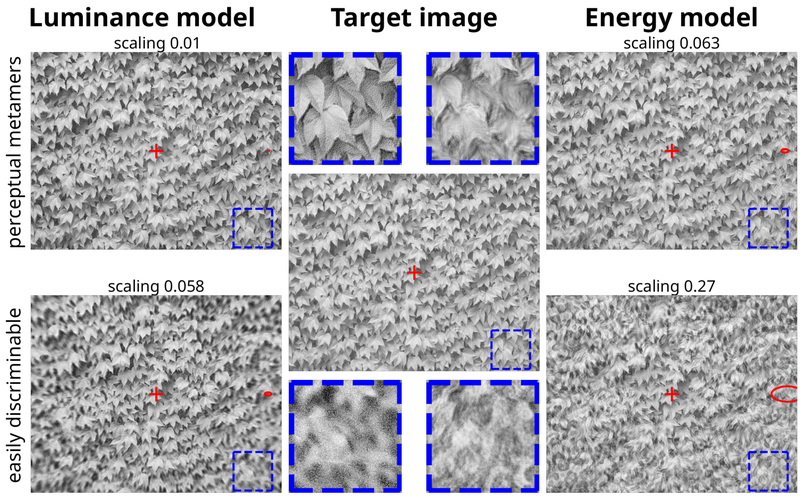
Psychophysical task structure

- Compared synthesized to synthesized (Synth vs. Synth) and natural images (Original vs. Synth)
- Participants had to determine whether left or right half changed.



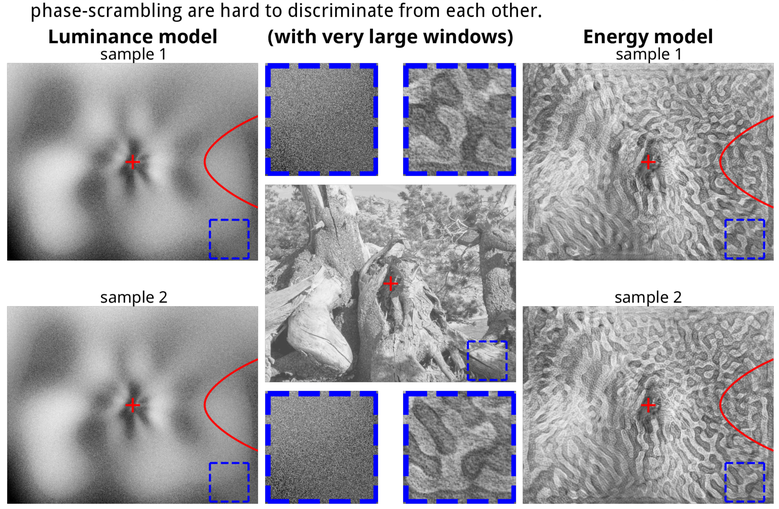
Example model metamers for different models and scaling

- Mean luminance or spectral energy are matched within windows, but details are unconstrained and thus fluctuate.



Synth vs. Synth is difficult, even at very large scaling values

- With large windows, luminance model metamers are essentially white noise and thus impossible to discriminate from each other, while energy model metamers' peripheral phase-scrambling are hard to discriminate from each other.

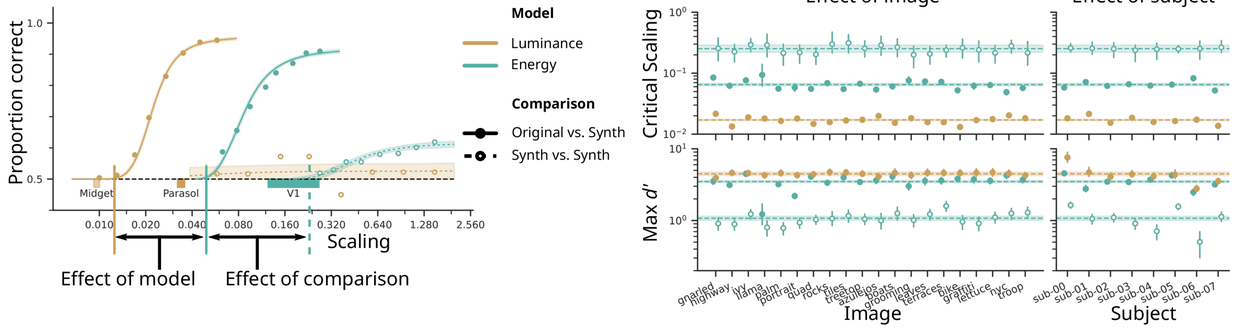


Contributors to critical scaling

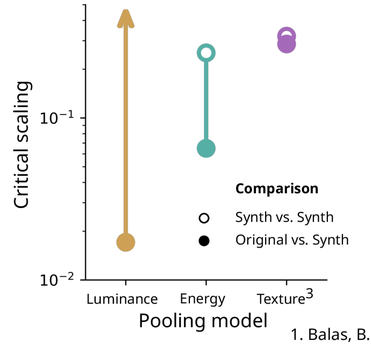
- **Comparison:** pooling models' critical scaling value is always larger for original vs. synth than synth vs. synth comparison.
- **Model:** critical scaling increases with statistic complexity.
- **Model/comparison:** the difference between these comparisons decreases with increasing complexity of statistics.
- **Initialization:** (data not shown) initializing metamer synthesis with a natural image also reduces this difference, decreasing synth vs. synth critical scaling while leaving original vs. synth unchanged (fig. 9 and 10 in paper).
- **Image content:** negligible effect on critical scaling, greater effect on max *d'*.

Critical scaling differs across model and comparison, but is stable across images and subjects

- Critical scaling: determines where performance falls to chance, scientifically interesting.
- Max d': determines asymptotic performance, unrelated to metamers.



Summary of results



1. Balas, B., Nakano, L., & Rosenholtz, R. (2009).
2. Freeman, J., & Simoncelli, E. P. (2011).
3. Wallis, T., et al. (2019).