"Can you use it in a sentence": Establishing how word-production difficulties shape text formation

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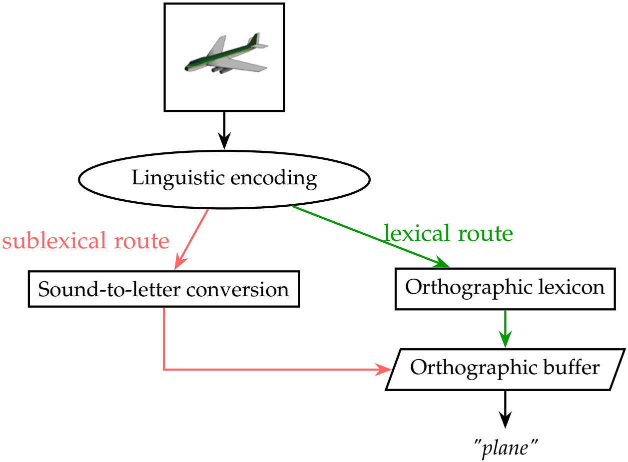
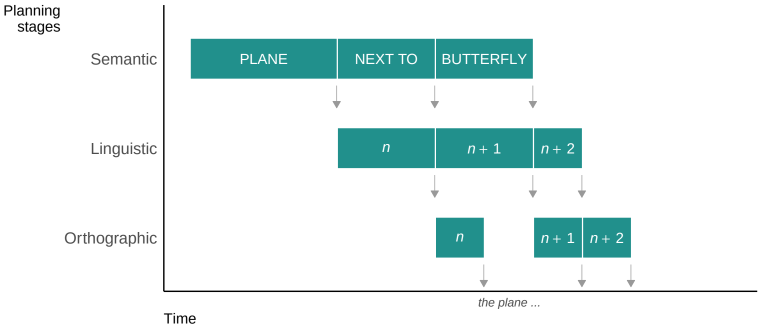
Writing a word involves three general planning stages



Classic model of word writing (Caramazza, 1991; Kandel, 2023).

Planning happens in parallel to writing



Difficulty at higher levels delays output; see e.g. Olive (2014).

Planning happens in parallel to writing

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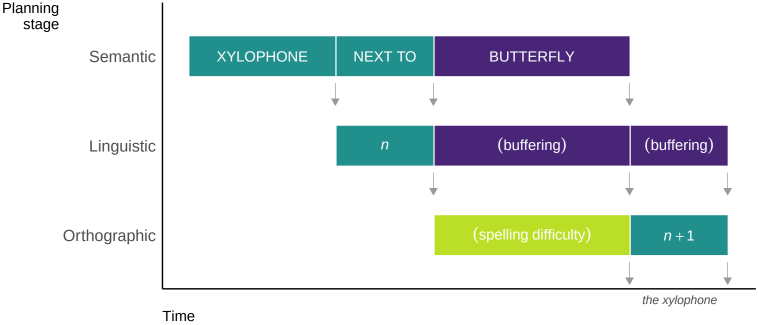

Difficulty at higher levels delays output; see e.g. Olive (2014).

Spelling difficult has knock-on effects for upstream processes

- Poor spellers produce weaker texts (Feng et al., 2019; Kent & Wanzek, 2016).
- Spelling difficulty affects writing fluency:
  - Irregular spelling affects keystroke dynamics (Lambert et al., 2011; Maggio et al., 2015; Suárez-Coalla et al., 2020).
  - Weak spellers write more slowly (Torrance et al., 2016) and less between pauses (Alves & Limpo, 2015; Limpo & Alves, 2017).
- Word-level difficulty in written production (familiarity, number of lexical alternatives) impacts syntax planning (Roeser et al., 2019; Torrance & Nottbusch, 2012).

Research question & aims

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To what extent does difficulty with word spelling affect our ability to convey ideas in writing. This research aims to …

- establish time course of orthographic retrieval in single word production.
- evaluate how difficult-to-spell words affects planning and execution of adjacent words?

Picture-word interference task

Type the name of the depicted item!

Picture-word interference task

Type the name of the depicted item!

Picture-word interference task

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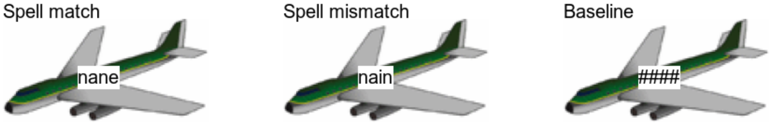


Target word: “plane”

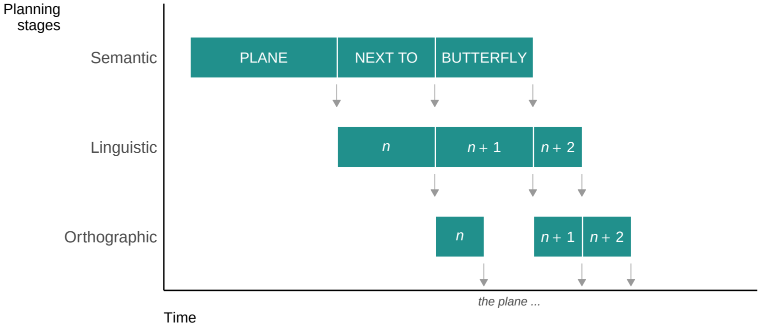
Writing as mixture process (Roeser et al., 2021)

Written response times result from mixture of two processes:

1. Picture encoding, naming retrieval, orthography, motor codes does not interrupt the information flow.
2. Difficulty at higher levels delay information flow and therefore the writing onset.

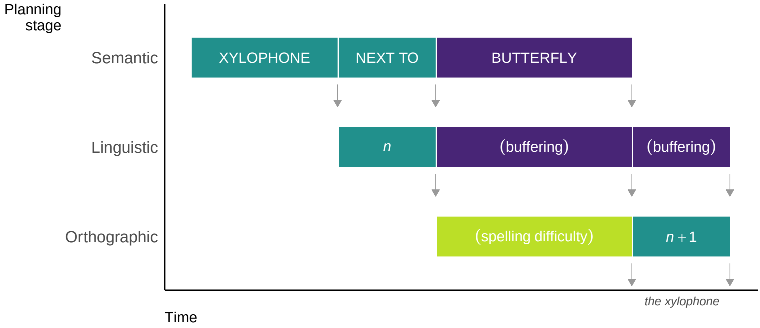
Data that arise as the result of two (probabilistic) underlying processes can be captured using mixture models.

Writing as mixture process



Prediction: Delays in information flow – and therefore response times – can in principle happen across all conditions but orthographic retrieval is more likely to be delayed in the spelling mismatch condition.

Writing as mixture process



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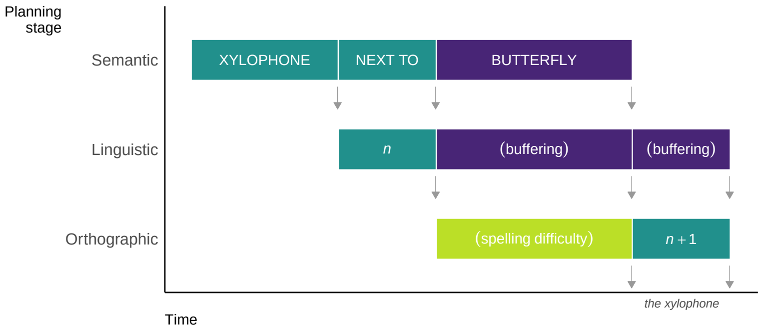
Writing as mixture process



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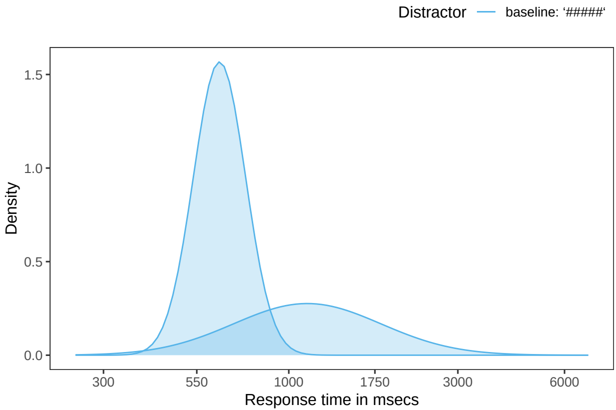
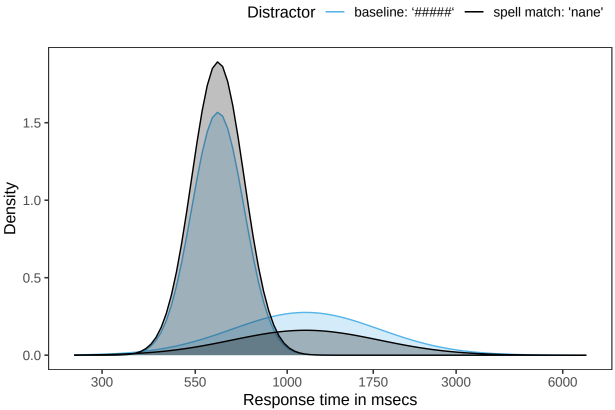
Writing as mixture process



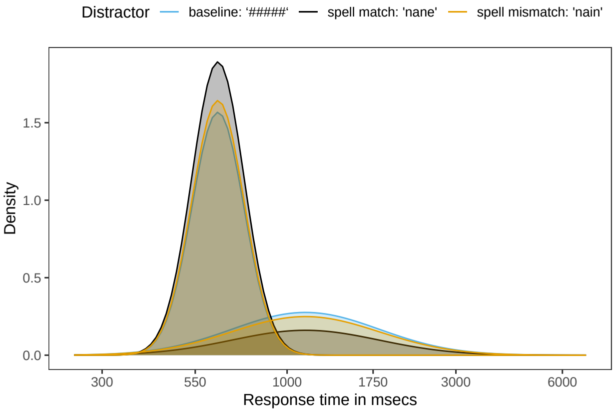
Mixture model distributions

Writing as mixture process



Mixture model distributions

Writing as mixture process



Mixture model distributions

Writing as mixture process

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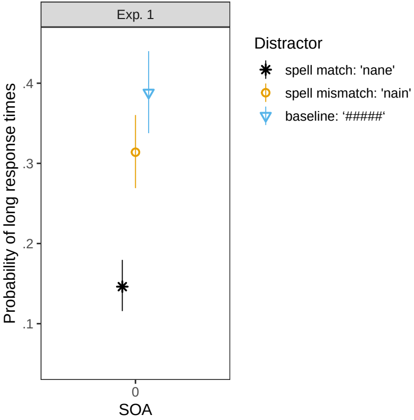
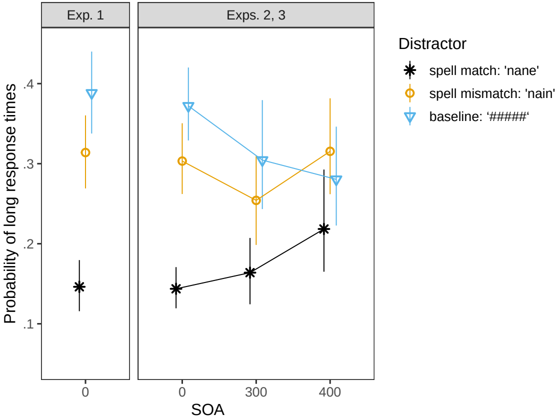
$$
\begin{aligned}
\mathrm{rt}_{ij} \sim\ & \theta_{\text{distractor-type}} \cdot \log\mathcal{N}(\beta + \delta + \mathrm{ppt}_i + \mathrm{item}_j, \sigma^2_{e'}) + \\
& (1 - \theta_{\text{distractor-type}}) \cdot \log\mathcal{N}(\beta + \mathrm{ppt}_i + \mathrm{item}_j, \sigma^2_{e}) \\
\text{where:} & \\
\mathrm{ppt}_i \sim\ & \mathcal{N}(0, \sigma^2_{ppt}) \\
\mathrm{item}_j \sim\ & \mathcal{N}(0, \sigma^2_{item}) \\
\text{constraints:} & \\
& \delta,\ (\text{and all } \sigma\text{s}) > 0 \\
& \sigma^2_{e'} > \sigma^2_{e}
\end{aligned}
$$

Mixture model results: response time



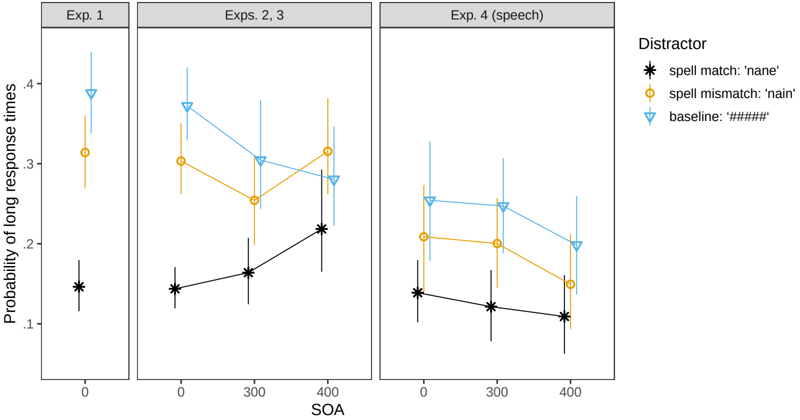
Example target word: “plane”

Mixture model results: response time



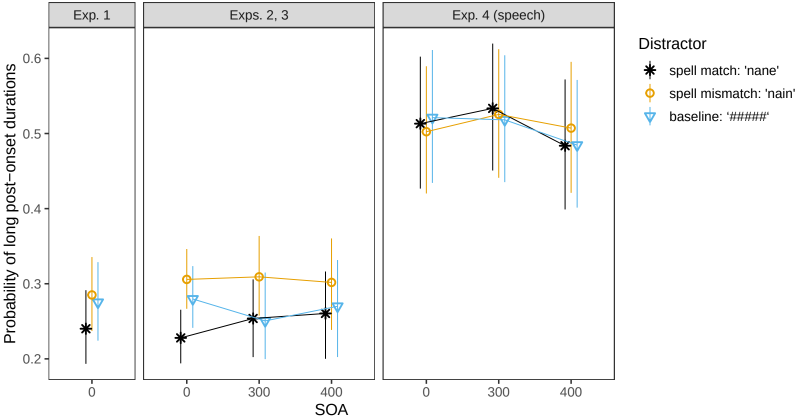
Example target word: "plane"

Mixture model results: response time



Example target word: "plane"

Mixture model results: post-onset hesitations



Example target word: "plane"

Orthographic retrieval happens late

- Early facilitation due to phonological overlap in both speech and writing independently of spelling overlap.
- Late orthographic inhibition after lexical representation was retrieved.
- Orthography is not fully retrieved at word onset.

Research question: Part II

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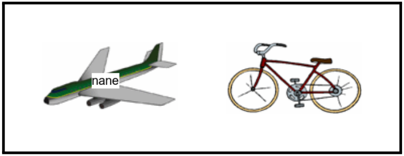
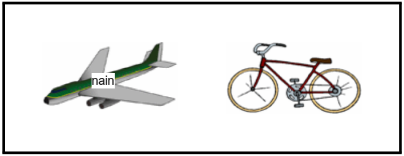
To what extent does difficulty with word spelling affect planning and execution of words adjacent to a difficult-to-spell word?

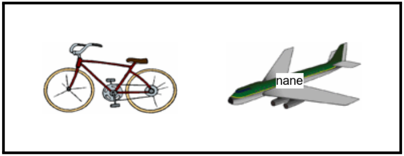
Design



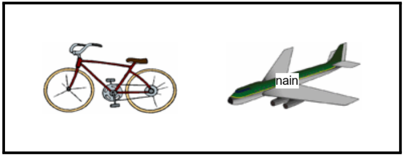
(a) Target initial, spell match



(b) Target initial, spell mismatch



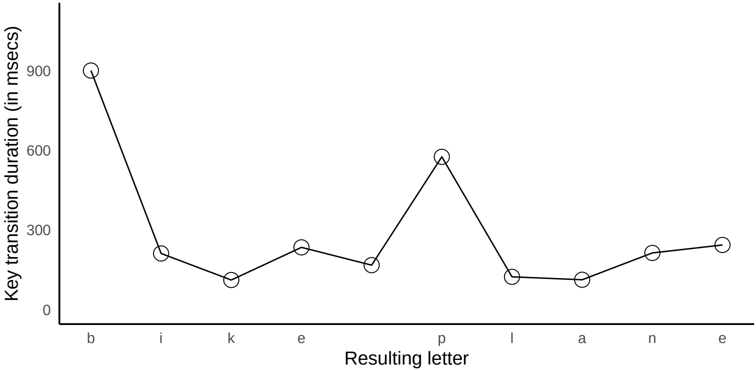
(c) Target final, spell match



(d) Target final, spell mismatch

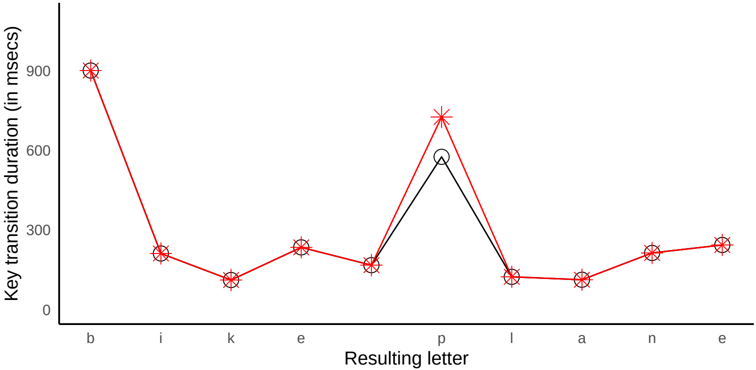
Target phrase "plane bike", "bike plane"

Predictions



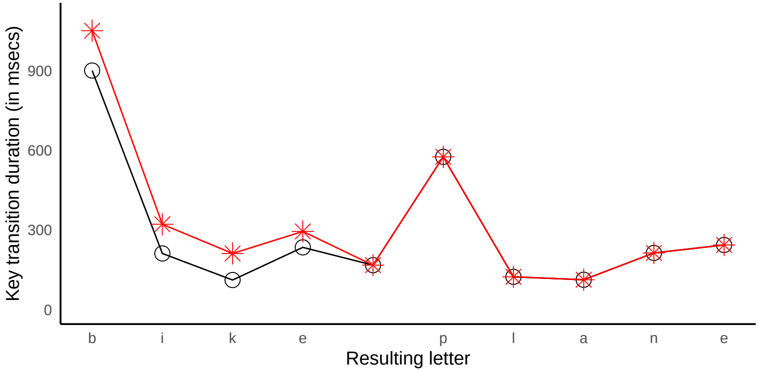
Keystroke intervals for “bike plane”

Predictions



Keystroke intervals for "bike plane"

Predictions



Keystroke intervals for “bike plane”

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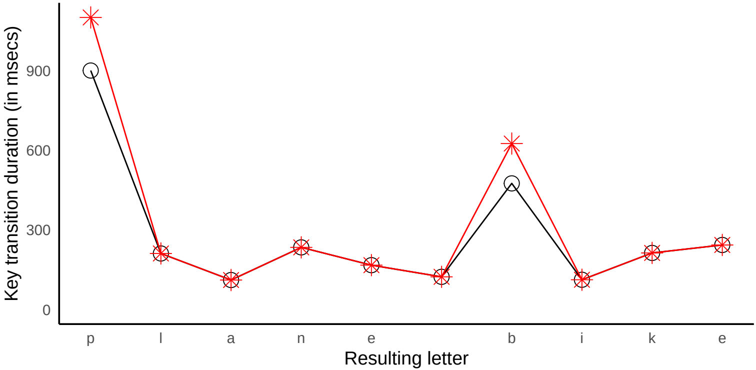

Keystroke intervals for “plane bike”

Mixture model results: Experiment (1 and) 2

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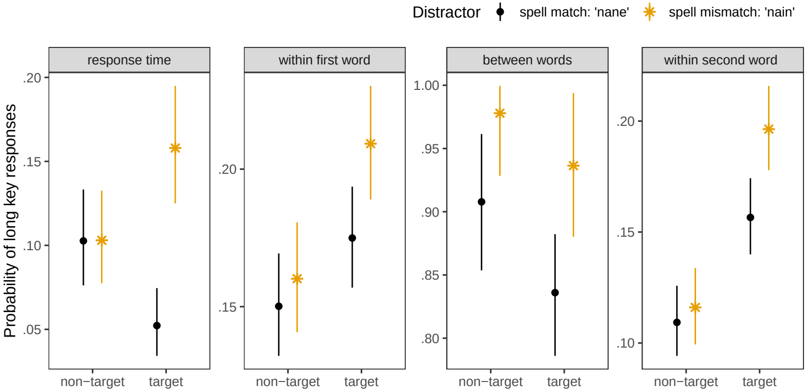

Example target phrase: "plane bike", "bike plane"

Orthography is planned in parallel to production

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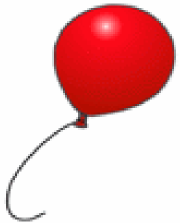
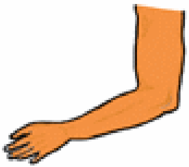
- Orthography is fully retrieved before production onset.
- No evidence that orthography of upcoming word affects the previous word.
- Spelling difficulty spilled over to pre-planning of next word.
- Whether or not parallel planning occurs depends on the time available for parallel planning (Griffin, 2003).

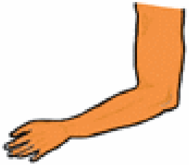
Reversed word-length effect (Griffin, 2003)

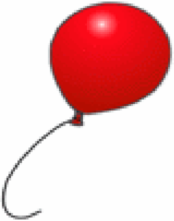




Target phrase "balloon arm"

Reversed word-length effect (Griffin, 2003)





Target phrase "arm balloon"

Reversed word-length effect (Griffin, 2003)

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- If only first noun is planned, response time for "balloon arm" should be longer than for "arm balloon".
- Griffin (2003) found the opposite.
- When the length of the first word doesn’t buy enough time to plan the second word in parallel to production, the second word must be pre-planned.
- Effect disappeared for "arm next to balloon".

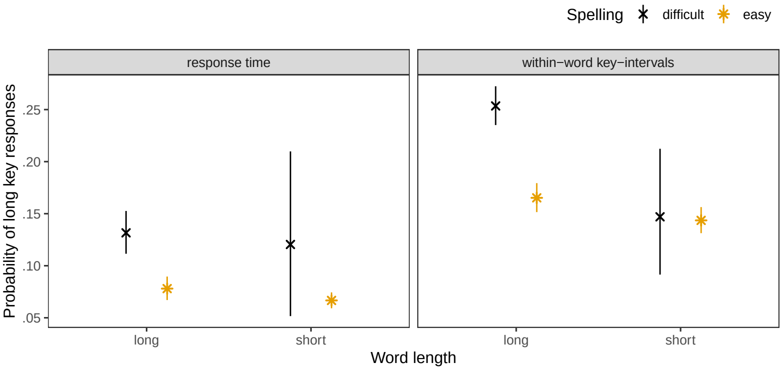
Spelling diversity

- Spelling manipulation: easy / difficulty spelling (long word); easy spelling (short word).
  - Long words: $\geqslant 2$ syllables
  - Difficult spelling: H-index > 0.5
- Naming data from Torrance et al. (2018).

$$H = \sum_{i=1}^{K} p_i \times \log_2\left(\frac{1}{p_i}\right)$$

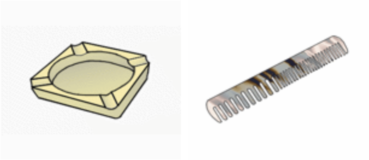
where k is the number of different spellings and p_i is the proportion of ppts producing the i^{th} spelling (Lachman, 1973).

Spelling diversity for single picture naming

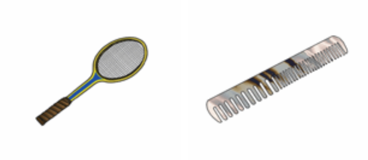


Data: Torrance et al. (2018)

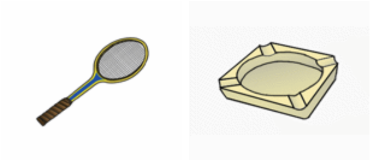
Design: Experiment 3



(a) difficult spelling, short word



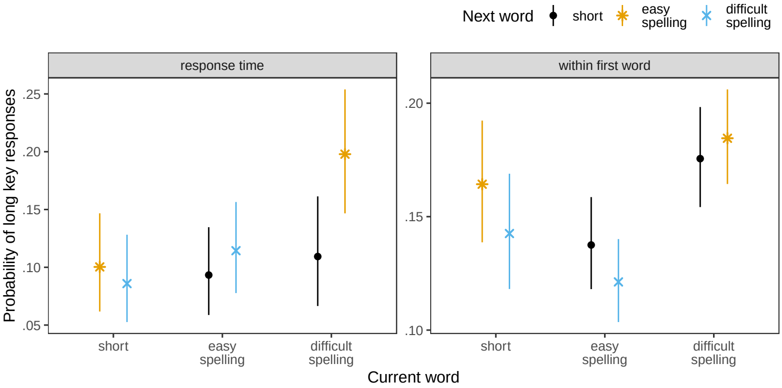
(b) easy spelling, short word



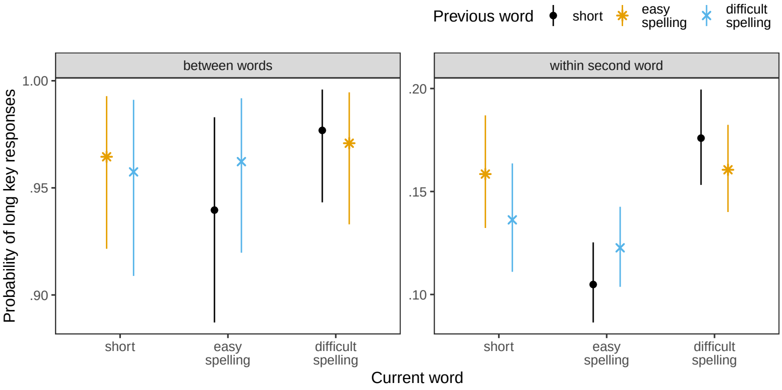
(c) easy spelling, difficult spelling

Word type (levels: difficult spelling ["ashtray"], easy spelling ["racket"], short ["comb"]) $\times$ order (levels: first word, second word)

Mixture model results: Experiment 3



Mixture model results: Experiment 3



Orthography is planned in parallel to production

- Spelling difficulty increased pausing probability before and after word onset; orthographic planning unit is smaller than the word (Kandel, 2023).
- Pre-planning of orthography depends – to some extent – on the location of the difficult-to-spell word.
- Difficulty with word spelling spills over to planning of subsequent words.
- Parallel planning of upcoming words is available if the current word and the next word are easy to spell; some general orthographic information is planned in parallel.

Thank you for listening!

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Questions / discussion points

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- Orthographic distractors that don’t match the spelling of the target name seem to slow down production time course regardless of phonological match.
- To what extent does syntactic material (e.g. "next to") reduce the word-on-word effect, and therefore facilitate parallel planning?
- Mixture models are relatively new in the writing / language production domain (but based on contemporary models [Bayesian mixed-effects models]); what criticism do I have to anticipate?

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