

"Write here, write now": real-time difficulty with word orthography delays language planning

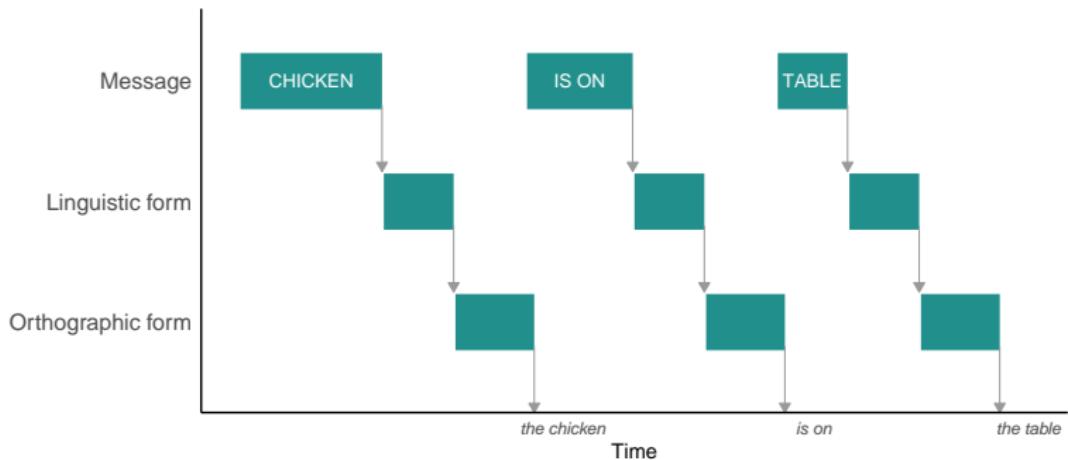
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Presented at Writing Words Workshop (Oxford Brookes)
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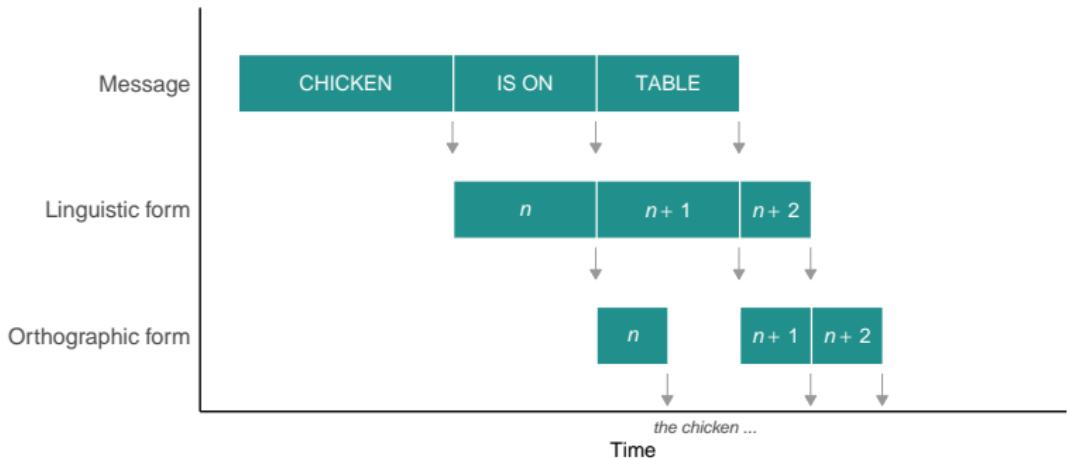
July 4, 2025

Writers pause to plan what to say next!



Planning happens at linguistic edges and unfolds in a serial fashion (Alves & Limpo, 2015; Hayes, 2012; Kaufer et al., 1986).

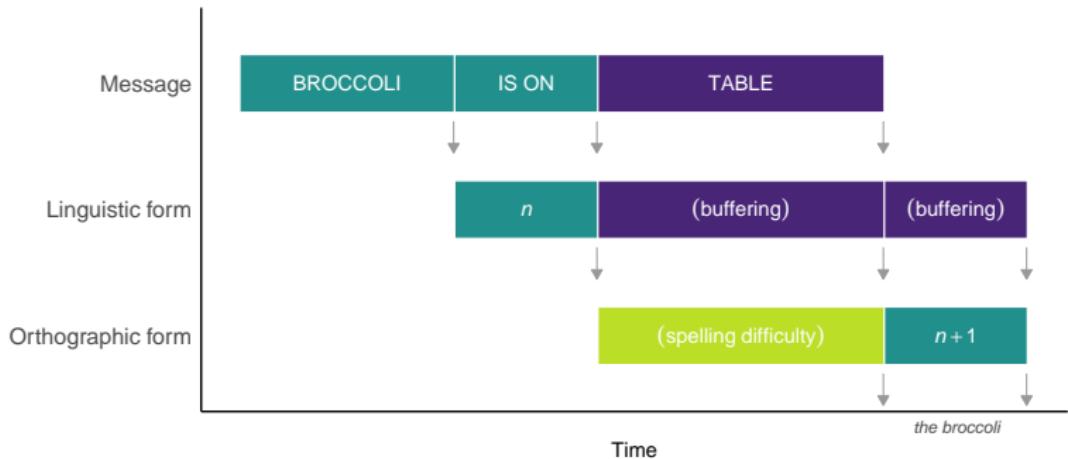
Planning can unfold in parallel to output!



Difficulty at higher levels delays output (Olive, 2014; Van Galen, 1991).

Prediction: Processing bottleneck – e.g. orthographic retrieval – has knock-on effects for upstream processes.

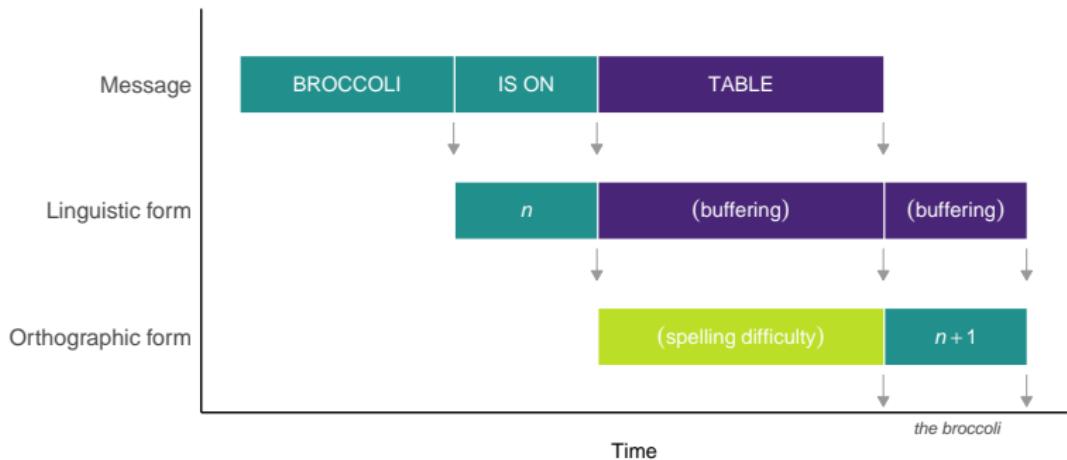
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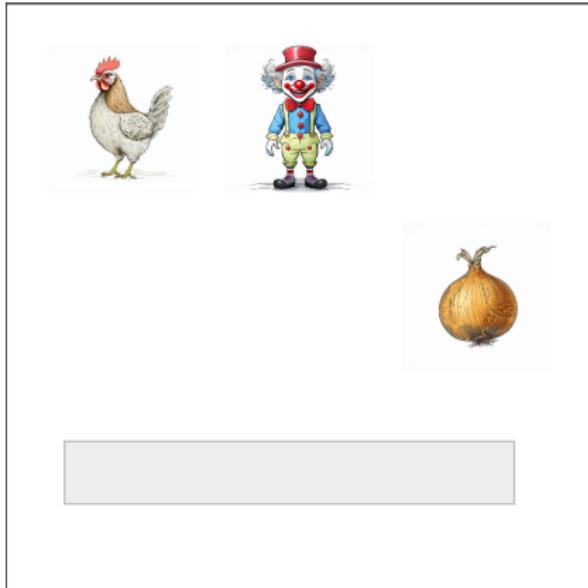
Research Question & Aims

To what extent does difficulty with word spelling affect our ability to convey ideas in writing?

This research aims to ...

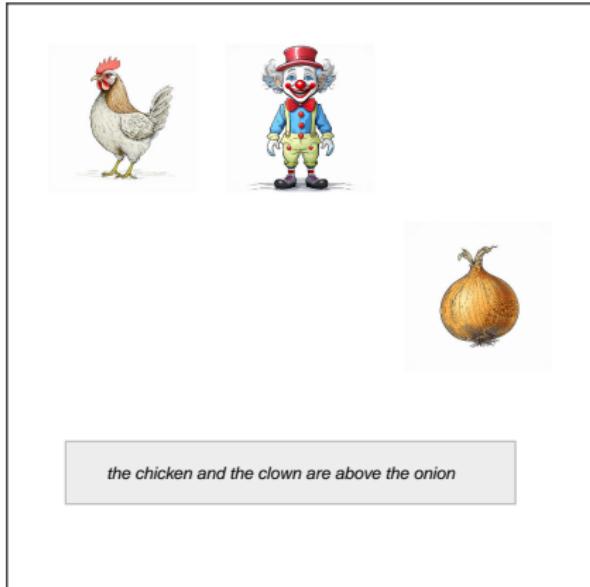
- ▶ identify crunch points that lead to typing hesitations.
- ▶ evaluate how difficult-to-spell words affect parallel planning.

Describe the arrangement from left to right!



Example screen (Roeser et al., 2019; Smith & Wheeldon, 1999)

Describe the arrangement from left to right!



Example screen (Roeser et al., 2019; Smith & Wheeldon, 1999)

Design: Example item set

N1: easy spelling / long



the chicken and ...

N1 difficult spelling / long



the broccoli and ...

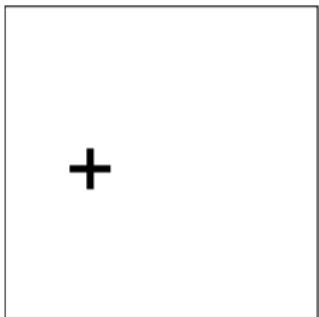
N1: easy spelling / short



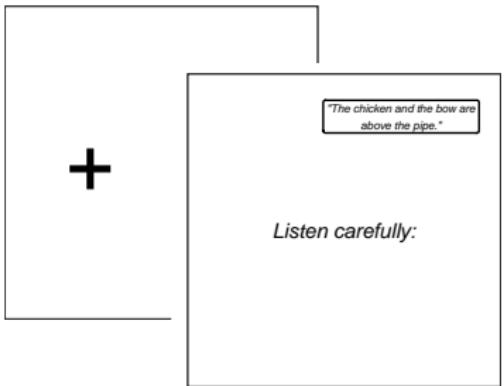
the wok and ...

Prediction: Hesitations for N2 (*clown*) result from (1) when properties of N1 (*broccoli*) couldn't be retrieved in time and (2) when N1 length (*wok*) didn't allow for parallel planning.

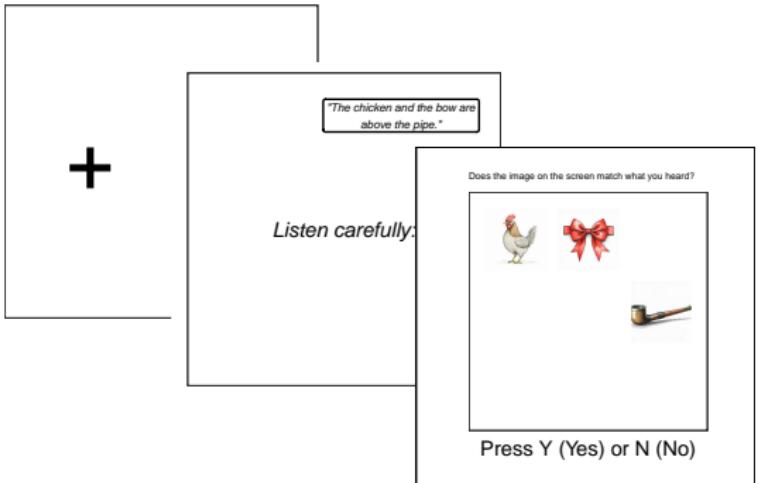
Window sequence



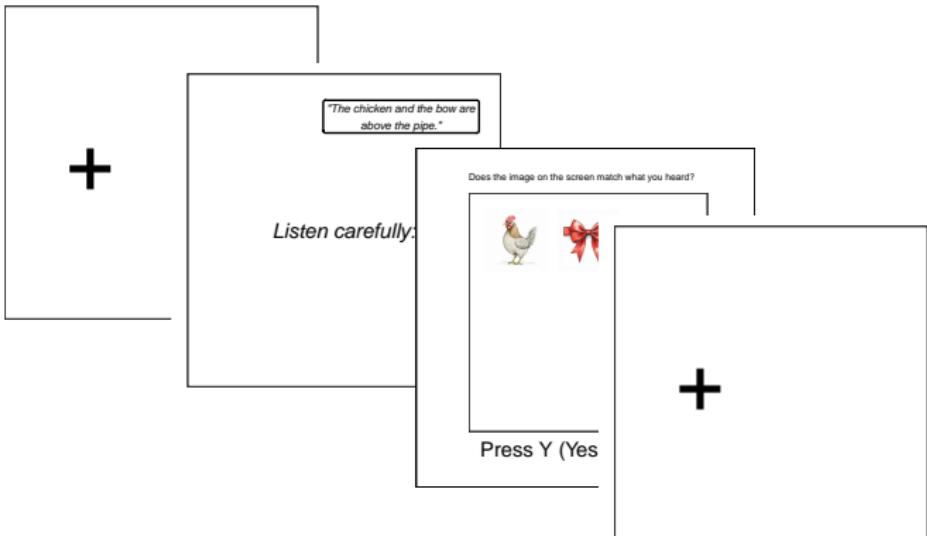
Window sequence



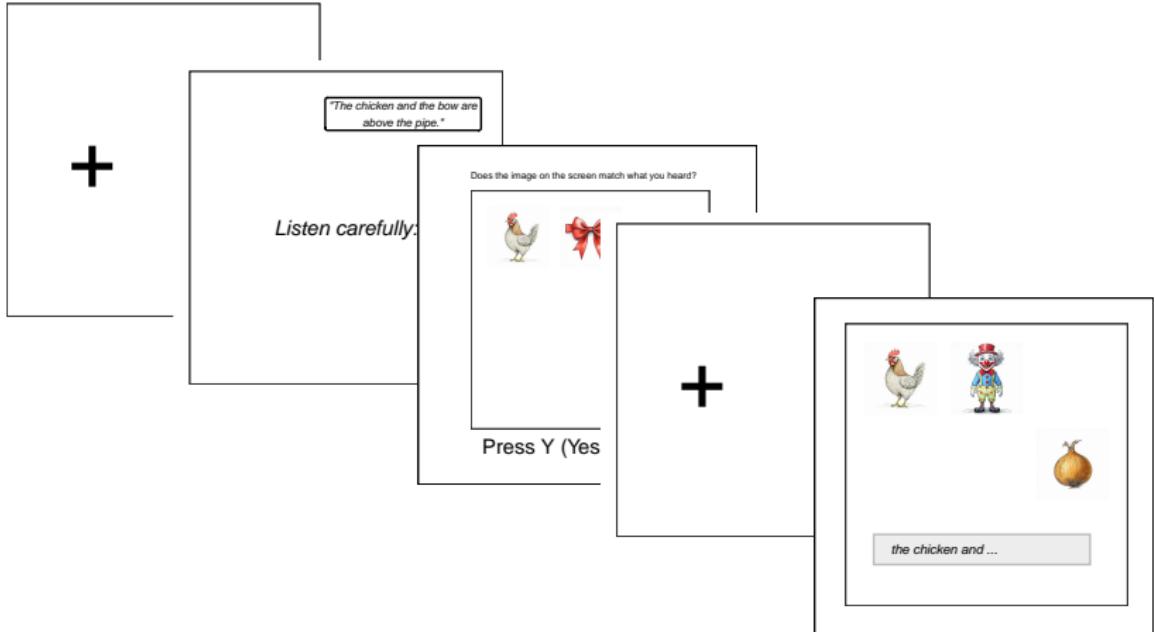
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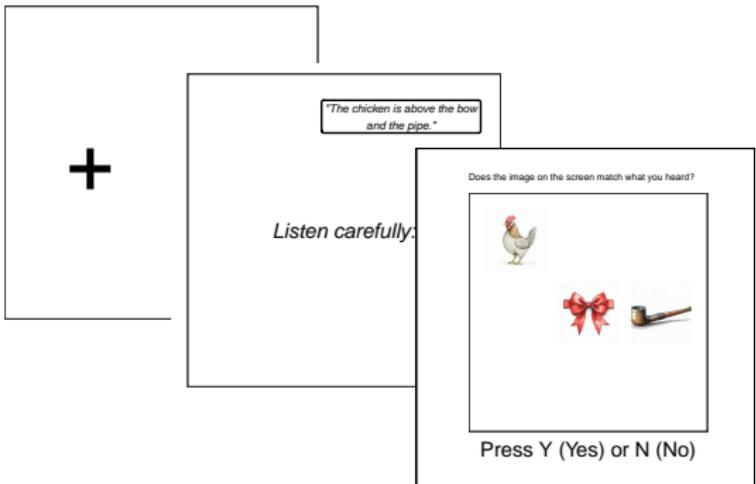
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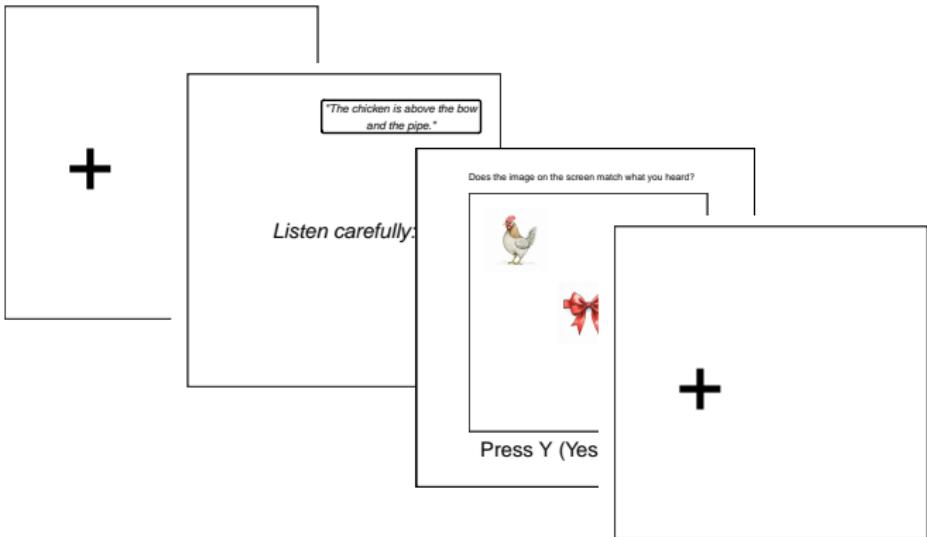
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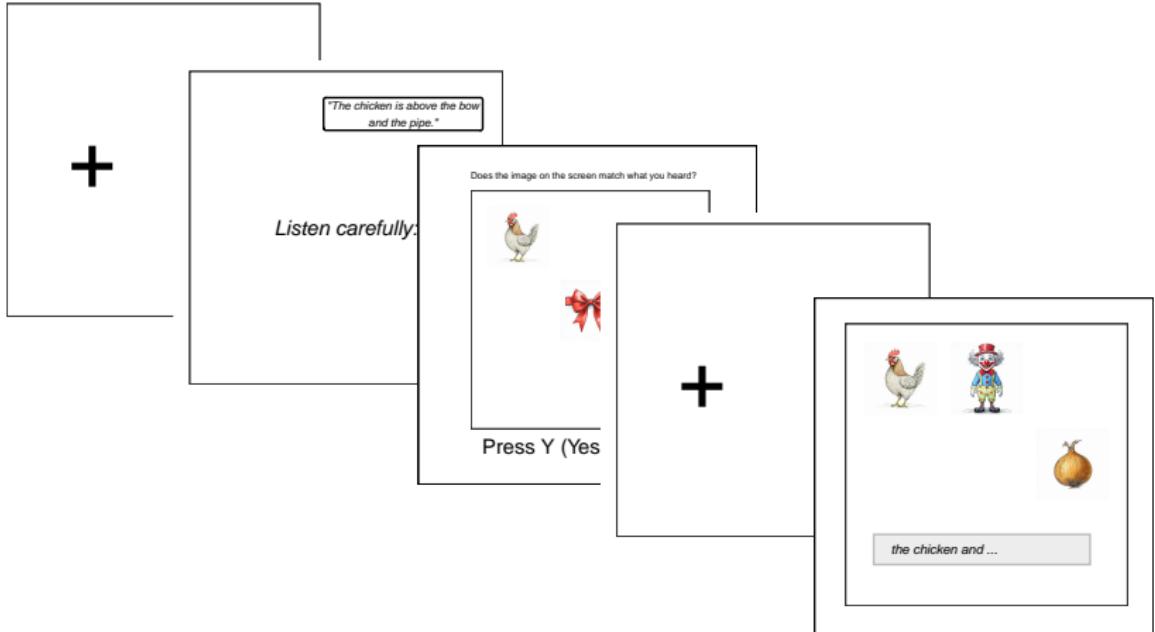
Window sequence



Window sequence



Window sequence



Materials

- ▶ Prime-target design controls for syntax (Konopka, 2012).
- ▶ N1 repetition in prime and target controls for lexical retrieval.
- ▶ N1 word type manipulation: easy spelling (long), easy spelling (short), difficult spelling (long):
 - ▶ Long: ≥ 2 syllables
 - ▶ Difficult: spelling diversity $H > 0.5$
- ▶ 36 items counterbalanced for prime structure and N1 word type.
- ▶ 24 fillers with structures different from items.
- ▶ Sentence-picture match: YES for items; NO for filler trials.

Spelling diversity

Images were based on Rossion and Pourtois (2004) and Snodgrass and Vanderwart (1980).

Spelling diversity was calculated using (Lachman, 1973; Torrance et al., 2018)

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

where k is the number of spellings for a picture name and p_i is the proportion of participants producing the i^{th} spelling.

Write the name of what you see!

Write the name of what you see!



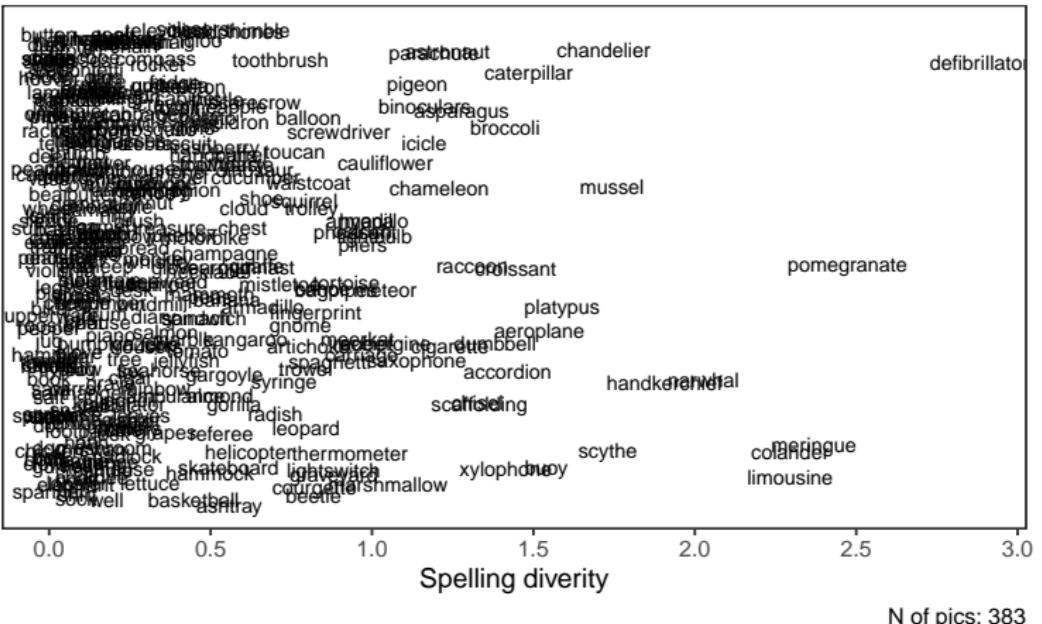
Spelling diversity

Example summary for “raccoon”.

response	N_{resp}	N_{name}	N_{ppts}	Pr_{name}	H_{name}	Pr_{spell}	H_{spell}
raccoon	41	75	97	.77	2.48	.55	1.31
racoon	30	75	97	.77	2.48	.40	1.31
raccon	2	75	97	.77	2.48	.03	1.31
raccoo	1	75	97	.77	2.48	.01	1.31
racoo	1	75	97	.77	2.48	.01	1.31
skunk	8	8	97	.08	2.48	1.00	–
badger	6	6	97	.06	2.48	1.00	–
lemur	2	2	97	.02	2.48	1.00	–
animal	2	2	97	.02	2.48	1.00	–
red panda	1	1	97	.01	2.48	1.00	–
possum	1	1	97	.01	2.48	1.00	–
cougar	1	1	97	.01	2.48	1.00	–
meer kat	1	1	97	.01	2.48	1.00	–

Note. H indicates the diversity statistic; Pr is the proportion of responses.

Spelling diversity



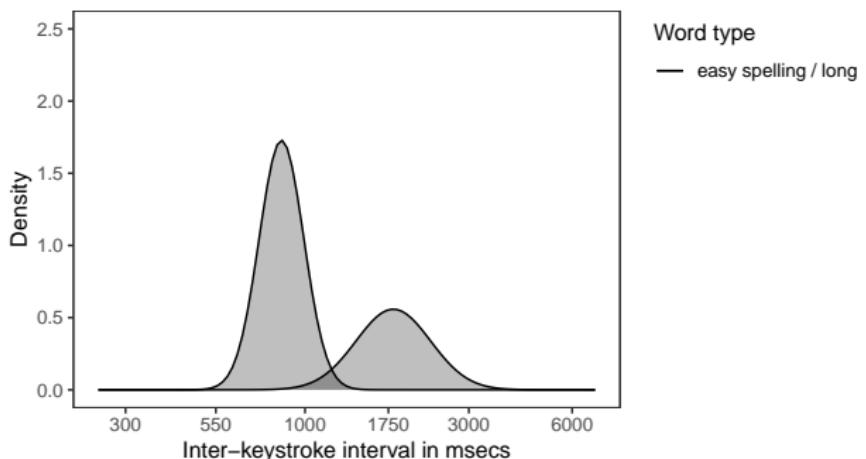
See poster presentation Aros Muñoz et al.

Participants

Ten ppts per counterbalancing list. After data cleaning:

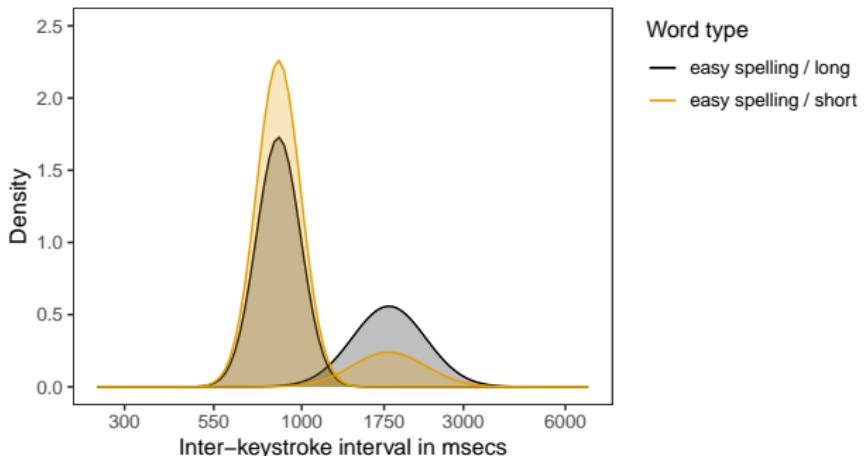
- ▶ Experiment 1: 56 ppts (6 lists)
- ▶ Experiment 2: 80 ppts (9 lists)
- ▶ Experiment 3: 96 ppts (12 lists)

Data analysis: typing as mixture process



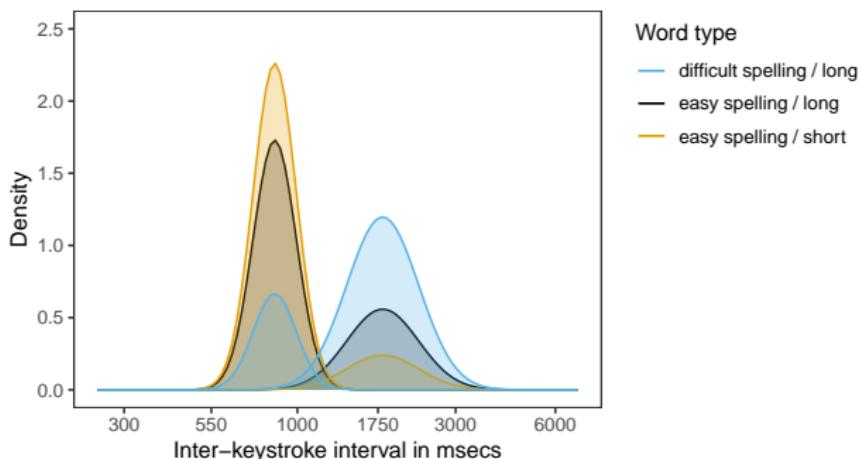
Inter-keystroke intervals were modelled as Bayesian mixed-effects mixture model (Roeser et al., 2024, 2025). For a tutorial see:
<https://rpubs.com/jensroes/mixture-models-tutorial>.

Data analysis: typing as mixture process



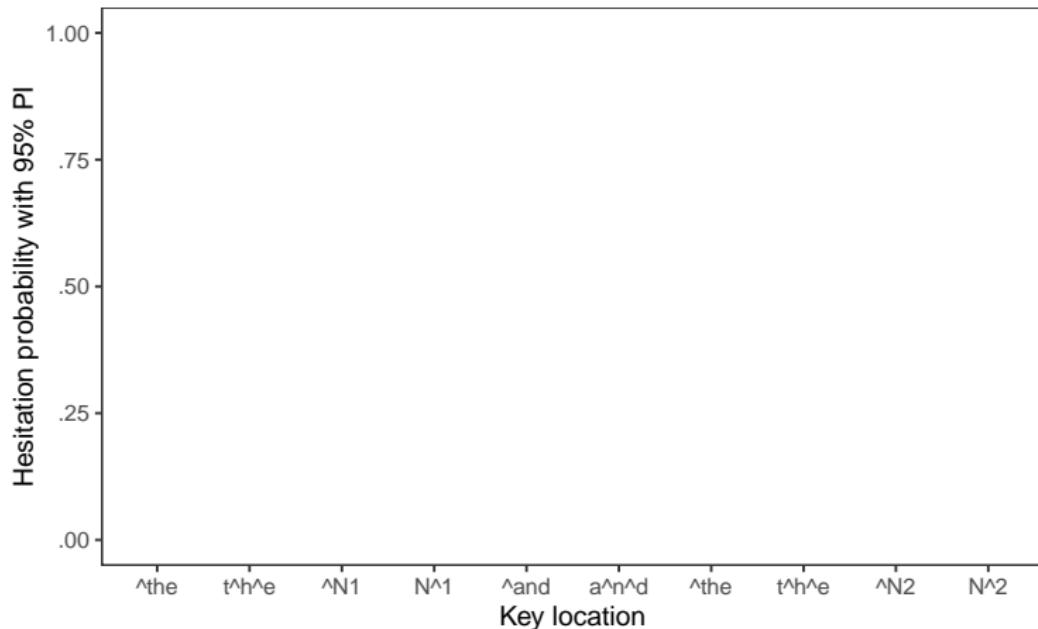
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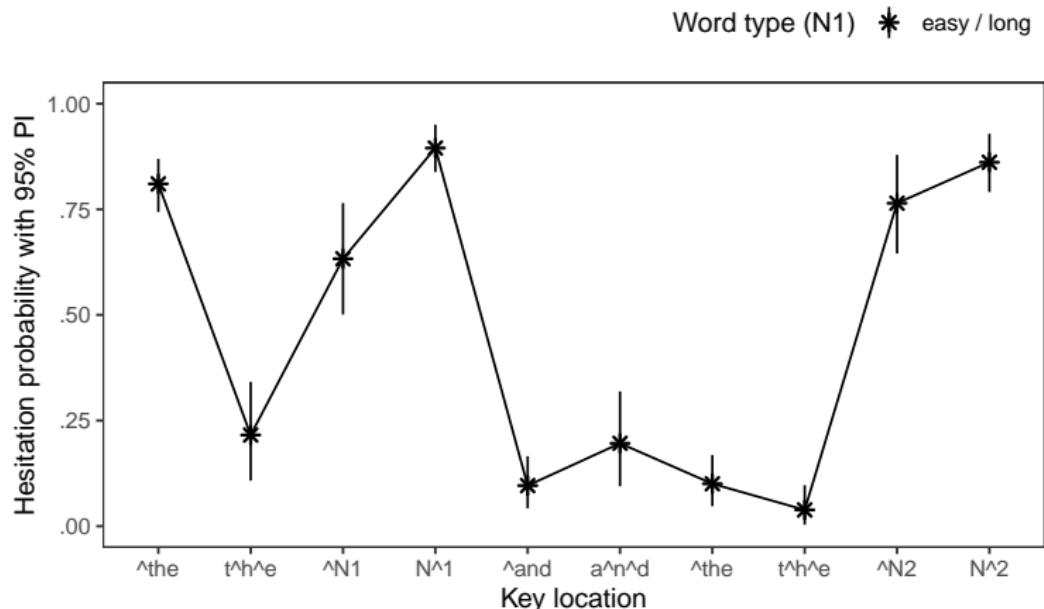


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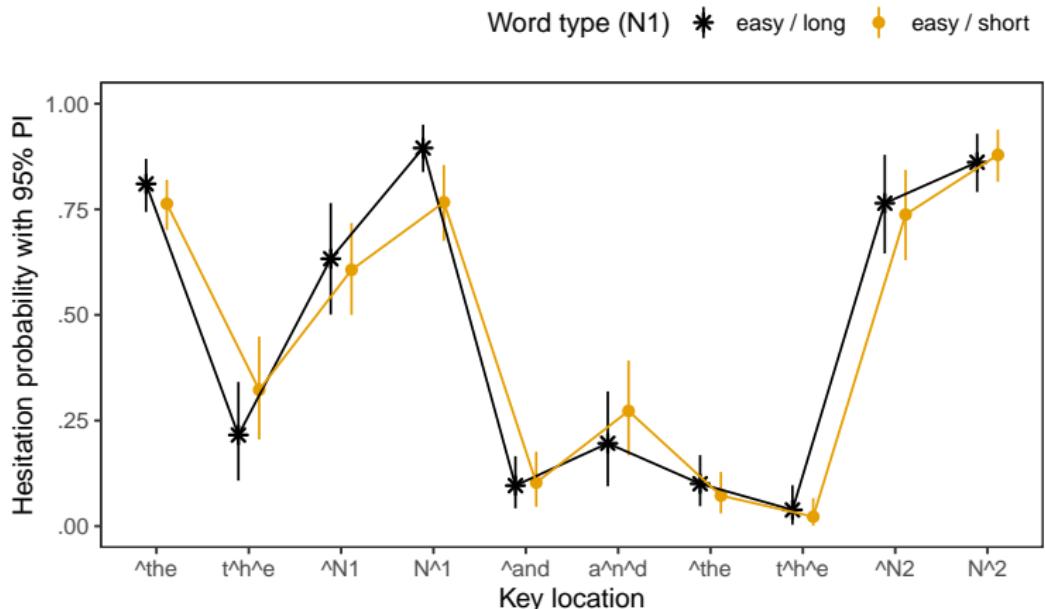
Experiment 1: typing timecourse



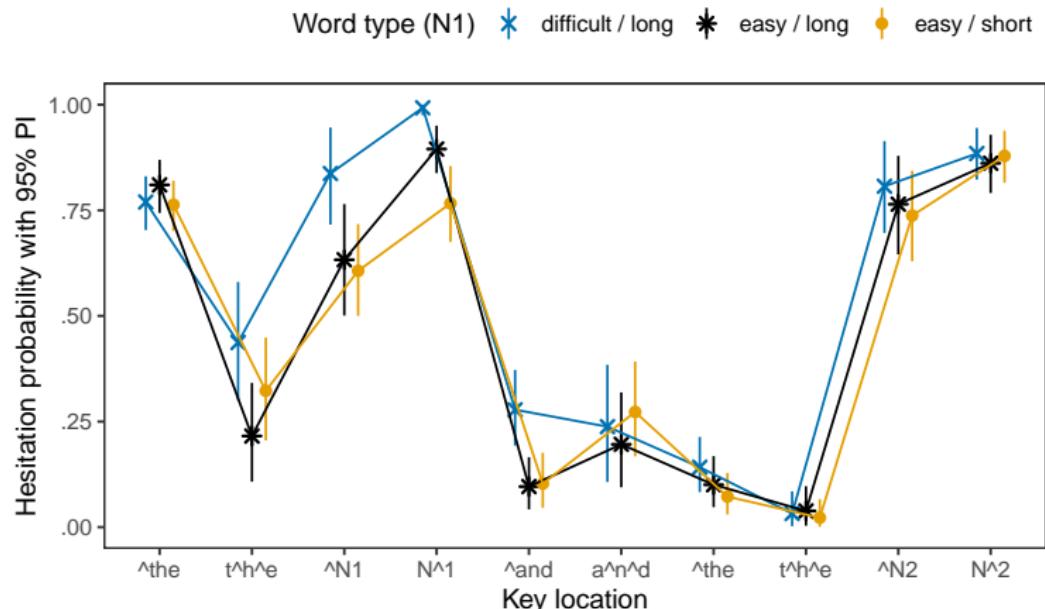
Experiment 1: typing timecourse



Experiment 1: typing timecourse



Experiment 1: typing timecourse



Experiment 2

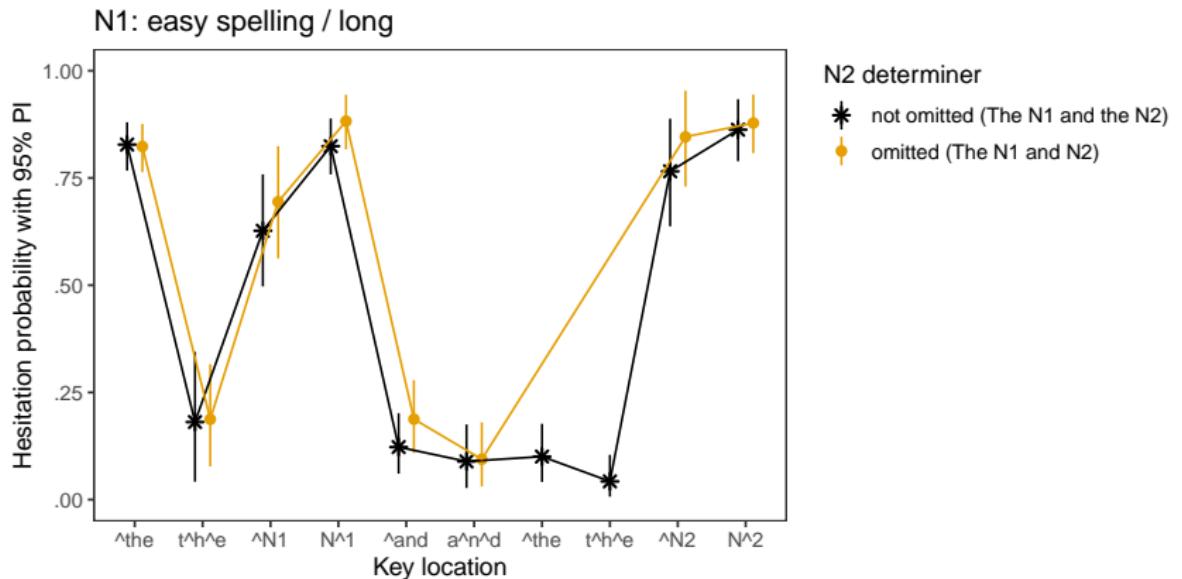
Function words might mediate spelling hesitations: Does *and the* buy enough time to avoid intra-sentence hesitations?

Additional prime condition and thus two target structures:

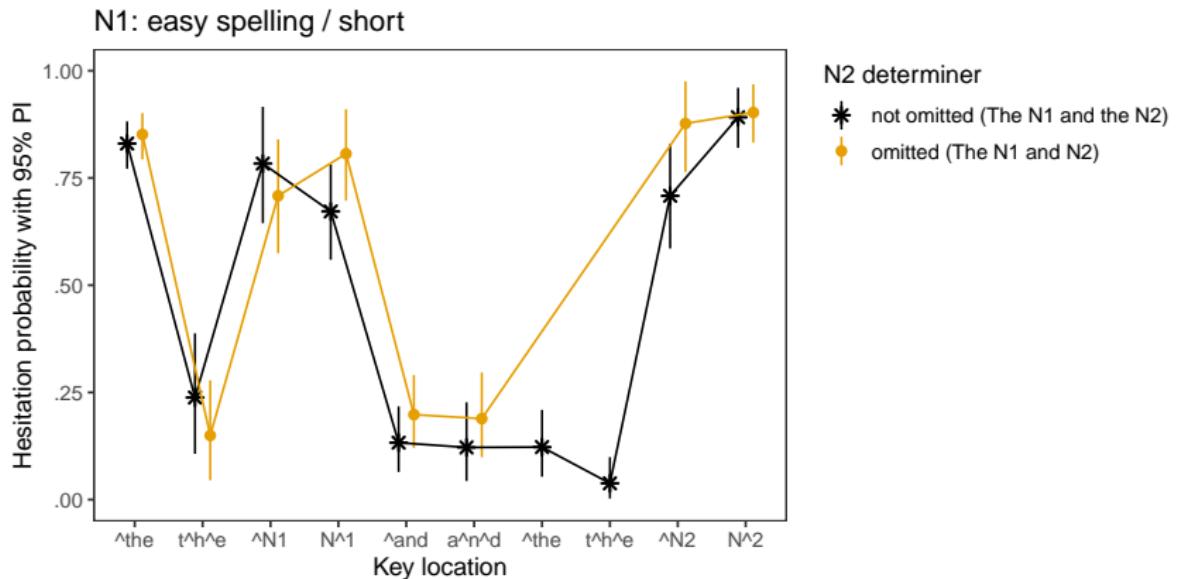
- ▶ With N2 determiner: *The N1 and the N2 are above the N3*
- ▶ Without N2 determiner: *The N1 and N2 are above the N3*

Prediction: If the omission of non-lexical functional words constraints parallel planning, we expect more hesitations before N2.

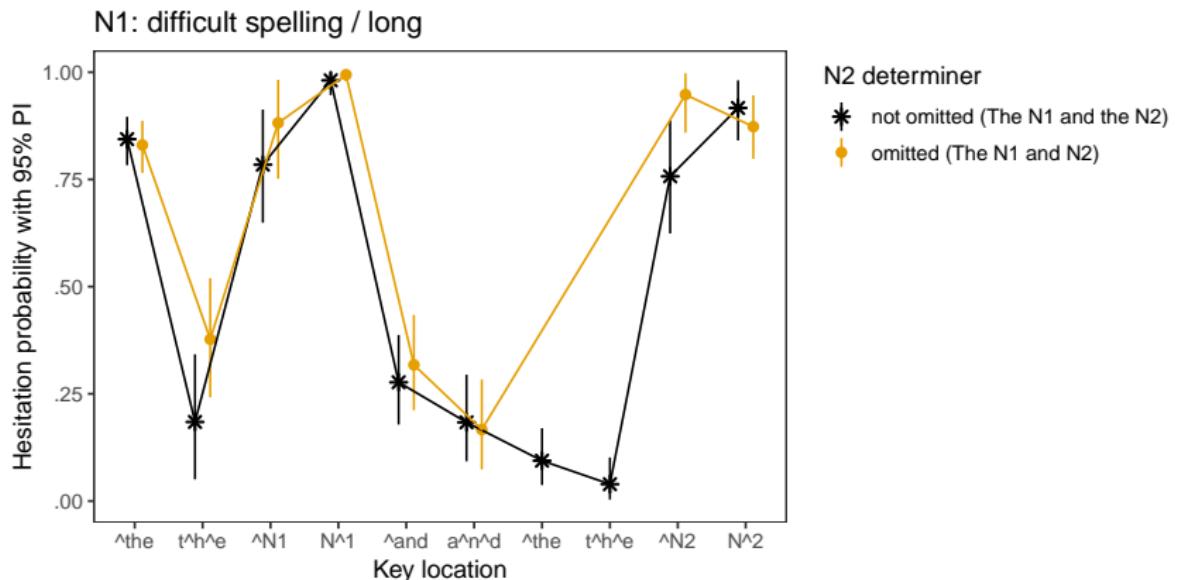
Experiment 2: typing timecourse



Experiment 2: typing timecourse



Experiment 2: typing timecourse



Experiment 3

Post-N1 hesitations can be explained by N2 retrieval or N1 error monitoring.

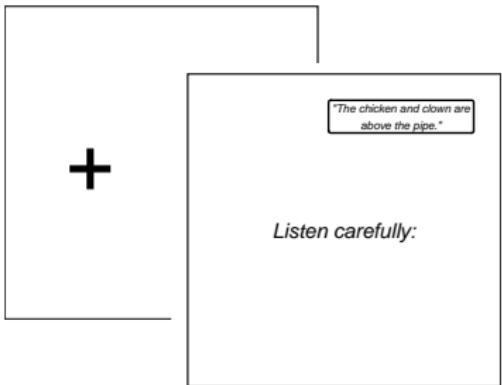
Prime with (auditory) N2 preview:

- ▶ N2 not previewed: *The N1 and bow are above the pipe*
- ▶ N2 previewed: *The N1 and clown are above the pipe*

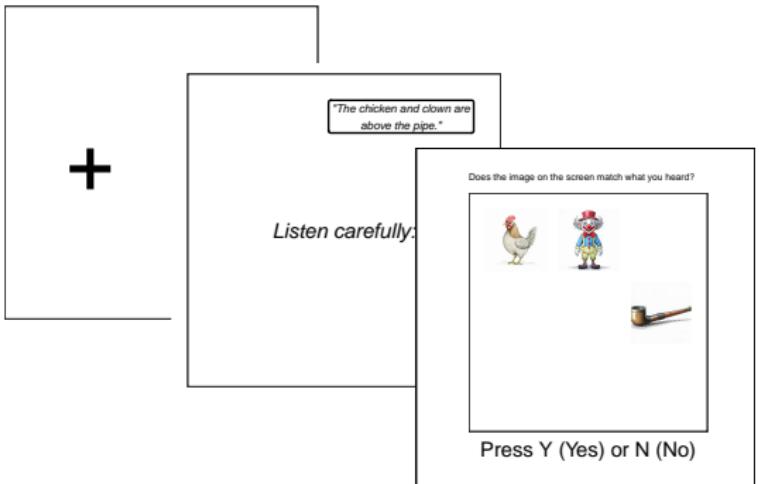
Target: *The N1 and clown are above the onion*

Prediction: If planning bottlenecks delay lexical retrieval of N2, preview will reduce associated hesitations.

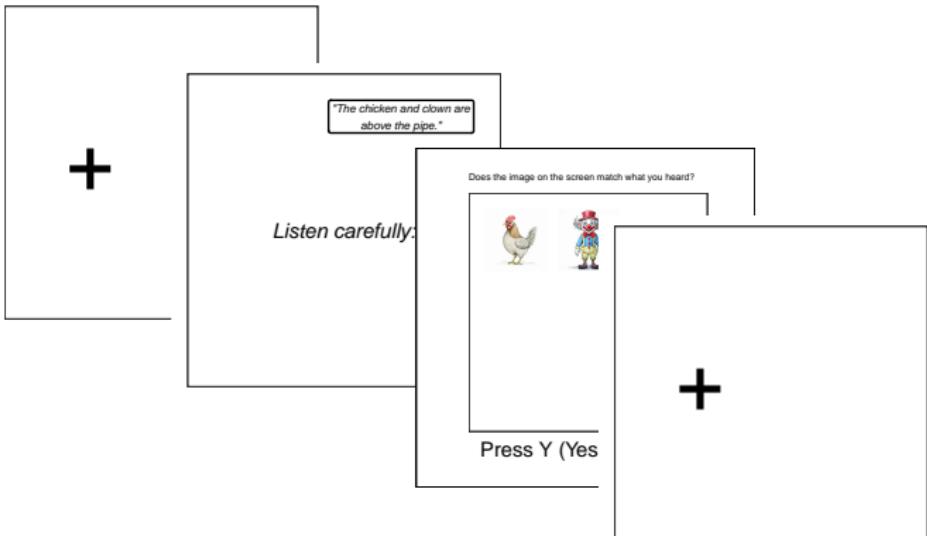
Experiment 3: N2 preview



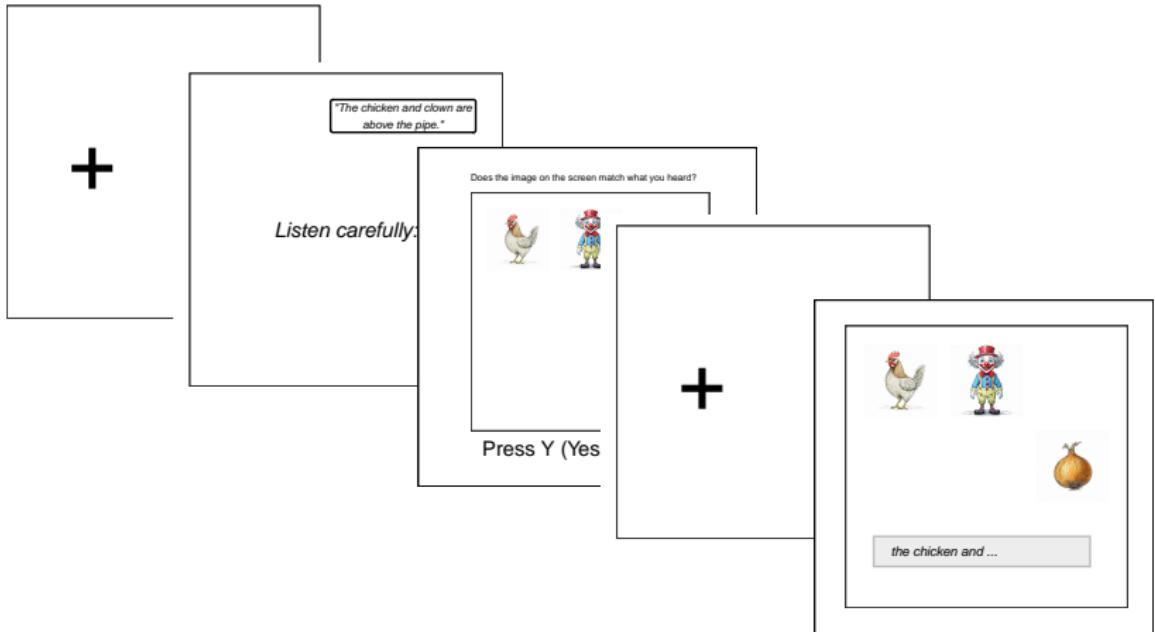
Experiment 3: N2 preview



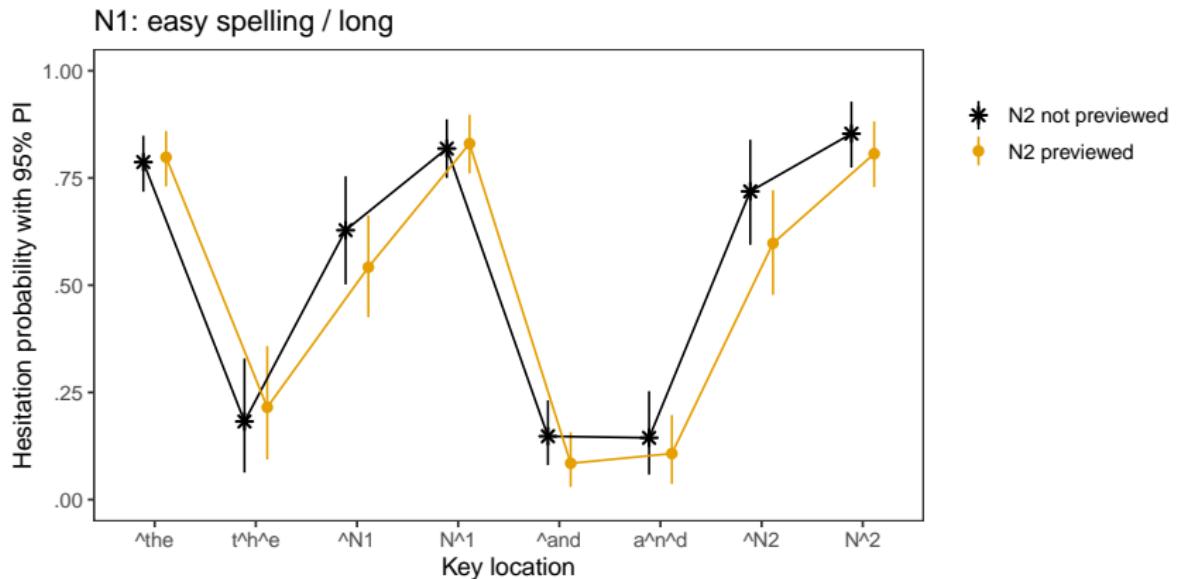
Experiment 3: N2 preview



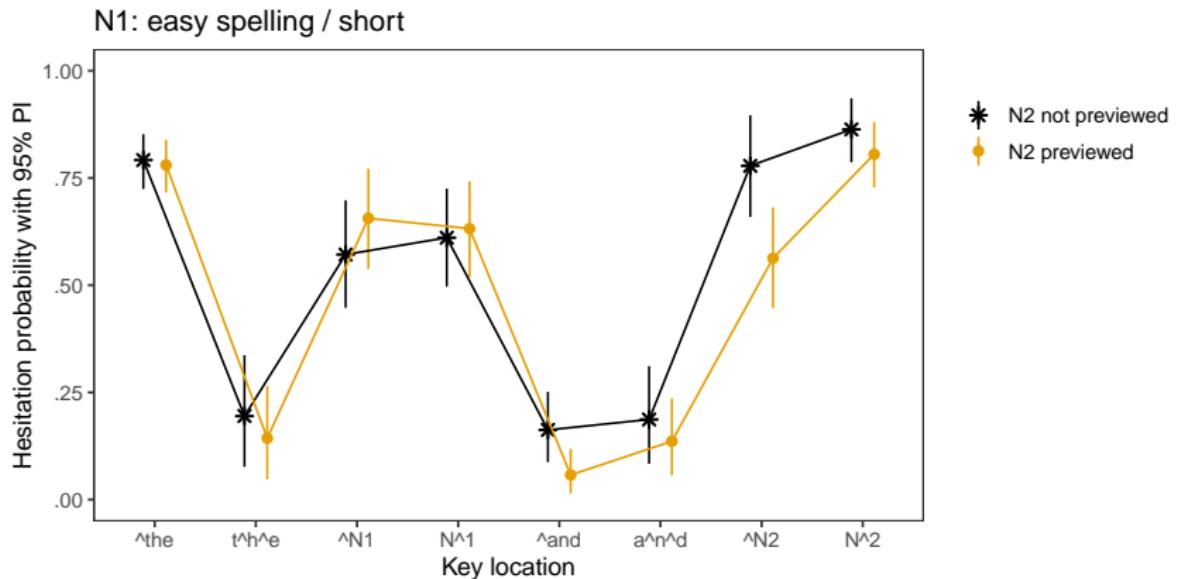
Experiment 3: N2 preview



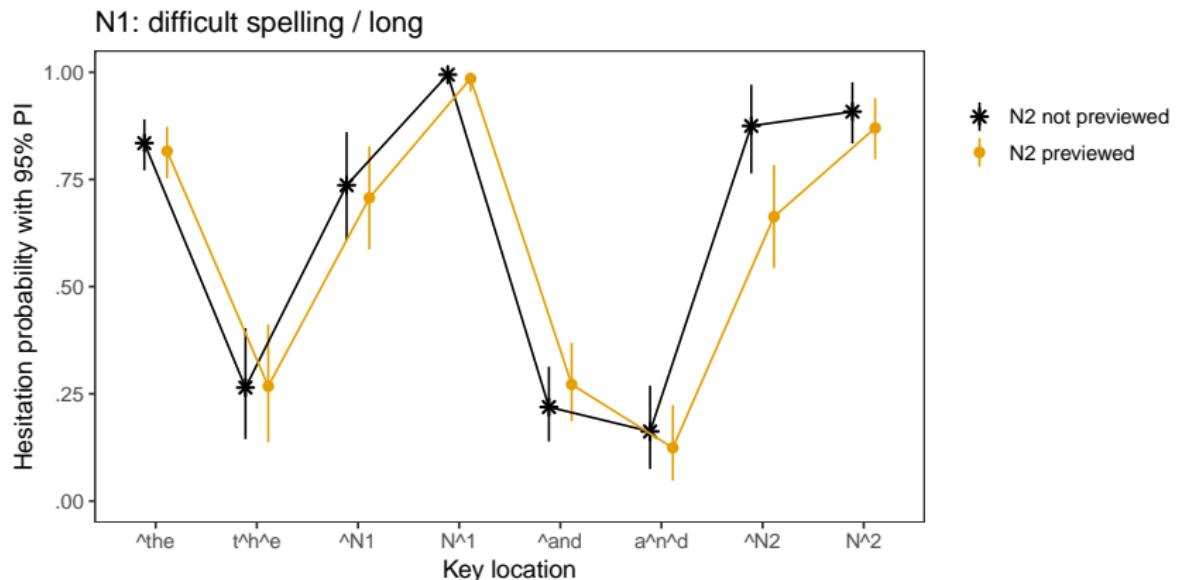
Experiment 3: typing timecourse



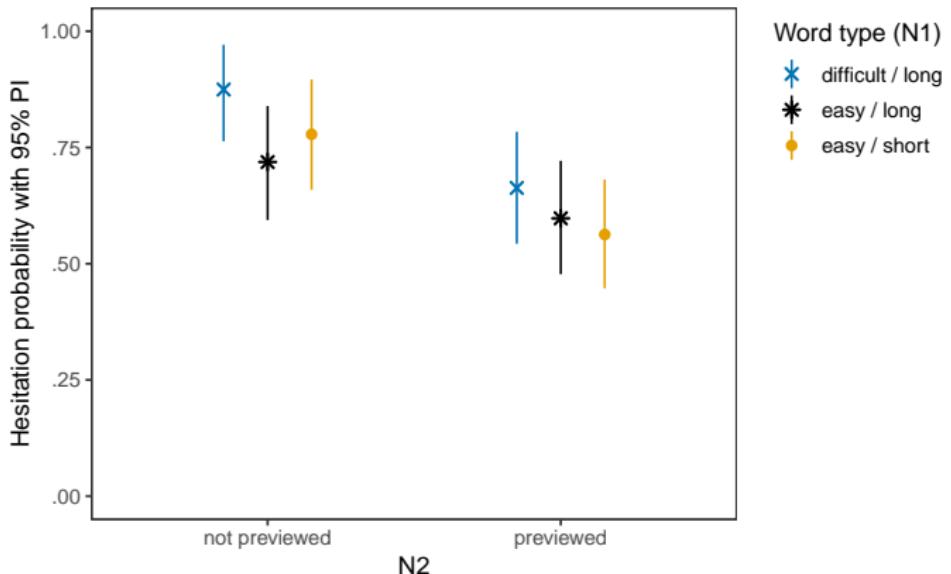
Experiment 3: typing timecourse



Experiment 3: typing timecourse



Experiment 3: N2-initial hesitations



Orthography is planned in parallel to production

- ▶ Pauses occur if lexical and orthographic information couldn't be retrieved in time.
- ▶ Parallel planning of upcoming words is available if the current word is long enough and easy to spell.
- ▶ Spelling difficulty increases pausing probability before and after word onset; orthographic planning unit is smaller than the word (Kandel, 2023).
- ▶ Spelling related pauses: retrieval of orthography, error monitoring, planning of subsequent words
- ▶ Function words – e.g. *the* – provide time for parallel planning.

Thank you for listening!

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Funded by UKRI ESRC (ES/W011832/1) – Project title: "Can you use it in a sentence?": Establishing how word-production difficulties shape text formation

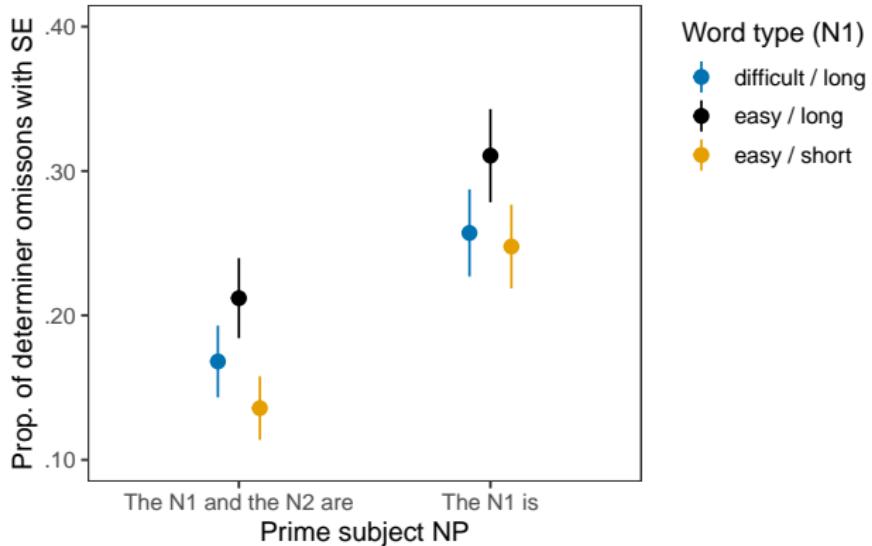
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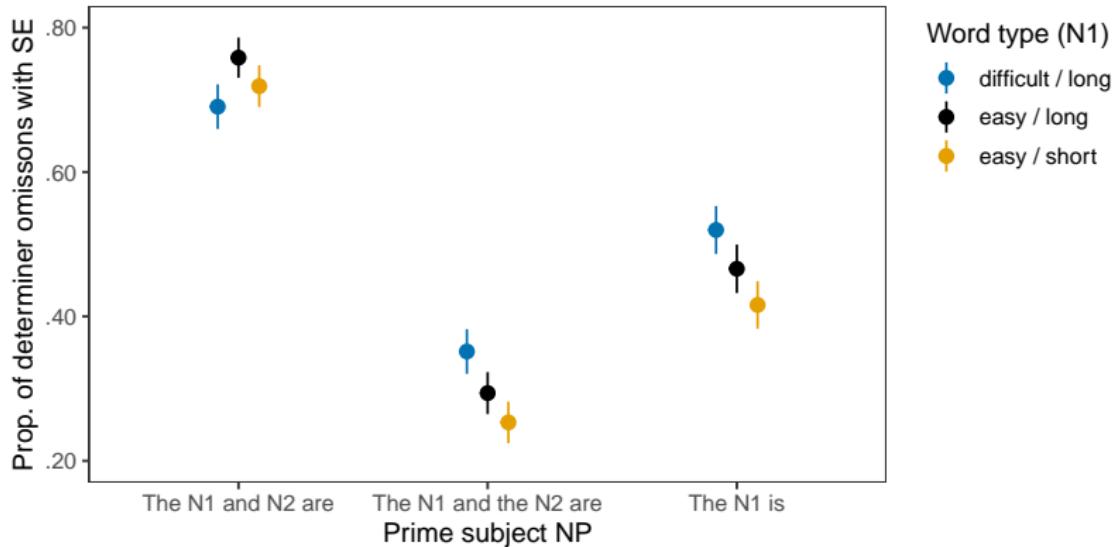
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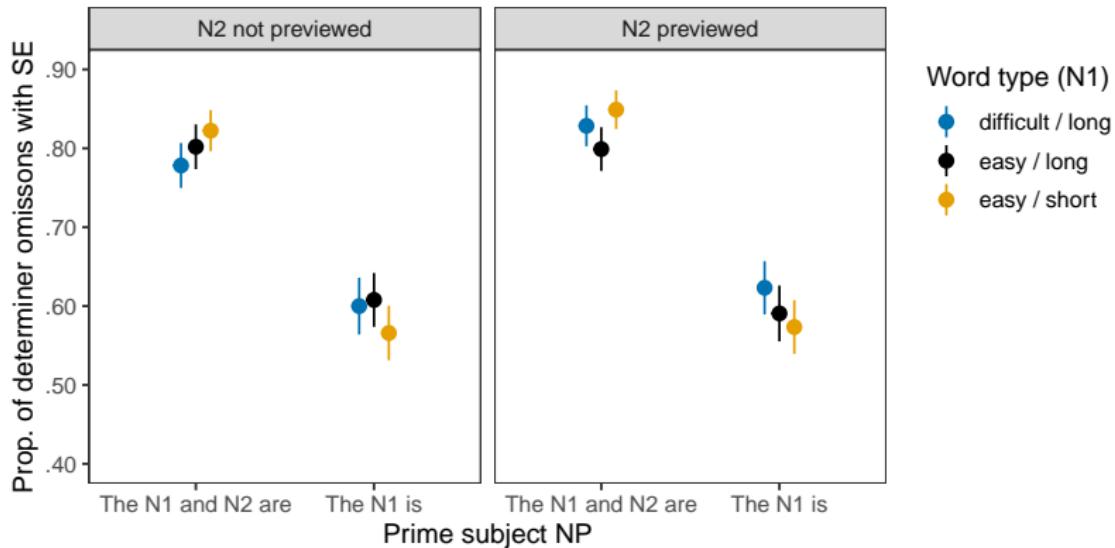
Experiment 1: determiner omissions before N2



Experiment 2: determiner omissions before N2



Experiment 3: determiner omissions before N2



Typing as mixture process

Inter-keystroke intervals were analysed in mixture models with shifted-lognormal distributions (Roeser et al., 2024, 2025).

$$(\log(iki_{ij}) - shift_i) \sim \theta_{condition} \times \mathcal{N}(\beta_{location} + \delta_{location} + u_i + w_j, \sigma_{e'}^2) + \\ (1 - \theta_{condition}) \times \mathcal{N}(\beta_{location} + u_i + w_j, \sigma_e^2)$$

where:

$$u_i \sim \mathcal{N}(0, \sigma_u^2)$$

$$w_j \sim \mathcal{N}(0, \sigma_w^2)$$

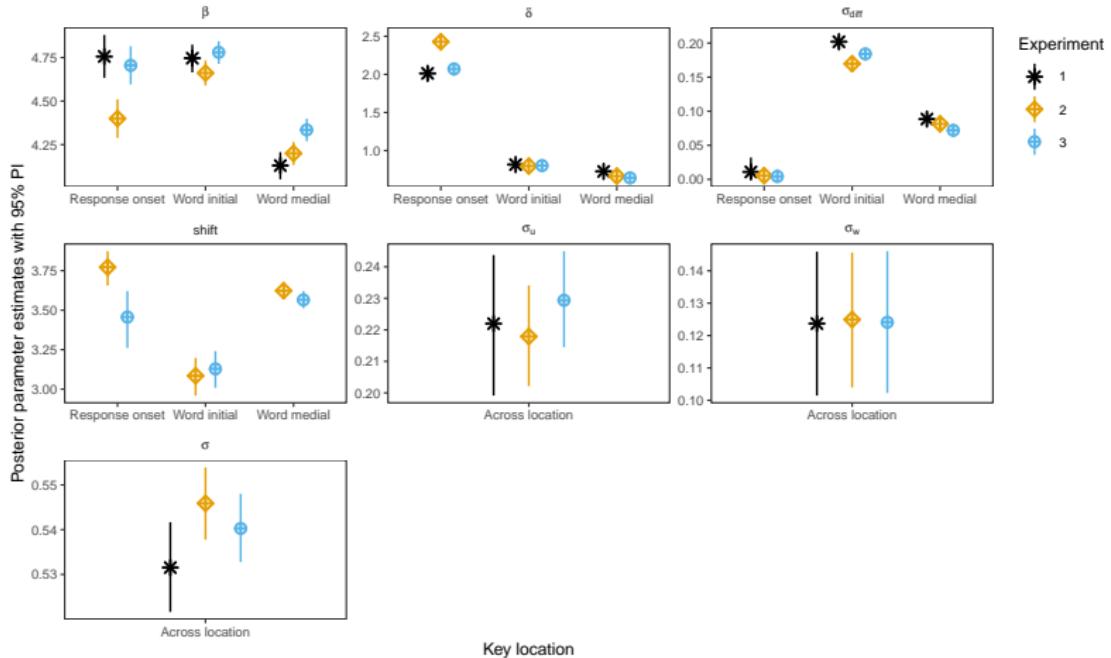
constraints:

$$\delta, \text{ (and all } \sigma\text{s)} > 0$$

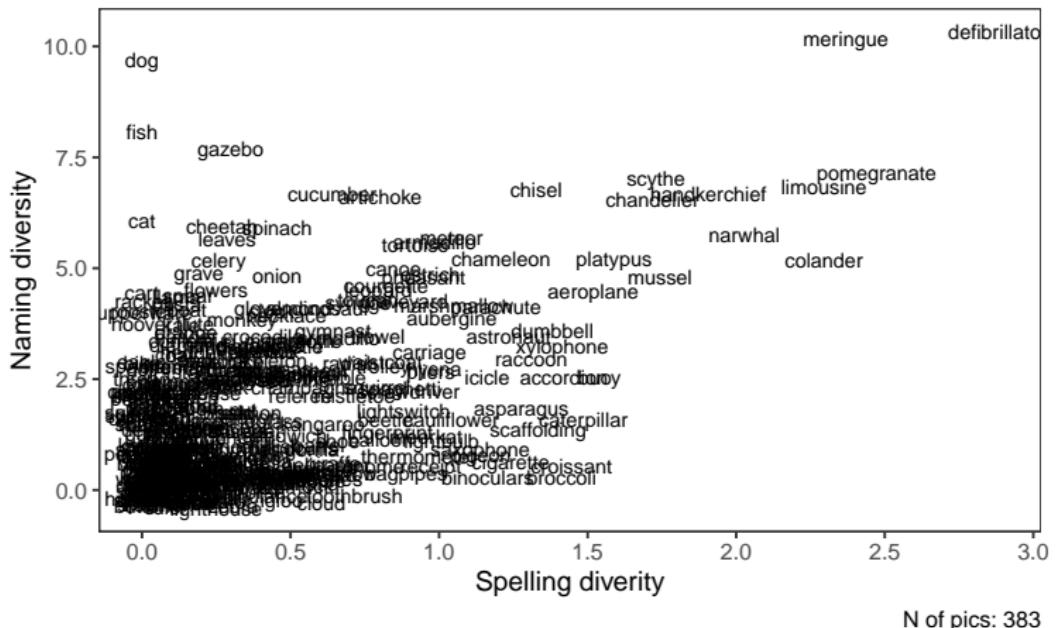
$$\sigma_{e'}^2 > \sigma_e^2$$

θ returns the proportion of hesitant inter-keystroke intervals for each key-location, prime and N1 condition.

Most other mixture model parameter estimates



Spelling and naming diversity



See poster presentation Aros Muñoz et al.