A single mechanism of temporal integration unites neural adaptation and norm-based coding

Marcelo Gomes Mattar*, David Alexander Kahn*, Sharon Thompson-Schill, Geoffrey Karl Aguirre
Center for Cognitive Neuroscience, University of Pennsylvania, Philadelphia, PA

*These authors contributed equally to this work.

Introduction:

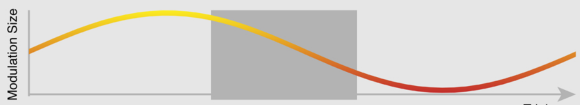
How does recent stimulus history affect neural responses to faces?

- **Neural adaptation** reflects the influence of short-term stimulus history; the neural response to a presented stimulus is reduced as a function of the distance from the previous stimulus within a multi-dimensional stimulus space.
- **Norm-based** coding suggests neural responses to faces reflect a stored prototype of the central tendency of sensory experience. Norm-based neural responses increase as a function of the distance of a presented stimulus to the center of a multi-dimensional stimulus space.
- Each effect depends on the distance between the current stimulus and a given reference point. Here, we consider that both effects are extreme versions of a single mechanism.

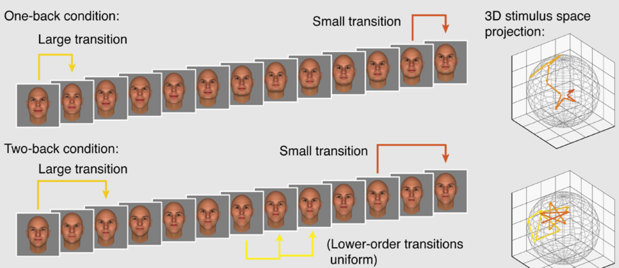
Motivation:

We observed the effect of neural adaptation at different lags; for instance whether the response to the final stimulus in a sequence such as ABA would differ from that in the sequence BBA.

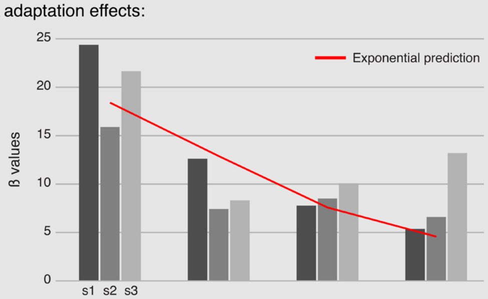
Lagged distance modulation:



Sample stimulus sequences:



Right FFA adaptation effects:

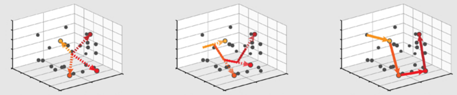


Neural adaptation effects persist for several trials, even in the presence of intervening stimuli.

Theory & methods:

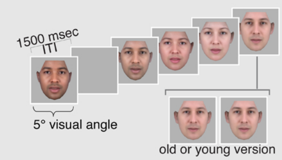
How is stimulus history integrated over time?

Neural adaptation and norm-based effects are both modeled as effects of distance. In between the two exists a continuum of intermediate models in which the reference point from which distance is calcuated drifts with variable elasticity.

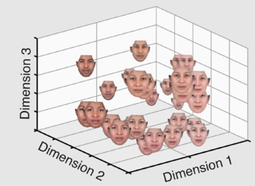


Stimuli:

Experimental design:



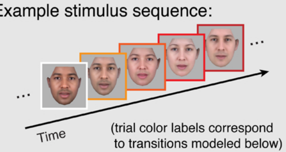
Stimulus perceptual similarity:



Region of interest analysis:

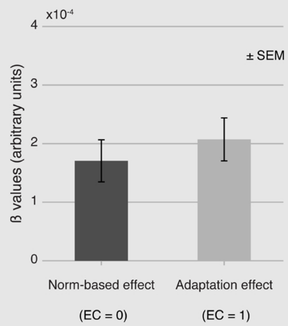
We compared traditional discrete models of norm-based and adaptation effects to a set of drifting norm models within a face-responsive ROI in the right fusiform gyrus.

Example stimulus sequence:

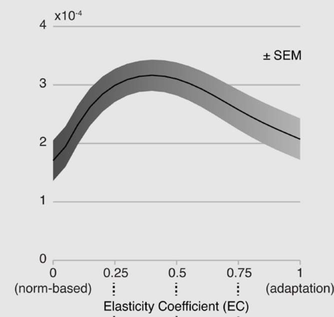


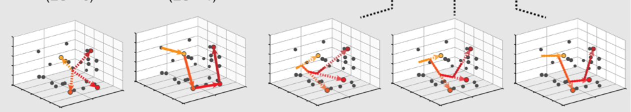
Region of interest:

Traditional discrete models:



Drifting norm model:





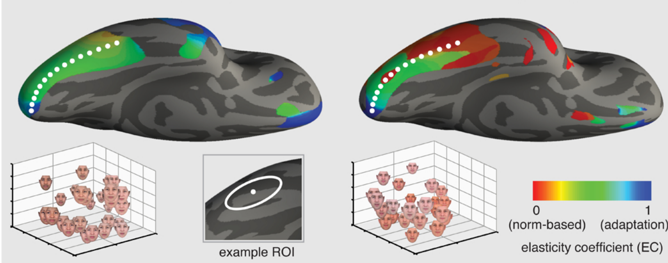
The drifitng norm model outperforms a weighted average of the traditional discrete models in all 15 subjects (larger R^2) using a leave-one-out approach.

Neural adaptation and norm-based coding can be described by a single mechanism.

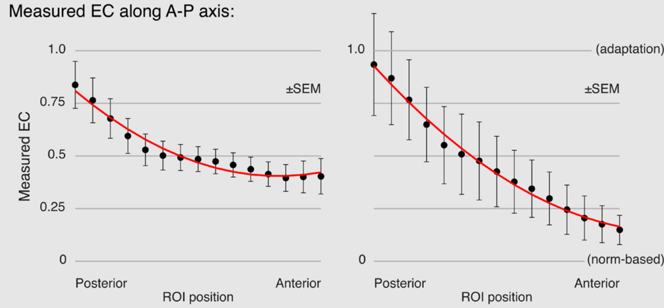
Whole-brain analysis:

We measured the peak elasticity coefficient at each cortical vertex that demonstrated a main effect of faces for two datasets.

Cortical surface maps:



Measured EC along A-P axis:



Stimulus information is integrated over longer time-scales in anterior as compared to posterior visual areas.

Acknowledgments:

This work was supported by a Burroughs Wellcome Career Development Award and NIH R01 EY021717-01.

Reprints:

https://cfn.upenn.edu/aguirre/wiki/lab_presentations