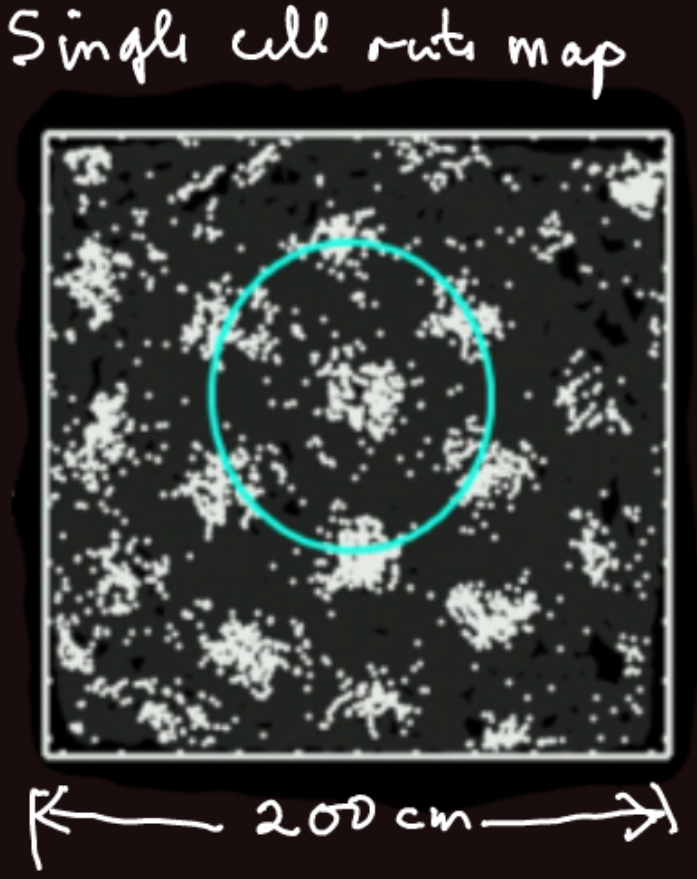
Grid Cells

principle: All parts of the arena should have equal spatial resolution



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2 Grid cell properties

(i) triangular array (hex eccentricity = 1.16)

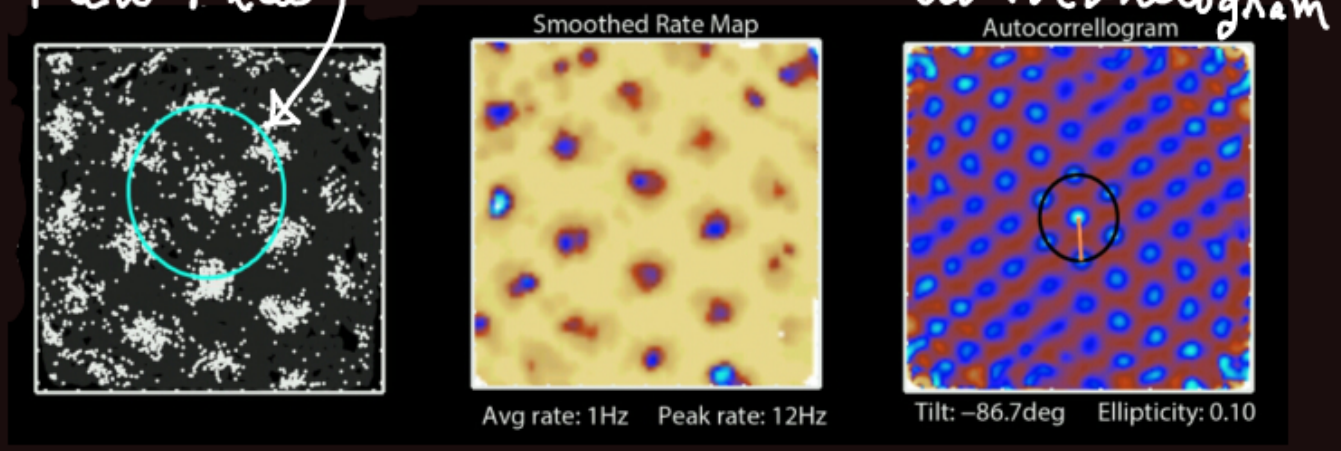
(ii) grid cells are found with all possible translations (but with same grid spacing)

$\varepsilon = 1.16 \pm .003$

raw rates

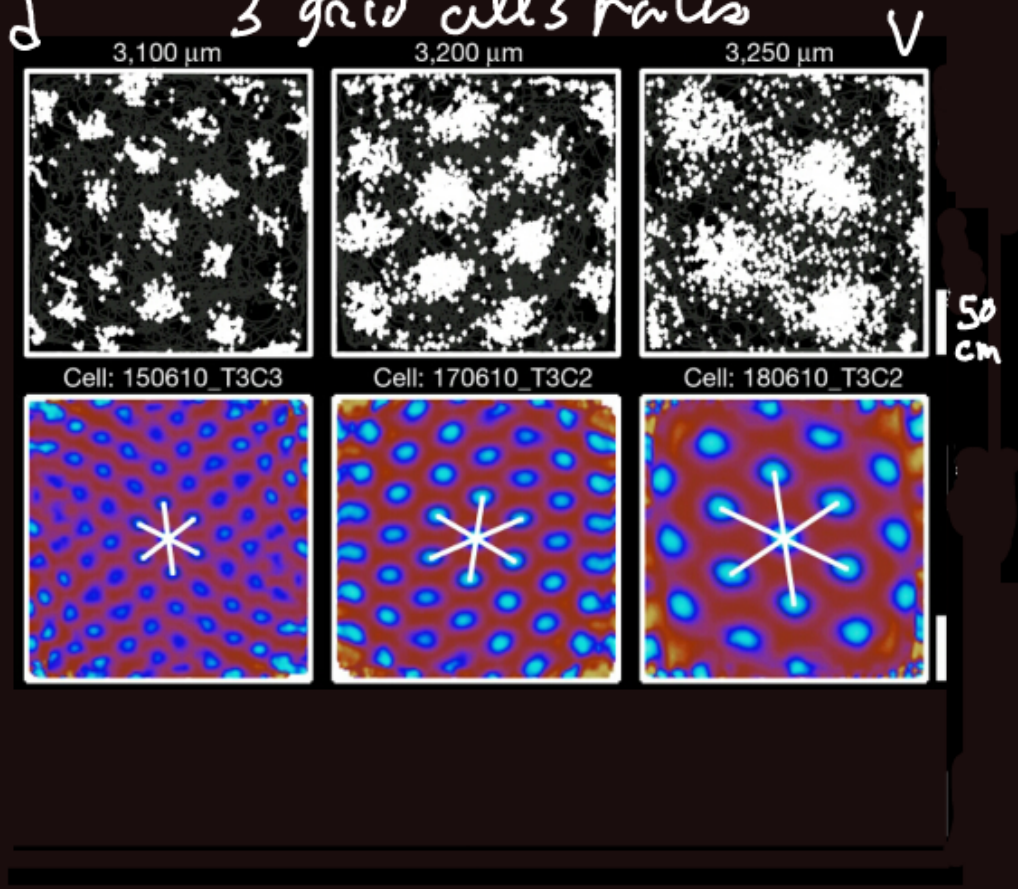
smoothed rate

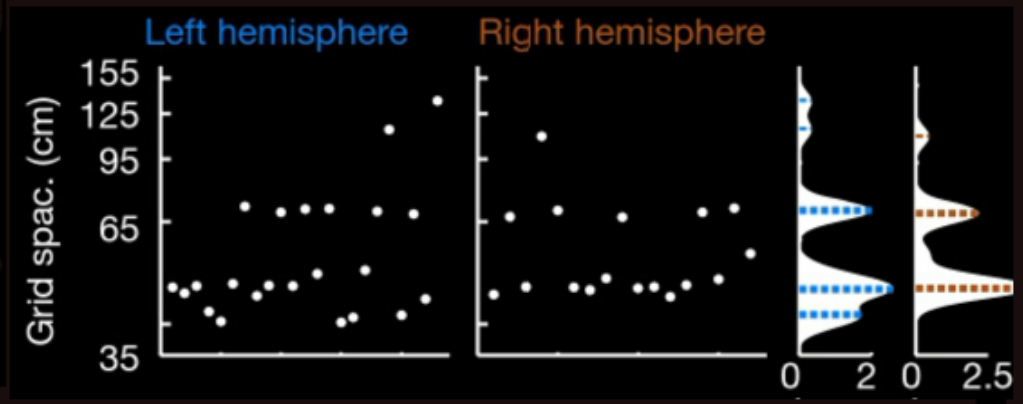
autocorrellogram



Multiple discrete levels of grid cell spacing

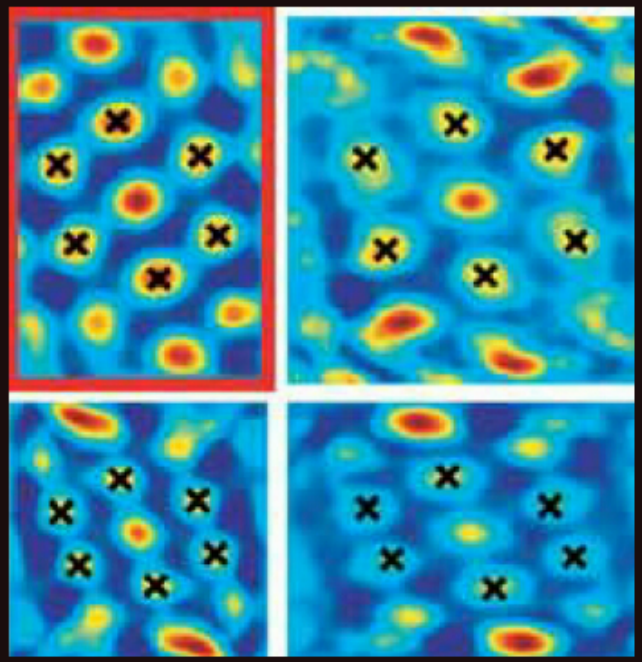
Here: 3 discrete levels (bilateral)
grid cell abundance increases with level





Grid spacing changes with arena size

4 arena sizes
1 cell



Grid spacing is stretched so that same grid fits different arena sizes.

4 observations to explain (+1)

(i) grid eccentricity ≈ 1.16. Why?

(ii) multiple discrete g.c. levels are found.
? How many.

(iii) What are the grid spacings for the various levels?

(iv) Why are finer grids represented by more cells (abundance question)?
(& why have grid cells?)

Equal spatial resolution everywhere

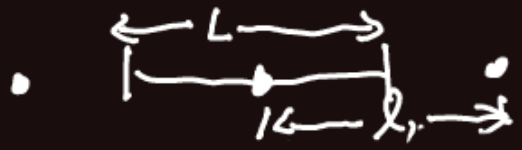
equal spatial resolution should be available throughout the arena (no "dead spots"). ⟶

equal number of neurons must provide spatial location for each place in the arena.

Equal resolution and ideal grids

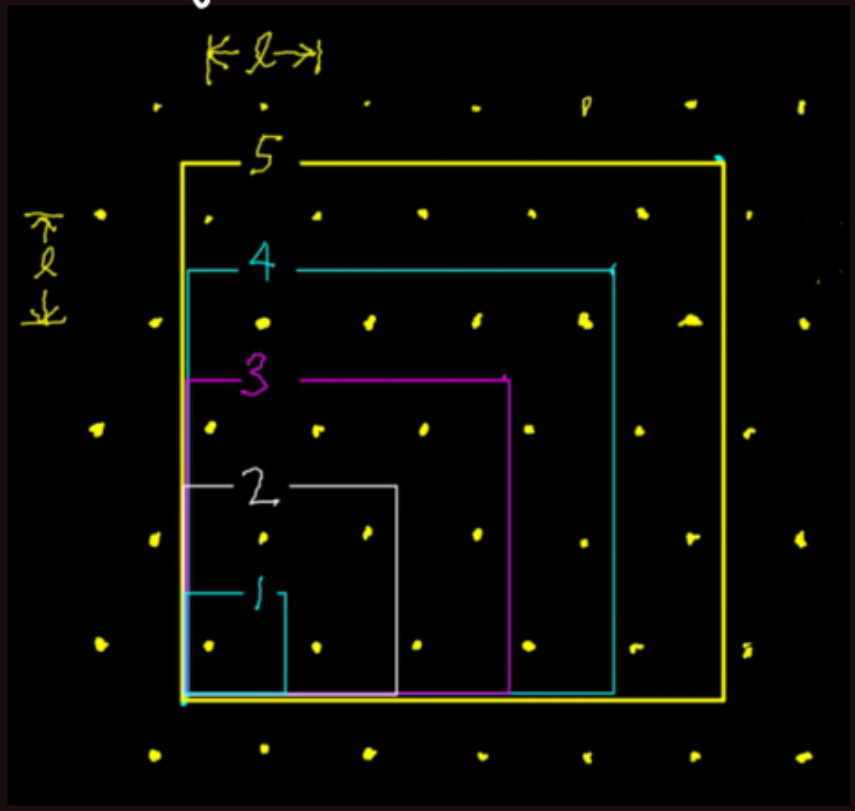
1-d grid

$l_2 = \frac{L}{2}$



$l_1 = L$ to resolve position for lowest grid level.

2-d triangular grid — ideal



Number of levels & eccentricity

rat picks L

For ideal grids, the number of grid points is k^2 (k = grid level).

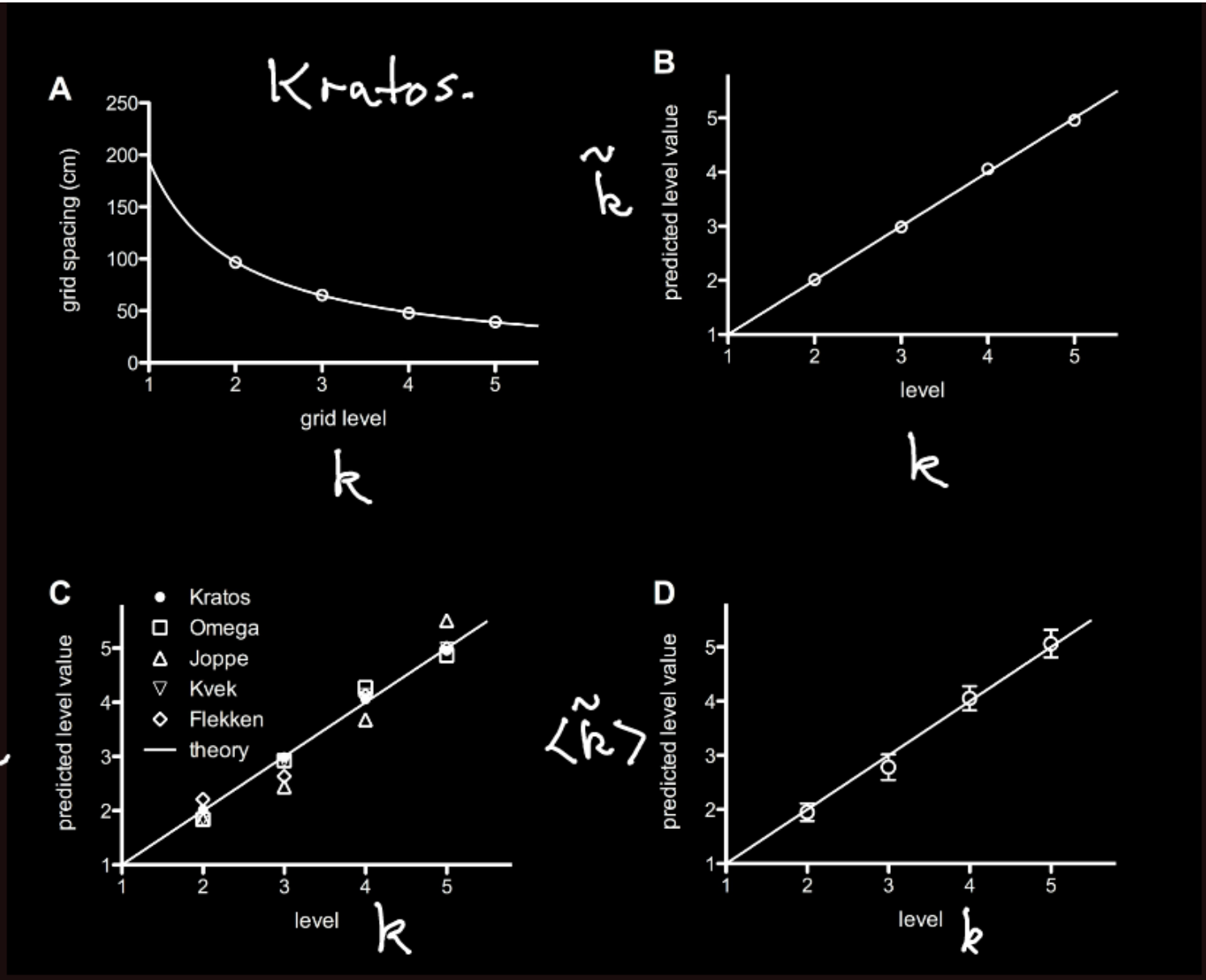
Because level 1 must have a single grid point ($l_1 = L$), the number of levels is set by the finest (most dorsal) grid. $k=5$ is highest level.

Grid spacing

$$l_k = \frac{L}{k}$$

$$\tilde{k} = \frac{L}{l_k}$$

(L is single adjustable parameter for each rat)



Cell abundance & why have grid cells

equal spatial resolution → $A_k \sim k^2$ (A_k = number of k-level g.c.s)

N = total g.c.s

$$N \sim \sum_{k=1}^{5} k^2 = 55$$

$\tilde{N}$ for number like retina

$\tilde{N} \sim k^4$ $\quad \frac{\tilde{N}}{N} \approx 10$