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## Orthographic learning of new words: from looking to memorizing

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## INTRODUCTION

Only a few studies have examined eye movements during the repeated reading of new words (Joseph et al., 2014; Joseph et al., 2018) and their implicit memorization. Recently, Nation et al. (2017) suggested that monitoring eye movements during novel word reading might be particularly useful for the real-time study of orthographic learning.

We used eye-tracking to examine the exposure-by-exposure evolution of eye movement patterns while French adults were reading novel words. A spelling task and an orthographic lexical decision task were administered offline to measure orthographic learning. The participants' visual-attention span (VAS) was further assessed.

## MATERIAL AND METHOD

### Participants

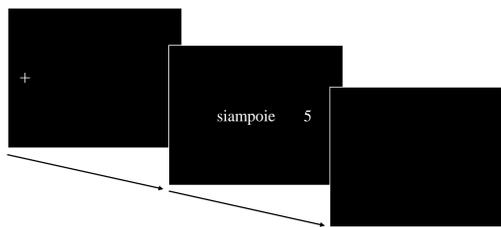
42 French young adults with normal vision and normal reading skills.

### Material

- 30 legal bi-syllabic 8-letter pseudo-words (PW) containing at least two ambiguous graphemes (mean  $f_{\text{trigram}} = 1,655$ ;  $SD_{\text{trigram}} = 1,176$ ; range: 327–2114;  $N = 0$ )
- 30 bi- or tri-syllabic 8-letter words that served as controls

→ Three lists of 10 PWs and 10 control Ws that were randomly mixed

### Experimental Reading Task: Exposure Phase



Each item (PW or W) is randomly presented 1, 3 or 5 times (180 trials). Eye movements are monitored.

## OBJECTIVES

- Investigate the effect of multiple exposures on eye movements and memorization
- Refine the time line of orthographic learning processing
- Explore whether VAS is a potential predictor of orthographic learning skills

## EXPECTED FINDINGS

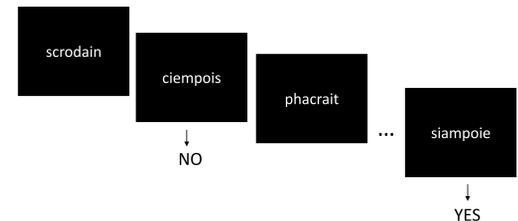
- Better memorization performance with increased exposure to novel words
- Fewer fixations and shorter processing times across exposures during reading
- Early orthographic learning effects on eye movement patterns
- Better orthographic learning for participants with higher vs. lower VAS

## Orthographic Learning Assessment

### Unexpected pseudo-word spelling



### Orthographic Decision



## Visual-Attention Span Measure

A 6 consonant string is briefly presented for 200 ms.

RFDHST

Participants report either all the letters they have identified in global report or a single postcued letter in partial report. Performance on this task reflects visual attention capacity deployed for multi-element simultaneous processing.

$$\text{Total Score (\%)} = \frac{(\text{Global score} + 2 \times \text{Partial score}) \times 100}{2 \times 144}$$

## RESULTS

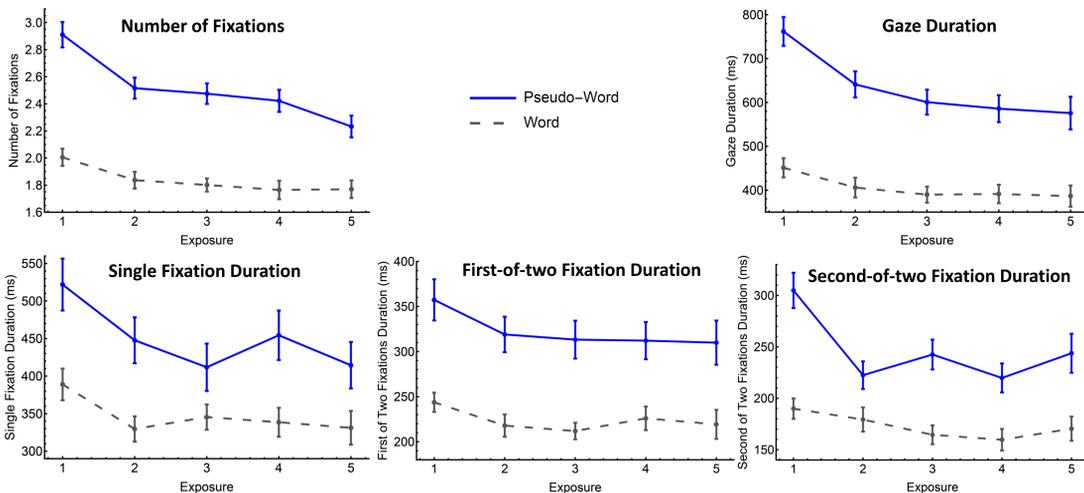
### How well did participants learn?

Exposures	PW spelling-to-dictation		Orthographic Decision			
	% correct	RTs	Targets PWs		Homophones	
			% correct YES responses	RTs	% correct NO responses	RTs
1	11.4 (9.0)	1231 (470)	54.4 (15.6)	1284 (492)	58.0 (17.1)	58.0 (17.1)
3	16.4 (15.0)	1114 (419)	72.5 (16.3)	1284 (500)	48.4 (17.5)	48.4 (17.5)
5	21.4 (16.2)	1007 (254)	78.7 (13.3)	1229 (395)	50.6 (16.5)	50.6 (16.5)

#### Test phase results:

- PWs were spelled more accurately ( $p < .001$ ) across exposures
  - PWs were recognized above chance level after 3 and 5 exposures
  - PWs were recognized more accurately ( $p < .001$ ) and faster ( $p < .001$ ) across exposures
- Orthographic learning did occur during the reading phase

### Oculomotor measures during implicit learning



#### Oculomotor results:

- Main effects of number of exposures and item-type on all oculomotor measures (all  $p_s < .001$ )
- Faster decrease of number of fixations and gaze duration for PW than for W (resp.,  $p = .027$  and  $p < .001$ )
- Decrease of processing time across exposures reflects orthographic learning
- Local Performance by Group interaction between the 1<sup>st</sup> and 2<sup>nd</sup> exposure for both gaze duration and second-of-two fixation duration (resp.,  $p = .046$  and  $p < .001$ )
- Local interaction between the 2<sup>nd</sup> and 3<sup>rd</sup> exposure for single fixation duration ( $p < .001$ )
- Orthographic learning occurs during the very early stages of the learning process

### Exploratory analysis of VAS Effect

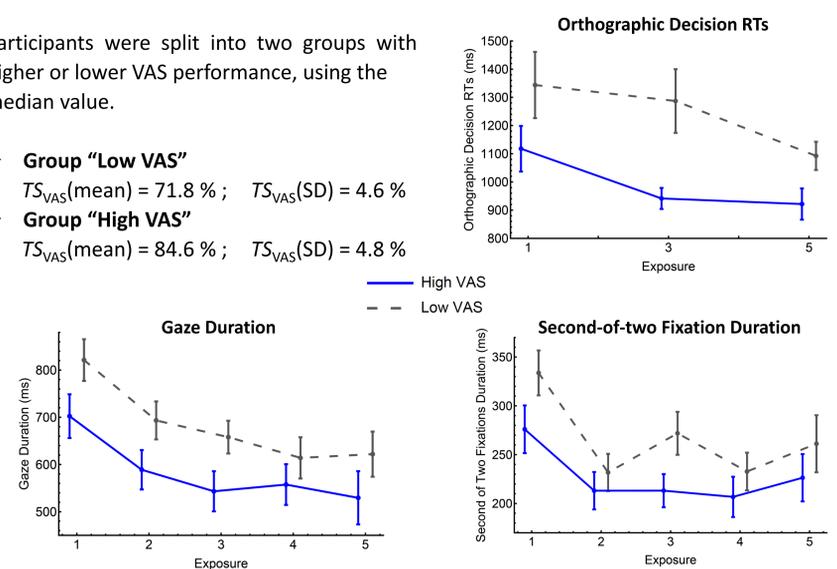
Participants were split into two groups with higher or lower VAS performance, using the median value.

#### Group "Low VAS"

$TS_{\text{VAS}}(\text{mean}) = 71.8\%$ ;  $TS_{\text{VAS}}(\text{SD}) = 4.6\%$

#### Group "High VAS"

$TS_{\text{VAS}}(\text{mean}) = 84.6\%$ ;  $TS_{\text{VAS}}(\text{SD}) = 4.8\%$



#### Results:

- Slower RTs in the orthographic decision task for "Low VAS" group than for "High VAS" group ( $p = .003$ )
- Longer Gaze duration and Second-of-two fixation duration for the group with lower VAS (resp.,  $p = .050$  and  $p = .021$ ). Both groups do not significantly differ on any other measures (Number of fixations, Single Fixation Duration, First of Two Fixation Duration).
- Similar decrease of performance with exposures in the two VAS groups

## SUMMARY AND DISCUSSION

- Memorization of new words' orthography increases across exposures
- Eye movement variations reflect orthographic learning
- Processing time decreases as a function of exposures
- Higher visual-attention span induces faster visual processing time

Current findings are accounted for by BRAID-Learn, our model of orthographic learning of new words. This allows interpreting results observed here; for instance, processing time decreases thanks to the top-down influence from the newly acquired orthographic representation

The role of VA span in orthographic learning requires further investigations