Self-Pacing in an Attention-Demanding Search Task Enhances Stimulus Discriminability and Reduces Uncertainty

#3025

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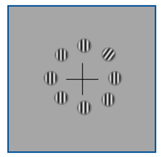
METACOGNITIVE CONTROL OF ATTENTION

Self-pacing of attention tasks improves performance (Patel et al., 2023)

Experimental Task

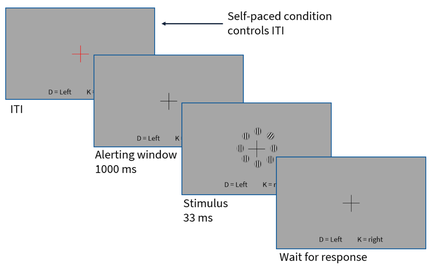


Report orientation (left or right) of angled Gabor patch among vertical patches

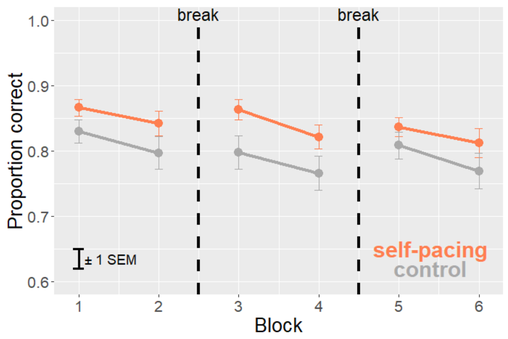
Example when n = 8

EXPERIMENT 1: Replication of benefit of self-pacing

Method
n = 50; n of trials = 432
Task calibrated for each subject to 80-85% accuracy.



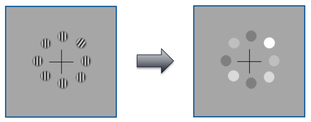
Results



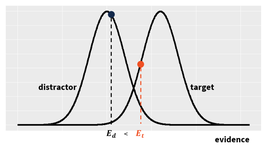
Experiment 1 successfully replicated:
- the benefit of self-pacing: superior performance by self-pacers
- vigilance decrement: downward slope between breaks
- the benefit of breaks: performance improvement after breaks

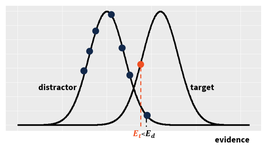
MODEL OF ATTENTION CAPTURE

Model Assumptions



The physical stimulus is converted to an activation map by sampling from two Gaussian distributions





1. Each stimulus yields independent evidence for tilt.

2. The angled stimulus yields probabilistically more evidence than vertical stimuli.

3. For each stimulus, the model samples one time from its corresponding distribution. Attention is drawn to the stimulus that yields the highest evidence.

4. When the target is identified, subjects respond correctly; when a distractor attracts attention, subjects respond with chance level accuracy.

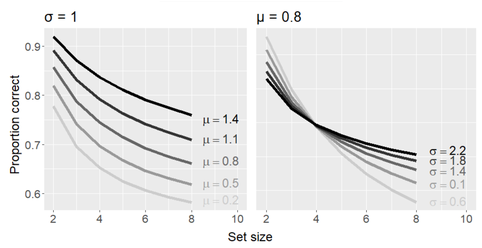
Model Parameterization

$$P(C) = \int_{-\infty}^{\infty} [f_t(x) G_d^{n-1}(x)]dx + 0.5 \int_{-\infty}^{\infty} [(n-1) f_d(x) G_d^{n-2}(x) G_t(x)]dx$$

$$f_d(x) \sim N(0,1) \qquad f_t(x) \sim N(\mu, \sigma)$$

where n is set size, $f_d(x)$ and $f_t(x)$ are normal density distributions, and $G_d(x)$ and $G_t(x)$ are distribution functions (model adapted from Eckstein, 1998)

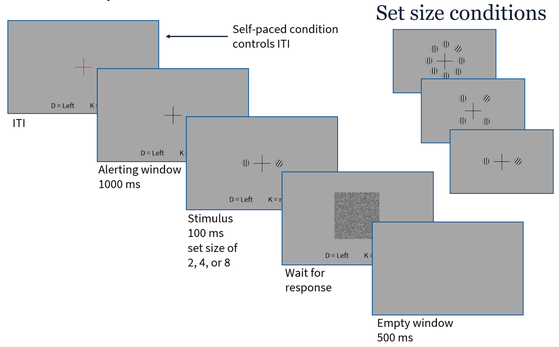
Model Simulation



Effect of varying μ and σ on performance as a function of set size

EXPERIMENT 2: Varying set size and fitting model

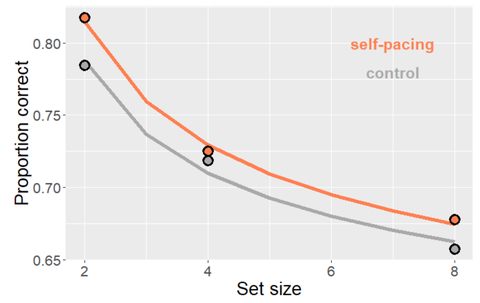
Method
n = 210; n of trials = 480
Task calibrated for each subject to 70-75% accuracy at set size of 4



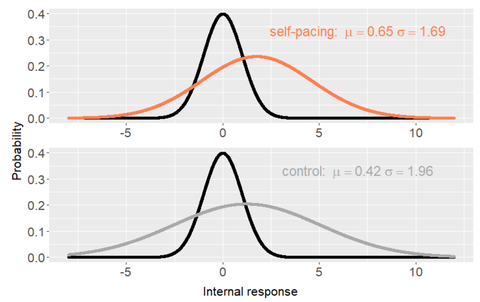
Results

We used 5-fold cross-validation and grid search to reach the conclusion that both μ and σ need to vary between conditions to describe the full dataset.

Four models (2μ-2σ, 2μ-1σ, 1μ-2σ, 1μ-1σ) were compared. The winning model 2μ-2σ indicated that self-pacing increases the target mean and decreases target variance.



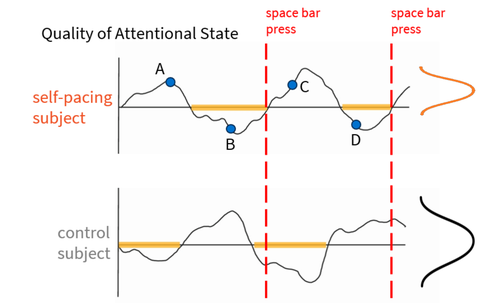
Points are behavioral data. Curves are model fits.



Distractor and target distributions in the self-pacing and control conditions.

DISCUSSION

Metacognition allows self-pacing subjects to wait out moments of inattention.



Waiting for moments of inattention to pass results in higher signal strength and lower variability.

Metacognitive control of self-pacing appears to benefit attention by enhancing the detectability of targets and minimizing target presentations during moments of lessened attention.

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References

Eckstein, M. P. (1998). The lower visual search efficiency for conjunctions is due to noise and not serial attentional processing. *Psychological science, 9*(2), 111-118.

Patel, T. N., Steyvers, M., and Benjamin, A. S. (2023). The metacognition of vigilance: Using self-scheduled breaks to improve sustained attention. *Manuscript under review.*

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