A hands-free visual search task to assess selective attention and working memory in children

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Background

- **Executive functions (EFs)** are key to quality of life, affecting job performance, mental health, and interpersonal relationships.[1]
- Covert and overt attention can be measured through **eye tracking**.
- This is also related to **locus coeruleus noradrenaline (LC-NE)** activity, a system indexable through pupillometry.[2]

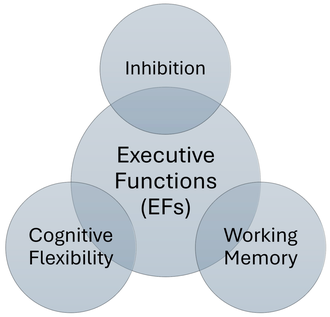

Fig 1. Primary EFs.[1]

- These relationships between pupillometry, eye tracking, and attention can enable ways to assess EFs.[3]

Objectives

1. Determine the relationship between pupillometry and visual search performance.
2. Examine feasibility of using task to assess EFs in **vulnerable populations**.

Methods

- We developed a **cluttered hands-free visual search task**, where participants were asked to locate a known character in a cluttered scene.
- Young adults [n=15, mean age: 25.5 ± 3.4 years] were recruited to complete task. Participants completed 30 scenes twice with different target characters for a total of 60 trials per participant.

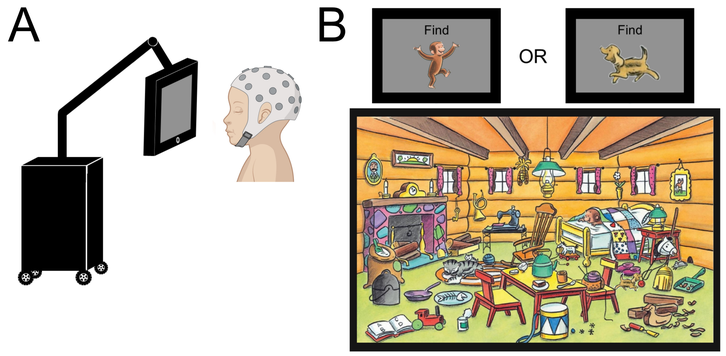

Fig 2. Task set up with custom cart and eye tracker (A). Search prompt and image display (B).

- Task performance indexed by **search time** and **strategy,** characterized by time spent in unseen locations (novel), instead of previously searched areas (redundant search).
- Linear mixed models were used to identify pupil and performance relationships with image and participant as random effects.

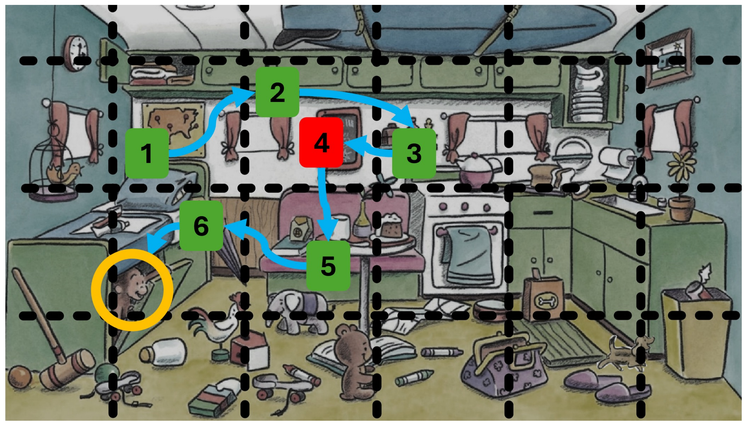

Fig 3. Search efficiency schematic with points showing gaze position, point 4 is redundant as gaze returns to a previously searched bin.

Results

- Mean time to task completion was 3.21 ± 4.29 seconds with 87.5 ± 19.6% of search being novel.
- Pupil size was smaller during novel as compared to redundant search. (β = -0.353, SE = 0.112, 95% CI [-0.573, -0.132], p=0.002).

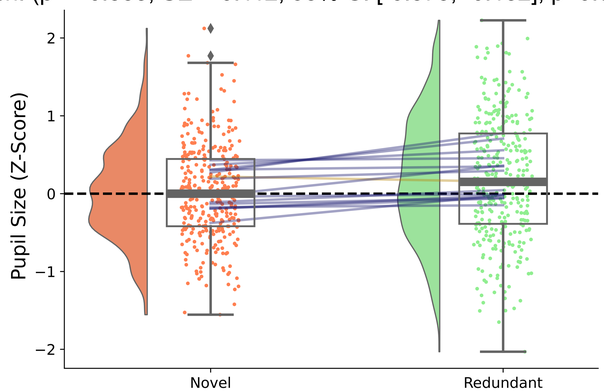

Fig 4. Comparison of pupil size during novel and redundant search.

- Larger and more variable pupil sizes were associated with:
  - Longer search time (β_{size}: 1.21, p<0.001, β_{stdv}: 10.62, p<0.001)
  - Less novel search (β_{size}: -0.38, p=0.006, β_{stdv}: -6.99, p<0.001)

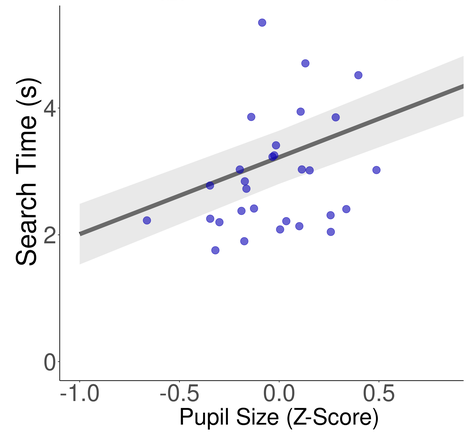

Fig 5. Effect of search time on pupil size. Regression fit with linear mixed model. Points are image means, with one removed for display.

Conclusion

- Hands-free visual search task developed with exclusive eye tracking analysis allowing for **accessible completion** by those who can't complete traditional cognitive testing.
- Decreased task performance was found with increasing pupil sizes as measured through search time and strategy.
- Future work includes larger studies in vulnerable populations, investigating the correlations between search efficiency and additional metrics, and finalizing a manuscript for publication.

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