A spatial frequency spectral peakedness model predicts discrimination performance of regularity in dot patterns

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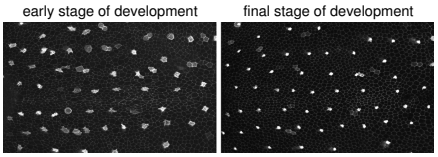
1. INTRODUCTION

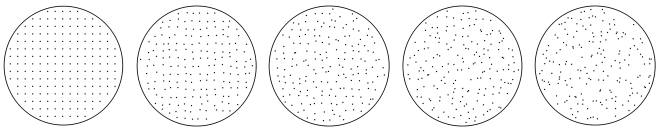
REGULARITY IN POINT PATTERNS

Subjective assessments of regularity in point patterns are common in the analysis of evolving systems (e.g. developmental biology).



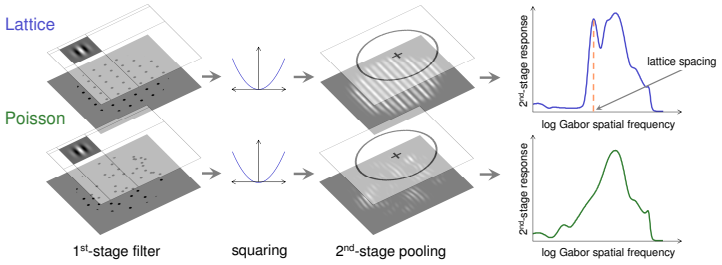
Bristle precursor cells in the dorsal thorax of a living fly pupa prior to hatching appear to increase in regularity. (image from the Baum Lab, UCL)

Humans are particularly consistent in assessing regularity even when diverse stimuli are considered [1]. For jittered square lattices of dots, we can distinguish up to 16.5 just-noticeable-differences (jnds) of regularity between perfect order (lattice) and total disorder (Poisson) [2].

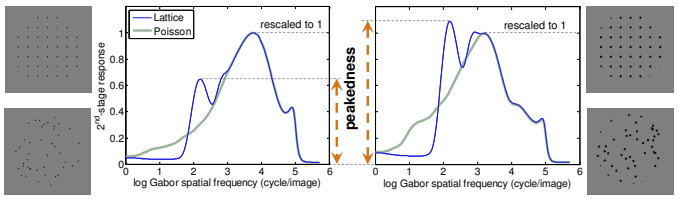


HOW IS REGULARITY CODED?

Ouhnana et al. [3] proposed that regularity is coded via the peakedness of the distribution of energy responses across receptive field size.



Here, we examine whether discriminability of regularity for jittered square lattices of dots correlates with a specific peakedness measure.

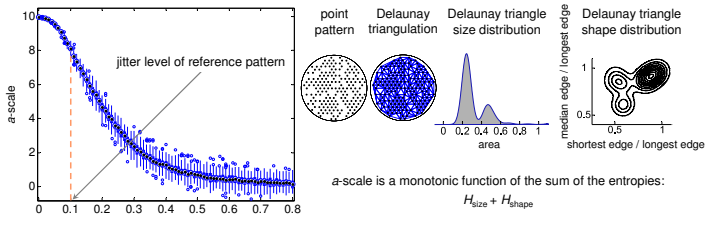


2. METHODS

SELECTION OF PATTERNS

Stimuli

A measure of regularity based on perception (*a*-scale) [1] is used to select stimuli to minimize variability in judgments for the specified jitter levels.



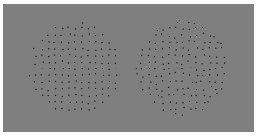
jitter level (SD of Gaussian jitter as a fraction of dot spacing)

a-scale is a monotonic function of the sum of the entropies:

$H_{size} + H_{shape}$

TASK

2AFC: Which pattern is more regular?

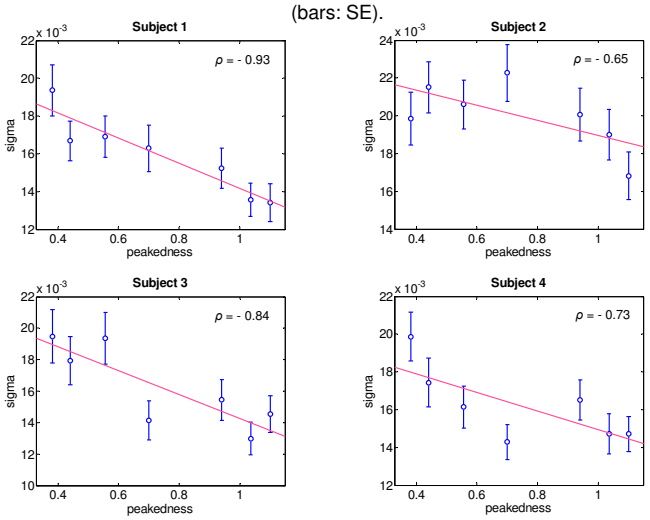


Condition	1	2	3	4	5	6	7
Dot size (px)	2	2	2	4	4	8	8
Dot spacing (px)	20	34	40	20	40	34	40
Pattern radius (px)	140	235	280	140	280	235	280
Peakedness	0.70	0.44	0.38	1.04	0.56	1.10	0.94

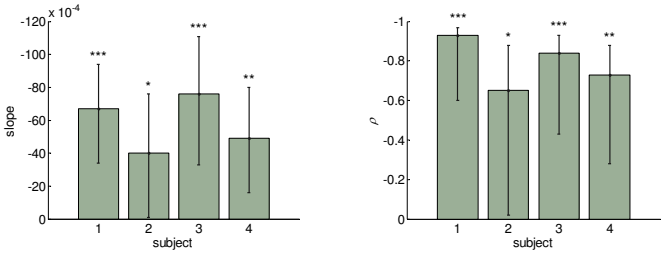
3. RESULTS

DISCRIMINABILITY vs. PEAKEDNESS

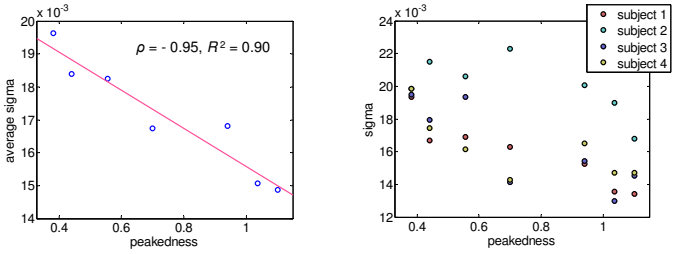
A cumulative normal psychometric function with SD sigma is fit to responses (bars: SE).



Summary data (bars: 95% CI)



Data pooled across subjects



4. CONCLUSION

The distribution of neural responses across scale predicts perceived regularity and discriminability of regularity.

References:

1. Protonotarios, E. D., Baum, B., Johnston, A., Hunter, G. L., & Griffin, L. D. (2014). An absolute interval scale of order for point patterns. *Journal of the Royal Society: Interface*,11(99), 20140342
2. Protonotarios, E., Johnston, A., & Griffin, L. D. (2016). Difference magnitude is not measured by discrimination steps for order of point patterns. *Journal of Vision*;16(9):2.
3. Ouhnana, M., Bell, J., Solomon, J.A., & Kingdom, F.A.A. (2013). Aftereffect of perceived regularity. *Journal of Vision*;13(8):18.

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