



LaCC Lab

Eye Movements & Reading Comprehension in **Repeated Reading**

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The 2nd Workshop on Eye Movements and the Assessment of Reading Comprehension

Eyettention: Attention-based Human Scanpath Prediction

- f -th word in the sentence
- BERT embedding of the f -th word
- t -th fixation
- Attributes of the t -th fixation
- BERT embedding of the word at t -th fixation
- Position embedding
- Concatenation
- Element-wise addition

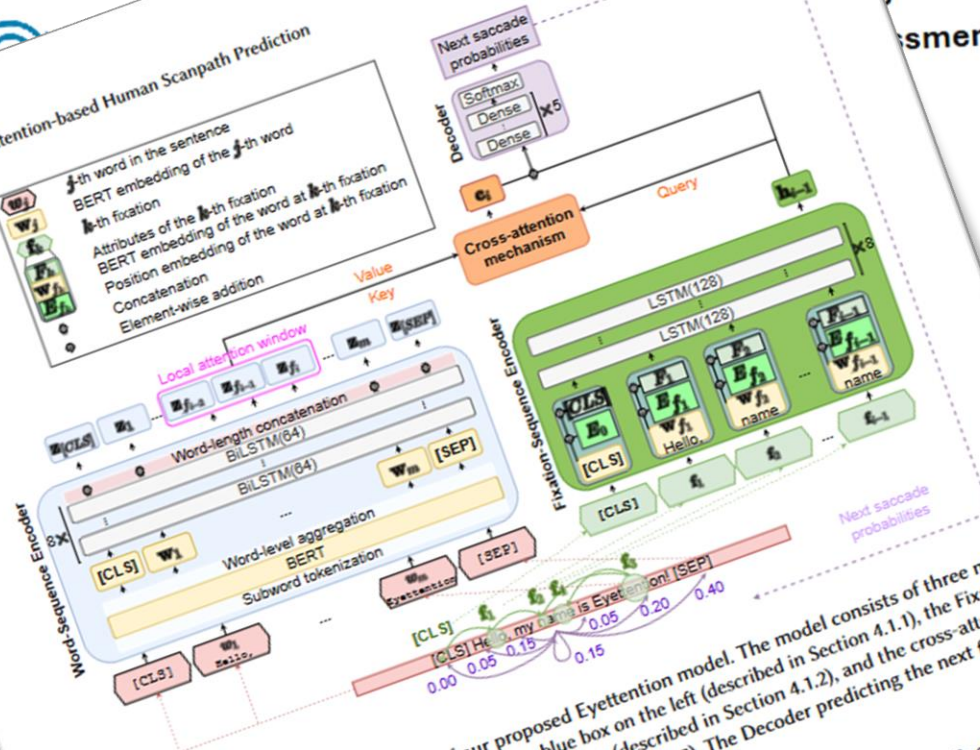


Fig. 1. *Eyettention* model. Overview of our proposed *Eyettention* model. The model consists of three main parts: the Word-Sequence Encoder shown in the blue box on the left (described in Section 4.1.1), the Fixation-Sequence Encoder in the green box on the right (described in Section 4.1.2), and the cross-attention mechanism in the red box on the top (described in Section 4.1.3). The Decoder predicting the next fixation location is shown in the purple box and described in Section 4.1.4.

4.1.2 Fixation-Sequence Encoder: Embedding the Temporal Sequence. The Fixation-Sequence Encoder processes a sequence of fixations together with the embeddings of the fixated words. Each fixation f_k consists of three attributes: word index f_k of the fixated word, fixation duration and landing position within a word. We denote the last two attributes together as F_k . The Fixation-Sequence Encoder consists of eight LSTM layers with 128 units each. To avoid overfitting, a dropout layer with a dropout probability of 0.4 is applied after each of the first seven LSTMs. The input at each time step is an embedding of the fixated word concatenated with both the z-score normalized fixation duration and landing position within the word. The embedding of a fixated word is calculated by the sum of the non-contextual BERT embedding (retrieved from the look-up table) of the fixated

What Kind of Strategies Do You Use When You Are Studying?

<i>Strategy</i>	<i>Percent who list strategy</i>		<i>Percent who rank as #1 strategy</i>	
1. Rereading notes or textbook	83.6	(148)	54.8	(97)
2. Do practice problems	42.9	(76)	12.4	(22)
3. Flashcards	40.1	(71)	6.2	(11)
4. Rewrite notes	29.9	(53)	12.4	(22)
5. Study with a group of students	26.5	(47)	0.5	(1)
6. “Memorise”	18.6	(33)	5.6	(10)
7. Mnemonics (acronyms, rhymes, etc)	13.5	(24)	2.8	(5)
8. Make outlines or review sheets	12.9	(23)	3.9	(7)
9. Practise recall (self-testing)	10.7	(19)	1.1	(2)
10. Highlight (in notes or book)	6.2	(11)	1.6	(3)
11. Think of real life examples	4.5	(8)	0.5	(1)

Karpicke, J. D., Butler, A. C., & Roediger III, H. L. (2009).
 Metacognitive strategies in student learning: **Do students
 practise retrieval when they study on their own?**

First Reading vs. Repeated Reading

Is the effect of repeated reading modulated by:



Reader's Goals



Task Similarity



Intervening
Material



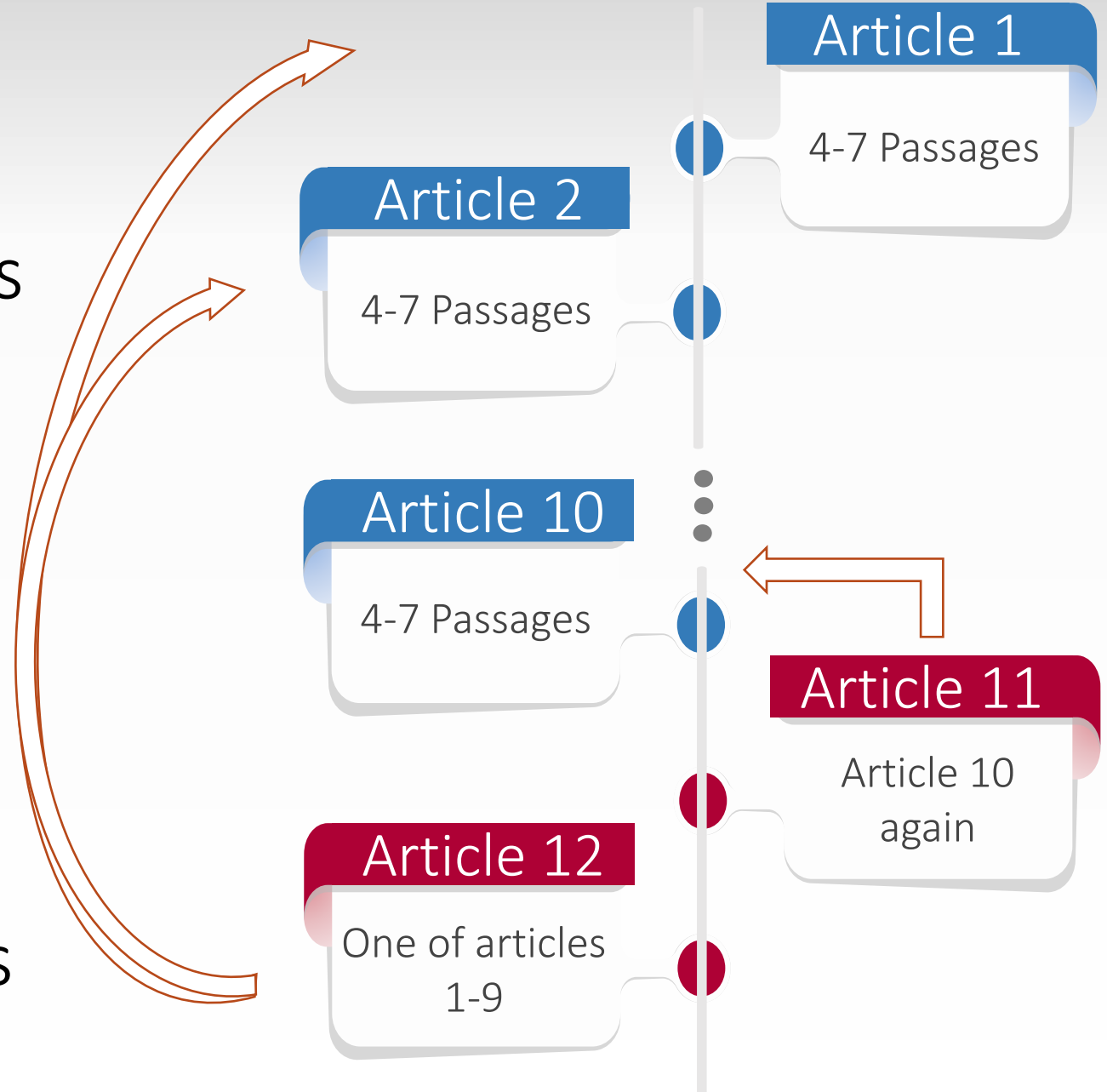
Individual
Differences

Design

- OneStop Eye Movements



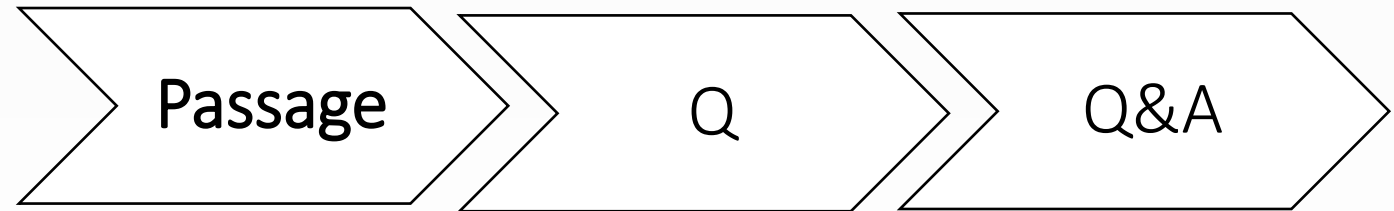
- 360 participants
- 2,110,632
first reading tokens
- 422,167
repeated reading tokens



Design



Gathering – Ordinary Reading



Hunting – Information Seeking



How do we quantify reading ?

How do people read?

CNN wants to change its viewers' habits.

Fixations

How do people read?

CNN    to change its viewers' habits.

Saccades

How do people read?

CNN wants to change its viewers' habits.



How do people read?

CNN wants to change ~~its~~ viewers' habits.

How do people read?

CNN wants to change its → viewers' habits.

How do people read?

CNN wants to change its viewers' habits.

How do people read?

CNN wants to ~~change its viewers'~~ habits.

How do people read?

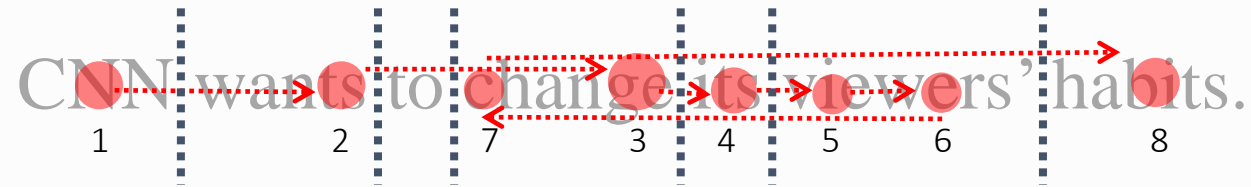
CNN wants to ~~change its viewers' habits~~.

How do people read?

CNN wants to change its viewers' habits.

The diagram shows the sentence "CNN wants to change its viewers' habits." with red dotted arrows indicating the reading path. The path starts at the first 'N' (1), goes to 's' (2), then to the second 'N' (3), then to 's' (4), then to 'v' (5), then to 'e' (6), and finally to the last 's' (8). A red dotted arrow also points from the second 'N' (3) back to the first 'N' (1), suggesting a return to the start of the sentence.

Eye Movement Word-Level Measures



- Total Fixation Duration
- First Pass Skip Rate

Eye Movement Word-Level Measures

- Total Fixation duration



- First Pass Skip Rate



First Reading vs. Repeated Reading

Is the effect of repeated reading is modulated by:



Reader's Goals



Task Similarity

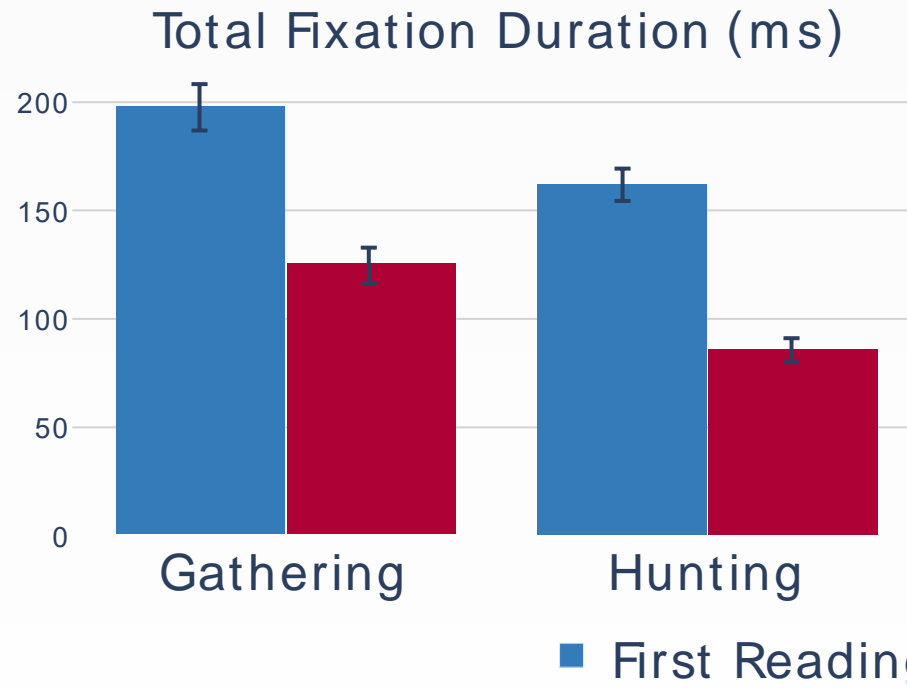


Intervening
Material

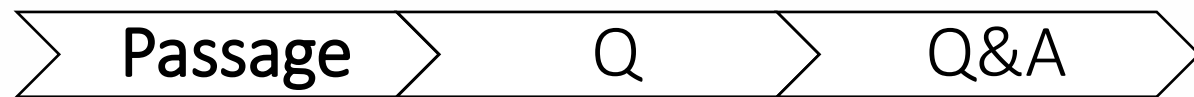


Individual
Differences

Hunting vs. Gathering



Gathering



Hunting

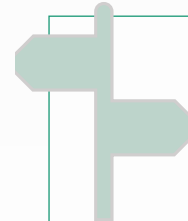


First Reading vs. Repeated Reading

The effect of repeated reading is modulated by:



Reader's Goals



Task Similarity



Intervening
Material



Individual
Differences

Task Similarity – Information Seeking

Critical span

In the next 30 years, the planet's human population will increase to nine billion. **Already one billion people do not get enough food. The increase will put more pressure on agricultural land, water, forests, fisheries and resources, and also food and energy supplies.** The cost of meat is increasing – it costs more money now, but also people have to destroy a lot of rainforest to make fields or to grow food for cows. Cows also make methane. The farming of cows, pigs and sheep makes very large amounts of greenhouse gases – 35% of the planet's methane, 65% of its nitrous oxide and 9% of the carbon dioxide.

Q: What will result from an increase in human population in the future?

- a) More pressure on farming resources.** (not verbatim!)
- b) One billion people will not have enough food
- c) The level of greenhouse gases will increase by 35%
- d) Food quality will decrease

Task Similarity

Critical
span

Q1, Q2

Critical
span

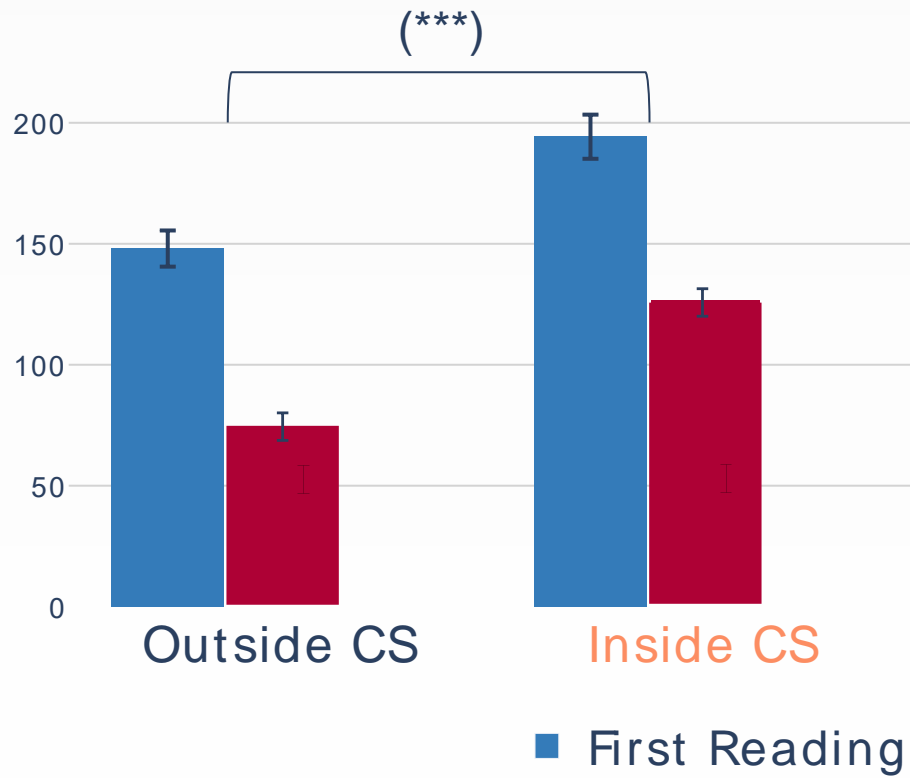
Q3

In the next 30 years, the planet's human population will increase to nine billion. **Already one billion people do not get enough food. The increase will put more pressure on agricultural land, water, forests, fisheries and resources, and also food and energy supplies.** The cost of meat is increasing – it costs more money now, but also people have to destroy a lot of rainforest to make fields or to grow food for cows. Cows also make methane. **The farming of cows, pigs and sheep makes very large amounts of greenhouse gases – 35% of the planet's methane, 65% of its nitrous oxide and 9% of the carbon dioxide.**

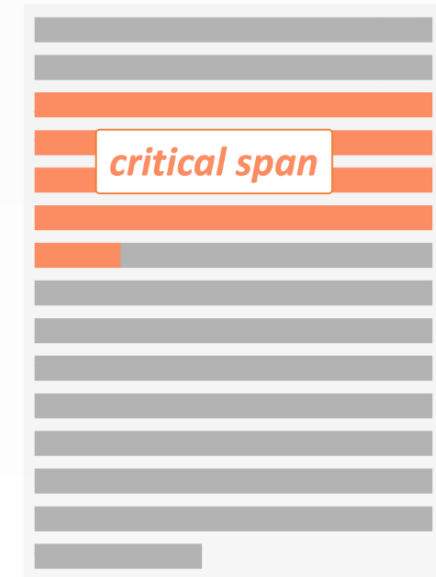
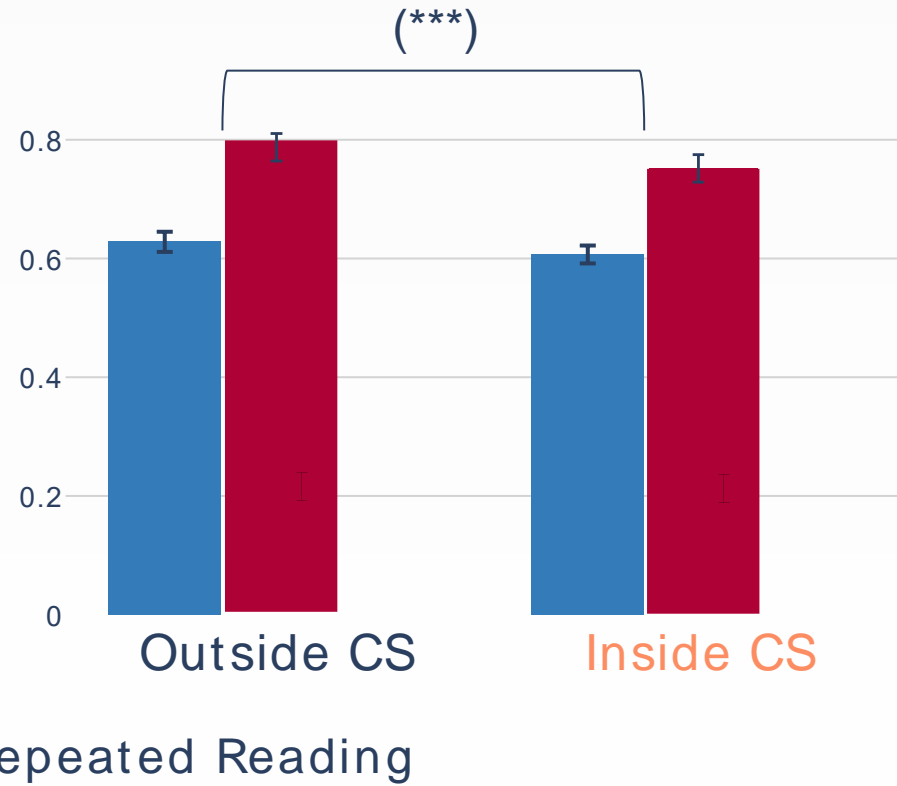
$Q_{\text{First Reading}} \neq Q_{\text{Repeated Reading}}$

Task Similarity

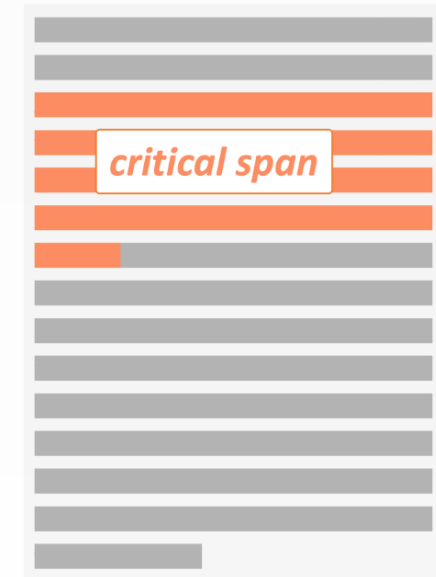
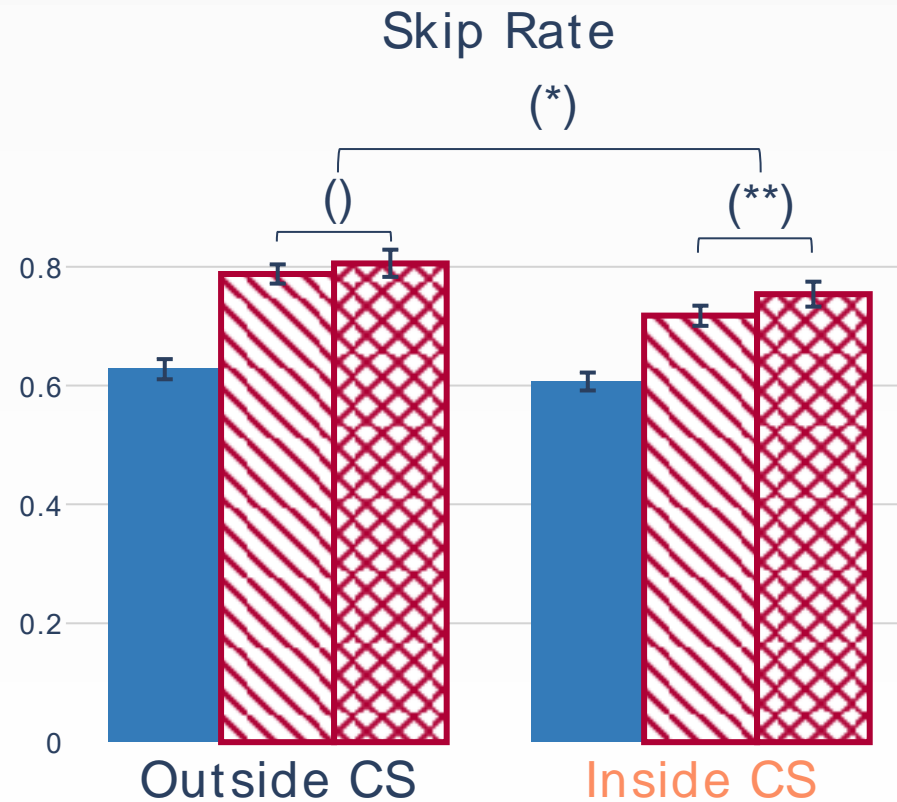
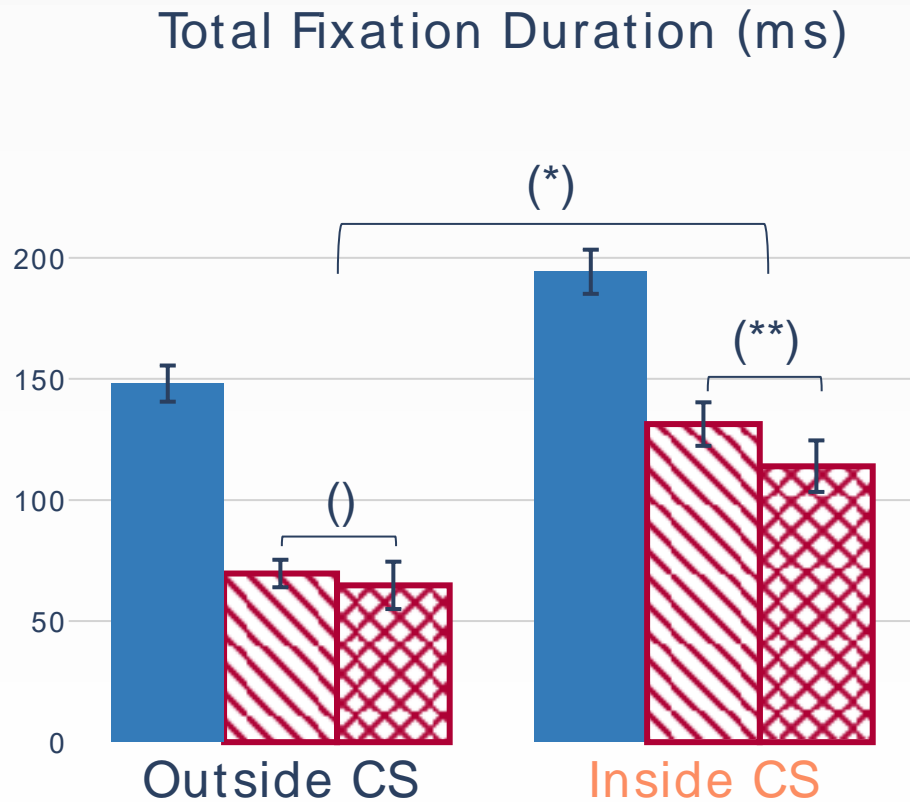
Total Fixation Duration (ms)



Skip Rate



Task Similarity



- First Reading
- ▨ Repeated Reading - Different CS between First and Repeated Reading
- ▩ Repeated Reading - Same CS between First and Repeated Reading

First Reading vs. Repeated Reading

Is the effect of repeated reading is modulated by:



Reader's Goals



Task Similarity

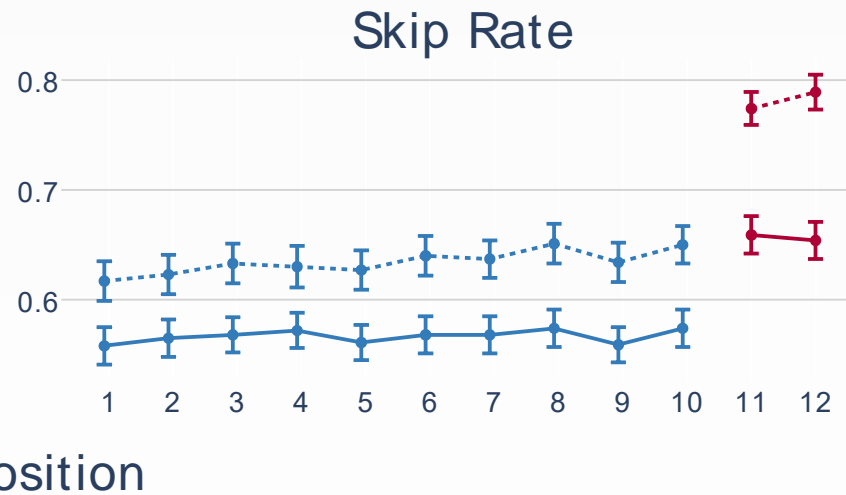
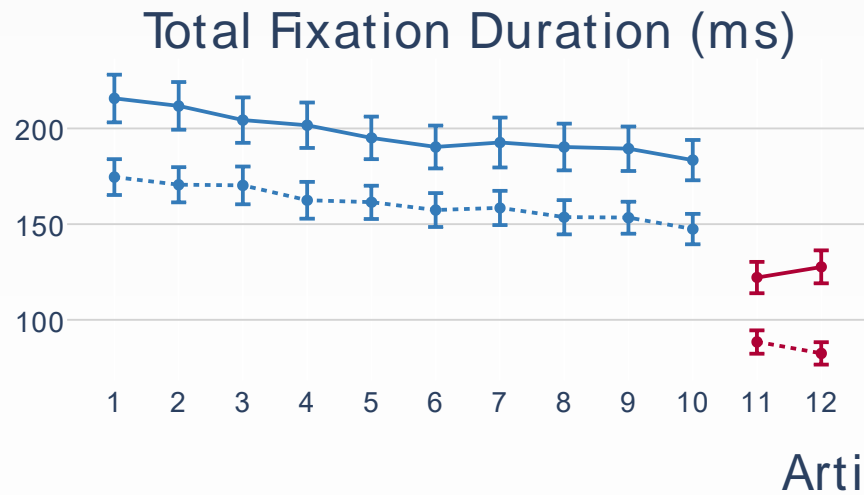


Intervening
Material



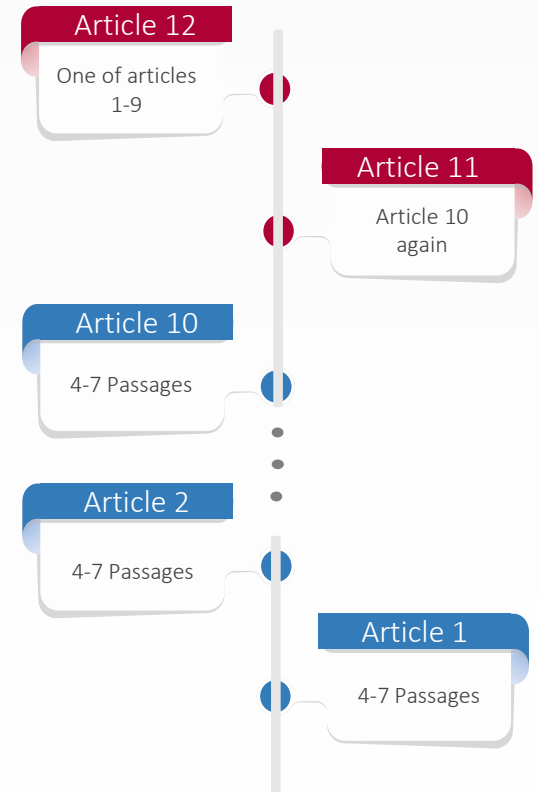
Individual
Differences

Intervening Material

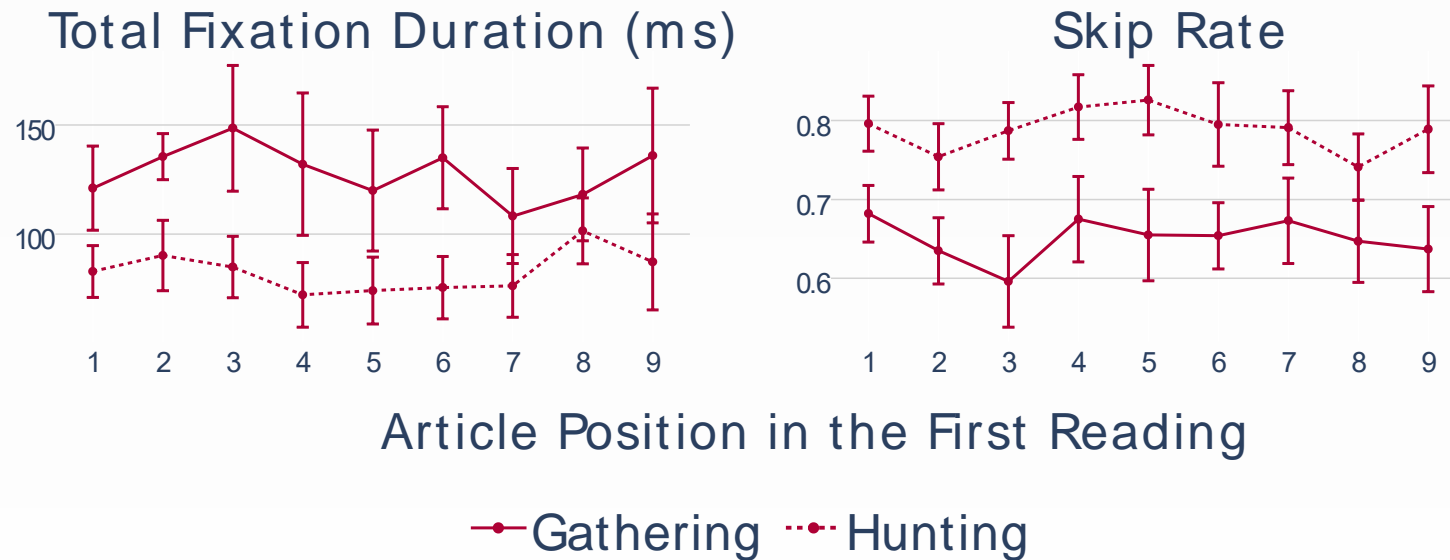


—●— Gathering, First Reading
 - - - ● - - - Hunting, First Reading

—●— Gathering, Repeated Reading
 - - - ● - - - Hunting, Repeated Reading



Intervening Material



Article 12

One of articles 1-9

First Reading vs. Repeated Reading

Is the effect of repeated reading is modulated by:



Reader's Goals



Task Similarity



Intervening
Material



Individual
Differences

First Reading vs. Repeated Reading



Δ Reading
times (RTs)
& Skips

By



Reading Speed



Comprehension
Level

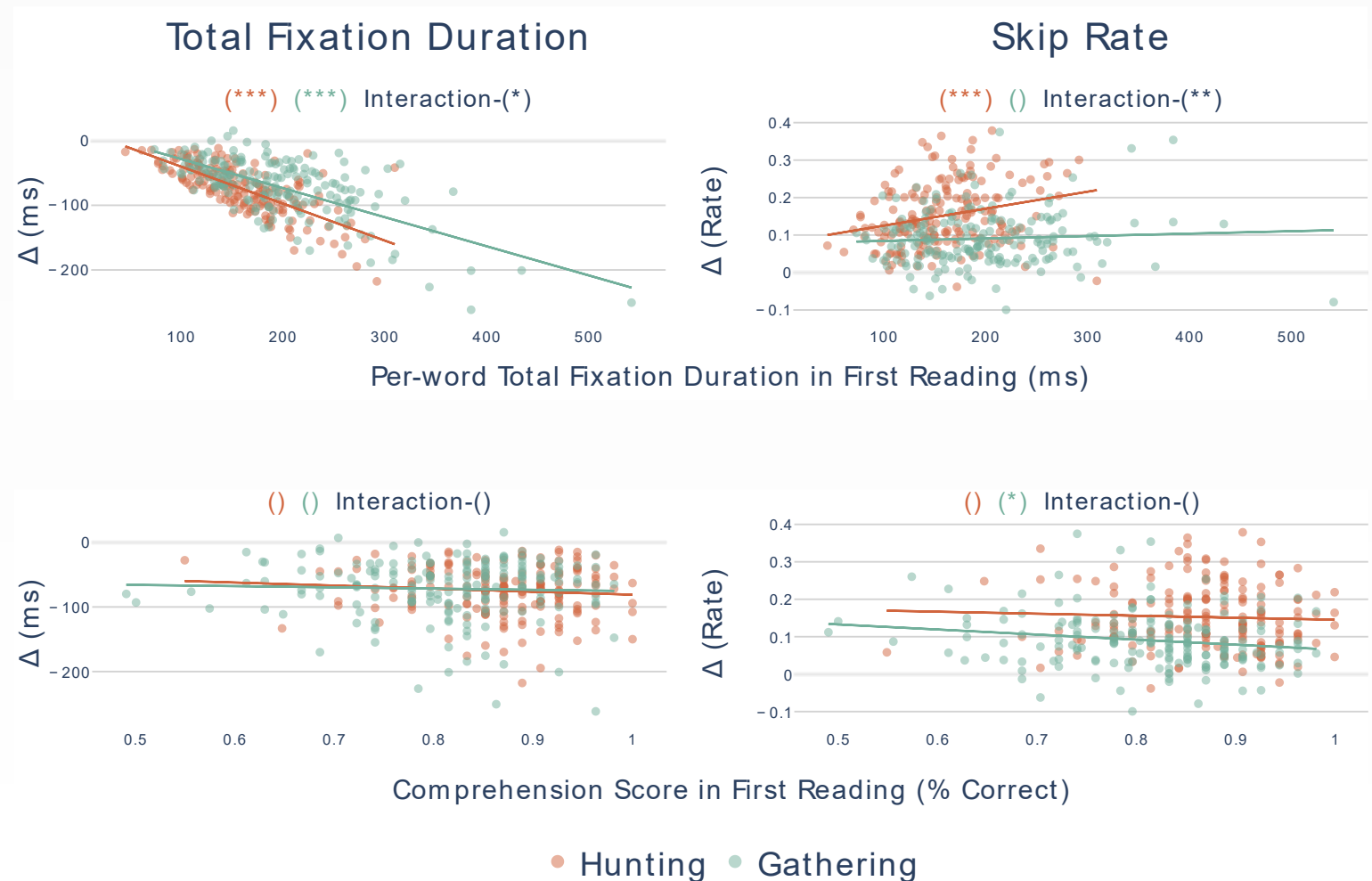
Individual Differences



Reading Speed



Comprehension Level



First Reading vs. Repeated Reading

Is the effect of repeated reading is modulated by:



Reader's Goals



Task Similarity

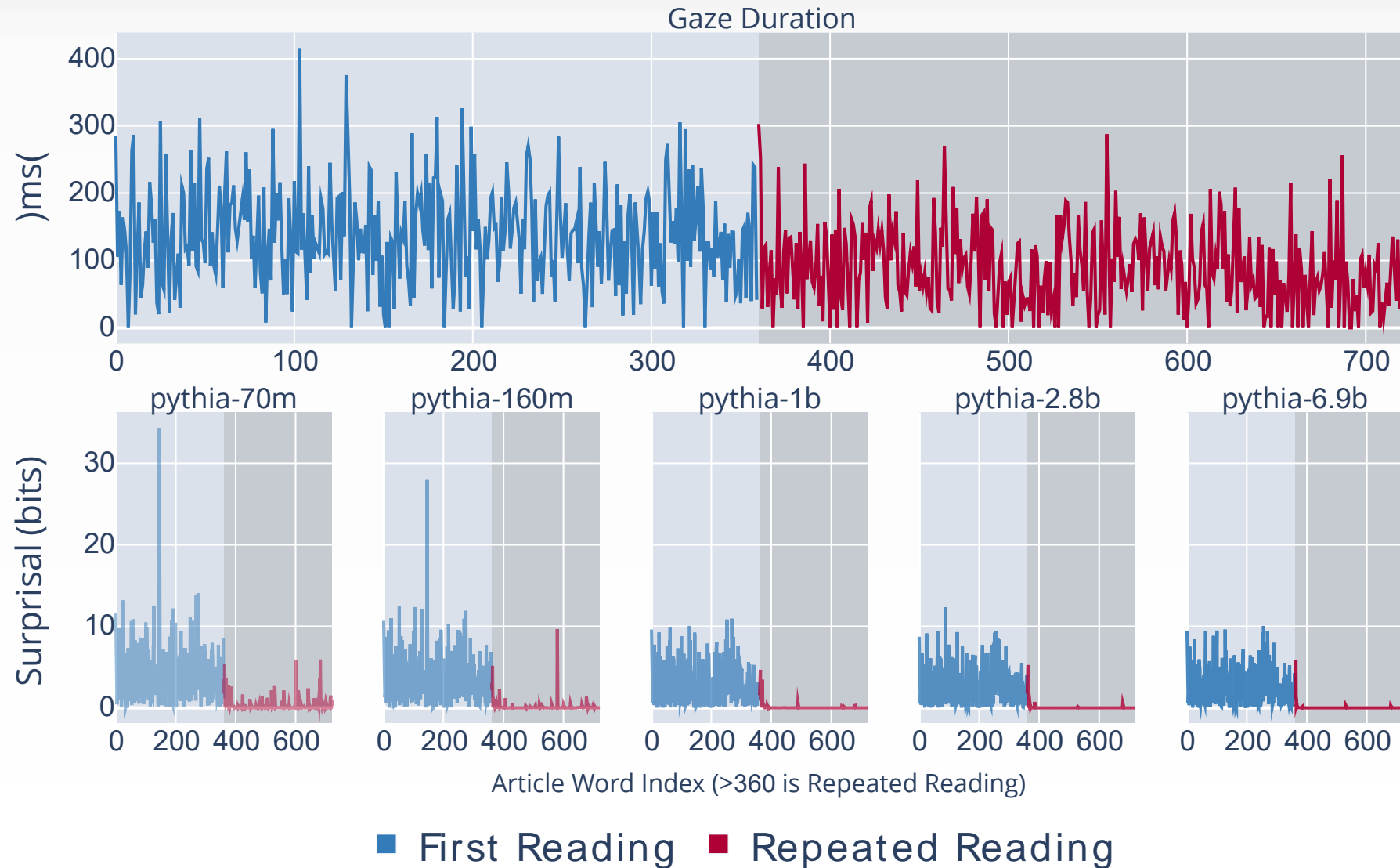


Intervening
Material



Individual
Differences

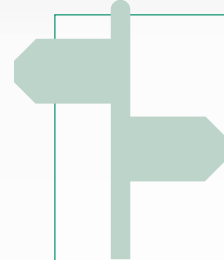
Next Steps



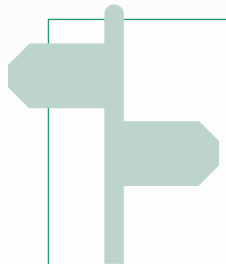
Conclusions



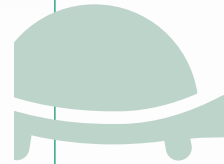
Larger facilitation in
information seeking



Larger facilitation
outside the critical span



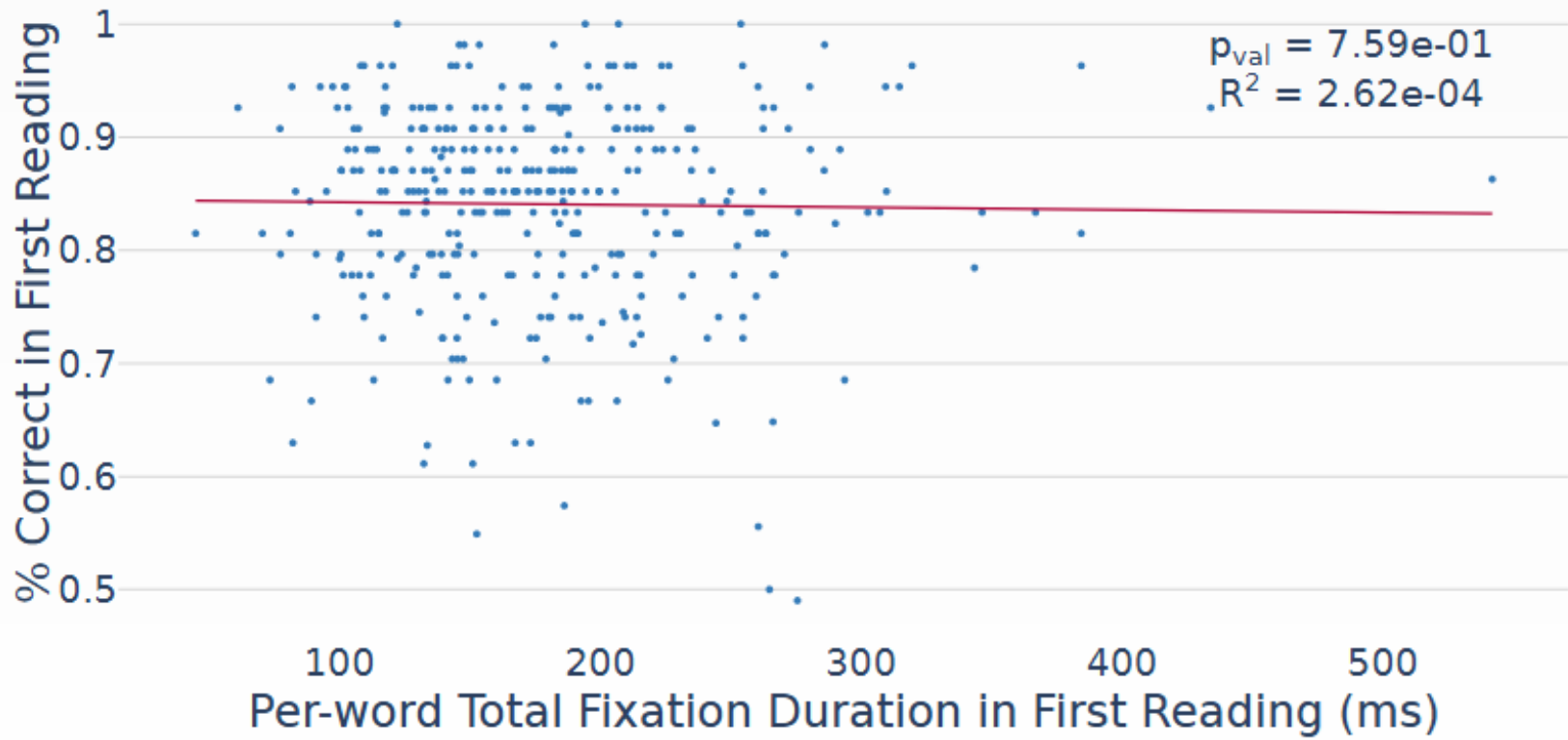
Larger facilitation **for
similar task**

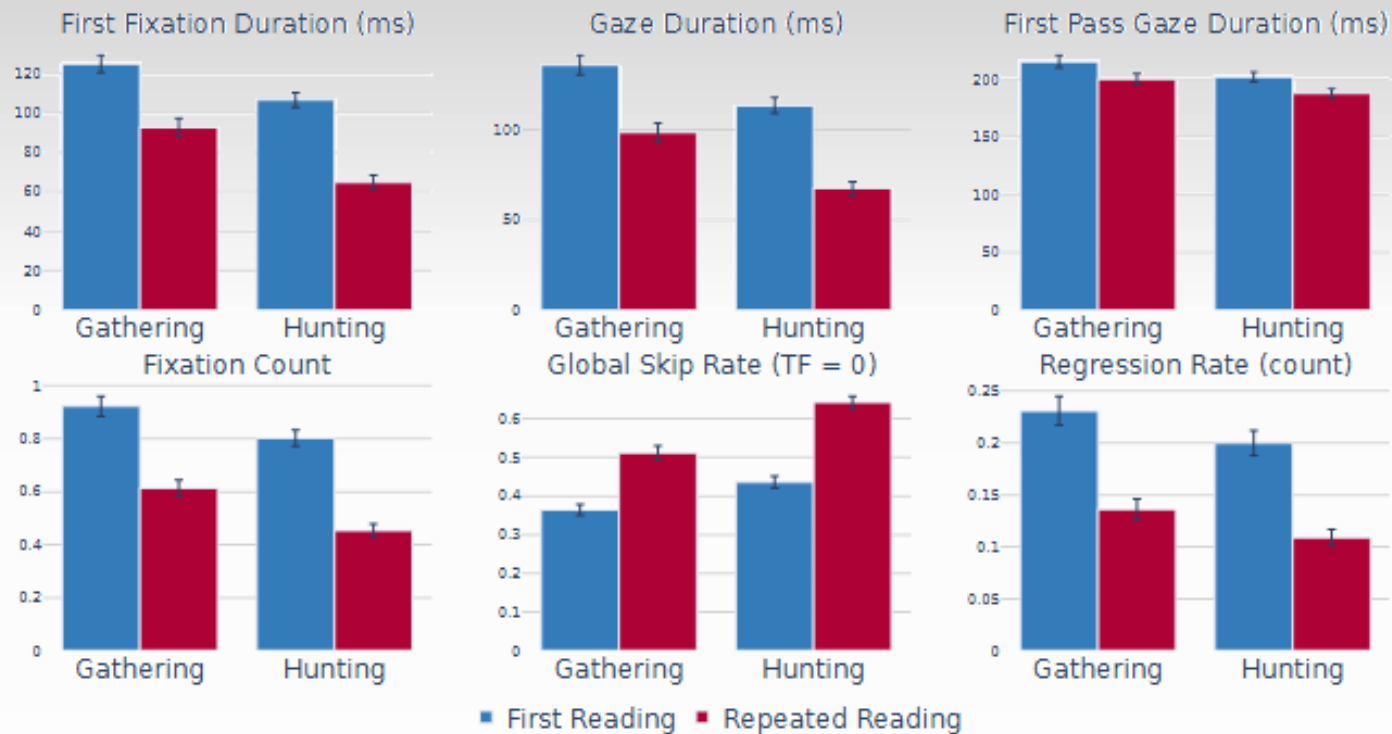


Facilitation is greater for
slow readers

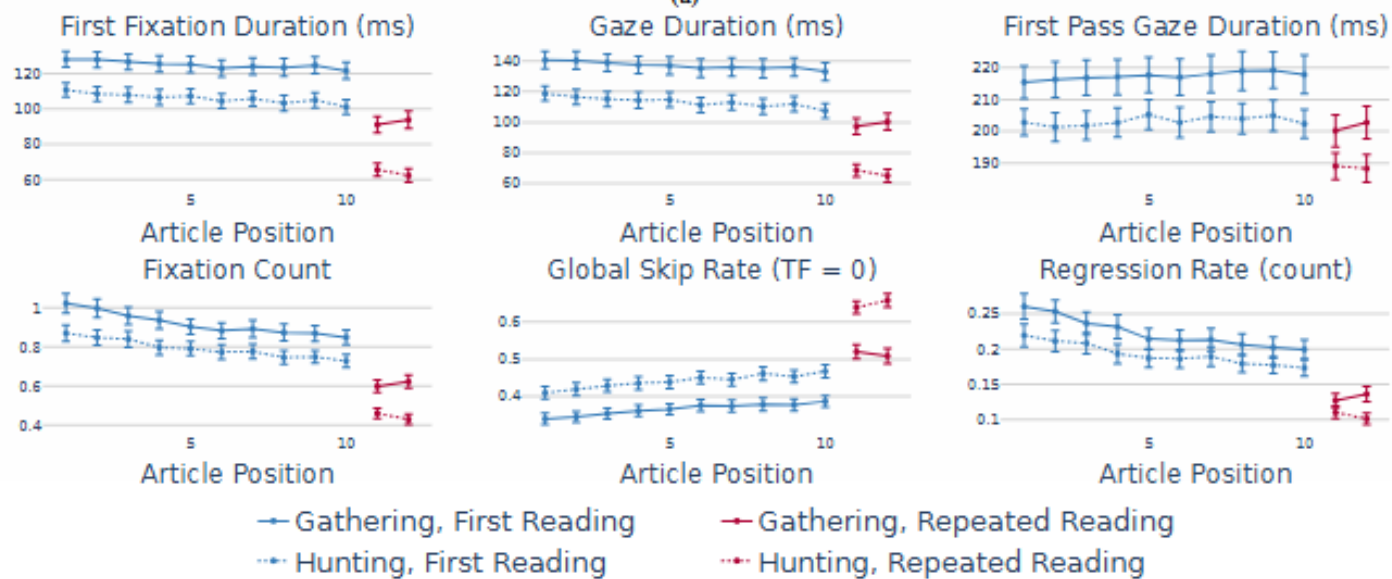


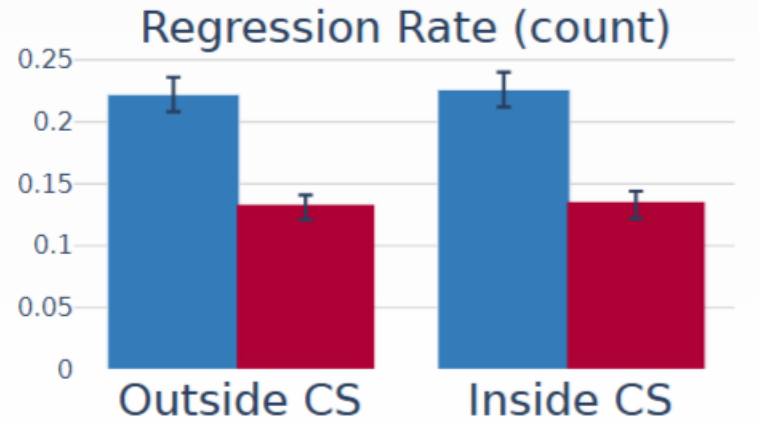
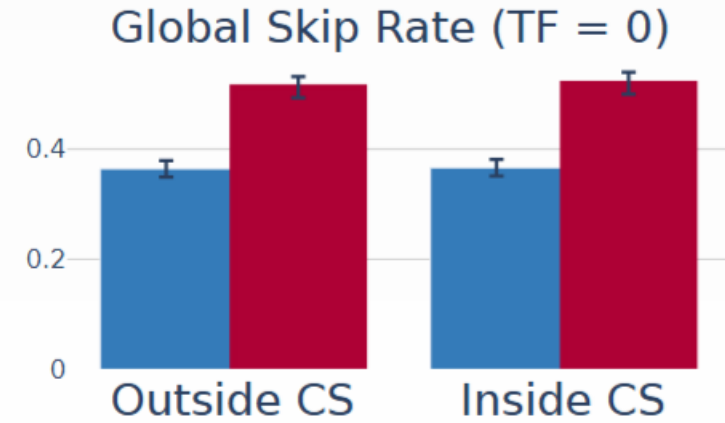
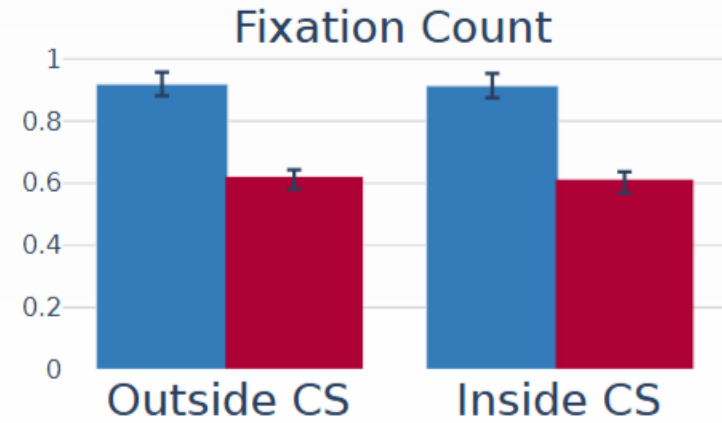
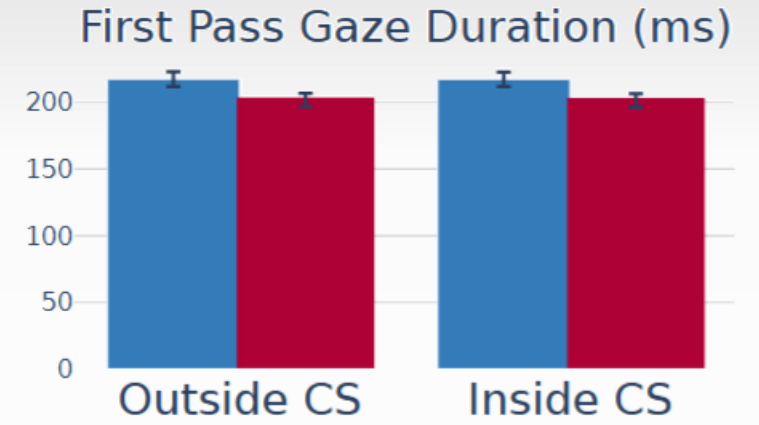
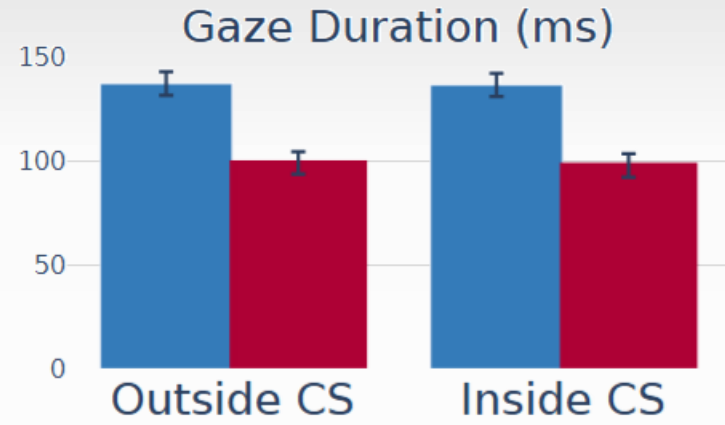
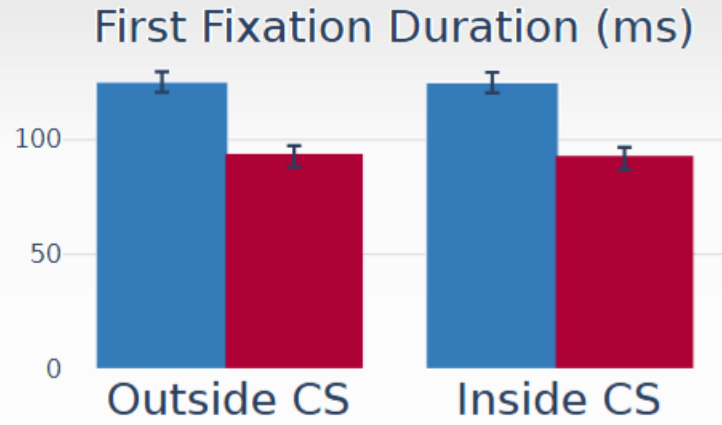
Facilitation is not
modulated by
comprehension level



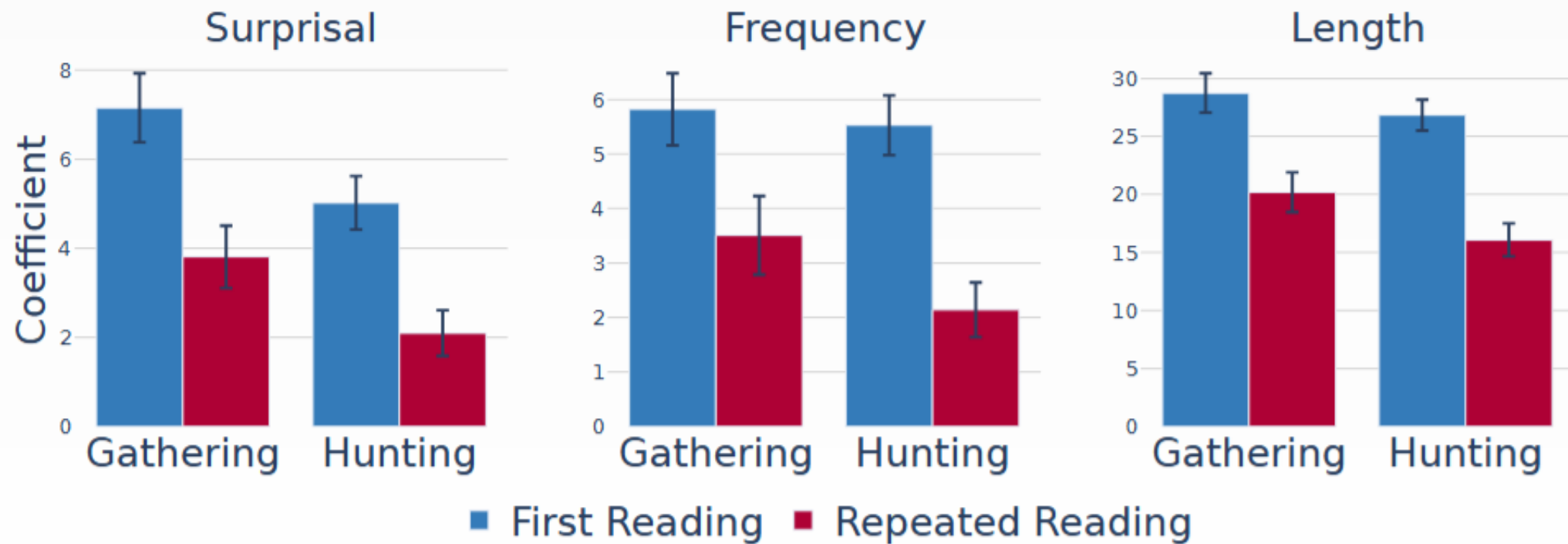


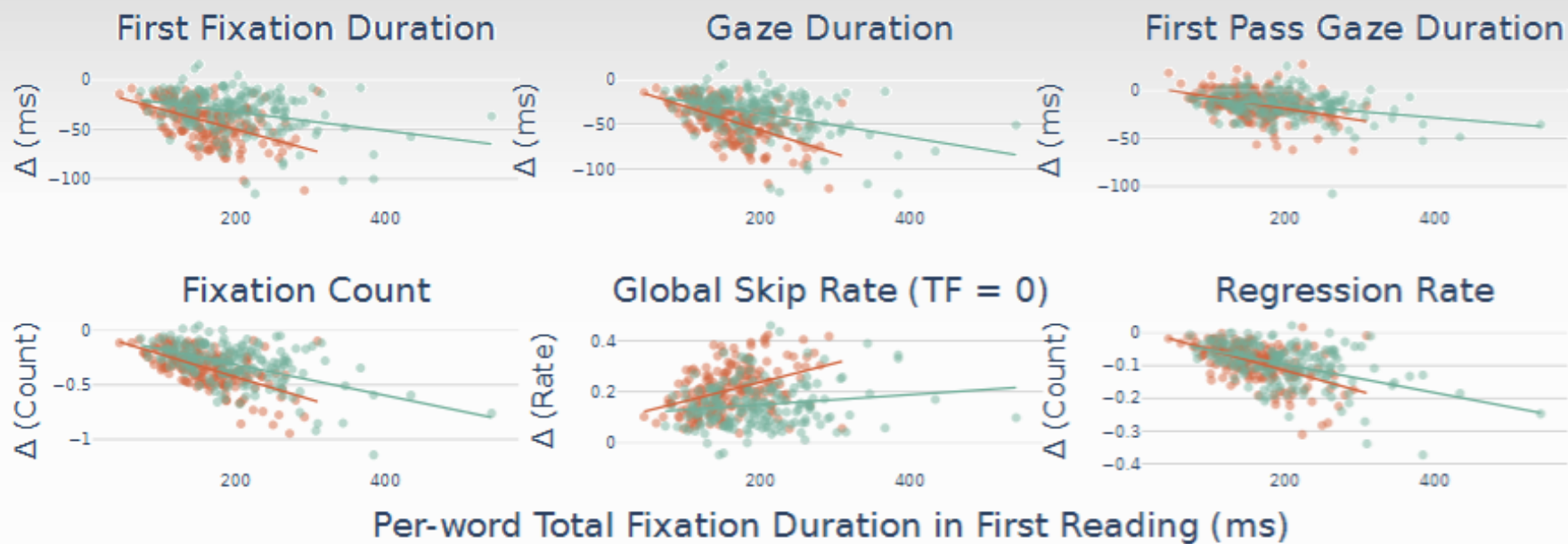
(a)





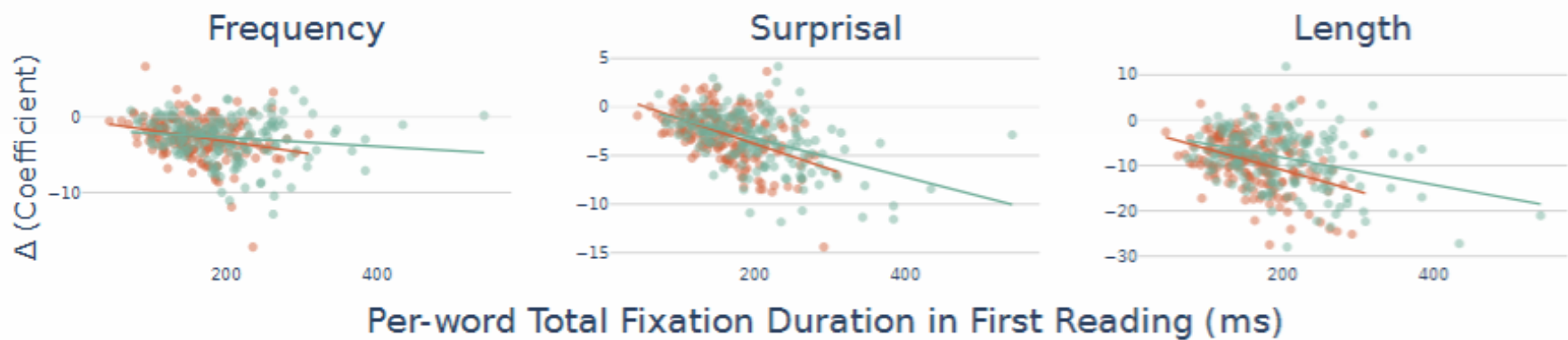
■ First Reading ■ Repeated Reading





● Hunting ● Gathering

(a)



● Hunting ● Gathering

Δ Comprehension Score in Repeated Reading

