



Introduction

At the beginning of primary school, children discover writing which requires the development of two crucial abilities: **spelling and handwriting**. The literature has demonstrated that those two abilities influence each other during writing acquisition. For example, children had a dysfluent graphic gesture when they were asked to copy irregular words in comparison with regular words (Kandel & Perret, 2009). This demonstrated that **the orthographic complexity** of words has an impact on handwriting outcomes.

The concept of **graphic complexity** of words is not as well-established as orthographic complexity. Recent findings lead to the establishment of a graphic complexity index (Gosse et al., 2017). No experiment has ever manipulated graphic complexity of words, and its impact on spelling accuracy has never been assessed.

Research is needed to investigate the relationship between spelling and handwriting throughout development. To that end, conducting longitudinal experiments that consider simultaneously the orthographic and the graphic sides of writing is a promising angle of approach.

Aim of the study

The objective of this longitudinal experiment was **to explore the evolution of the relationship between spelling and handwriting throughout development**.

Over a period of three years, children were tested on a single-word dictation task, with words varying in orthographic and graphic levels of complexity.

- 1 How is **spelling accuracy** influenced by graphic complexity ?
- 2 How is **handwriting quality** influenced by orthographic complexity?
- 3 How is **handwriting speed** influenced by orthographic complexity?

Method

Participants

	Grade 2 (T1)		Grade 3 (T2)		Grade 4 (T3)	
	N = 71 (37 girls)		N = 70 (36 girls)		N = 64 (33 girls)	
	M	SD	M	SD	M	SD
Age	7.56	0.40				
Receptive vocabulary	0.35	1.31				
Nonverbal reasoning	-0.28	0.90				
Word reading	0.22	0.77	0.31	0.90	0.40	0.96
Word spelling	-1.05	1.27	-0.96	1.51	-1.30	1.62
Handwriting quality	-0.57	1.06	-1.34	1.35	-1.53	1.95
Handwriting speed	0.11	0.87	0.35	1.02	0.24	0.90

Procedure

Testing started in February and March 2017 when children were in Grade 2 (T1). The children were tested again at the same period in Grade 3 (T2) and in Grade 4 (T3). At each testing time, children were individually administered **standardised control tasks**.

Children also performed on an **experimental dictation task**, which took place at school in small groups of four. For this dictation task, each child was given an interactive inking pen and a digital Wacom Intuos Pro tablet.

Measures

Control tasks: Receptive vocabulary (EVIP), Nonverbal reasoning (WISC-IV), Word reading (LUM), Word spelling (Chronosdictées), Handwriting quality and speed (BHK)

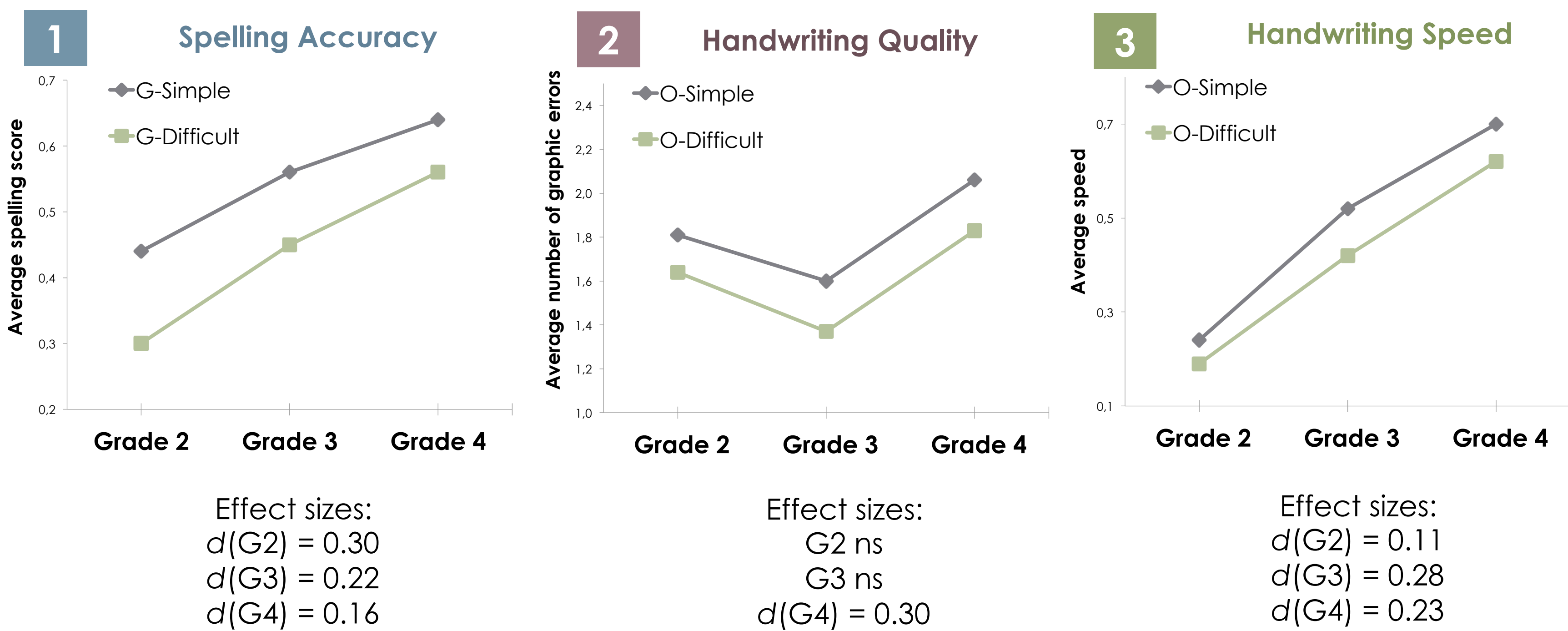
Experimental task: Single-word dictation (N = 40)

- Two levels of orthographic complexity (simple/difficult; success rate in EOLE)
- Two levels of graphic complexity (simple/difficult; complexity index in Gosse et al., 2017).
- Three scores per word: **Spelling accuracy:** 0 or 1 (low score refers to poor spelling performance); **Handwriting quality:** 0 to 5 based on 5 aesthetic criteria: distortion, horizontality, respect of letter height, relative size and correction (high score refers to poor quality); **Handwriting speed:** cm/ms, extracted from the Wacom tablet (low value refers to slow performance)

Results

General Linear Mixed Model (GLMM) on each dependent variable.

Dependent variables	1		2		3	
	Spelling accuracy		Handwriting quality		Handwriting speed	
Fixed effects	F	p	F	p	F	p
Orthographic complexity			1.9	.17	115.4	.000
Graphic complexity	94.8	.000				
Testing time	119.6	.000	3.8	.000	1142.5	.000
O-complexity × Time			4.1	.017	5.9	.003
G-complexity × Time	3.2	.043				



Discussion

- 1 How is **spelling accuracy** influenced by graphic complexity ? For the first time, this experiment demonstrated that graphic complexity of words has a negative impact on children's spelling accuracy. This impact tends to decrease throughout the years (G2 > G3 > G4).
 - 2 How is **handwriting quality** influenced by orthographic complexity? Orthographic complexity of words does not influence children's handwriting quality. In other words, the legibility does not depend on how challenging spelling is.
 - 3 How is **handwriting speed** influenced by orthographic complexity? Globally, speed of handwriting improves significantly between the grades. Our results reveal that **orthographic complexity** leads to slower handwriting, and this effect is the strongest in Grade 3 (G3 > G4 > G2).
- **Implications:** While handwriting is only taught at the very beginning of primary school, these results demonstrate that it remains a challenge beyond Grade 1. Our results highlight the importance of developing an efficient graphic gesture, since the graphic side of writing has an influence on spelling outcomes. From a clinical viewpoint, by highlighting the presence of interactions between spelling and handwriting, our results open up new perspectives for research among children with dyslexia who struggle with writing.