

# Contributions of synaptic depression on the contrast-invariance of orientation selectivity

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## Introduction

It has been determined through separate animal experiments that contrast-invariant orientation selectivity is potentially due to at least 3 features: inhibition, synaptic depression and membrane noise. The relative contributions of these features to cortical responses are, however, unknown. This leads to the following research question: What is the relative contribution of synaptic depression to contrast-invariant orientation selectivity?

## Objectives

Determine the extent to which synaptic depression alone, without inhibition and membrane noise, contributes to contrast-invariant orientation selectivity.

## Methodology

Through the use of a neural network modeling tool (i.e. NEURON); a biologically realistic model of the visual network was used to quantify the effects of synaptic depression on contrast-invariance in orientation selectivity. The simulation included a sinusoidal grating drifting across the receptive fields of 90 thalamocortical cells (TCC) converging onto a single cortical spiny stellate cell (SSC) selective for vertical edges. The response of this cortical cell to stimuli of different orientations and contrasts was studied in the presence or absence of thalamocortical synaptic depression.

## Acknowledgements

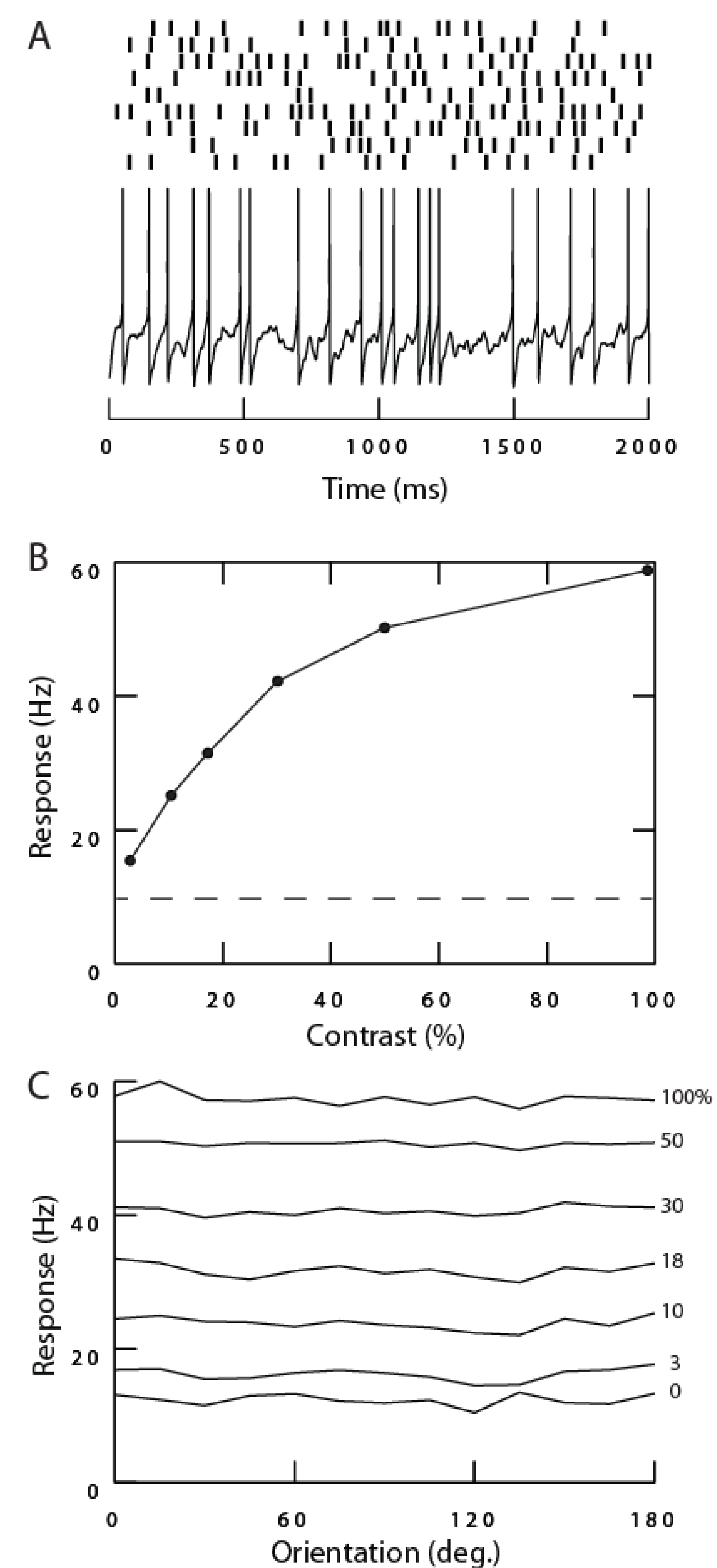
I would like express my special thanks and gratitude to Prof. Fortier and to the UROP, without whom this project wouldn't have ever been possible.

## References

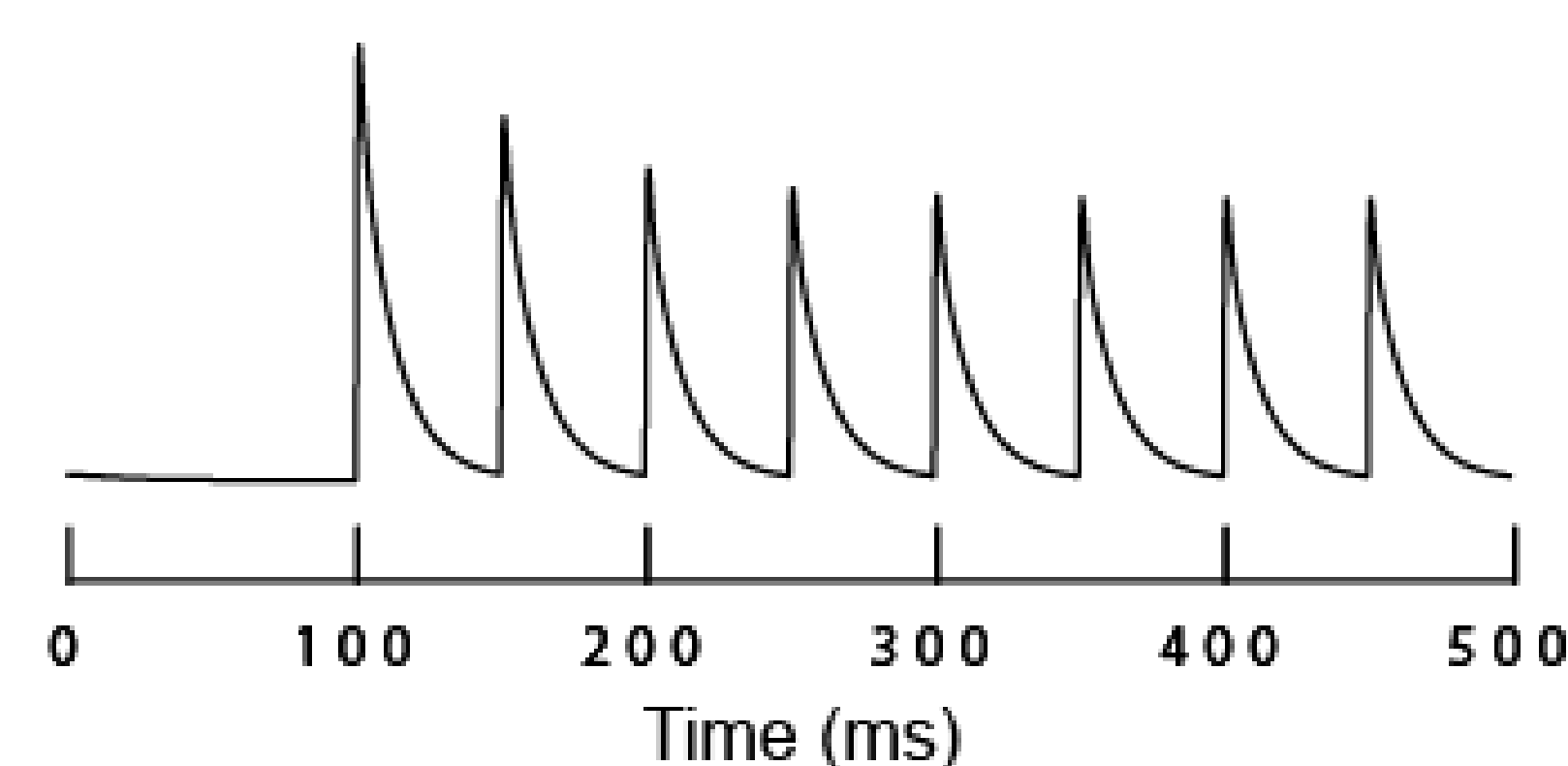
Banitt Y, Martin KA, Segev I (2007) A biologically realistic model of contrast invariant orientation tuning by thalamocortical synaptic depression. *J Neurosci* 27:10230–10239.

Finn IM, Priebe NJ, Ferster D (2007) The emergence of contrast-invariant orientation tuning in simple cells of cat visual cortex. *Neuron* 54:137–152.

## Results

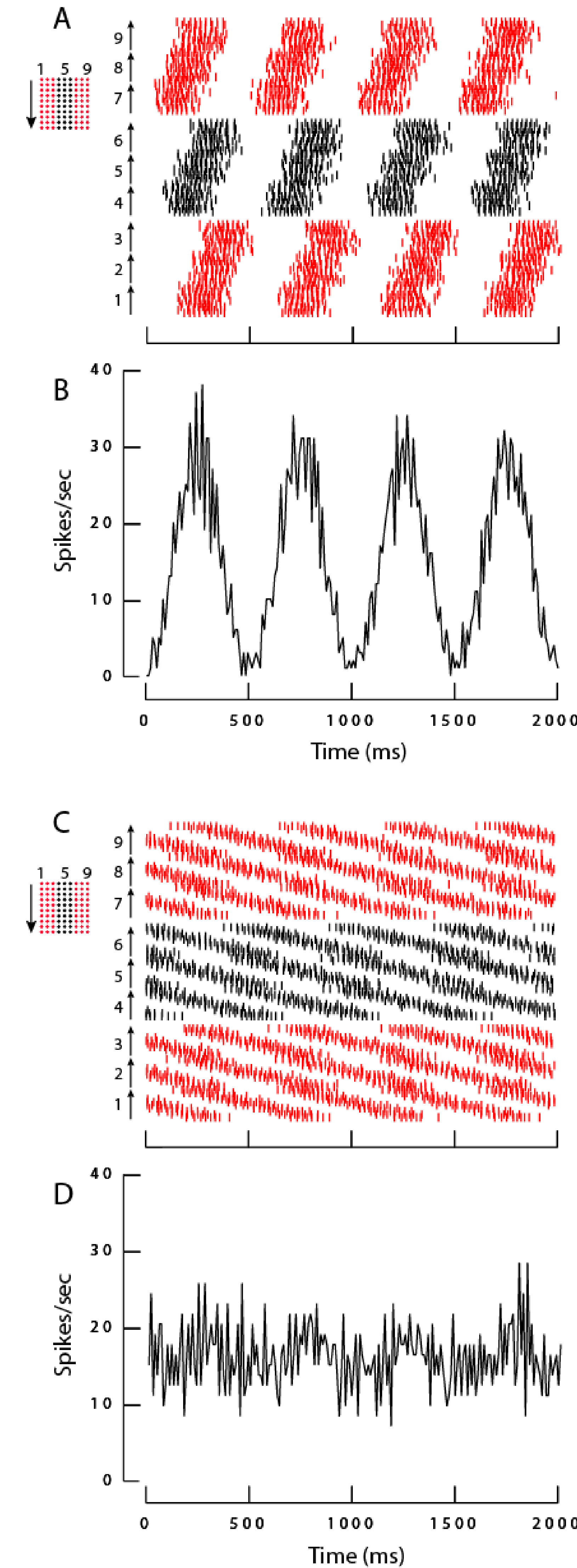


**Figure 1.** Responses of the modeled TCC. **A**, Background firing rate (10Hz) of a single TCC recorded for 10 of 2 seconds trials (each bar represents an action potential). **B**, Peak firing rates for stimuli of different contrasts. **C**, Peak firing rates for different orientations and contrasts. Note that the responses of TCC are not orientation selective and not contrast-invariant.



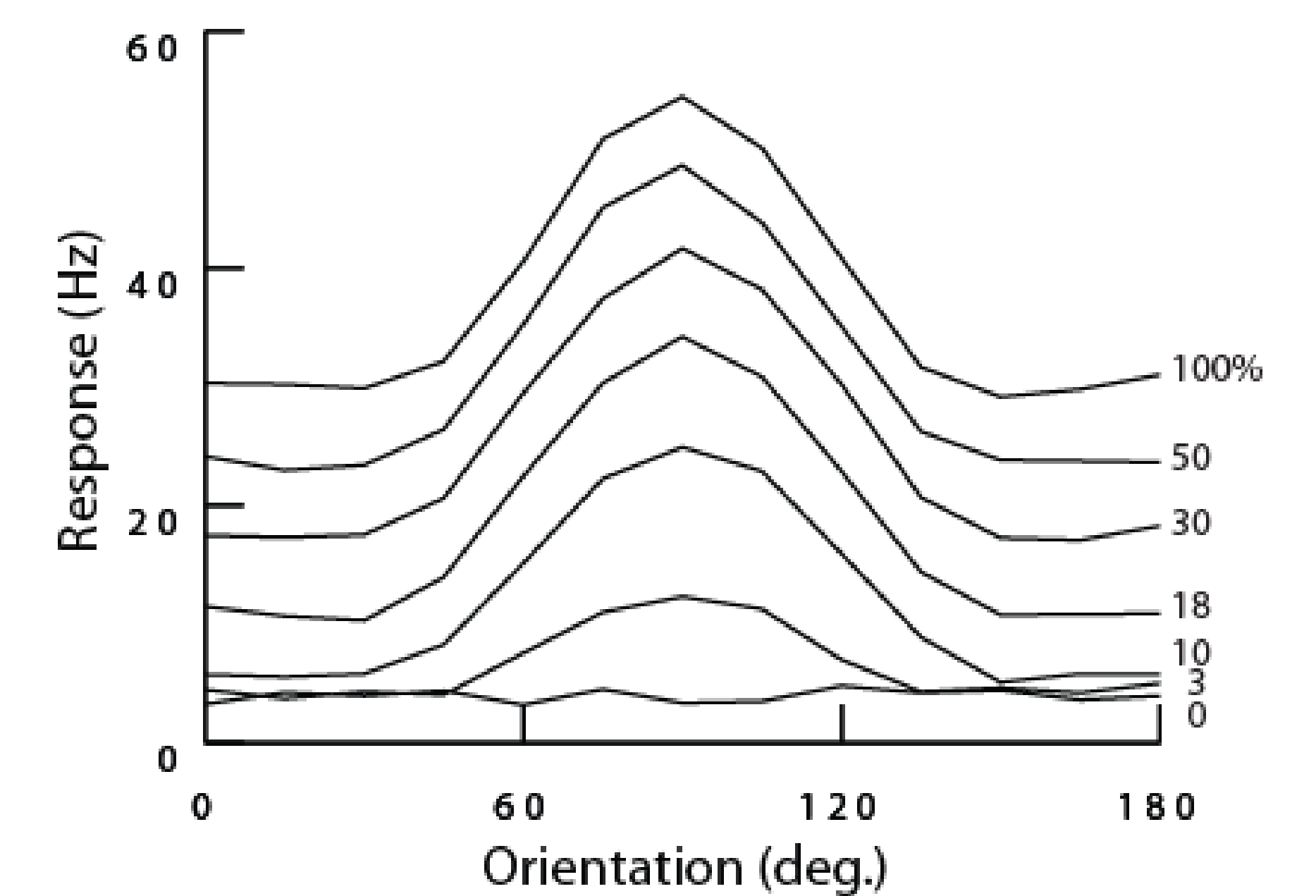
**Figure 4.** Synaptic depression causes the amplitude of postsynaptic excitatory potentials in SSC to decrease to a steady-state level with repetitive stimuli.

## Results

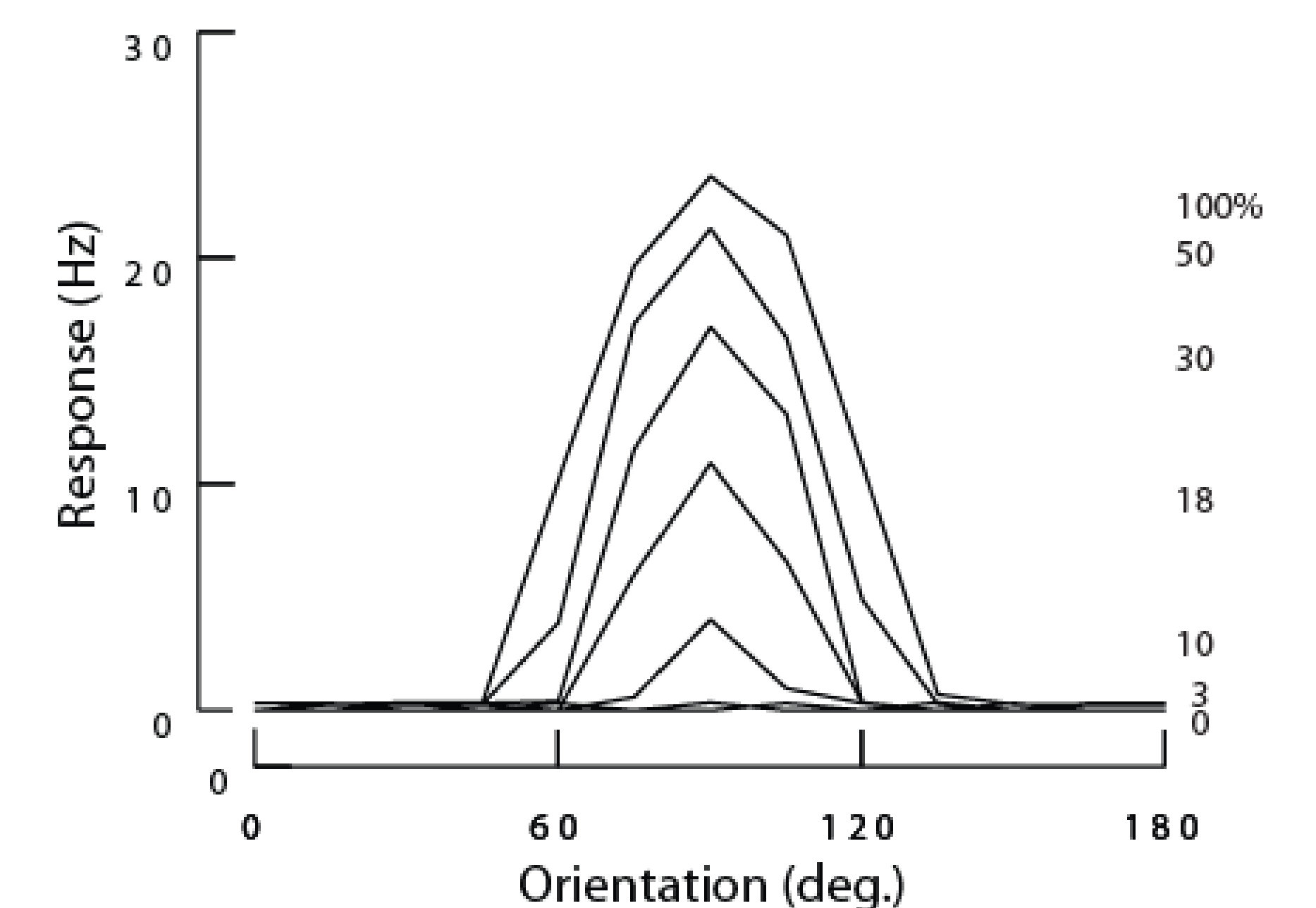


**Figure 2.** Responses of the 90 OFF-center (red) and ON-center (black) TCC in response to a drifting sinusoidal grating stimulus at 50% contrast. Cells are placed in a 9 x 10 grid as shown. **A**, Response to a stimulus with an orientation of 90 deg.; **B**, Sum of firing from 90 TCC projecting to the single SSC. **C**, Response to a stimulus with an orientation of 0 deg.; **D**, Sum of firing from 90 TCC projecting to the single SSC.

## Results



**Figure 3.** Firing responses of modeled SSC for different contrasts without synaptic depression and noise. Results of stimulus orientations varying by 15 degree increments are shown.



**Figure 5.** Firing responses of modeled SSC for different contrasts with synaptic depression. Results of orientations varying by 15 degree increments are shown. Note that the tuning width is contrast-invariant.

## Conclusion

It was concluded that synaptic depression alone, without inhibition or noise, can completely offset the global increase in activity produced with increases in stimulus contrast such that contrast-invariant orientation selectivity is produced.