Children's sensitivity to novel graphotactic constraints with no phonological counterpart: Evidence from an incidental learning task

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BACKGROUND

Written language is rich in underlined statistical patterns or regularities. Some of them are not explicitly taught, yet young learners' real and nonword spellings reveal sensitivity to them (Pacton et al., 2001; Hayes et al., 2006). Some of these patterns are found in a graphotactic context, which refers to legal letter arrangement and sequencing, e.g.:
• in English, a word does not start with the letters *ck*;
• *ee* occurs frequently as a doublet while *k* never doubles;
• final consonants often double when preceded by one vowel: ball vs. bawl, etc.

Our previous work (Samara and Caravolas, 2014; Samara, Singh & Wonnacott, under review) suggests that 7-year-olds are able to extract the graphotactic patterns incidentally, and they can learn patterns from word beginnings and word ends independently.

Although only the written forms of CVC pronounceable nonwords were provided, the stimuli conform to English graphotactic rules and it is possible that learners attempted to covertly pronounce the stimuli and thus learned the same patterns from spoken word unit (e.g., /t/ can occur with /o/ but never with /ɛ/ *in word beginning)* (so-called phonotactic learning).

RESEARCH QUESTIONS

1. Can purely visual (non-phonological) graphotactic constraints on letter contexts be learnt incidentally via statistical learning processes?

2. Is learning through exposure to print as efficient as teaching the underlying rule or regularity?

3. Are individual differences in implicit and explicit learning related to spelling ability?

STATISTICAL ANALYSES

Alongside frequentist analyses (Logistic Mixed Effect (LME) models with legality endorsements as DV, we conducted Bayes Factor (BF) analyses (following Dienes, 2014), to asses the strength of evidence for the four studies' H1 (above chance performance) over H_0 (at chance performance).

Study1, 2 & 3:	plausible predicted effect size: Samara, Singh, & Wonnacott (under review)
Study4:	plausible maximum effect size: Study3

BF < 0.33: substantial evidence for H_0
0.33 < **BF** < 3: inconclusive evidence
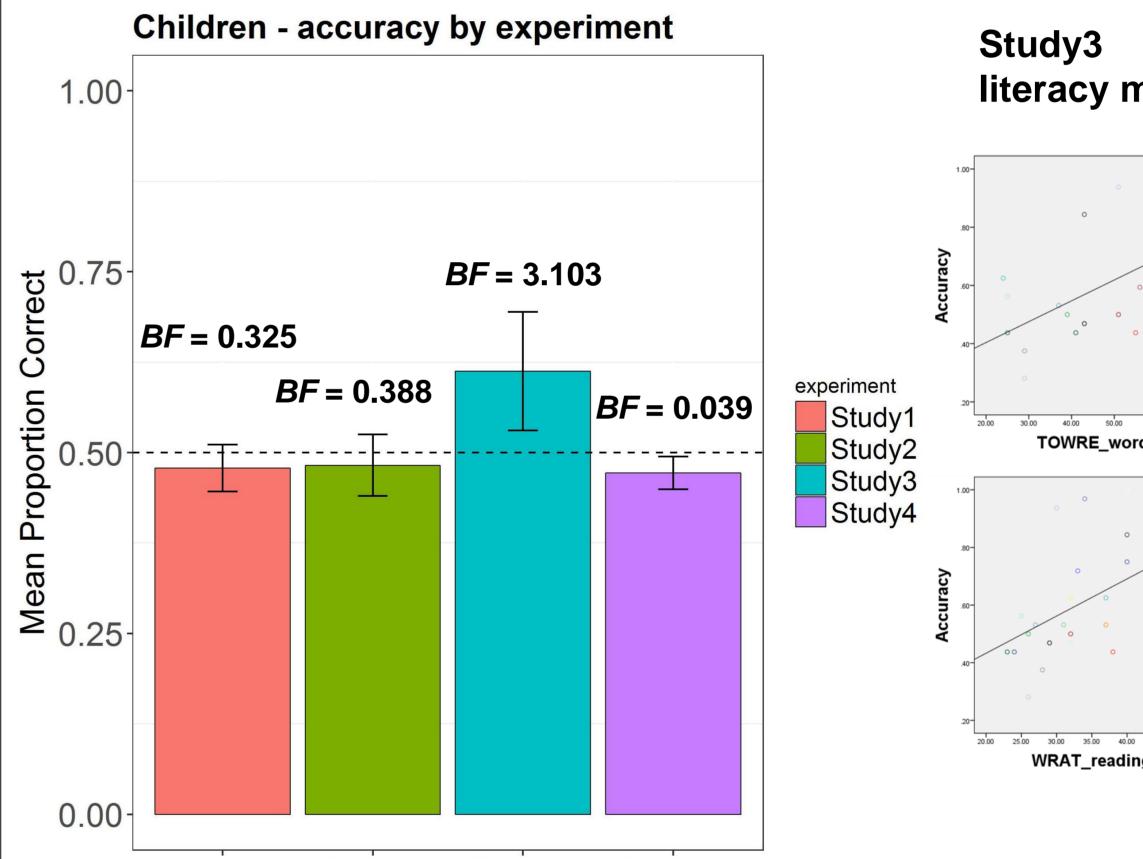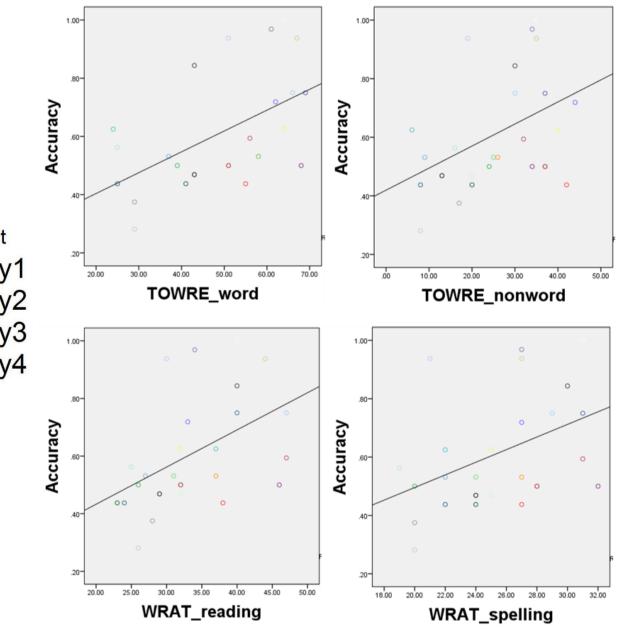**BF** > 3: substantial evidence

METHOD

The Study Design

2-phase task: learning of graphotactic patterns of different complexity (simple and complex) and with different instructions (implicit and explicit, with two types of explicit instruction).
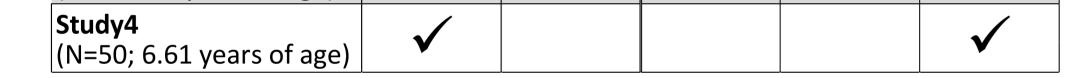
	COMPLEXITY		INSTRUCTION		
	Simple	Complex	Implicit	Explicit Taught	Explicit Search
Study1 (N=25; 7.25 years of age)		✓	✓		
Study2 (N=25; 7.24 years of age)	✓		✓		
Study3 (N=25; 7.2 years of age)	✓			✓	
Study4 (N=50; 6.61 years of age)	✓				✓

Procedure

1. Exposure

One-Back Task: "*Press the green button if the word is the same as the one before it, or the red button if it's not the same.*"

Added matched phonology

tef
ned
+
ned
tef
+
deb
lep

0 ms — 350 ms — click — 500 ms — click — 350 ms — click — 500 ms — click — 350 ms — click — 500 ms — click — 350 ms — click

2. Test

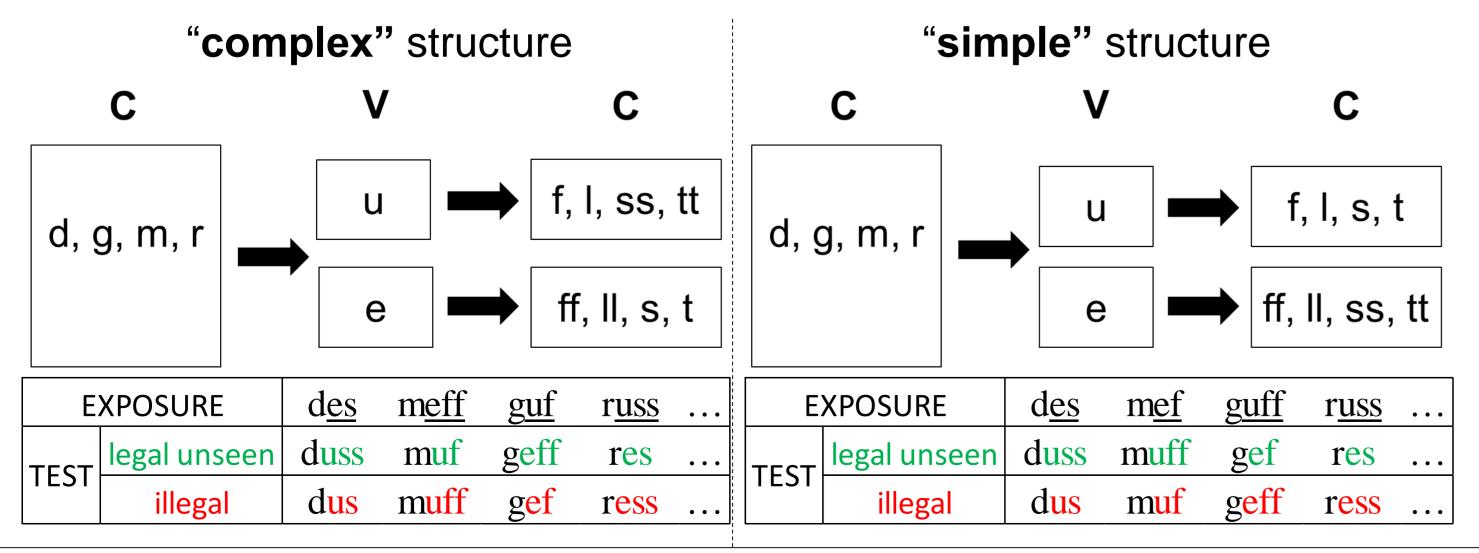Legality Decision Task: legal unseen and Illegal items: *"Can this work exist in Zorib's language?"*

Literacy Measures
(1) WRAT reading and spelling subtests; (2) TOWRE word and nonword reading subtests

Stimuli

CVC pronounceable nonwords (32 C_1VC_2) - homophones

"complex" structure

C	V	C
d, g, m, r	u	f, l, ss, tt
	e	ff, ll, s, t

"simple" structure

C	V	C
d, g, m, r	u	f, l, s, t
	e	ff, ll, ss, tt

EXPOSURE	des	meff	guf	russ	…
TEST legal unseen	duss	muf	geff	res	…
TEST illegal	dus	muff	gef	ress	…

EXPOSURE	des	mef	guff	russ	…
TEST legal unseen	duss	muff	gef	res	…
TEST illegal	dus	muf	geff	ress	…

RESULTS

Children - accuracy by experiment

BF = 0.325
BF = 0.388
BF = 3.103
BF = 0.039

Mean Proportion Correct

experiment: Study1, Study2, Study3, Study4

Study3 correlations with literacy measures

Accuracy vs TOWRE_word, TOWRE_nonword, WRAT_reading, WRAT_spelling

✓ Children could learn the graphotactic constraints only when they were **taught explicitly what the "simple" pattern was.** Performance in our experimental condition correlated with all literacy measures.

✗ Children did not learn **implicitly** the non-phonological novel graphotactic constraints of neither **"complex"** or **"simple"** structure and they did not pick up on the patterns even when **explicit instruction encouraged awareness** of these.

DISCUSSION

Our results showed that children were not able to exploit the patterns in order to consistently generalise over the test stimuli neither when these were simplified and when explicit instruction encouraged them to search for them. Learning only occurred when children were explicitly told what the rule governing the patterns was. Interestingly, it was only when we observed a significant effect of learning that we also found significant correlations between performance at legality judgement task and all literacy measures.

The significant correlations we saw under explicit teaching instructions support previous literature (Kaufman et al., 2010; Gebauer & Macintosh, 2007). They also potentially suggest an advantage for learning via explicit instruction, as shown in populations with dyslexia (Bhattacharya & Ehri, 2004).

FUTURE DIRECTIONS

We are currently collecting data from adult participants for Study1 & 2.

Questions to be addressed by future work: Why are purely visual graphotactic patterns so hard to learn? Do children need more exposure, under current experimental conditions, to such non-phonological patterns? Can children learn constraints with no meaningful phonological counterpart? Does complexity modulate learning? Do children only benefit from purely explicit instruction?

We plan to assess the implicit learning of graphotactic patterns of varying statistical complexity (positional vs. contextual constraints) using symbols and look for individual differences.

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Samara, A., & Caravolas, M. (2014). Statistical learning of novel graphotactic constraints in children and adults. *Journal of Experimental Child Psychology, 121*, 137-155.