A Bayesian Hierarchical Model of Flanker Interference

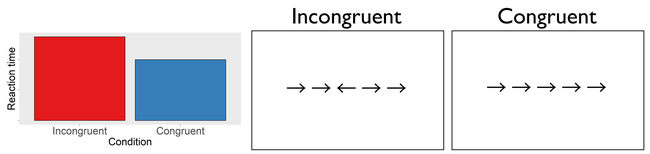
Honami Kobayashi[1], Hiroyuki Muto[2], Hiroshi Shimizu[1], Hirokazu Ogawa[1]

[1]Kwansei Gakuin University, [2]Ritsumeikan University

Introduction

Eriksen flanker task: identify the central stimulus (target) while ignoring flanking stimuli (flankers)

- Flankers congruent or incongruent with the target
- Responses delayed compared to congruent trials

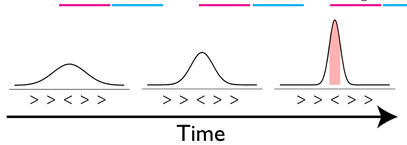


Shrinking spotlight model (White et al., 2011)

- During the time course of a trial, the attentional spotlight narrows to focus on the target stimulus
- The model rested on two assumptions:
  1. The attentional spotlight is first **normally** distributed over the stimulus
  2. The rate of information accumulation, which drives a response, is determined by **the sum of perceptual input value** weighted by **the amount of attentional resources** allocated to each stimulus

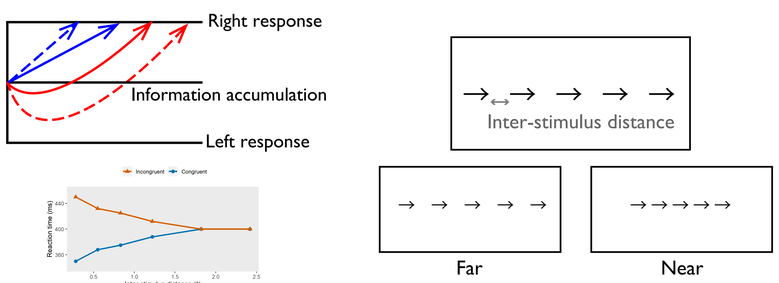
  →i.e., Addition model

$$v(t) = 2\alpha_{outer}p_{outer} + 2\alpha_{inner}p_{inner} + \alpha_{target}p_{target}$$



Question: Can this model explain what happens when the inter-stimulus distance is manipulated?

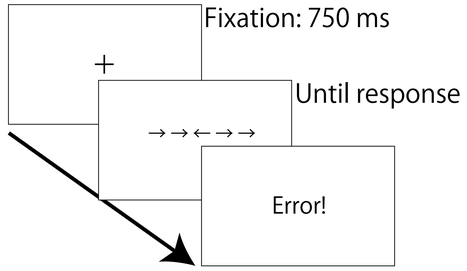
- According to the assumptions of the addition model, more attentional resources should be distributed over the stimuli in a "near" than in a "far" condition



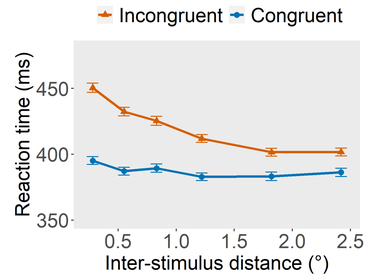
▲ Predicted reaction time based on the model by White et al. (2011).

Methods & Behavioral Data

- 30 undergraduate students participated
- Respond to identify whether the target is pointing right or left, while ignoring flankers
- Six levels of inter-stimulus distances used:
  - 0.28, 0.55, 0.83, 1.22, 1.82, 2.42 degrees of visual angle
- Flankers either congruent or incongruent with the target
- Drift diffusion model (Ratcliff, 1978) used to model the reaction time and accuracy in the task



▼ The median reaction time in the flanker task. Error bars represent the standard error values.

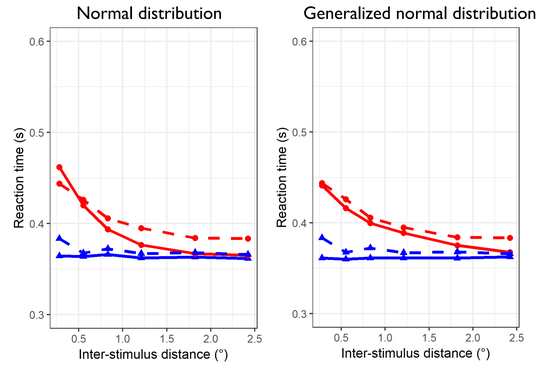


Modeling and Results

- The addition model does not explain the change in reaction time when the inter-stimulus distance is manipulated
- Our model assumptions:
  1. The attentional spotlight is first **normally** distributed over the stimulus
  2. The rate of information accumulation is determined by **the ratio of perceptual input value from the target to the input value from the flankers** weighted by the amount of attentional resources allocated to each stimulus →i.e., Ratio model

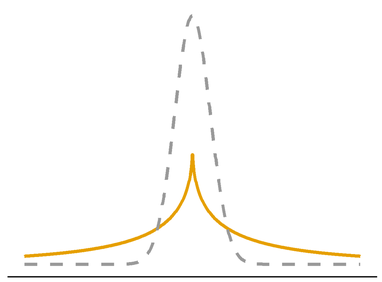
$$v(t) = \alpha_{target}p_{target} / (\alpha_{target}p_{target} + \alpha_{flanker}p_{flanker})$$

The input from the target / The sum of the perceptual input



▲ The estimated reaction time based on our ratio model. The solid lines represent the estimated values, and the dashed lines represent the median reaction time obtained in the experiment.

Discussion



▲ The illustration of the generalized normal distribution with the shape parameter β = 0.52 (the yellow line). The grey dashed line represents the normal distribution with the same width.

- The assumption that the attentional resources are normally distributed does not fit well with the data
- The ratio model describes the congruent trials well
- An exploratory estimation with a generalized normal distribution resulted in a more converged distribution with heavier tails
- Implications:
  1. Attention is distributed in a more focused manner than the normal distribution assumed, in addition to a slower reduction at greater distances from the center
  2. The rate of information accumulation is based on the ratio of target-like information to other information, rather than the sum of all the information

References

Eriksen, B.A., & Eriksen, C.W. (1974). Effects of noise letters upon identification of a target letter in a non-search task. *Perception & Psychophysics, 16*, 143-149.

Ratcliff, R. (1978). A theory of memory retrieval. *Psychological Review, 85*, 59–108.

White, C. N., Ratcliff, R., & Starns, J. J. (2011). Diffusion models of the flanker task: Discrete versus gradual attentional selection. *Cognitive Psychology, 63,* 210-238.

For further information, please contact: honami-k@kwansei.ac.jp