Use of Contextual Constraint among Adults with Varying Age and Literacy Skill

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Abstract

The processing of individual words is facilitated by sentence context, yet little is known about how such contextual facilitation varies differentially through the adult lifespan as a function of literacy skill. We examined comprehension and contextual facilitation among adults varying in age and literacy skill, who read simple sentences, in which semantic constraint was manipulated, as their eye movements were monitored. Comprehension was generally better for older readers and for high-skill readers. Low-skill readers had differential poor comprehension as constraint decreased. Reading time (RT) was generally faster with increasing literacy skill, but this depended on age for measures of early lexical processes: first fixation durations became faster with age among those with intact literacy skills, while those with underdeveloped literacy skill showed the reverse pattern. Older readers, regardless of literacy skill, were differentially facilitated by increased semantic constraints in measures of later reading processes (e.g., regression path duration). Collectively, these results suggest that while the negative effects of undeveloped literacy become exacerbated with age, the ability to utilize semantic constraints increases with age and is not moderated by literacy skill.

Rationale

- Proficient readers are facilitated in word-level processing by semantic constraints especially for older adults (e.g., Stine-Morrow et al., 2008), but little is known about development among those who do not acquire strong literacy skills.
- Among good readers, age effects in sentence processing and the use of contextual constraints have been found to depend on experience and verbal skills (Federmeier & Kutas, 2005; Payne et al., 2012).
- We measured eye-movements as younger and middle-aged adults varying in literacy skill read grade-level appropriate sentences to examine age differences in the use of contextual constraint as a function of literacy level.

Method

Participants

	Low Literacy				High Literacy				Total	
	Y (n = 25)		MA (n = 19)		Y (n = 20)		MA (n = 16)		N = 80	
Measures	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age	26.96	7.58	52.58	6.07	24.15	6.90	49.44	5.14	36.84	14.34
Education Level	11.56	1.39	11.26	2.72	11.52	1.35	12.41	1.97	11.65	1.90
Speed*	0.03	0.97	-0.52	0.76	0.48	0.88	-0.02	0.55	0.00	0.88
Crystallized Ability (Gc)*	-0.34	0.59	-0.32	0.86	0.29	0.69	0.53	1.15	0.00	0.88
Fluid Ability (Gf)*	-0.04	0.74	-0.68	0.55	0.43	0.84	0.32	0.94	0.00	0.87
Reading Grade Level	6.97	1.98	7.62	1.38	11.79	1.79	11.72	1.54	9.28	2.83

* estimated as standardized composites of component measures.

Materials and Procedure

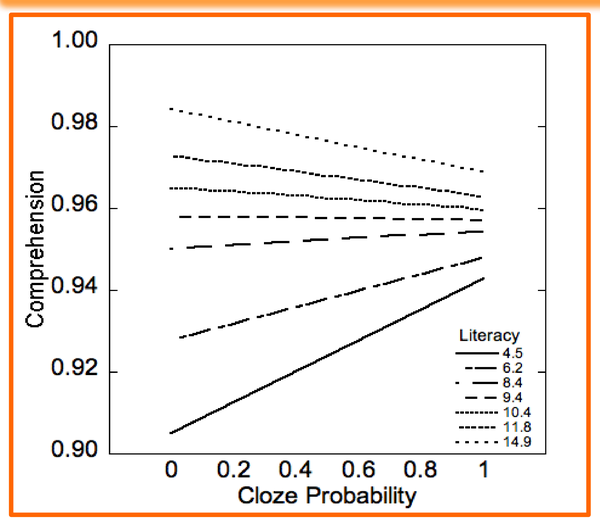
Texts were 60 sentences (mean FK grade level = 2.1) in which contextual constraint (i.e., the cloze probability for a sentence-final word) and expectancy of the sentence-final target (based on that context) were manipulated. Target words were controlled for length and word frequency; sentences were controlled for length and grade level. Participants read these sentences in order to answer comprehension questions as their eye-movements were monitored.

Table 1.
Examples of Stimulus Items

Constraint	Sentence Frame	Target		Cloze Probability Mean(range)			
		Expected	Unexpected	Expected		Unexpected	
Strong	As soon as they reached the sand, he stopped to take off his	shoes	watch	0.90	(0.70 – 1.00)	0.03	(0.00 - 0.13)
Weak	They had to shampoo the new rug after the accident with the	wine	table	0.37	(0.20 – 0.65)	0.03	(0.00 - 0.15)

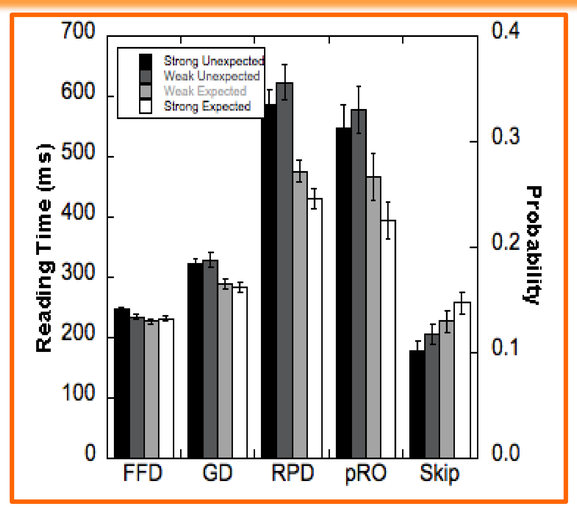
Comprehension Probe Example: Did he stop to take off his shoes/watch?

Figures

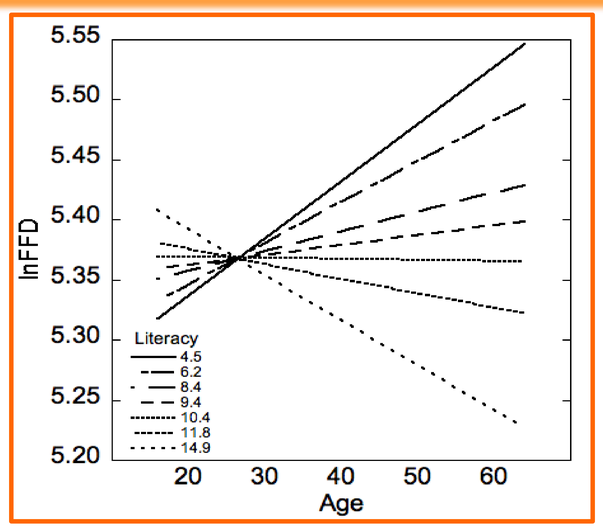


Lit x Cloze: $c^2(1, N = 80) = 5.8$, $p < .05$
Lit: $c^2(1, N = 80) = 18.9$, $p < .01$

Fig 1. Comprehension accuracy as a function of cloze probability for varying levels of literacy skill.

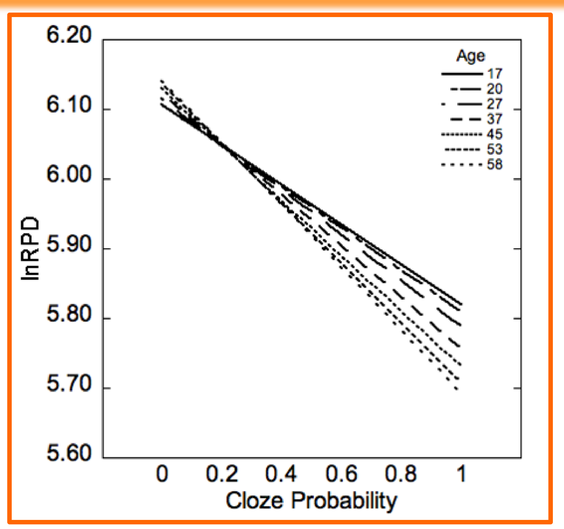


Cloze: $c^2(1, N = 80) > 12.5$, p's $< .01$
Fig 2. The effects of constraint and expectancy on the untransformed indices for the sample as a whole. Reading time measures (in milliseconds) are on the left y-axis, and probabilities are represented on right y-axis. Error bars represent one standard error of the mean. FFD, first fixation duration; GD, gaze duration; RPD, regression path duration; pRO, probability of regressing out; Skip, probability of skipping.



Age x Lit: $c^2(1, N = 80) = 3.7$, $p = .05$

Fig 3. FFD, log transformed, as a function of age for varying levels of literacy skill.



Age x Cloze: $c^2(1, N = 80) = 4.3$, $p < .05$
Cloze: $c^2(1, N = 80) = 93.6$, $p < .01$

Fig 4. RPD, log transformed, as a function of cloze probability and age.

Results

Comprehension

Generally, performance on comprehension questions was very high (M = 0.89, SD = .31). However, there was a small but significant difference in comprehension performance favoring the middle-aged adults (.88 vs. .91, for Y and MA, respectively), $c^2(1, N = 80) = 9.7$, $p < .01$. Those with lower literacy skill showed poorer comprehension, especially for low-cloze items (cf. **Figure 1**).

Eye Movement Measures

- All processing measures showed facilitation with increasing cloze probability (cf. **Figure 2**).
- Relative to their high-literacy counterparts, low-literacy adults showed longer GD (332 vs. 277), longer RPD (627 vs. 496), and an increase in pRO (0.30 vs. 0.27), c^2's > 4.1, p's < 0.05.
- FFDs were faster with age among adults with intact literacy skills, but increased among adults with underdeveloped literacy skills (cf. **Figure 3**). GD patterned the same way but this interaction was not significant.
- Older readers, regardless of literacy skill, showed differential facilitation in RPD with increasing semantic constraint (cf. **Figure 4**).

Conclusions

- Literacy may have a selective benefit in counteracting the effects of age-related slowing on the efficiency of early lexical processing, at least into midlife.
- Both younger and older readers, regardless of literacy skill, showed strong sensitivity to contextual constraints, as measured in all indices of processing. This effect increased with age specifically for regression path duration, suggesting that older adults differentially rely on semantic constraint to support text integration processes.
- Collectively, these results suggest that while literacy experience over the lifespan may differentially facilitate word recognition processes, the increased reliance on contextual constraints with age may be linked to aspects of cognitive development unrelated to engagement with print.

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