MIT Department of Brain and Cognitive Sciences
9.641J, Spring 2005 - Introduction to Neural Networks
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Lateral inhibition

Truth 1:

Lateral inhibition amplifies differences relative to commonalities.

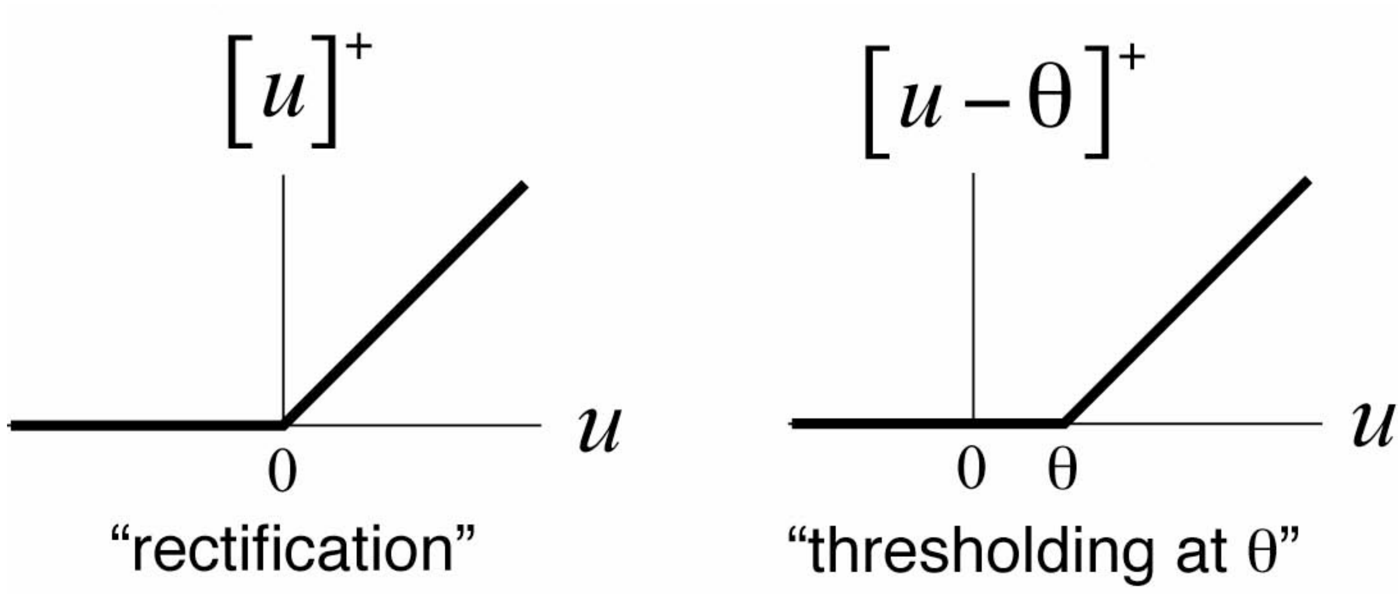
Truth 2:

Lateral inhibition regulates response selectivity by setting a dynamic threshold

Truths 1 and 2 are related:

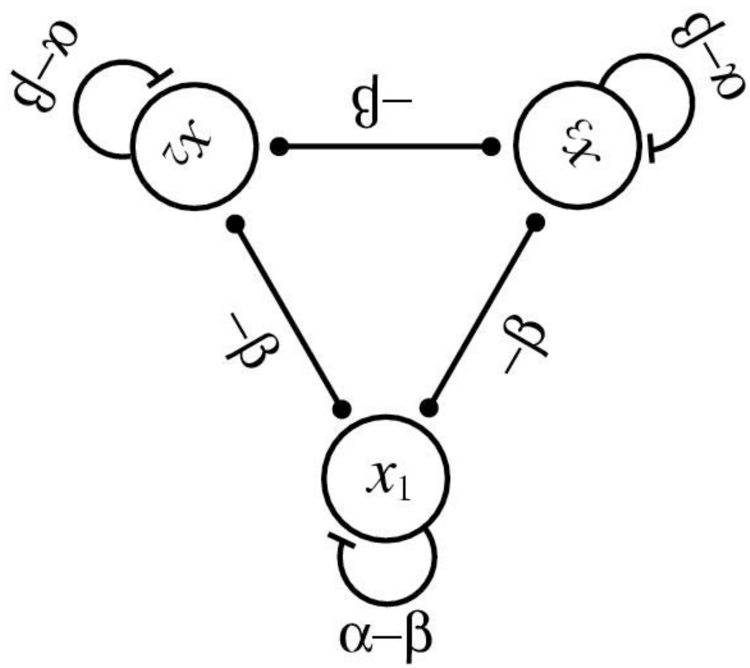
The ratio between differential gain and common gain is dynamic in a nonlinear network.

Rectification vs. thresholding



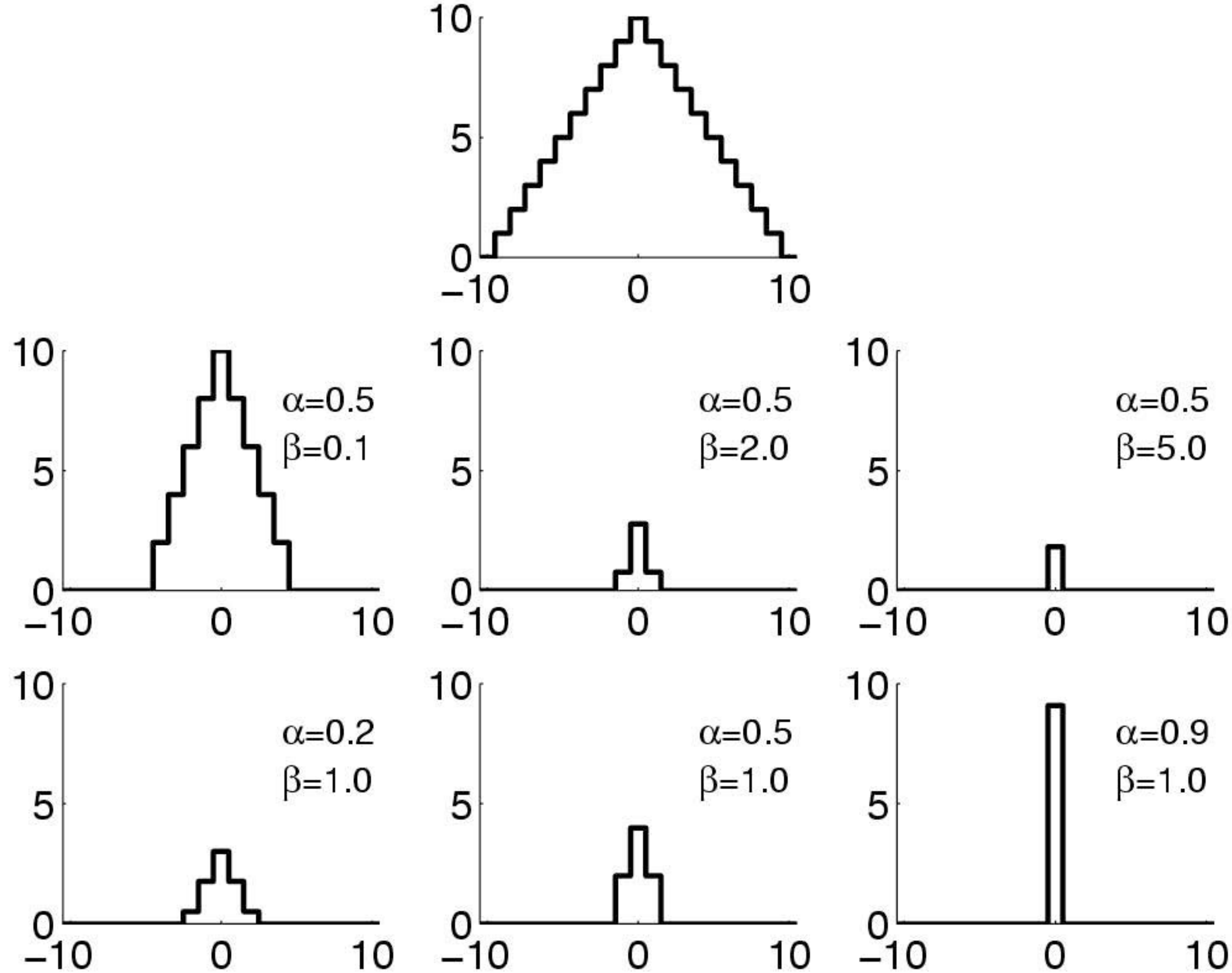
All-to-all inhibition

$$\dot{x}_i + x_i = \left[b_i + \alpha x_i - \beta \sum_j x_j \right]^+$$

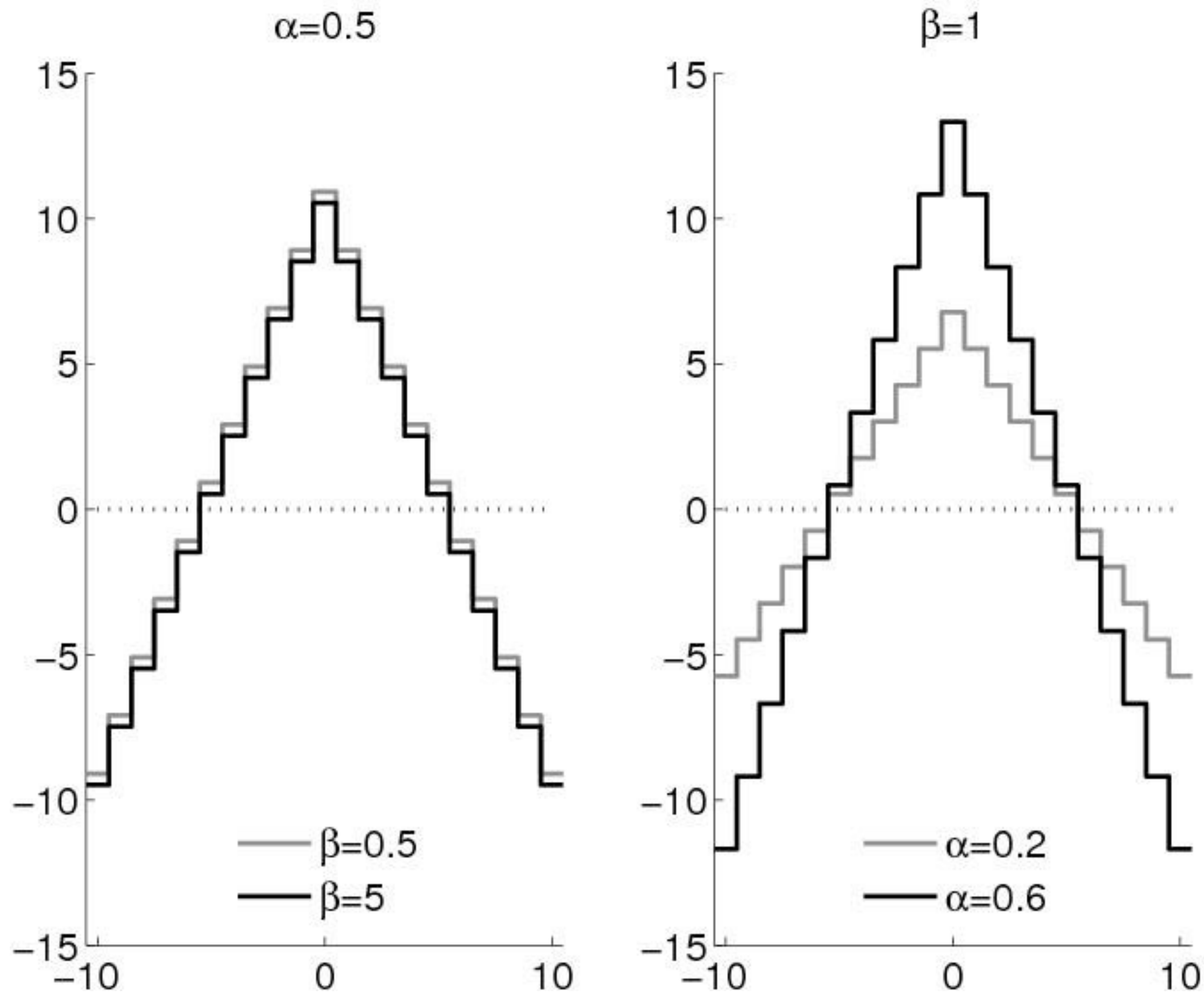


Consider α<1 for now.

Increasing α or β enhances selectivity



Without nonlinearity



Response of a linear network

$$x_i = \frac{b_i - \bar{b}_N}{1 - \alpha} + \frac{\bar{b}_N}{1 - \alpha + N\beta}$$

Piecewise linear behavior

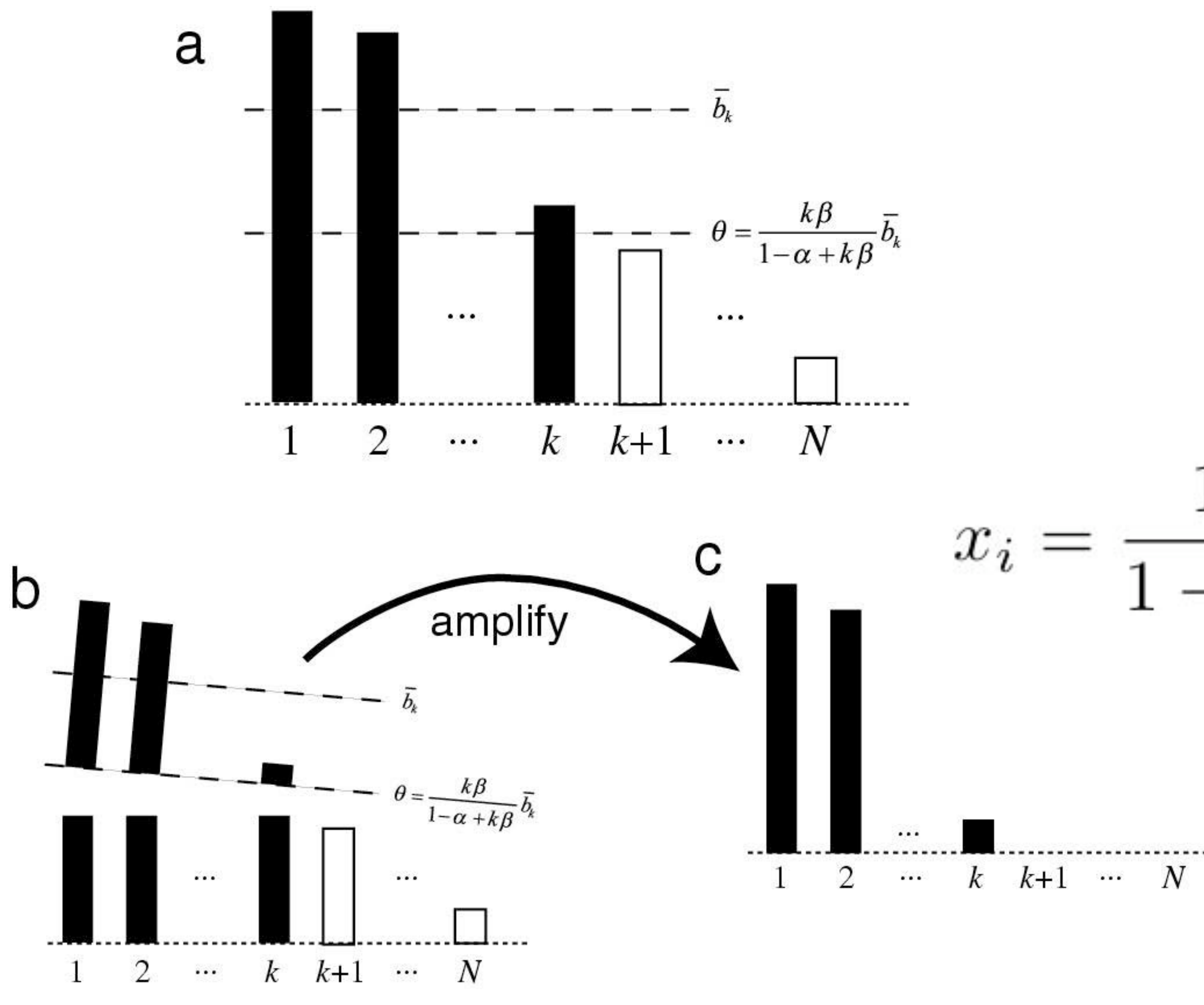
$$x_i = \frac{1}{1-\alpha}[b_i - \theta(k)]^+$$

$$\theta(k) = \frac{\beta}{1-\alpha+k\beta}\sum_{j=1}^{k} b_j = \beta \sum_{j=1}^{k} x_j$$

$$b_k > \theta(k) \geq b_{k+1}$$

$$b_1 \geq b_2 \geq \ldots \geq b_N$$

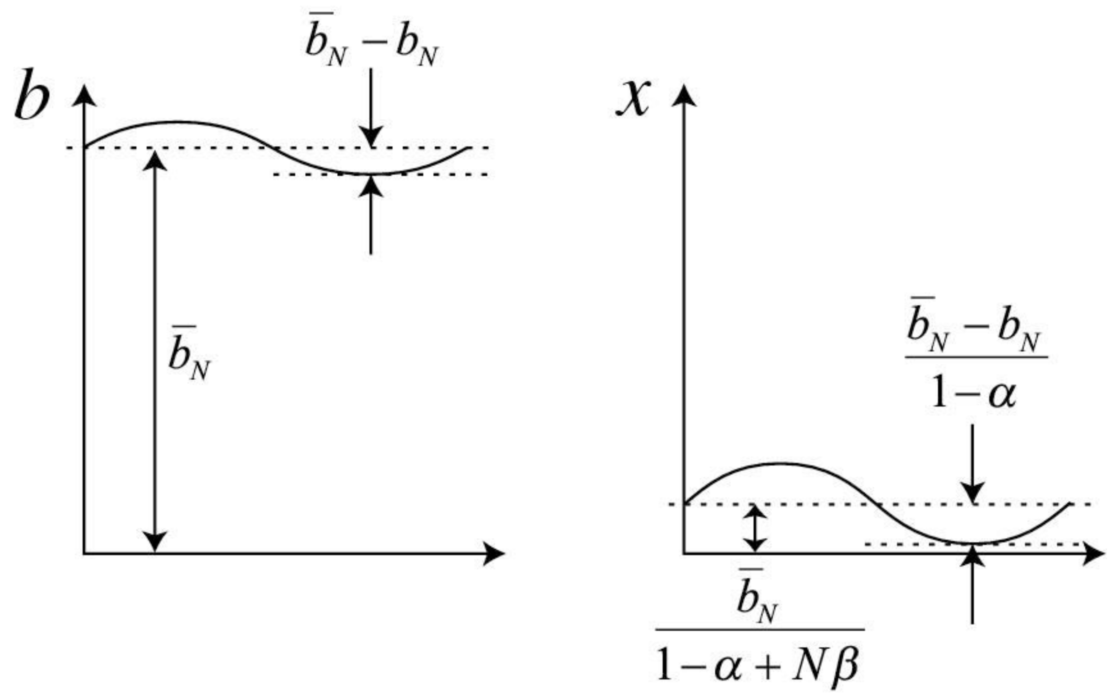
A dynamic threshold



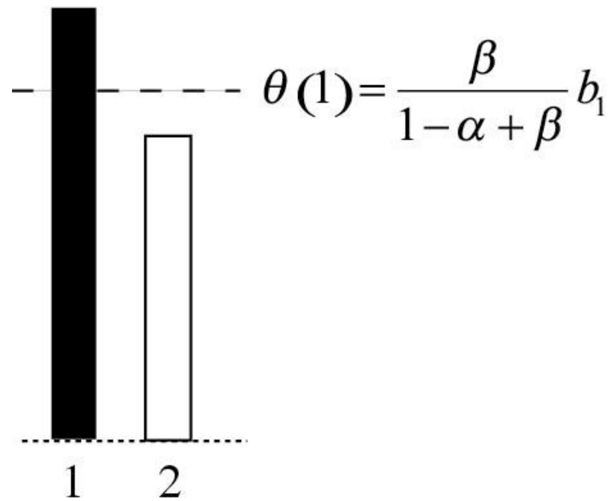
$$x_i = \frac{1}{1-\alpha}[b_i - \theta(k)]^+$$

All neurons active

$$\frac{\bar{b}_N - b_N}{\bar{b}_N} < \frac{1-\alpha}{1-\alpha+N\beta}$$

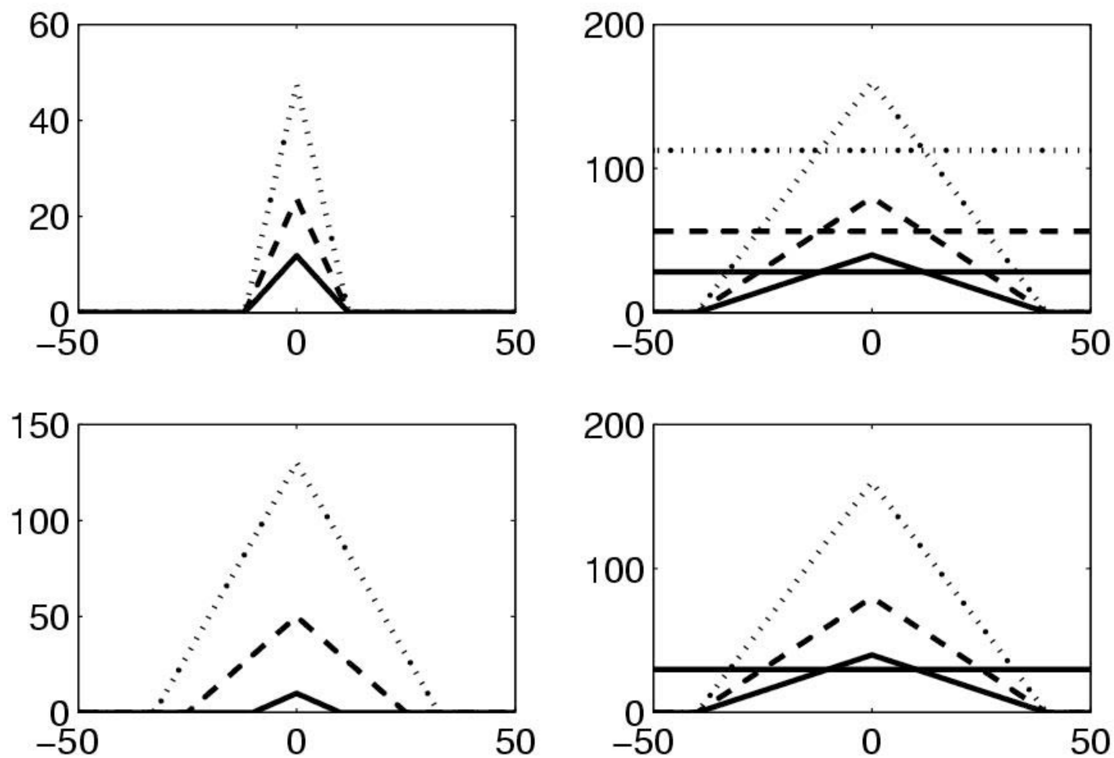


Conditional winner-take-all



$$\frac{b_1 - b_2}{b_1} \geq \frac{1-\alpha}{1-\alpha+\beta}$$

The active set is scale invariant



Gain depends on the active set

$$\frac{x_i - x_j}{b_i - b_j} = \frac{1}{1-\alpha}$$

$$\frac{\bar{x}_k}{\bar{b}_k} = \frac{1}{1-\alpha+k\beta}$$

Nonlinear amplifier

- Unique steady state
- State-dependent gain

There is a unique output