The Impact of Inter-Word Spacing on Inference Processing: Evidence from Eye-Movements

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Introduction

Removing word segmentation (i.e., inter-word spacing) disrupts early word identification (i.e., lower-level) processes and slows single-line reading (e.g., Rayner et al., 1998; Sheridan et al., 2016).

Removing spacing has also been shown to impact processing at the sentence-level (e.g., Mirault et al., 2019), suggesting that disruptions to word identification interact with subsequent reading processes. However, it is unknown how removing spaces impacts later, post-lexical integration (i.e., higher-level) processes during passage reading.

Our preliminary study uses an eye-tracking paradigm to explore if removing spaces (to disrupt early word identification) in multi-line passages impacts later, inferential processing.

Research Question

How do earlier, lower-level processes interact with later, higher-level processes during reading?

Predictions

If lower-level (lexical & pre-lexical) processing ***does interact*** with higher-level (post-lexical integration) processing → Removing inter-word spacing ***will disrupt*** the effect of inferential constraint

If lower-level (lexical & pre-lexical) processing ***does not interact*** with higher-level (post-lexical integration) processing → ***No impact*** of removing inter-word spacing on the effect of inferential constraint

Methods

Participants

- Seven undergraduates at the University at Albany, SUNY participated for course credit.
- Participants were native English-speakers, had normal or corrected-to-normal vision, and had no history of neurological or reading disorders.

Materials

- Eighty-four two-sentence, multi-line passages were created.
- Passages were either strongly or weakly constrained toward a predictive inference target word.
- The target words were always in the second sentence and consisted of at least five characters to reduce skipping.
- Passages either had normal inter-word spacing or had each inter-word space replaced with a random number between 2 and 9.

Apparatus

- An EyeLink 1000 Plus (*SR Research*) eye-tracker was used to record eye movements as participants read passages on a computer screen.

Procedure

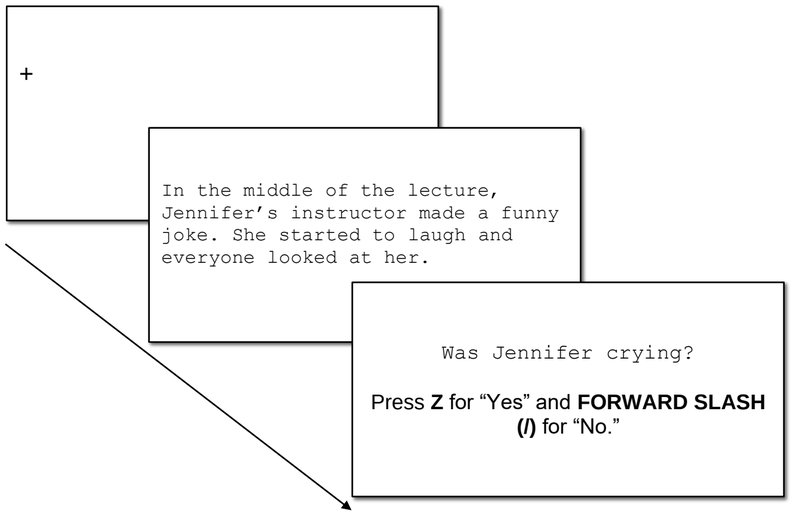
- Four practice trials were followed by 80 experimental trials.
- Participants were instructed to read each passage for comprehension and answered yes/no comprehension questions for 15% of trials.

Table 1. Sample Passages

Spacing Condition	Strong Constraint Passage Beginning	Weak Constraint Passage Beginning	Passage Ending
Spaced	In the middle of the lecture, Jennifer's instructor made a funny joke.	In the middle of the lecture, Jennifer's instructor lost his train of thought.	She started to laugh and everyone looked at her.
Unspaced	In4the7middle8of2the 5lecture,3Jennifer's9 instructor4made2a 6funny5joke.	In4the7middle8of2the 5lecture,3Jennifer's9 instructor4lost2his 6train5of3thought.	She3started6to4laugh8 and7everyone9looked2 at9her.

Note: Target word depicting the passage inference is underlined.

Figure 1. Sample Trial with Comprehension Question



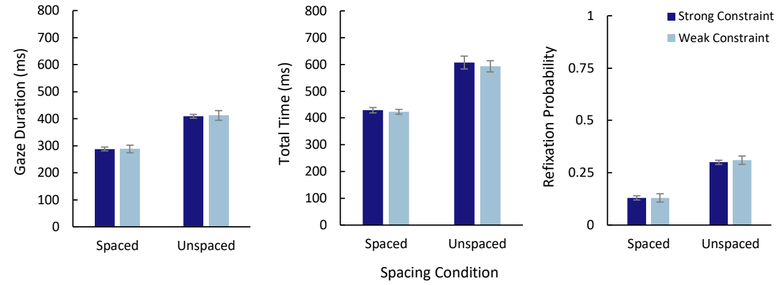
Data Analyses

Multiple linear mixed-effect models were performed in R to examine the effect of Spacing (Spaced, Unspaced) and Constraint (Strong Constraint, Weak Constraint) on global and target word eye-movement measures. All measures are limited to first pass-reading. Models were fit with subject and item as random intercepts.

Results – Global Measures

	Gaze Duration	Total Time	Refixation Probability
Main Effect: Spacing	$p < .0001$	$p < .0001$	$p < .0001$
Main Effect: Constraint	$p = .74$	$p = .96$	$p = .79$
Spacing X Constraint	$p = .91$	$p = .79$	$p = .77$

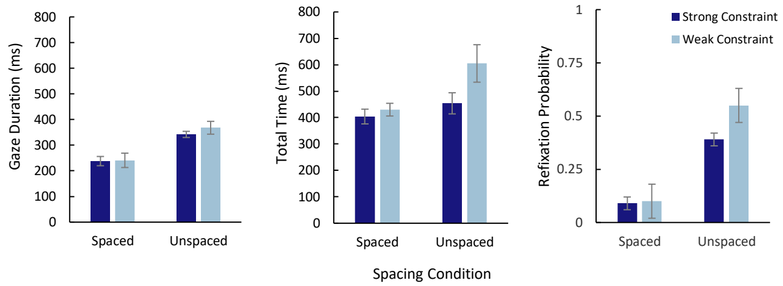
Figure 2. Global measures as a function of Spacing and Constraint.



Results – Target Word Measures

	Gaze Duration	Total Time	Refixation Probability
Main Effect: Spacing	$p < .0001$	$p < .001$	$p < .0001$
Main Effect: Constraint	$p = .67$	$p = .04$	$p = .30$
Spacing X Constraint	$p = .55$	$p = .11$	$p = .11$

Figure 3. Target word measures as a function of Spacing and Constraint.



Conclusions

Consistent with prior work, our preliminary findings show a detrimental effect of removing word segmentation on reading, such that participants show longer gaze durations, longer total times, and higher probabilities of making a refixation when passages were unspaced compared to when they were spaced.

Preliminary data show a significant effect of constraint on total time spent on target words, and numerical interactions between spacing and constraint on target word measures, such that effects of inferential constraint are magnified for unspaced passages. Significant interactions may emerge as power is increased with more participants. Data collection is ongoing.

Our findings will inform models of eye movement control during reading. Our future work will simulate the resulting eye movement data using the *E-Z Reader* model of eye movement control (Reichle et al., 1998; Reichle et al., 2009) to further examine the interaction of lower- and higher-level processing during reading.

References

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