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Improving saccadic eye movements in young and poor readers

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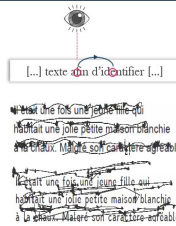
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Where to look next?

The initial saccade of experienced readers lands preferentially halfway between the beginning and the middle of words, at the **preferred viewing location** (PVL, Rayner, 1979)

- ↳ gaze duration, refixation probability, and mean number of fixation
- Mainly influenced by low-level visual feature processing of the next parafoveal word (McConkie et al., 1988; Radach & McConkie, 1998)
- A clean oculomotor behavior is reflected in a narrower spread of initial landing positions (ILPs), around the PVL (Snell and Theeuwes, 2020)

INTRODUCTION



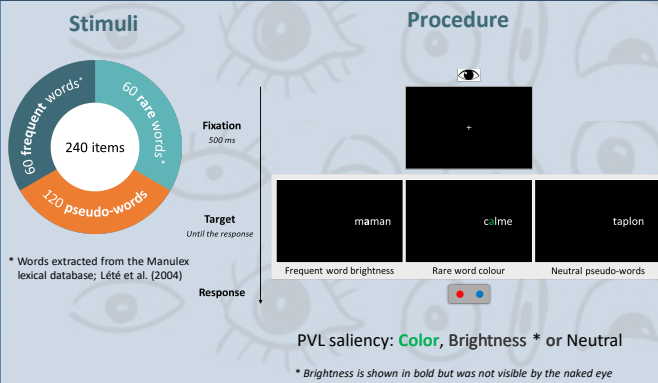
Learning to read can be a hard task for some beginners, requiring becoming more efficient in linguistic processing and to **gain cognitive control of saccadic eye movements**

- ILPs gradually shift towards the word center during the first years of formal reading instruction (Ducrot et al., 2013; Joseph et al., 2009; Vorstius et al., 2014)
- Poor readers and dyslexics exhibit inefficient saccade targeting strategies (Gagl et al., 2014; Hawelka et al., 2010; Kirkby et al., 2022; Vernet et al., 2023)
- Eye-tracking training can improve saccadic eye movements in beginning children, with accurately aiming for the PVL of each word (Lehtimäki & Reilly, 2005)

AIM OF THE STUDY: examined whether the **saliency of the character located at the PVL** positively influences the saccadic computation system

A brighter/colored letter in a word could act as a salient signal for launching the saccade and **optimize the location of the initial fixation** within the word

METHOD



PARTICIPANTS

	children	Adults
N	14	15
Age (in years)	8.1 (0.5) Ranging from 7 to 8 years (Grade2)	23.6 (3) Ranging from 18 to 33 years
Sex ratio (F/M)	8/14	12/15



Normal or corrected-to-normal vision

Reading skills

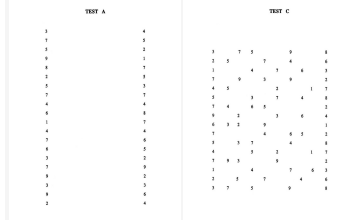
Alouette Test (Lefavrais, 2005)



CM – Reading accuracy
CTL – Reading speed

Oculomotor and visuo-attentional skills

DEM test (Richman & Garzia, 1987)



VT – Vertical naming time
HTaj – Horizontal adjusted time

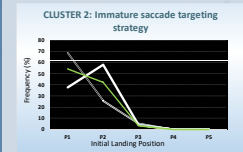
RESULTS

Change in landing site distributions



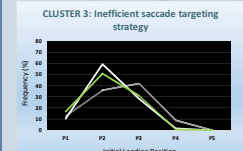
CLUSTER 1: Expert saccade targeting strategy

- No effect of enhanced PVL saliency on the location of the ILPs for **proficient readers**



CLUSTER 2: Immature saccade targeting strategy

- Effect of **brightness** of the character located at the PVL on the location of the ILPs for **poor/beginning readers**



CLUSTER 3: Inefficient saccade targeting strategy

- Effect of **brightness/color** of the character located at the PVL, on the location of the ILPs for **readers with visuo-attentional/oculomotor deficits**

The peak of the **landing site distribution** moved toward the PVL for cluster 2 (brightness) and cluster 3 (brightness/color)

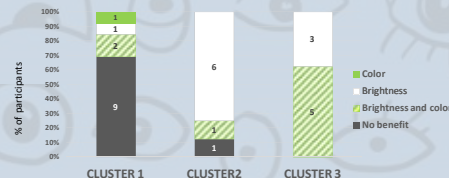
CLUSTER ANALYSIS

confirmed that the ILP is a sensitive index of reading efficiency

CLUSTER 1 = Expert reader strategy, with an ILP most of the time at the PVL
CLUSTER 2 = Immature saccade targeting strategy, with ILPs near the words' beginning and sequential reading
CLUSTER 3 = Oculomotor Instability, with ILPs covering a wider area around the center of the word with high variability

	PARTICIPANTS			READING		VISUAL ATTENTION	
	N	children	Adults	dsCM	dsCTL	dsVT	dsHTaj
CLUSTER 1	13	4	9	0,74	1,22	0,61	0,07
CLUSTER 2	8	7	1	-0,71	-1,54	0,18	-0,018
CLUSTER 3	8	3	5	0,26	-0,03	-1,17	-1,69

Saliency benefit on the location of the initial fixation



- A salient PVL is more beneficial to the less proficient readers
- Both types of saliency can help to control saccade programming

Change in RT/gaze duration

Effect of PVL Saliency on RTs



- Significant Interaction Cluster x PVL Saliency on RTs [F(4,52) = 4.33, p = .004]
- PVL saliency did shorten RTs for cluster 2** [F(2, 52) = 6.99, p = .006] and **cluster 3** [F(2, 52) = 5.30, p = .022]
- No observable change for proficient readers [F(2,52)=1.49, ns]

Change in mean number of fixations

Effect of PVL Saliency on the mean nb of fixations



- This interaction was also found on the number of Fixations [F(4,52) = 2.47, p = .05]
- PVL saliency ↓ the number of Fixations for cluster 2** [F(2, 52) = 5.21, p = .02]
- Did not reach significance for cluster 3 [F(2, 52) = 2.68, p = .08]
- No effect for cluster 1 [F<1]

No Change in accuracy

- No effect of enhanced PVL saliency on response accuracy [F(2,28) = 0.120, p = .88]

1. We demonstrated the irrelevance of enhanced PVL saliency for readers having developed automatized routines for saccade computation.

2. This manipulation had the **desired effect on the LP-curves** for the cluster of participants with **immature** (characterized by ILPs near the words' beginning and lowest reading level scores) and **inefficient saccade targeting strategy** (characterized by flattened and diffuse LP-curves and visual-processing deficits).

DISCUSSION

3. We also determined that our manipulation had a positive effect on RT/gaze duration and on the mean number of fixation per word, in less proficient readers.

These results suggest that attracting the eye towards the PVL could represent a new way to help reading. See Vernet et al., 2023, POSTER 6, *Improving reading through visual saliency: a remedial tool for neurodevelopmental disorders*

A brighter/colored character in a word probably acts as a **salient signal for launching the saccade**, helping young/poor readers to **optimize their saccade targeting strategies, with ILPs shifted toward the PVL**. Reducing the number of fixations also reduces the gaze durations thereby **making the reading process faster**.