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► **To cite this version:**

Stéphanie Ducrot, Marie Vernet, Bernard Lété, Delphine Massendari, Jérémy Danna. Improving Saccadic Eye Movements In Young And Poor Readers. 23rd Conference of the European Society for Cognitive Psychology, Sep 2023, Porto (Portugal), Portugal. hal-04632430

HAL Id: hal-04632430

<https://hal.science/hal-04632430v1>

Submitted on 2 Jul 2024

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Improving saccadic eye movements in young and poor readers

Ducrot, S.¹, Vernet, M.^{1,2}, Lété, B.³, Massendari, D.¹, & Danna, J.²

¹ Aix Marseille Univ, CNRS, LPL, Aix-en-Provence, France ² CLLE, University of Toulouse, CNRS, Toulouse, France

³ Laboratoire d'Étude des Mécanismes Cognitifs, Lyon 2 University, Lyon, France

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



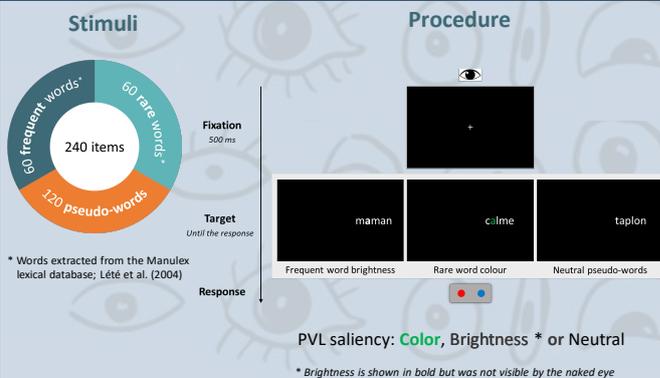
Learning to read can be a hard task for some beginners, requiring becoming more efficient in linguistic processing and to **gain cognitive control of saccadic eye movements**

- 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)

Oculomotor and visuo-attentional skills

DEM test (Richman & Garzia, 1987)

CM – Reading accuracy
CTL – Reading speed

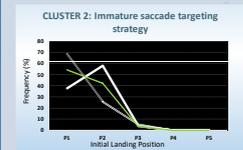
VT – Vertical naming time
HTaj – Horizontal adjusted time

RESULTS

Change in landing site distributions



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



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



- 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)

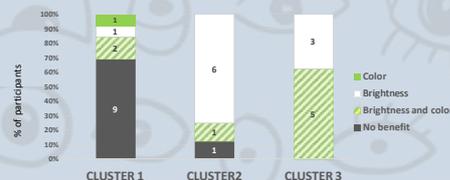
CLUSTER ANALYSIS

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

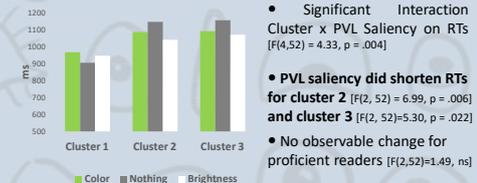
Saliency benefit on the location of the initial fixation



- 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

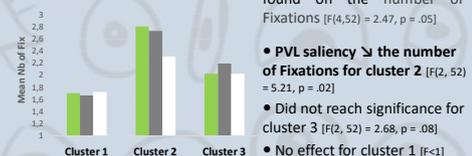
Effect of PVL Saliency on RTs



- 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 \searrow 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**.