A-maze of Natural Stories:

Texts are comprehensible using the Maze task

Veronica Boyce, Roger Levy

AMLaP 2020

Incremental processing methods

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Want a measure of processing difficulty

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Want a measure of processing difficulty
Assume that longer RT = more difficulty

Incremental processing methods

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Assume that longer RT = more difficulty

How to measure RT?

Incremental processing methods

Common ways to measure RT

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Common ways to measure RT

Eye-tracking

Incremental processing methods

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Eye-tracking

Self-paced reading

Incremental processing methods

Common ways to measure RT

Eye-tracking

Self-paced reading

The - - - - - - - - - - -

Incremental processing methods

Common ways to measure RT

Eye-tracking

Self-paced reading

- - - cat - - - - - - - -

Incremental processing methods

Common ways to measure RT

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- - - - - - drank - - - -

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- - - - - - - - - - -milk.

Incremental processing methods

Common ways to measure RT

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Different methods have different trade-offs

An alternative: Maze

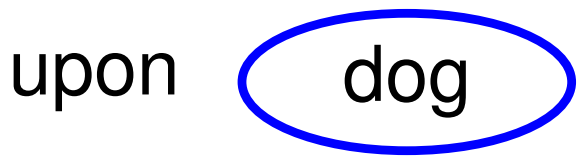
The x-x-x

An alternative: Maze

An alternative: Maze

upon dog

An alternative: Maze



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revise chased

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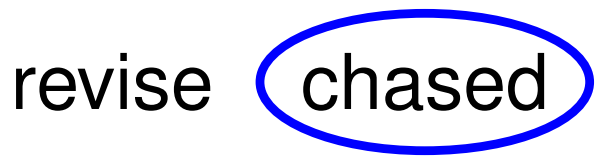

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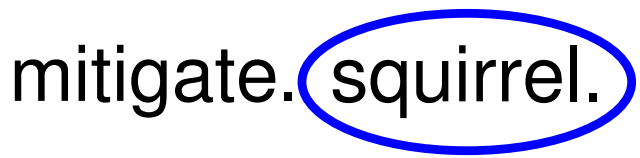

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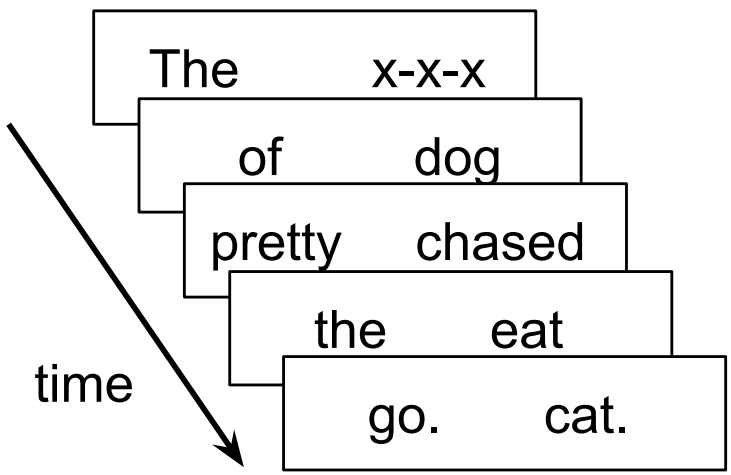
(Forster et al. 2009; Witzel et al. 2012)

G-maze

‘Grammatical’ choices



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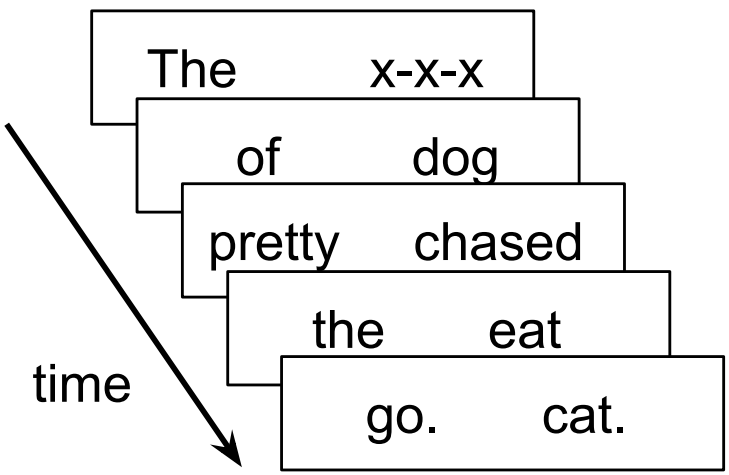
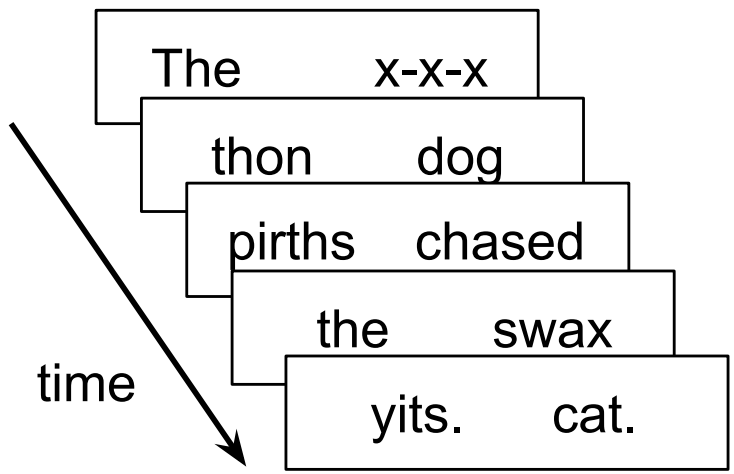


L-maze

'Lexical' choices



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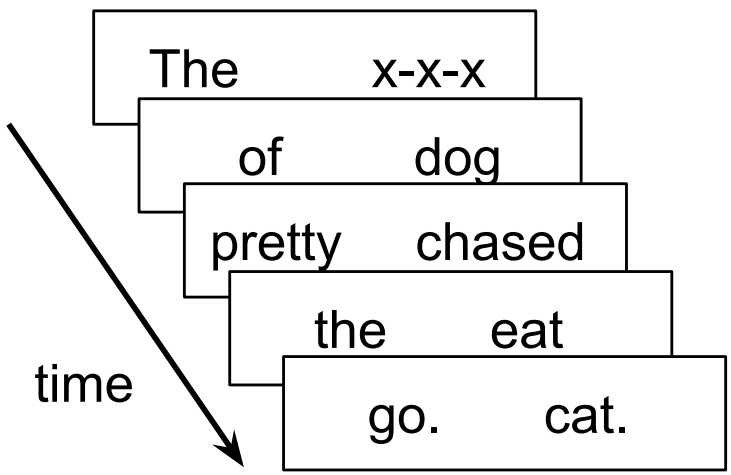

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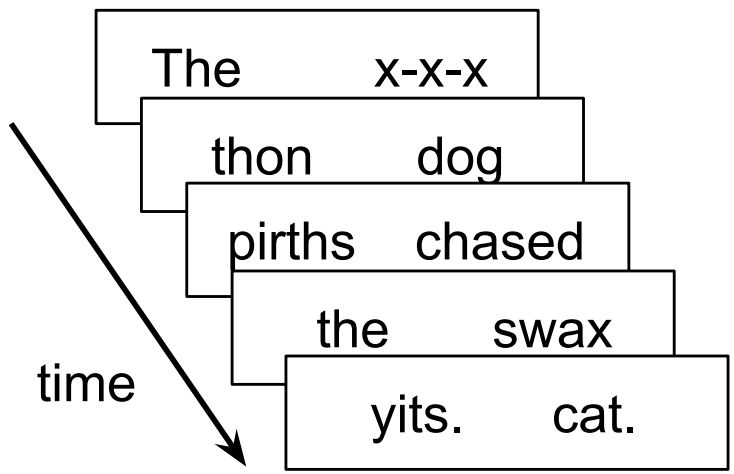

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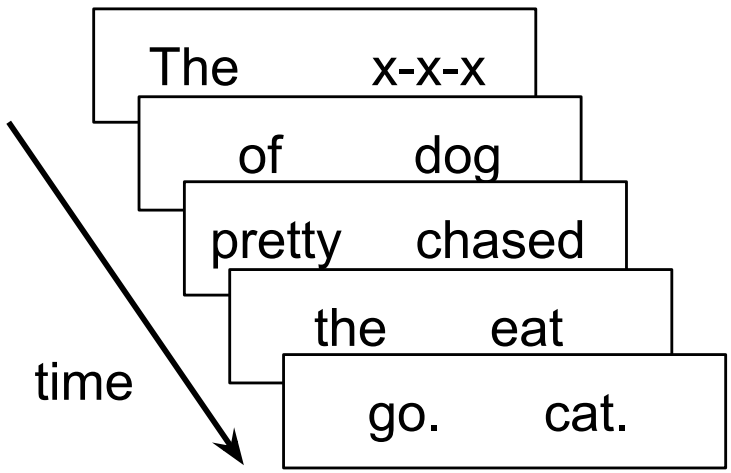

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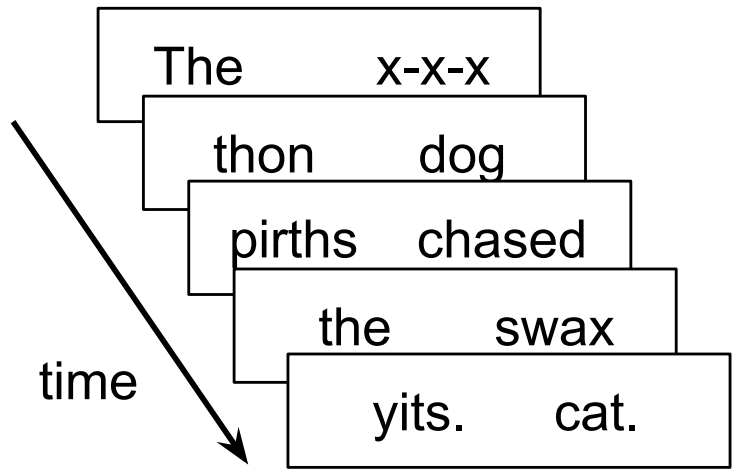

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Claim: forces incremental processing (no spillover)

Maze Made Easy

Can we use Maze instead of web SPR?

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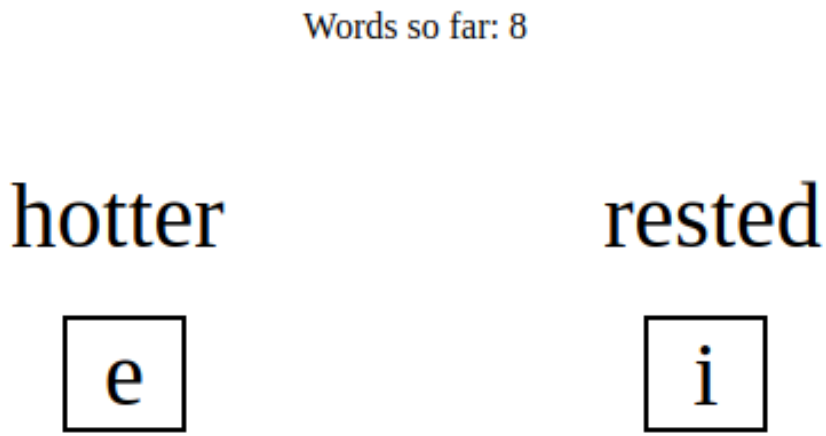

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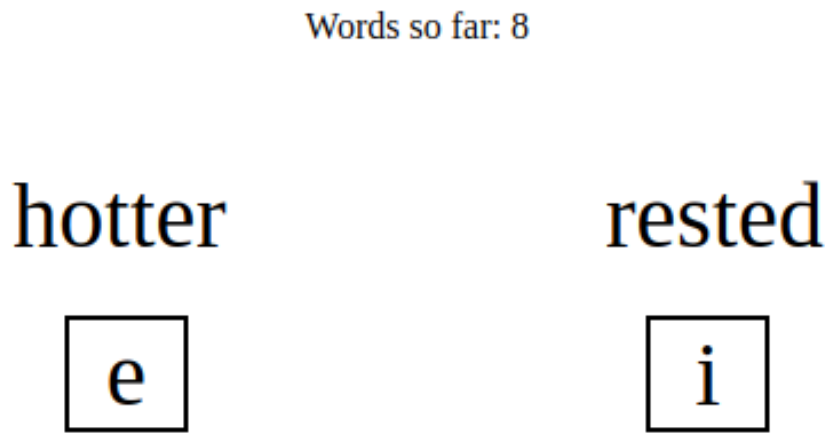

Replicated Witzel et al. (2012) results (Boyce et al. 2020)

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Goal: Find a word that can’t continue a partial sentence

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Can we use Neural Language Models?

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Run items through LM, choose high surprisal words as distractors

Add some restrictions:

- Restrict to a list of possible distractors
- Only consider length, frequency matches

Does it work?

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Yes, at least well enough.

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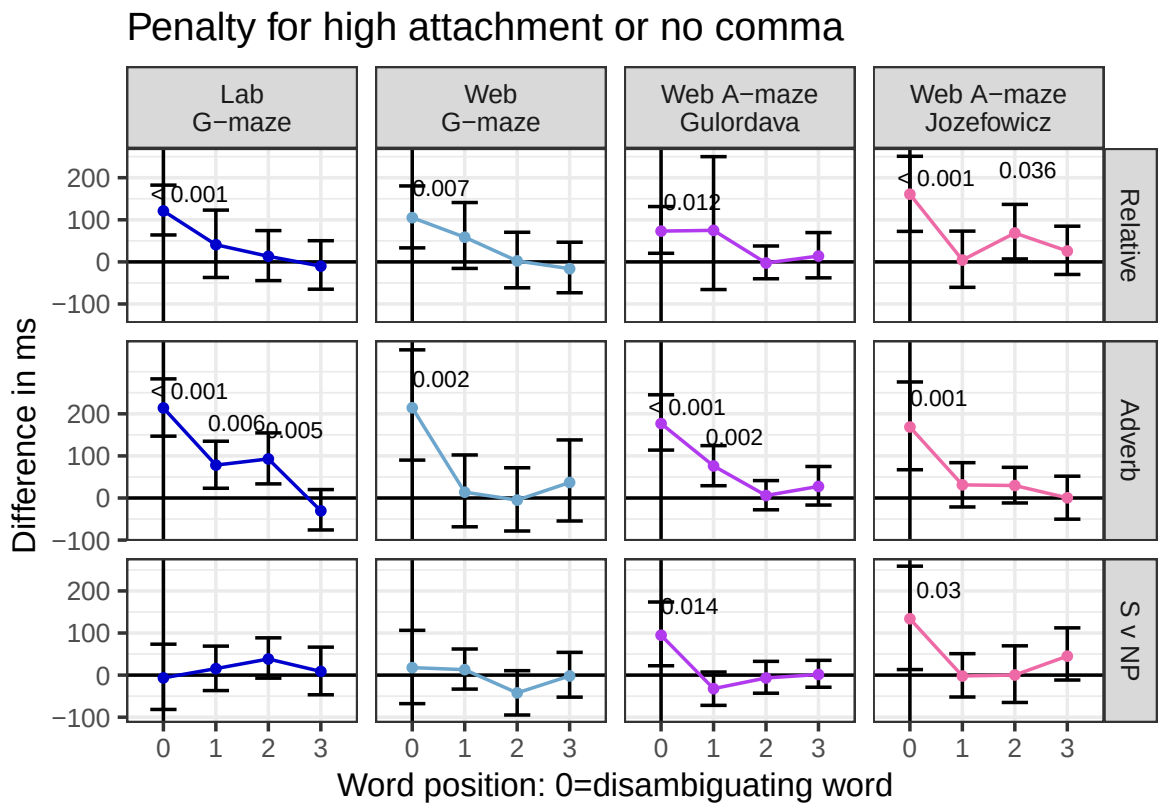

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Long items

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What if after an error, participants corrected errors and the sentence continued?

Maze with Error Correction

The x-x-x

Maze with Error Correction

Maze with Error Correction

upon dog

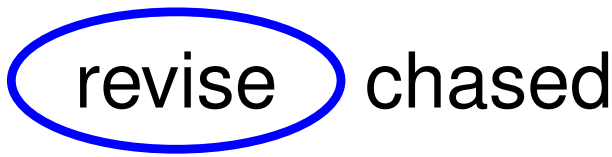
Maze with Error Correction

upon 

Maze with Error Correction

revise chased

Maze with Error Correction



Maze with Error Correction

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Incorrect. Please try again.

Maze with Error Correction

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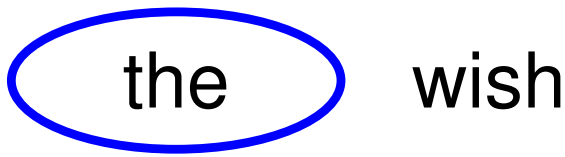

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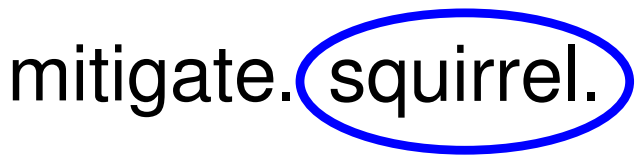

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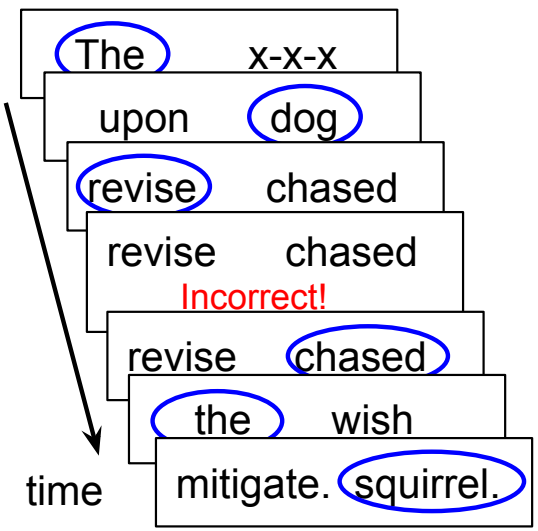

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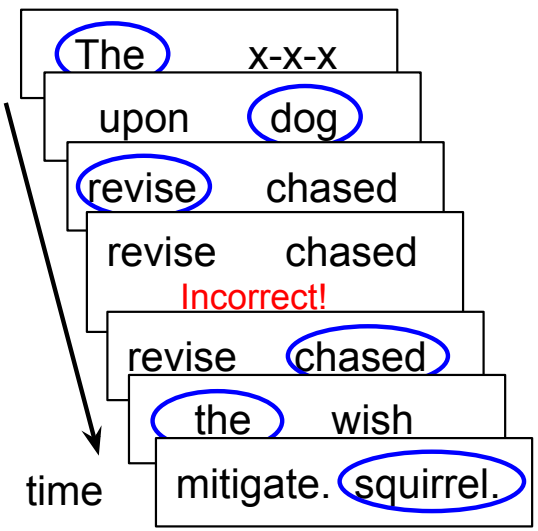

- Can be toggled in Ibex Maze

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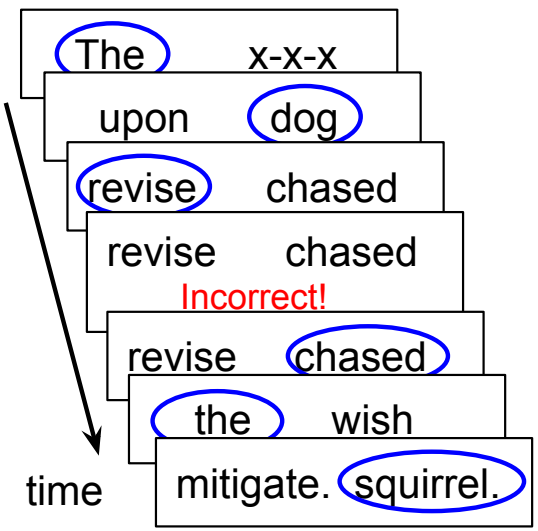

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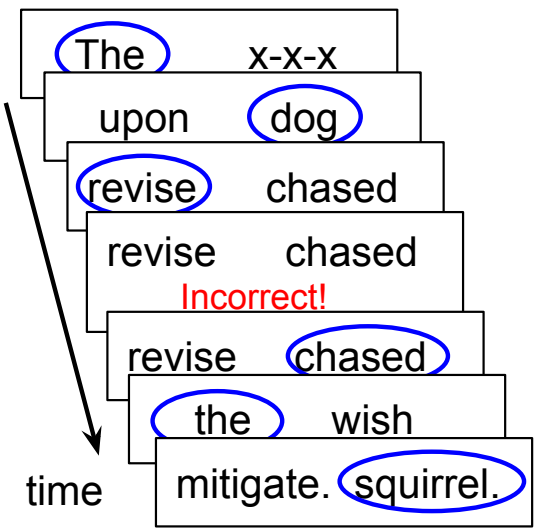
- Long materials feasible

Maze with Error Correction



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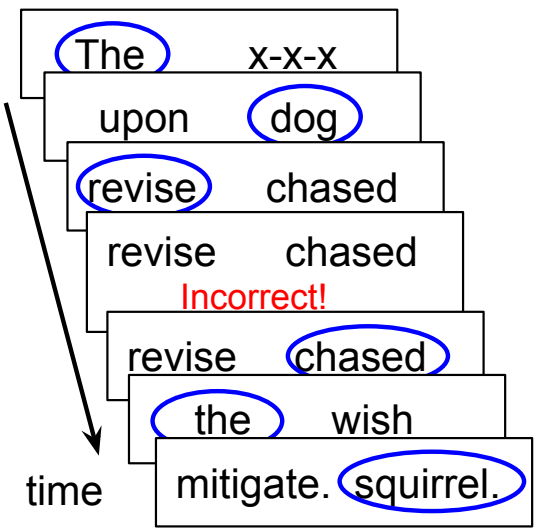

- Can be toggled in Ibex Maze
- Long materials feasible
- Have all the data
- Compensates for bad distractors

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Current experiment

Various open questions to address

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- Does the error correction variant work?
- Do we get predictability effects?

Natural Stories

Natural stories corpus (Futrell et al. 2017)

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- 10 stories, each about 1000 words

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- 10 stories, each about 1000 words
- 6 comprehension questions per story

Natural Stories

Tulip mania was a period in the Dutch Golden Age during which contract prices for bulbs of the recently introduced tulip reached extraordinarily high levels and then suddenly collapsed. At the peak of tulip mania in February sixteen thirty-seven, tulip contracts sold for more than ten times the annual income of a skilled craftsman. It is generally considered the first recorded economic bubble. [...]

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Q: When did tulip mania reach its peak?
A: 1630's 1730's

Participant accuracy

100 participants from MTurk each read 1 story (20 minutes)

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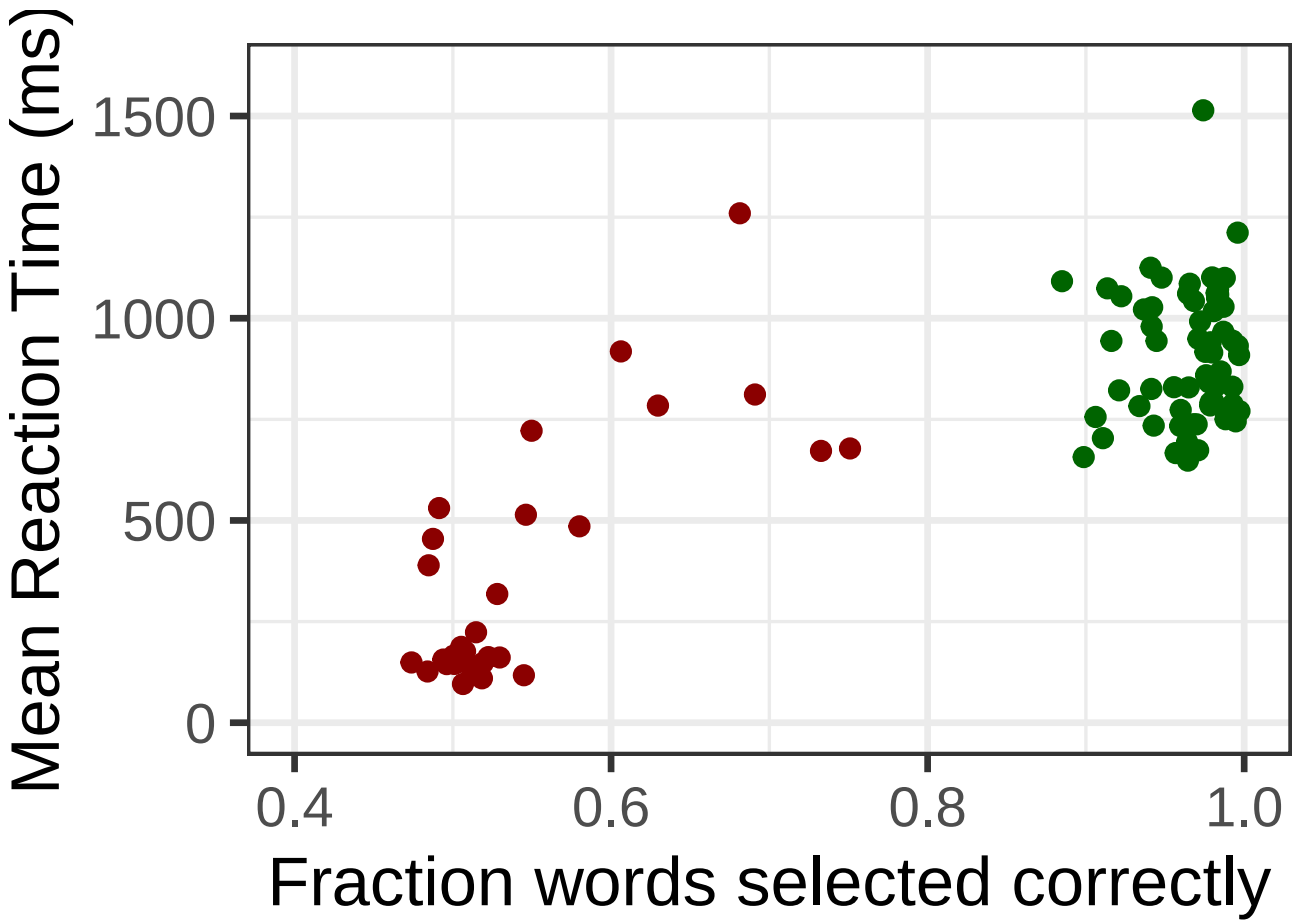

Comprehension questions

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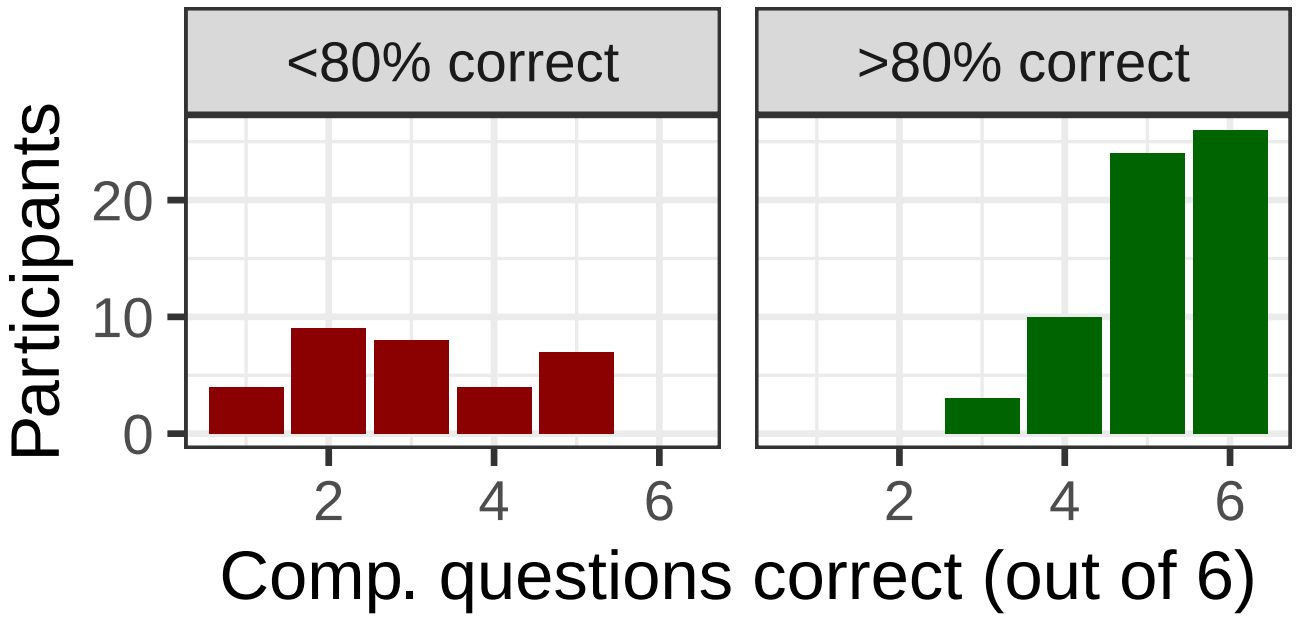

Surprisal Effects

Is RT linear in terms of surprisal?

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Estimate surprisal from 3 models:

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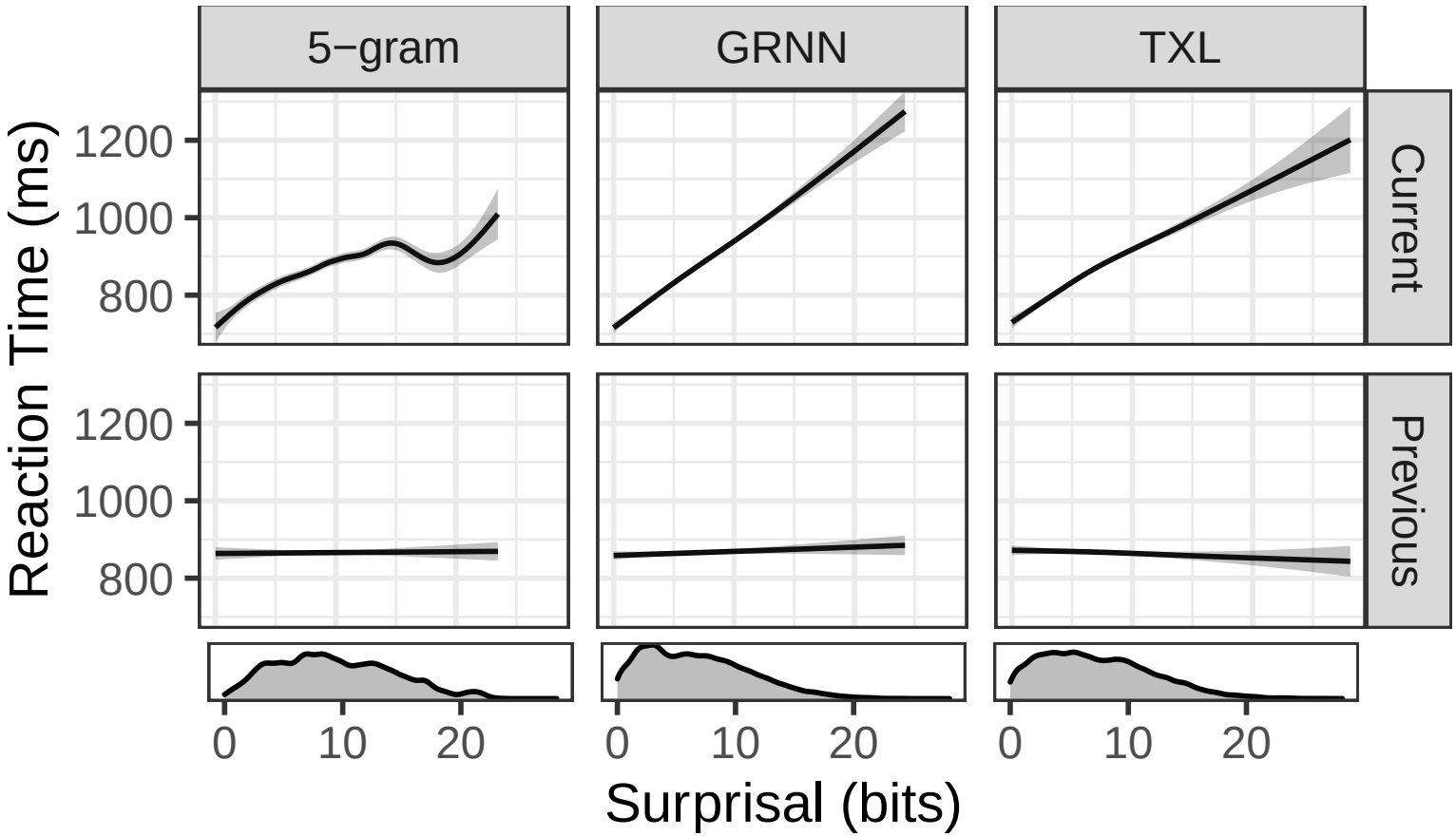
Fit GAMs

- Limit to single-token words
- Fit to both current and past word surprisal
- Include frequency, length as predictors

Surprisal Effects



Surprisal Effects

Linear Models

Surprisal Effects

Linear Models

	5-gram	GRNN	TXL
Intercept	**865.3**	**871.1**	**870.8**
Surprisal	**11.7**	**23.7**	**18.5**
Frequency	-2.9	2.9	0.4
Length	**20.5**	**18.5**	**21.4**
Surprisal:Length	**-2.0**	**-1.8**	**-1.4**
Freq:Length	-1.0	-0.1	0.2
Past Surprisal	1.6	**2.7**	0.8
Past Freq	2.6	1.9	1.2
Past Length	**-4.8**	**-6.6**	**-5.2**
Past Surp:Length	-0.2	**-0.9**	-0.6
Past Freq:Length	-1.0	**-1.8**	**-1.5**

Surprisal in bits, Length in characters,

Frequency in log_2 occurrences/billion words

Surprisal Effects

Takeaways:

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Model comparison: GRNN is best, but TXL complementary

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Framework: Look at words long enough to ID with some threshold of certainty
Could hypothesize mechanisms for difference:

- Task leads to higher threshold
- Task demands reduce available resources for processing
- Presence of second word

Conclusion

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Consider A-maze!

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- Documentation: vboyce.github.io/Maze

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Natural Stories A-maze:

- Participants comprehend what they read
- Find linear, large surprisal effects

Surprisal Effects

GAM if we only exclude mistakes (all participants, post-mistake data)