Pupillary Response Indicates the Resolution of Proactive Interference in a Visual Working Memory Task

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Motivation

Cognitive effort, as indexed by pupil diameter, affects proactive interference (PI) resolution during verbal memory retrieval (Johansson et al. 2018). It is unclear how effort is implicated in PI resolution in visual working memory.

In Study 1 (online), we tested the strength of PI in a VWM task. In Study 2 (in lab), we assessed the role of cognitive effort in PI resolution.

Introduction

Working memory (WM) is a capacity-limited system that temporarily increases information availability for in-the-moment processing (Cowan, 2017).

WM's capacity limits are in part due to **proactive interference (PI),** which occurs when currently irrelevant, previously learned information disrupts the retrieval of relevant, more recently learned information.

Cognitive effort is needed to resolve proactive interference. In a verbal task, Johansson et al. (2018) showed that pupil diameter, a proxy for cognitive effort, was associated with PI level and PI resolution dynamics during a verbal word list recall task.

In **visual working memory (VWM)** paradigms, the importance of PI is debated (e.g., Endress & Potter 2014; Lin & Luck 2012). The role of cognitive effort in PI resolution in VWM has not yet been studied.

Participants

Study 1: N = 32, mean = 25, range = 18 - 33 (online)
Study 2: N = 33, mean = 20, range = 18 - 30 (in lab)

*Exclusion criteria: accuracy not significantly >25% (chance), >75% pupil data missing, or performance on verbal questions < 70%.

Lab Publications ***Preregistration***

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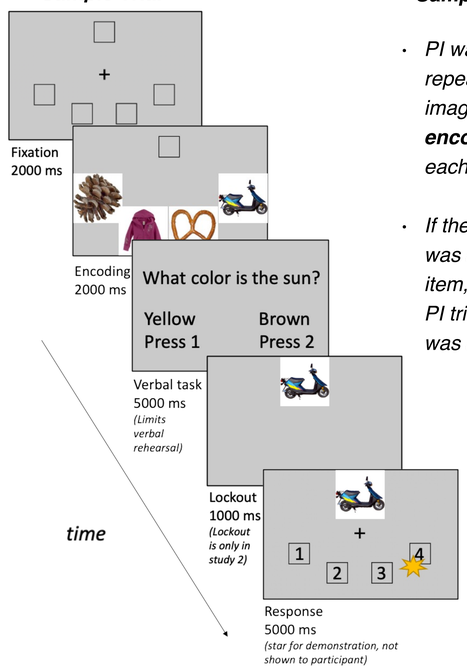
Methods

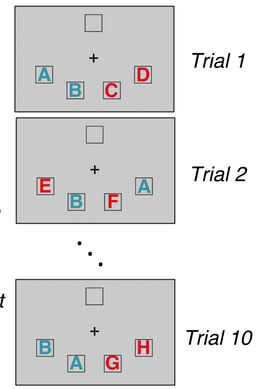
Delayed Match Retrieval Task (Kaldy et al. 2016)

Sample Trial



Sample block (encoding periods only)

- *PI was induced by repeating two images during **encoding** across each trial in a block.*
- *If the response item was a repeated item, the trial was a PI trial. Otherwise, it was a NoPI trial.*



Stimuli

- *Images from Brady et al. (2008)*
- *Presented in grayscale (shown in color for clarity)*
- *Images were made isoluminant to control luminance-driven pupil response*
- *True size: 3.5° X 3.5°*

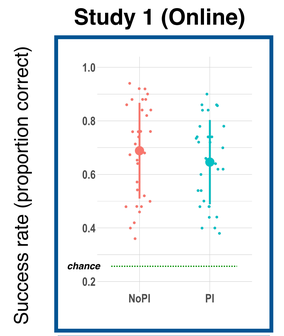
- We employed a within-participants design
- Behavioral responses were recorded by keyboard number press

Pupil Analysis

- A Tobii TX300 eye tracker was used to collect pupil and eye movement data
- Pupil data were filtered, cleaned, and baseline corrected using the PupillometryR pipeline created by Forbes (2020)

Results

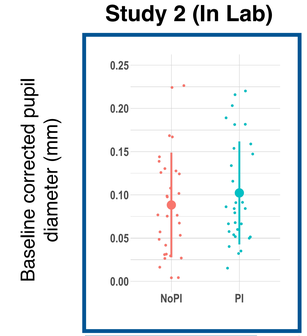
Performance is lower during PI trials



Study 1 (Online): t(31) = 3.68, p < 0.01; Mean of differences: 0.043; Cohen's dz - 0.65

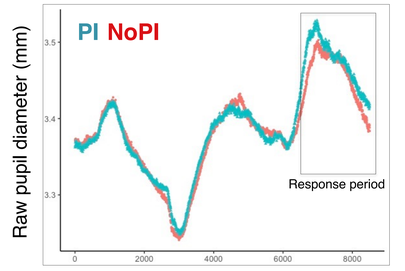
Study 2 (In Lab): t(32) = 3.39, p < 0.01; Mean of differences: 0.049; Cohen's dz = 0.59

Pupil dilation is larger during PI trial retrieval

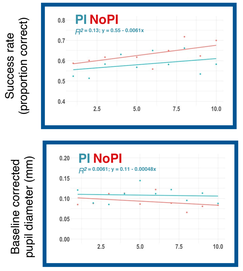


Study 2 (In Lab): t(32) = -2.77, p < 0.01; Mean of differences: 0.016; Cohen's dz = 0.48

Visualization of the pupil trace collapsed across participants and trials (Study 2, In Lab)



PI does not accumulate across trials (Study 2, In Lab)



Success rate is unrelated to pupil size (Study 2, In Lab)

trial-by-trial Kendall correlations

PI trials only:

Kendall's τ = 0.014

NoPI trials only:

Kendall's τ = 0.019

Both:

Kendall's τ = 0.015

Discussion

- Pupil dilation was larger in the PI condition, indicating that participants exerted more cognitive effort in those trials
- However, the amount of pupil dilation did not correlate with performance. We interpret that by the time the target item is presented, increased effort does not afford better performance.
- Future directions include replicating Study 1 with a larger sample and adapting the task to children

Acknowledgment & References

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