Developing a normalization framework of adaptation
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1 Background
- Adaptation phenomena may arise in part from altered normalization.
- Normalization is a computational mechanism whereby a neuron's responses are modulated (typically reduced) by the activity of other neurons (normalization pool).
- Normalization signals from the receptive field surround can be weakened by adaptation. The impact of adaptation on normalization signals within the receptive field may be less direct.
- To explain the suppressive effects of adaptation — those that cannot be explained by simple fatigue mechanisms — normalization must also be strengthened by some adapters.
- Theoretical work suggests that contingent adaptation — consistently pairing a target and mask grating — should produce strengthened normalization (stronger masking). Presenting a target post mask asynchronously should weaken normalization signals.

2 Methods and experimental design
- Single- and multi-unit recordings from V1 of anesthetized macaques
- Adapt neurons for 40 s with different patterns of drifting, sinusoidal gratings within their receptive fields (1.5 deg, 1 cycle/deg, 3 Hz drift)
- Measure strength of normalization in each unit before and after adaptation

3 Example cells
- Normalization strength was measured using an Area Index (AI), calculated separately for each mask contrast

4 Population summary

5 Does summation change after adaptation?
- Normalization strength was measured using an Area Index (AI), calculated separately for each mask contrast
- Apparent adaptation-induced changes in normalization could be due to altered intrinsic excitability
- We calculated a rate-matched normalization index (NI) to measure summation, while controlling for changes in responsivity

6 Conclusions
- Normalization signals within the receptive field can be altered by adaptation.
- Normalization signals change in qualitatively different ways when a neuron and normalization pool are co-activated or driven asynchronously.
- Contingent adaptation strengthens normalization signals, even after controlling for changes in responsivity.
- Asynchronous adaptation weakens normalization signals; however, much of this effect can be explained by altered neuronal responsivity.
- The effects of contingent adaptation may provide a neural basis for contingent perceptual aftereffects.
- These results support a normalization framework of adaptation, suggesting some suppressive effects of adaptation may be due to strengthened normalization.

References