Adaptation survives intervening stimulation in area MT

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What are the timescales of adaptation?

Prolonged exposure to a sustained stimulus changes perceptual detection and discrimination of similar stimuli. These perceptual changes have been explained in terms of two changes in neuronal tuning: *reductions in gain* and *shifts in tuning* toward or away from the adaptor.

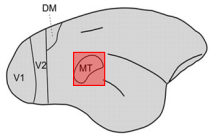
Standard adaptation protocols attempt to saturate the effects of adaptation, by presenting stimuli lasting many seconds, and testing the effects of neurons or perception immediately after adaptation ends.

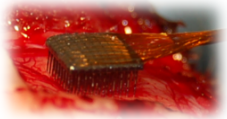
Here, we examine how adaptation lasting 33-500 ms influence neuronal tuning over time periods exceeding the adaptation duration.

Array recordings in marmoset MT

Extracellular activity was recorded from the middle temporal area (MT) in a sufentanil and nitrous oxide anaesthetised marmoset (*Callithrix jacchus*) using a 96-electrode Utah array spanning 4x4 mm of cortex.

After spike-sorting, well-isolated, direction-selective multi-units were recorded from 55 electrodes.

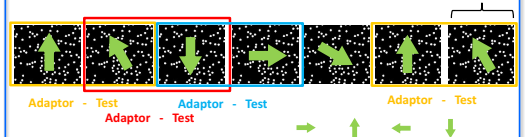




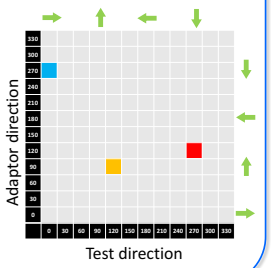
Stimuli and data analysis

Stimuli comprised continuously moving, full-screen random dots:

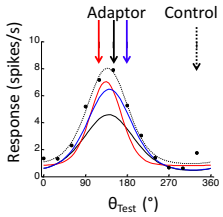
- 33 or 500 ms motion at 40 deg/s with no intervening blank period
- 12 randomly chosen directions (30° spacing)
- Presented on a VPixx LCD monitor at 120 Hz.



- Spiking rates were determined for all Adaptor-Test pairings
- von Mises functions were fit to all post-adapt tuning curves
- A neuron's preferred direction was obtained from the tuning curve after collapsing across all adaptors.
- The "control" condition comprises test responses following the adaptor closet to the anti-preferred direction.



Adaptation predominantly changes gain



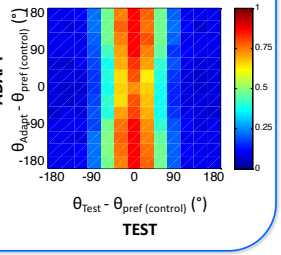
Tuning curves for a single neuron in the control condition and after adaptors 0 & ±30° from the preferred.

Responses were averaged 70-170 ms after test motion onset.

Adaptors were not customized for each neuron, and do not align with the exact preferred direction.

Population-average normalized tuning for all adapt-test pairs.

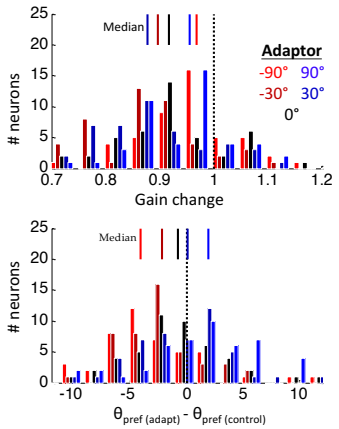
Gain reductions are primarily evident for adaptors within ±60° of the preferred direction.



Attractive shifts in post-adaptation tuning

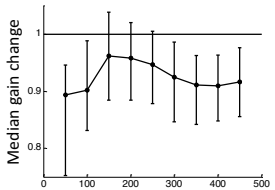
Across the population, post-adaptation gain was significantly reduced and tuning curves were shifted "attractively" towards the adaptor.

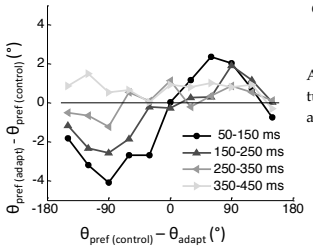
All tuning changes were measured relative to tuning observed after control adaptation in the anti-preferred direction.



Gain and shifts have different time courses

Gain reductions following adaptation to preferred direction motion (±30°) are evident throughout the test period (i.e. for 500 ms after a 500 ms adaptor).

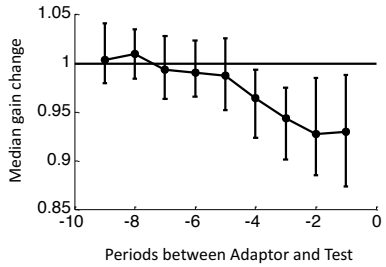




Attractive direction tuning shifts dissipate after 250 ms.

Gain changes outlast adaptor duration

Gain differences following preferred direction and anti-preferred (control) adaptation are evident even when adaptor and test are separated by up to 4 periods (2 seconds).
Responses were averaged 70-470 ms after test motion onset.



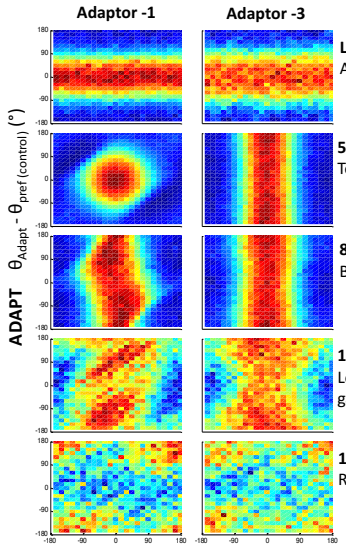
What about rapid adaptation?

Stimulus direction was updated every 33.3 ms (24 possible directions).

Panels below show population-average neuronal tuning for all Adapt-Test stimulus pairs separated by 1 or 3 motion periods.

Tuning was calculated in 30 ms windows with latencies of 0-140 ms relative to test motion onset.

Brief tuning repulsion is accompanied by long-lasting gain changes.



Latency 0 ms
Adaptor dominates

50 ms
Test response emerges

80 ms
Brief tuning repulsion

110 ms
Long-lasting gain reductions

140 ms
Recovery

Summary

- 500 ms adaptation produces brief, attractive shifts in direction tuning
- 500 ms adaptation produces long lasting gain changes (> 2 seconds)
- 33 ms adaptation produces repulsive tuning shifts and gain changes
- gain changes are small, reflecting purely direction-dependent adaptation – there is no differential contrast adaptation
- Gain reductions are consistent with a tuned normalization model in which a neuron's activation by a stimulus determines how much the neuron's sensitivity is subsequently reduced

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