Aging and Stereotype Violation During Reading: Eye-tracking Reveals Age Differences in Anaphor Resolution

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RATIONALE

One key component of reading comprehension is the ability to bind current information to previously processed text, which is often accomplished via anaphoric expressions (e.g., a pronoun referring to a previous noun). Some early offline work suggested that aging brings about increased difficulty in resolving anaphoric expressions (e.g., Kahn & Till, 1991; Light & Capps, 1986); however, little work has examined the effects of aging on the online demands of anaphor resolution, to determine the time course of older adults' anaphor resolution processes.

In the current study, we used eye-tracking to examine older and younger adults' eye movements as they read sentences containing anaphoric violations of stereotype expectations (e.g., "The firefighter burned *herself* while rescuing victims from the building."). If older adults have greater difficulty with resolving anaphoric expressions, they should show longer processing times (reflected in longer fixation durations and/or a higher probability of regressions (i.e., rereading)) when the stereotyped noun does not match the pronoun anaphor.

METHODS

Participants

	Young		Old	
N	19		19	
Age Range	18-32		60-80	
Age †*	21.37	(0.70)	67.53	(1.39)
Verbal Working Memory Span †*	5.56	(0.29)	4.54	(0.27)
WAIS-R Vocabulary †	47.84	(1.81)	51.11	(1.33)
Education (yrs) †*	14.37	(0.41)	15.89	(0.56)

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

Design, Procedure & Apparatus

Passages were presented in a single random order. After 25% of the trials, participants answered yes/no comprehension questions to ensure comprehension. 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.

Materials

24 experimental sentences were created, each with a different stereotypical role name. Gender (male/female) and stereotype (match/mismatch) were counterbalanced, such that each participant read equal numbers of sentences of each of the four types (see examples in the Table). Only stereotypical roles that were age-equivalent in ratings of masculinity/femininity were included (based on a norming study with an independent sample of 40 young and 40 old). All sentences were syntactically structured identical to the examples, i.e., a role name character with a reflexive pronoun referring to the character, followed by a main verb.

		Stereotype	
		Match	Mismatch
Gender	Male	The firefighter burned himself while rescuing victims from the building.	The firefighter burned herself while rescuing victims from the building.
	Female	The babysitter found herself humming while walking up to the door.	The babysitter found himself humming while walking up to the door.

RESULTS

Eye Tracking Measures

Gaze Duration (GD): total sum of all fixation durations from the very first fixation to enter the target region through the last fixation *before* leaving the region in either direction (aka 1st Pass Reading Time).

Go-Past Time (GPT): total sum of all fixations from the very first to enter the target region, through the last fixation before going *forward* in the sentence (including time spent regressing; aka Regression Path Duration).

Regressions-In (RGI): Probability of the word being a "landing spot" from a regression.

Skipping (SKP): Probability of skipping the word during the 1st pass thru the text.

Gaze Duration

Initial encounters with the pronoun indicating a stereotype violation engendered longer gaze durations relative to the control condition (see Figure 1), $F_1(1,36)=2.23$, $p=.06$; $F_2(1,23) = 2.54$, $p = .12$.

The young spend longer on the initial encounter with the pronoun before moving eyes elsewhere; older readers spent less time on the pronoun during the initial encounter. (see Figure 1), $F_1(1,36) = 4.45$, $p < .05$; $F_2(1,24) = 16.28$, $p < .01$ (though the interaction did not reach significance, $p = .15$).

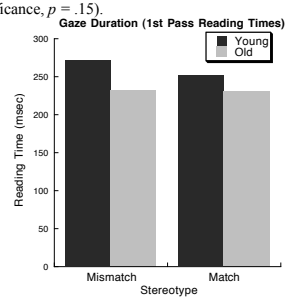

Figure 1. Gaze Duration on Target Pronoun for Young and Old as a Function of Stereotype Matching

Go-Past Time

Go-past times for the pronoun were also reliably increased by stereotype violation (see Figure 2), $F(1,36)=4.67$, $p<.05$, $F_2(1,23) = 7.01$, $p < .05$, suggesting the violation produced special demands for integration. However, there was age-equivalence in the time spent.

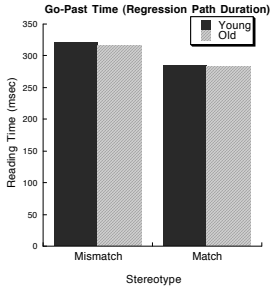

Figure 2. Go-Past Time on Target Pronoun for Young and Old as a Function of Stereotype Matching

Regressions-Out

Older adults were more likely to regress backward in text immediately upon encountering the unexpected pronoun (See Figure 3), $F(1,36)=7.28$, $p<.02$, $F_2(1,23) = 16.65$, $p < .001$.

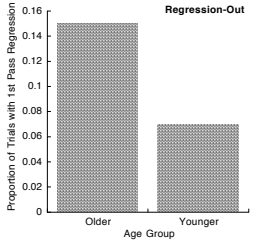

Figure 3. Proportion of Trials with Regression from Target Pronoun for Young and Old.

Skipping

On the initial reading, older adults were more likely to skip the noun (see Figure 4, left panel), $F_1(1,36) = 3.72$, $p = .06$; $F_2(1,23) = 20.13$, $p < .01$, as well as the verb (see Figure 4, right panel), $F_1(1,36) = 8.65$, $p < .01$, $F_2(1,23) = 16.30$, $p < .01$, suggesting a possibly more "risky" reading strategy (cf. Rayner et al., 2006).

Figure 4. Proportion of Trials with 1st Pass Word Skipping for the Role Noun (left panel) and the Verb (right panel) for Younger and Older Adults

CONCLUSIONS

Readers are sensitive to stereotype violations in anaphoric expressions, but there may be age-related differences in how this sensitivity is reflected in reading patterns: during the initial encounter with the reflexive pronoun, older adults were more likely to spend less time on the pronoun and more likely to regress backward in the text; younger adults spent longer fixating on the pronoun to resolve the anaphoric expression before moving forward.

Measures of go-past time showed age equivalence, suggesting age differences in the ultimate resolution of the anaphor may be qualitative rather than quantitative, i.e., the amount of time younger and older adults needed to comprehend the anaphoric expression was similar, but the older adults were more likely to spend some of that processing time rereading.

Older adults may adopt more risky reading behaviors, as evidenced by greater likelihood of skipping words earlier in the sentence.

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