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The measurement of motion aftereffect by the difference of reaction time†

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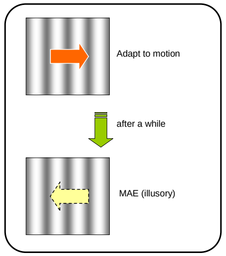
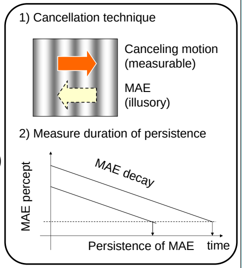
Introduction

- Motion aftereffect (MAE): illusory motion percept from static figure after prolonged observation of constant motion stimulus.
- This phenomenon has been used in various studies on visual motion mechanisms.
- In psychophysical studies, the strength of adaptation is often measured by the velocity of physical motion in the opposite direction of illusory motion percept to null (cancellation technique) or by using the duration of the persistence of MAE.





A problem

- However it is difficult to introduce behavioral tasks using these methods in the studies with non-invasive brain-activity-imaging techniques.
  - Persistence of MAE may vary trial to trial.
  - Method of adjustments (cancellation) evoke brain activities irrelevant to the study.

Purpose

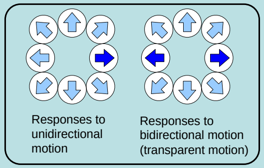
- We examine whether the *difference of reaction times* (dRT) can be used as a behavioral measure of MAE.

Experiments

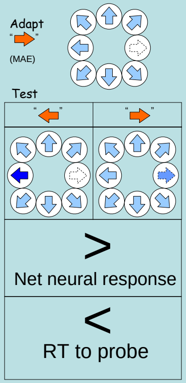
- We tested property of motion mechanisms by MAE from High- & low-spatial-frequency (SF) overlapped moving gratings (Shioiri & Matsumiya, submitted) with dRT method.
- Exp.1: Efficiency of SF components on MAE
- Exp.2: Temporal property relating to 2SF grating MAE

Rationale

- Motion sensitive areas of visual cortex have numerous neurons, each of which respond selectively to a particular direction of motion.

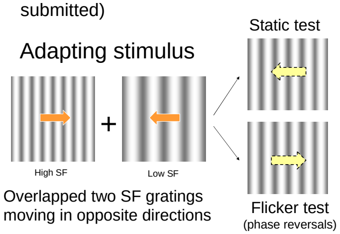


- Motion percepts can be coded by the net response of such neurons.
- The net neural responses among motion directions would be changed by adaptation.
- If reaction time (RT) to motion onset reflects net intensity of neural activity (Amano et al, 2006), the reaction time to the probe stimuli in the same and opposite directions of motion could be different.



- MAE from overlapped moving gratings of two spatial frequency (SF) (Shioiri & Matsumiya, submitted)

Adapting stimulus



Overlapped two SF gratings moving in opposite directions

Different MAE from same adapter.

Two or more motion mechanisms

Exp.1 Efficiency of two SF components on MAE

Methods

Stimuli: sinusoidal overlapped gratings (size: 10 deg x 10 deg, separated by 2.4 deg around a fixation point)

Spatial frequency: 2.0 cycles/deg. (high SF)
0.5 cycles/deg. (low SF)

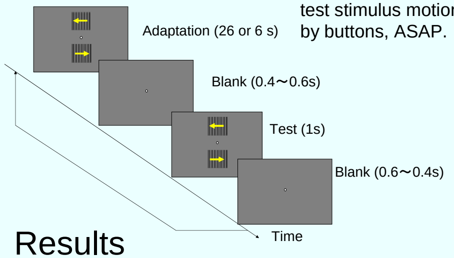
Test stimulus contrast: threshold ×10

Adapting stimulus contrast: (Low SF: 0, High SF: θ×200), (L: θ×25, H: θ×150), (L: θ×50, H: θ×100), (L: θ×75, H: θ×50), (L: θ×100, H: 0)

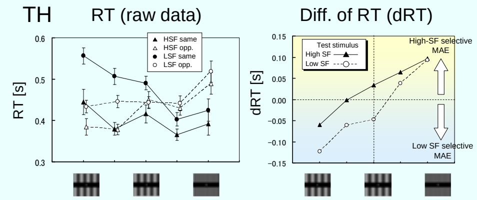
Adapting and test stimulus temporal frequency: 5Hz

Procedure

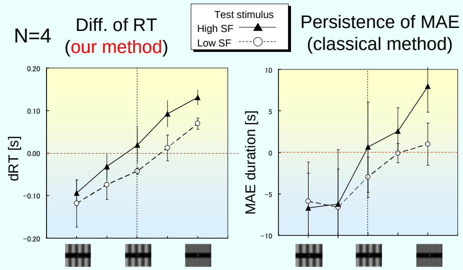
Subject's task was to report the direction of test stimulus motion by buttons, ASAP.



Results



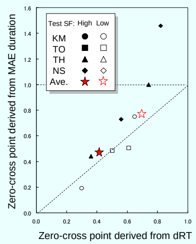
Adapting-grating relative contrast (High SF / Low SF)



Adapting-grating relative contrast (High SF / Low SF)

- dRT result shows clear monotonic changes in the efficiency of adaptation as relative SF contrast vary, and this is consistent with classical method.
  - Points crossing vertical axes show MAE switches to the SF of test stimulus.

Comparison between methods



- Estimated points that cross horizontal axis (i.e., efficiency of two SF gratings on MAE balance) were compared between the two methods.
- Consistent result is observed between these methods.

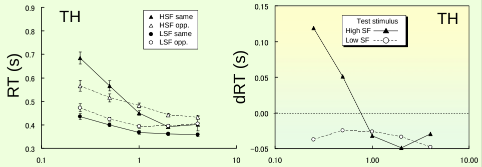
- Our dRT method was able to measure MAE direction changes consistently.

Exp.2 Temporal frequency profile of 2SF overlapped grating MAE

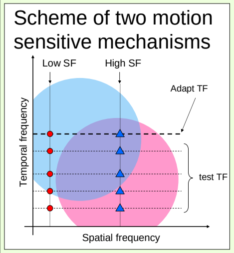
Methods (difference from Exp.1)

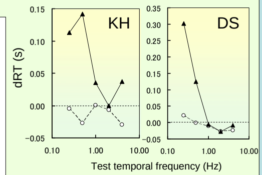
- Adapting stimulus:
  - Two overlapping moving gratings (High + low SF)
  - Contrast: Low SF: θ×32, High SF: θ×32
  - Temporal frequency: 5 Hz
- Test stimulus:
  - Either high or low SF moving grating
  - Contrast: threshold ×32
  - Temporal frequency: 0.25, 0.5, 1.0, 2.0 and 4.0 Hz

Results



Test temporal frequency (Hz)





- High-SF sensitive mechanisms show larger MAE at lower temporal frequency, while low-SF-sensitive system shows smaller MAE changes.

The present result supports the scheme of two motion mechanisms proposed by Shioiri & Matsumiya.

Summary & Discussion

- Our *dRT* method allows us to measure MAE successfully during a procedure like event-related-brain-activity measurements.
- Since the difference of RT (dRT) is an indirect measure, the results are not biased by subject's intension. This is a clear and big advantage to the classical methods.
- Temporal frequency profile supports existence of two (or more) motion sensitive mechanisms with different spatio-temporal frequency characteristics.

References

- Shioiri S. and Matsumiya K., (submitted).
- Amano K. et al., *J. Neurosci.*, 2006.