Ocular tracking abilities in preadolescent children

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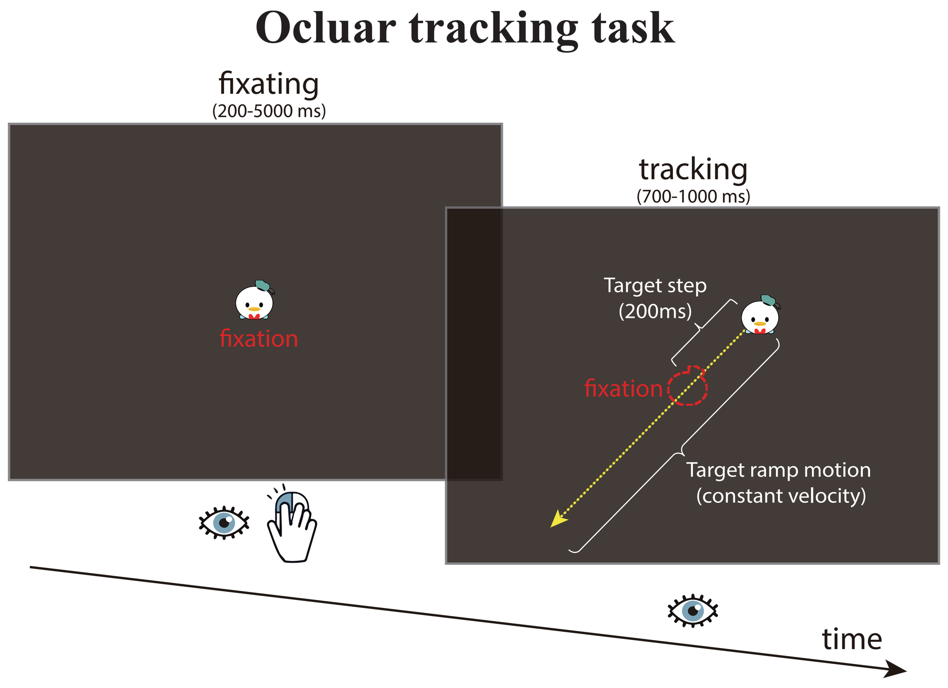
Introduction

Humans combine smooth pursuit and saccades in ocular tracking of moving objects of interests. Although many studies have examined ocular tracking in children, these studies used predictive targets or stimuli of low uncertainty, thus ocular tracking abilities were assessed in conjunction with predictive error correction abitilites instead of on their own. In addition, very few studies to date have examined the development of ocular tracking abilities from children to adults. The current study aims to address these research gaps.

General Methods

Oclar tracking task



(Rashbass, 1961; Chen et al., 2021; Chen et al., 2022)

Participants: 81 children aged 8-9 years (female/male: 47/34) and 77 adults aged 18-30 years (female/male: 43/34).

Four different aspects of ocular tracking (12 metrics)

Stage of ocular tracking	Aspects of ocular tracking	Oculometric measures	Function
Open-loop	Pursuit initiation	Latency	Measuring smooth pursuit
		Open-loop acceleration	
Closed-loop	Steady state tracking	Pursuit gain	
		Proportion smooth	
		Saccadic amplitude	Measuring coordination between smooth pursuit and saccades
		Saccadic dispersion	
		Saccadic rate	
Open-loop	Direction tuning	Direction noise	Measuring the visual processing of target motion signals during ocular tracking
		Anisotropy	
		Asymmetry	
Closed-loop	Speed tuning	Speed noise	
		Speed responsiveness	

Task: keep head still and track the **unpredictable** step-ramp motion of a cartoon target (0.64°) with its speed (16-24°/s) and moving direction (0°-360°) randomly varied from trial to trial.

Serial dependence in pursuit direction (open-loop vs. closed-loop response)

Open-loop response: the 160-ms interval immediately following smooth pursuit onset eye movements are primarily driven by input target motion

Closed-loop response: the interval from 400 to 700 ms after target motion onset eye movements are also driven by extra-retinal information

Serial dependence

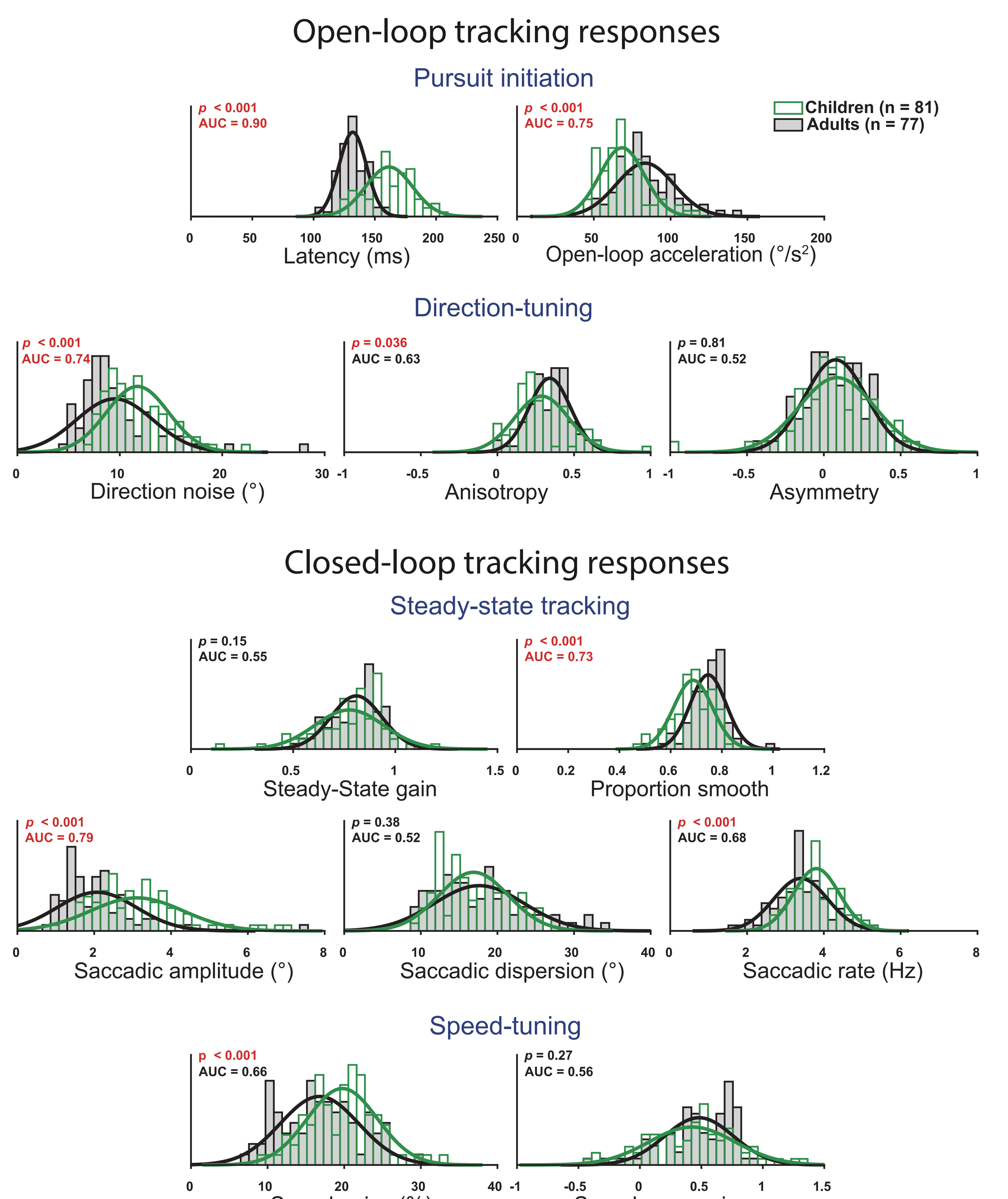
Pursuit direction error (D_E) : the difference between pursuit direction and the target moving direction

The relative target moving direction of the previous trial (D_{Rn}): the difference between the target moving direction in the nth previous trial (n = 1, 2, 3, etc.) and the current trial

Serial dependence effect: pool the D_E and the corresponding D_{Rn} of all participants in each group (adults or children) and fit a first derivative of a Gaussian function. The magnitude of the fitted curve peak indicates the amplitude of serial dependence effect.

Results

Oculometric measures



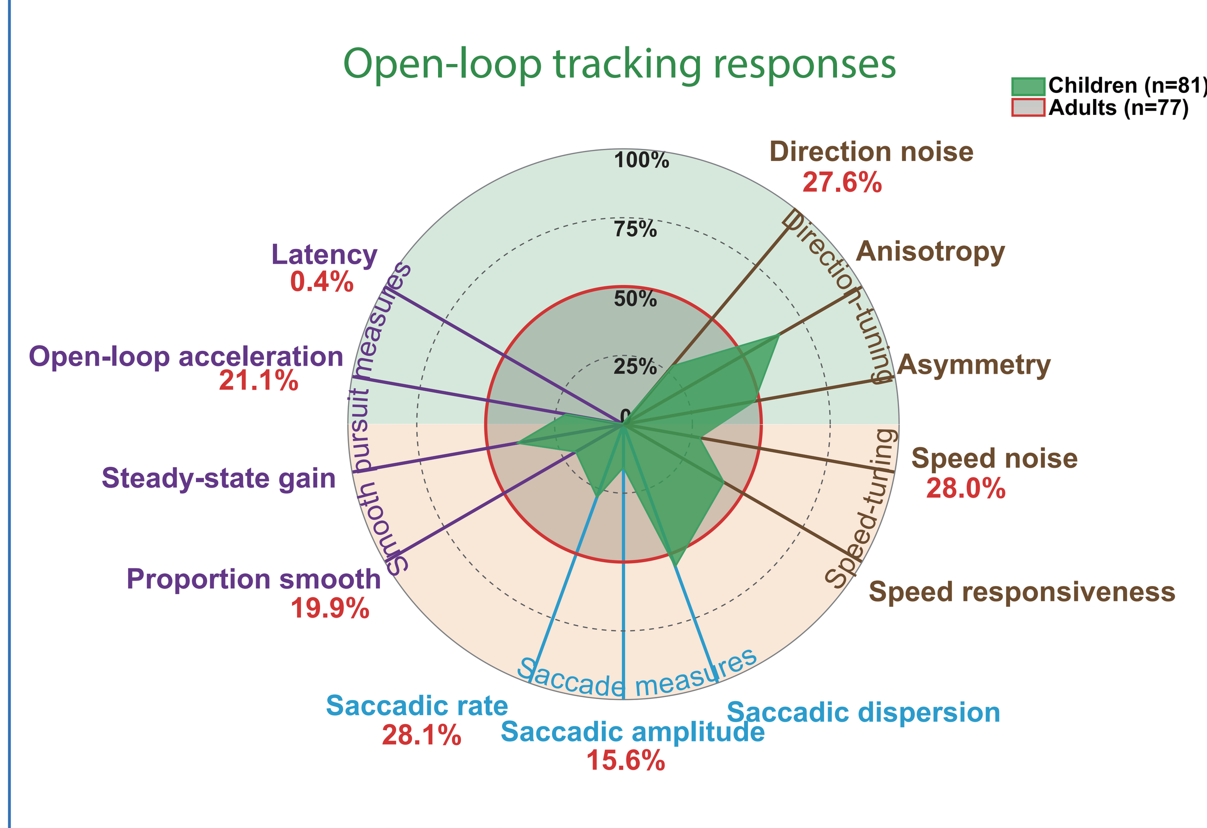
- Smooth pursuit
  - prolonged latency and slower eye acceleration in children
  - lower proportion of smooth pursuit in children
- Coordination between smooth pursuit and saccades
  - larger catch-up saccadic amplitude and higher saccadic rate in children
- Visual processing of target motion signals during ocular tracking
  - response magnitudes (except for anisotropy) for open-loop pursuit direction and close-loop tracking speed were similar in children and adults but both were less precise in children than in adults.

Converted percentages of oculometric measures

Children's mean values for each oculometric measure were converted into percentages with respect to the adult population, using adults' performance as the normative standard.

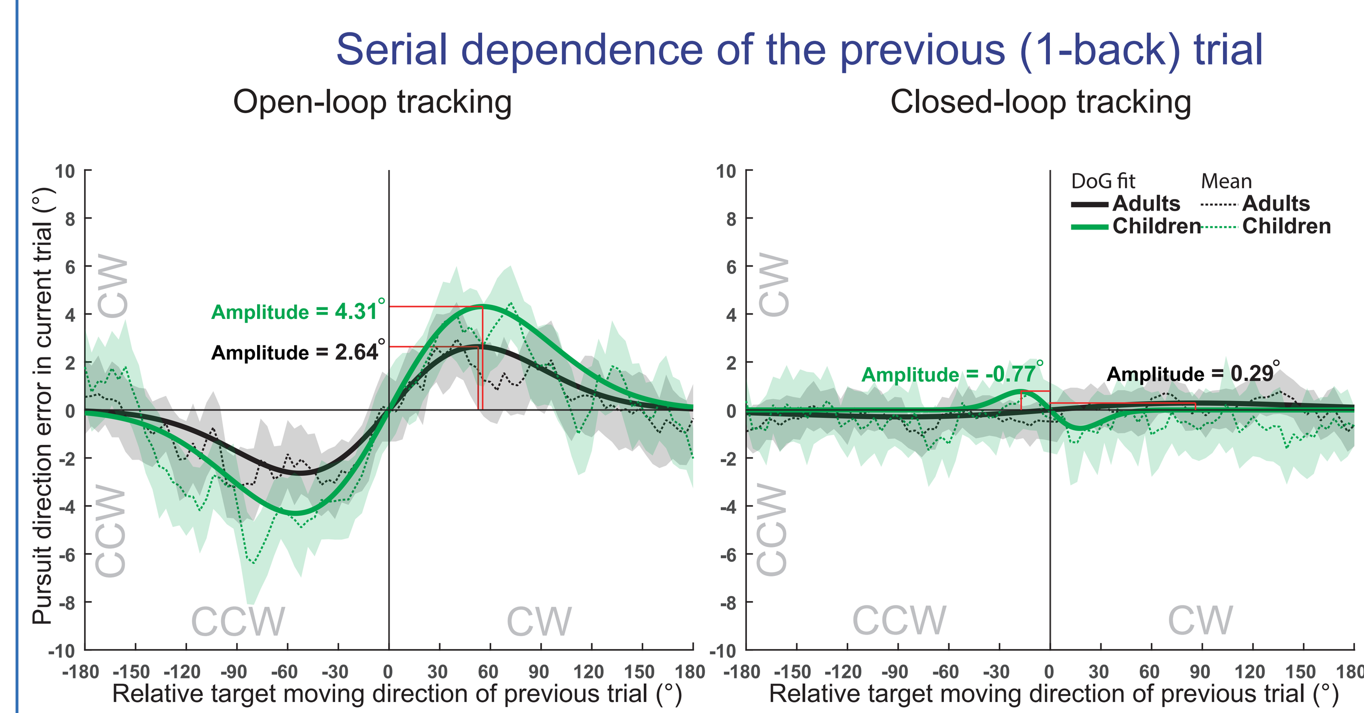
The percentages smaller than 50% (representing adults' mean values) indicate worse performance in children and vice versa.

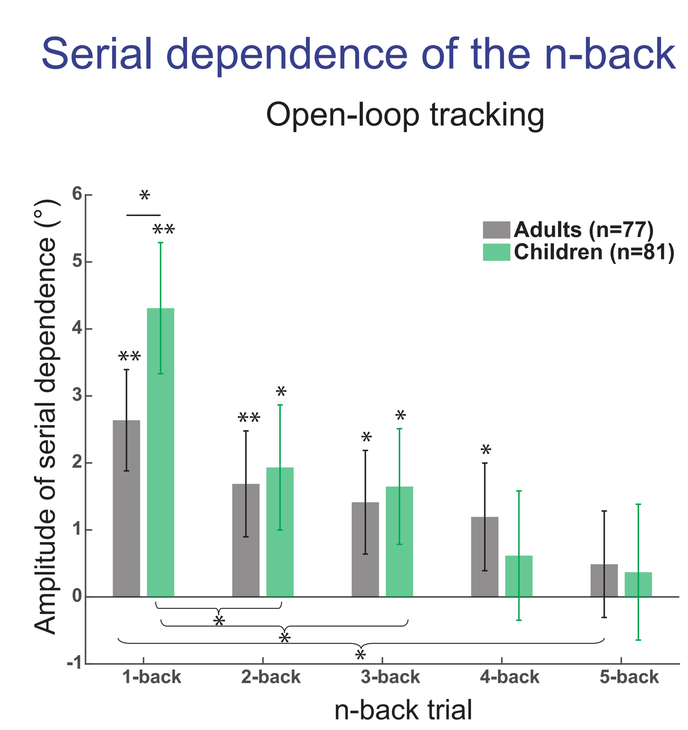
Only the percentages associated with a significant group difference in the oculometric measures are shown (in red).



- Of all the oculometric measures, the greatest difference between children and adults was in the latency of pursuit initiation (children's mean at 0.4% of the adult latency distribuation).

Serial dependence effect





- For both children and adults, the pursuit direction in the open-loop response was pulled toward the target moving direction in the previous trial, and this was not observed in the closed-loop response,
- This serial dependence effect was stronger in children than in adults, and fell off with an increasing number of intervening trials in both adults and children.

Conclusion

- Both open-loop and closed-loop ocular tracking responses in children are inferior to those in adults.
- For the first time, we found that the response magnitudes of open-loop pursuit direction and close-loop tracking speed in children are comparable to those in adults, whereas the precision of both in children does not reach the adult level. This might be due to less reliable visual processing of target motion signals in children than in adults, which leads to the finding that the open-loop pursuit direction depends more on the previously presented target motion in children than in adults (i.e., stronger serial dependence effect in children).
- The development of different aspects of ocular tracking abilities follow different time courses, with the open-loop pursuit latency maturing the last.

References

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