Aging and Eye Movements During Reading

Matthew C. Shake, Soo Rim Noh, Shoshana B. Hindin, & Elizabeth A. L. Stine-Morrow

Department of Educational Psychology & Beckman Institute for Advanced Science & Technology

University of Illinois Urbana-Champaign

RATIONALE

- Relative to younger adults, older readers tend to allocate time for conceptual integration ("wrap up") more frequently during language processing (Stine, 1990; Miller & Stine-Morrow, 1998). This has been hypothesized to be a self-regulatory strategy that enables effective processing in the face of age-related declines in working memory capacity (e.g., Stine-Morrow, Miller, & Hertzog, 2006).
- In the current study, we directly tested this notion by measuring eye movements as participants read passages in which syntactic structure was manipulated so as to increase the salience of early boundaries (while holding conceptual load constant). We hypothesized that early boundary salience would increase wrap-up at that point, resulting in reduced downstream processing (the "pay now or pay later" effect), and that these effects would be exaggerated for older adults.

METHODS

Participants

	Young		Old	
N	18		18	
Age Range	19-25		60-85	
Age †*	20.33	(0.44)	70.39	(1.63)
Digit Span †	6.33	(0.30)	5.92	(0.20)
WAIS-R Vocab †	50.61	(1.36)	46.28	(2.42)
Education (yrs) †*	14.06	(0.32)	15.56	(0.68)

† Means reported w/ standard errors in parentheses
* significant group difference, p<.05

Materials

- For each passage, two variations were constructed (examples below). The two versions were identical through the first target word (T1; i.e., *gym*), which fell at the end of a main clause or sentence (marked by a comma or period) or not (unmarked). Text after T1 was constructed to be as similar as possible in the different conditions in length and semantic content. The second target was always a sentence-final word (T2; i.e., *position*), with distance from T1 held constant across conditions.

Sample Sentences:

Unmarked:

The athletes tried out for the national team in the gym for a chance to earn a position. Their efforts paid off with a trip to the finals.

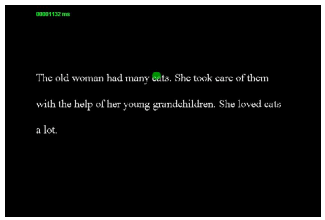
Marked:

The athletes tried out for the national team in the gym, where they worked to earn a position. Their efforts paid off with a trip to the finals.

The athletes tried out for the national team in the gym. They worked hard to earn a position. Their efforts paid off with a trip to the finals.

Design, Procedure & Apparatus

- Passages were presented in a single random order, with the stimulus sets counterbalanced across boundary condition. Each set contained 25 passages in the Unmarked condition and 50 in the Marked condition. Participants answered yes/no comprehension questions after each passage to ensure active text processing. Eye movements were recorded using a head-mounted SR Research EyeLink II system with a sampling rate of 500 Hz. Passages were shown on a 19-inch CRT monitor with a resolution of 1024 x 768 pixels in 16-bit high color, and text was sized so that 2-3 characters equaled roughly 1 degree of visual angle.



RESULTS

Eye Tracking Measures

- *First Fixation Duration (FFD)*: Duration of the first fixation on a word; *Total Fixation Duration (TFD)*: Total fixation time on a word
- *Regressions-In (RGI)*: Probability of being a "landing spot" from a regression; *Regressions-Out (RGO)*: Probability of being a "launch site" for a regression

Fixation Durations

- Readers demonstrated wrap-up, as shown by longer FFD for boundary words (M = 239, SE = 4) than for non-boundary words (M = 229, SE = 5), $F(1,34) = 12.70$, $p < .01$. This wrap-up effect did not vary by boundary type (unmarked vs. marked) or by age.
- Both FFD, $F(1,34) = 4.54$, $p < .05$, and TFD, $F(1,34) = 7.97$, $p < .01$, showed a significant Location x Age interaction, such that older adults allocated more integration time at T1 than at T2, while younger adults allocated time similarly to the early and late boundaries (see Figure 1).

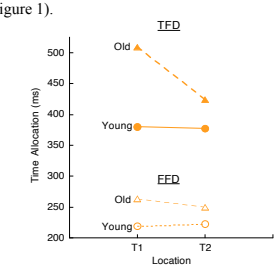


Figure 1. Total fixation duration (top) and first fixation duration (bottom) at T1 and T2 for older and younger adults.

- The Location (T1 vs. T2) x Boundary Type (Unmarked vs. Marked) x Age interaction, $F(2,68) = 3.89$, $p < .05$, was reliable for FFD (see Figure 2). Older adults allocated more time to wrap-up at T1 when there was a marked syntactic boundary, and this led to reduced processing time at the downstream boundary (T2), the "pay now or pay later" effect; younger adults' allocation to T1 and T2 did not significantly vary as a function of boundary type. This interaction was not reliable for TFD, $F < 1$.

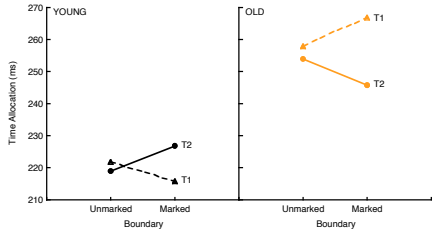


Figure 2. First Fixation Duration for younger (left) and older (right) adults, at Unmarked and Marked early syntactic boundaries (T1) and sentence-final syntactic boundaries (T2).

Regression Probabilities

- The probability of a regression landing on (RGI) T1 (M = .26, SE = .02) was greater than to T2 (M = .15, SE = .01), $F(1,34) = 25.99$, $p < .001$, but particularly when T1 was an unmarked boundary, shown by a significant Location x Boundary interaction, $F(1,34) = 5.97$, $p < .05$ (see Figure 3). This did not significantly vary with age, $F < 1$.

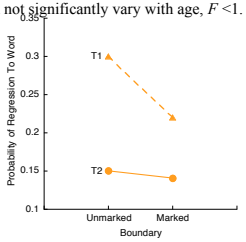


Figure 3. Probability of regression to T1 & T2 for Unmarked & Marked passages.

- The probability of launching a regression (RGO) was greater from T2 (M = .33, SE = .02) than T1 (M = .21, SE = .02), $F(1,34) = 55.92$, $p < .001$, but launching from T1 was relatively more likely if it was marked, as shown by a significant Location x Boundary interaction, $F(1,34) = 14.92$, $p < .001$ (see Figure 4). This did not significantly vary with age, $F < 1$.

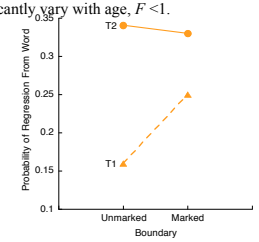


Figure 4. Probability of regression from T1 & T2 for Unmarked & Marked passages.

CONCLUSIONS

- Both younger and older adults' eye movements reflect conceptual integration (i.e., wrap-up effects).
- Older and younger adults' resource allocation to conceptual integration was differentially influenced by the salience of syntactic boundaries:
  - Older adults wrap-up more frequently when given strong syntactic boundary markers; this behavior leads to reductions in downstream processing load
- Regressive eye movements among younger and older readers were similarly influenced by boundary salience:
  - Readers were more likely to regress *to* Unmarked boundaries, suggesting less salient wrap-up points are more frequently the target of processing demands to "pay later" by re-reading.
  - Readers are more likely to regress *from* early boundaries when they are Marked, suggesting that boundary salience evokes more thorough, opportunistic integration.
- An age-related shift in reading strategy toward more frequent conceptual integration (Stine, 1990; Miller & Stine-Morrow, 1998) may be adaptive in conserving processing resources and enabling older adults to maintain language comprehension.

REFERENCES

Miller, L.M.S., & Stine-Morrow, E.A.L. (1998). Aging and the effects of knowledge on on-line reading strategies. *Journals of Gerontology: Psychological Sciences, 53B,* 223-233.

Stine, E.A.L. (1990). On-line processing of written text by younger and older adults. *Psychology and Aging, 5,* 68-78.

Stine-Morrow, E.A.L., Miller, L.M.S., & Hertzog, C. (2006). Aging and self-regulated language processing. *Psychological Bulletin, 132,* 582-606.

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Contact Information: email: mshake@uiuc.edu