Binocular integration in human vision adapts to maximize information coding efficiency

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Static binocular adaptation affects perceived direction of motion!

Background
- Li and Atick's theory of efficient stereo coding (Li & Atick, 1994; Network, 9, 157–174)
- Summation (S) and difference (S') channels decorrelates the ocular signals
- Gain control maximizes information capacity for a given energy budget and signal-to-noise ratio

Cyclopean motion

\[ Y = \cos(\beta \cos(\alpha \gamma)) \]

- \( Y = 2\gamma \), where \( \gamma = 0.25 \) c/deg, and \( \gamma \) is vertical position
- \( Y = 2\pi \gamma \), where \( \gamma = 6 \) Hz, and \( r \) is time
- Michelson contrasts: \( \alpha = 0.1; \beta = 0.02 \) in Expts 1 and 3, and 0.025 in Expt 2
- Shadlen and Carney invented this stimulus (Shadlen & Carney, 1986, Science, 232, 95–97)
- Shadlen and Carney always used \( \beta = 0 \). This gives equal signal strength in each channel, but motion is perceived in the summation (S) direction
- Perceived direction should depend on which channel (S' or S) responds most strongly
- By selectively adapting S' or S channel, we should be able to control perceived direction

Procedure
- Experiments 1 and 2: 1D 1/60 Hz noise adaptors instead of natural images
- Experiment 2 differed from Experiment 1 only in that it used 1D noise adaptors instead of natural images
- These 1D noise adaptors could be vertical or horizontal
- The cyclopean test stimulus was horizontal in all experiments
- In Experiment 3, the initial adaptation was always uncorrelated, but top-up adaptation switched between correlated and antecorrelated on alternate trials

Results and discussion
- \( S' \) channel adapts more quickly
- This fits with the idea that the adaptation achieves efficient coding; efficiency savings are maximized if efficient coding is implemented as early as possible

Adaptation of binocular channels

- Correlated Adaptation:
  - both eyes see the same image
  - S' channel stimulated
  - S channel silent

- Uncorrelated Adaptation:
  - each eye sees a completely different image
  - S and S' channels stimulated

- Antecorrelated Adaptation:
  - each eye sees the photonegative of the other eye's image
  - S channel silent
  - S' channel stimulated

- Experiments 1 and 3: four 1000 ms top-up adaptation stimuli each trial
- Experiment 3: one top-up stimulus (duration varied between sessions)

- C = Correlated adaptation (C+ and C- refer to positive and negative natural images, respectively)
- U = Uncorrelated adaptation
- A = Anticorrelated adaptation

- Dashed lines indicate significant bias from 50%
- Long dashes: \( p < 0.05 \) (two-tailed)
- Short dashes: \( p < 0.001 \) (two-tailed)

- Adaptation to static binocular stimulus affects perceived direction of motion

- Switching between correlated (C+) and antecorrelated (A) adaptation on alternate trials shows that adaptation to a single static binocular stimulus for one second can be sufficient to determine perceived direction of motion
- S' bias with short or zero adaptation duration suggests S' channel adapts more quickly

Supported by The Gatsby Charitable Foundation and BBSRC grant BB/E0025361