More predictive, easier to detect? Contrast sensitivities in different predictability contexts

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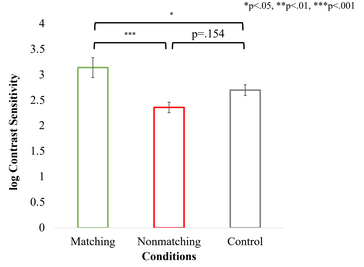
Introduction

Predictive processing in perception

Top-down information such as prediction can aid bottom-up sensory processing, with much evidence that prediction signals can lead to both neural and behavioral differences in broad levels of the processing hierarchy [1].

Our previous study showed higher contrast sensitivity to simple low-level targets matching the predictive information compared to those not matching or without such information, even in the situation that engagement of higher-level brain areas are unnecessary [2].



Song et al., 2023.

Can predictive processing be modulated?

Building on this finding, we explored whether this behavioral enhancement effect can be modulated by the degree of predictability—such that more predictive targets will be easier to detect than less predictive targets.

References

[1] Bar, M. (2004). Visual objects in context. *Nature Reviews Neuroscience, 5*(8), 617-629.
[2] Song, S., Park, M., & Kim, C-Y. (Nov, 2023) Behavioral evidence of predictive coding: Contrast sensitivity enhanced for stimuli matching the prediction from the preceding information, Neuroscience 2023, Washington, D.C.

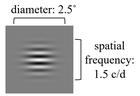
Methods

• Participants

- 29 participants (19-35 years of age, 9 males)

• Stimuli

- Gabor patches

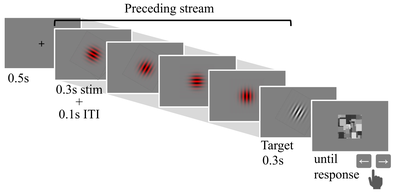


• Procedures

1. Main Session

- 1-up-1-down adaptive staircase method to measure the 50% contrast threshold (sensitivity = 1/threshold)

- 2-AFC task of reporting the tilted orientation (left/right) of the achromatic target Gabor patch

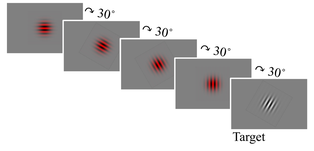


- Conditions

1) Predictability conditions: preceding stream gave the impression of rotation in a certain direction, and the target orientation also matched the stream rotation

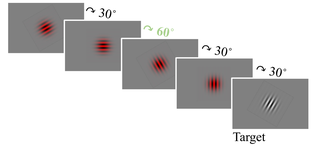
Strong

: the step angles of the rotation stream were regular (30˚)



Weak

: among the regular step angles of the rotation stream, an irregular 60˚ step was introduced

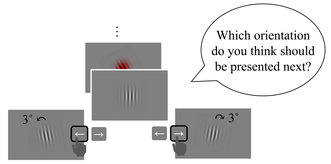


2) Control condition: the preceding stream was presented in random angles

2. Post-test Session

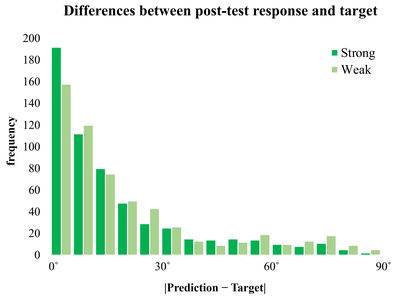
- Task of adjusting the orientation predicted to appear following the preceding stream of Gabor patches

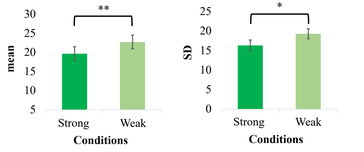
- Responses for predictability conditions were recomputed as differences between response and target in absolute value



Results

• Manipulation check





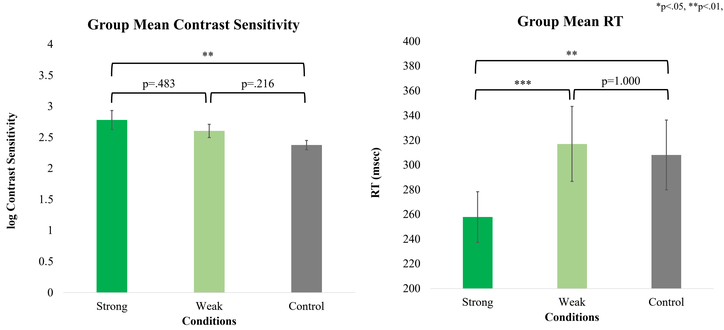
*p<.05, **p<.01, ***p<.001

- Successful experience of prediction: differences showing a dense distribution towards 0 in both Strong and Weak

- Successful manipulation of predictability: stronger and more consistent experience of prediction in Strong compared to Weak

• Behavioral enhancement effect found according to predictability

*p<.05, **p<.01, ***p<.001

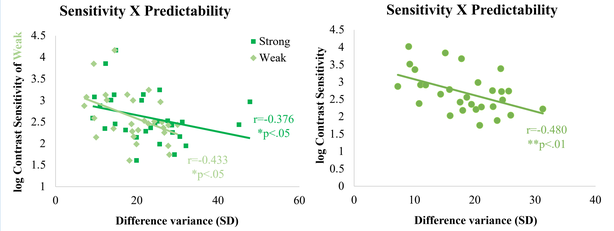


- Enhanced performance on both contrast sensitivity and RT in Strong compared to Control

- Modulated enhancement on contrast sensitivity and absence of such effects on RT in Weak

• Modulation of enhancement effect found according to predictability: The stronger the prediction, the higher the sensitivity

*p<.05, **p<.01, ***p<.001



- Negative correlation between Weak sensitivity and Strong/Weak difference variance

- Pooled the two predictability conditions together for continuous parameter of predictability

- Again found the negative correlation

Conclusions

- Our study replicated the existence of predictive effects in even the lowest levels of the visual processing hierarchy.

- Strong and consistent predictive information led to enhancement in detection performance on its matching target. This effect was modulated by predictability—weaker predictability led to lower sensitivity.

- RT was speeded only when prediction was sufficiently strong and consistent, with no modulation.

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