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

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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	
	Young	Middle-Aged	Young	Middle-Aged
N	23	17	22	18
Age (yrs)	26	52	25	50
Education (yrs)	11.6	12.0	11.5	11.6
Gc*	-0.29	-0.27	0.18	0.35
Gf*	-0.03	-0.45	0.39	-0.03
Reading Level**	7.6	7.9	11.8	11.5

* Estimates of crystallized (Gc) and fluid (Gf) abilities were based on the WASI.
** Estimated as a composite of the Slosson Oral Reading Test (word recognition), Woodcock Johnson Reading Fluency (speeded sentence comprehension), and Rapid Automatized Naming/Rapid Alternating Stimulus (speeded naming of nonverbal stimuli in sequence).

Procedure

Participants read 60 sentences (mean FK grade level = 2.1) varying in contextual constraint and expectancy of a sentence final target word in order to answer comprehension questions. Their eye-movements were monitored during reading. Target words were controlled for length and word frequency; sentences were controlled for length and grade level.

Materials

Condition	Sentence	Cloze Probability	Questions
Strongly Constrained - Expected	As soon as they reached the sand, he stopped to take off his shoes.	0.70 – 1.00	Did he take off his shoes?
Weakly Constrained - Expected	They had to shampoo the new rug after the accident with the wine.	0.20 – 0.65	Did they have to clean the rug?
Strongly Constrained -Unexpected	As soon as they reached the sand, he stopped to take off his watch.	0.00 – 0.14	Did he take off his watch?
Weakly Constrained - Unexpected	They had to shampoo the new rug after the accident with the tray.		Did they have to clean the rug?

Results

Comprehension

Whether the target word was expected or unexpected had no effect on comprehension, so we report performance as a function of constraint (collapsed across expectancy).
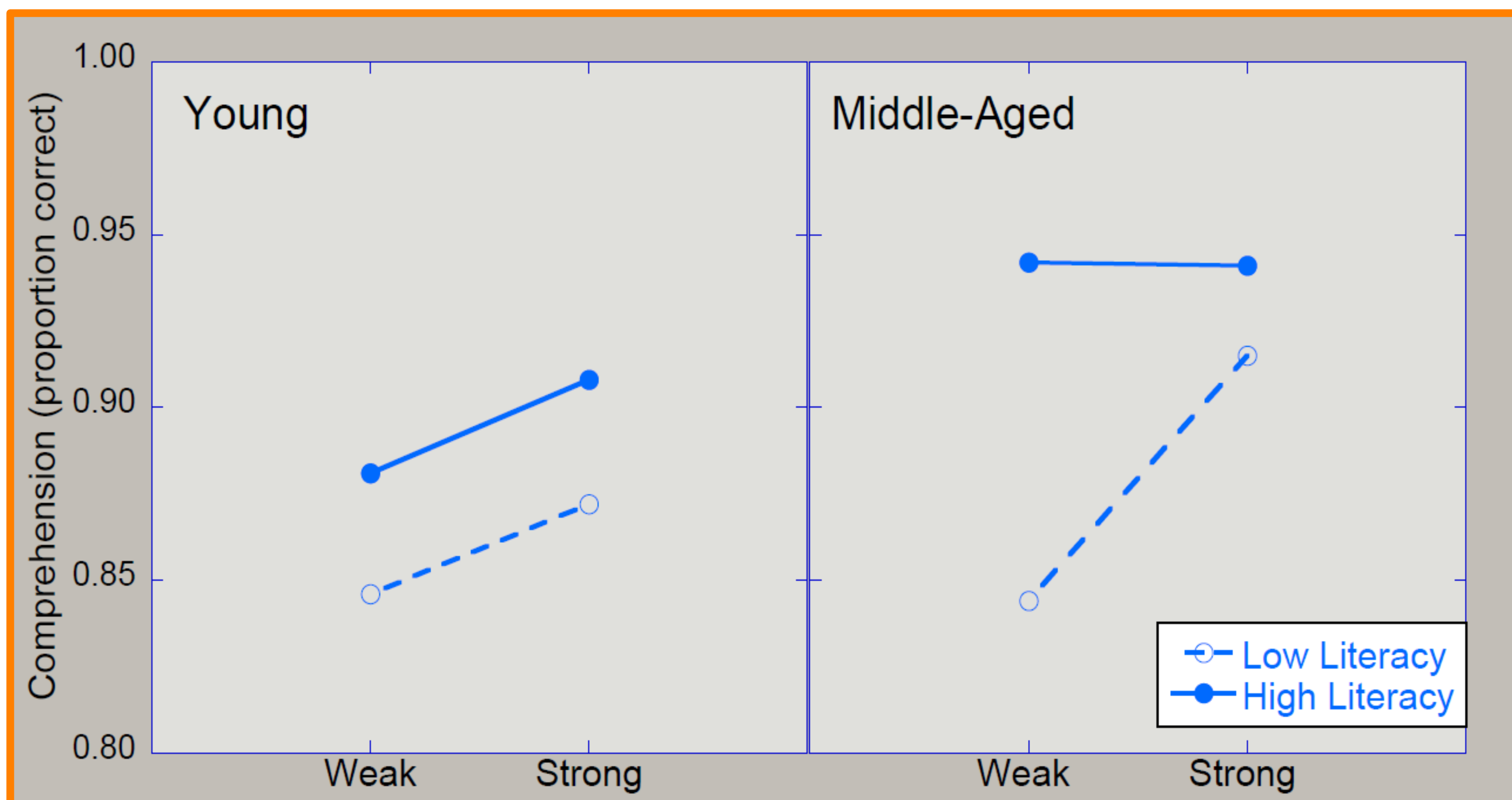

- **Literacy Skill**, HL>LL, $F_{(1,75)} = 4.44$, $p < 0.05$
- **Age**, Y=M, $F_{(1,75)} = 2.10$, $p = .15$
- **Constraint**, S>W, $F_{(1,75)} = 12.33$, $p = 0.001$
- **Constraint X Age X Literacy**, $F_{(1,75)} = 4.39$, $p < 0.05$

Generally, performance on comprehension questions was better for strongly constraining sentences (regardless of expectancy), but literacy skill moderated this effect for middle-aged adults only. While low-literacy middle-aged adults had differential difficulty comprehending weakly constraining sentences, high literacy middle-aged adults showed good comprehension regardless of constraint.

Results (continued)

Reading Time Measures

Reading Time measures did not differ across the two unexpected conditions and so they were combined for analysis. All eye-tracking measures showed main effects of expectancy, though effects were larger for later pass measures. Differences between weak and strong conditions only emerged at later pass measures (left). Those with lower reading level showed longer gaze durations and regression path durations than those with higher reading level (right).


Fig. 1

Fig. 2
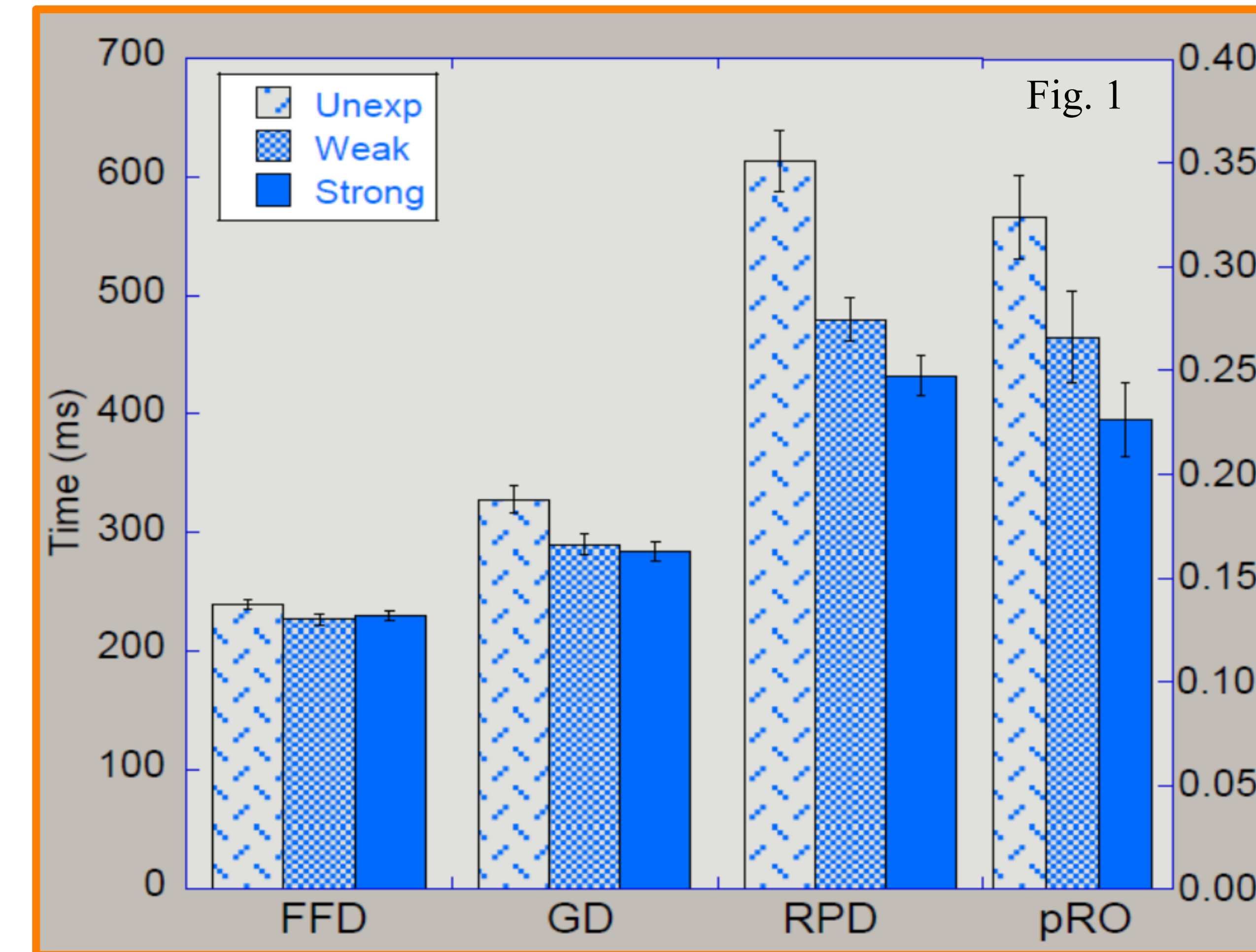
- **FFD, First Fixation Duration**, U>W=S, $F_{(2,76)} = 5.30$, $p = 0.01$
- **GD, Gaze Duration**, U>W=S, $F_{(2,76)} = 23.35$, $p < 0.001$
- **RPD, Regression Path Duration**, U>W>S, $F_{(2,76)} = 46.52$, $p < 0.001$
- **pRO, Probability of Regressing Out**, U>W>S, $F_{(2,76)} = 18.71$, $p < 0.001$
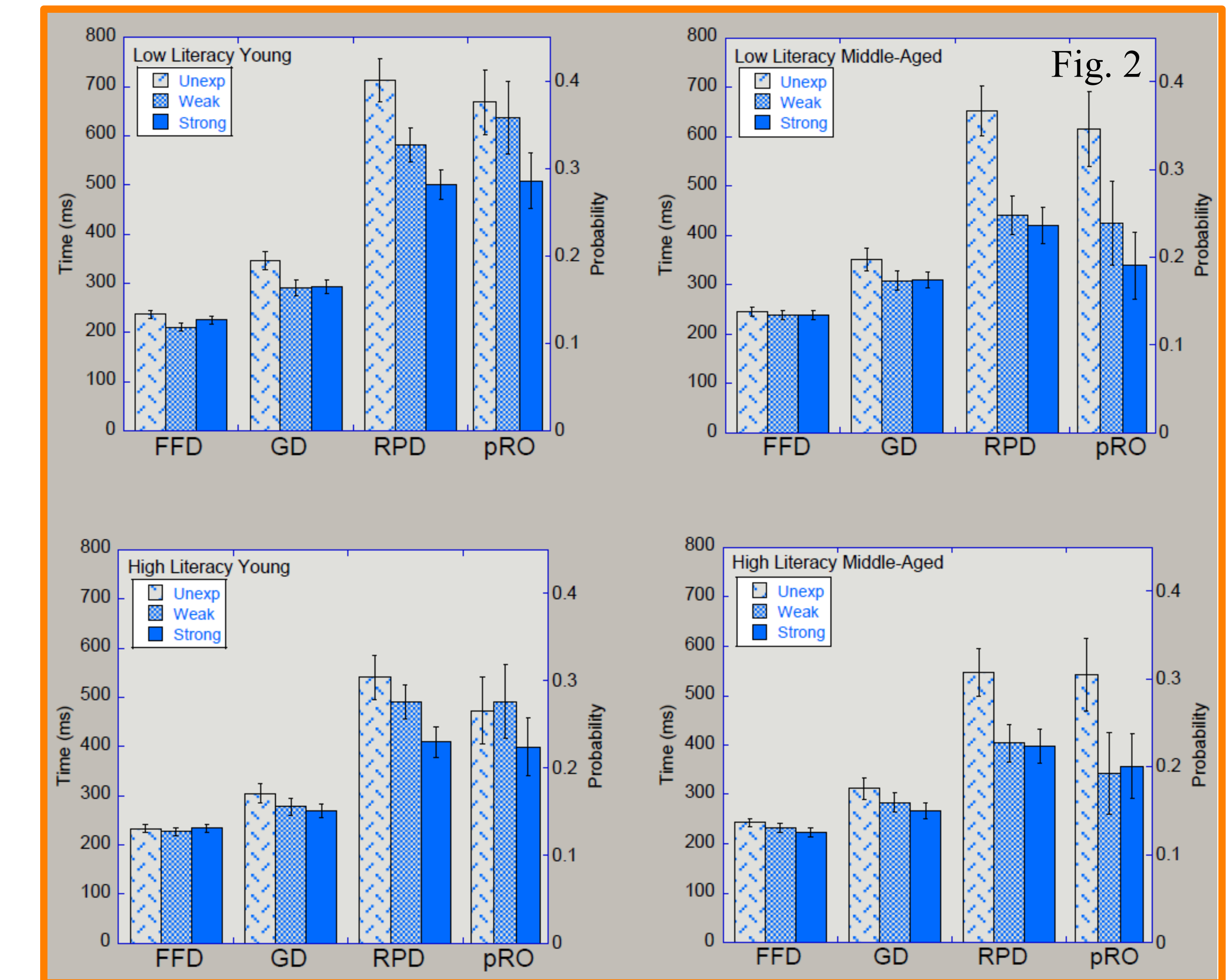
- **GD**, LL≥HL, $F_{(1,76)} = 3.62$, $p < 0.10$
- **RPD**, LL≥HL, $F_{(1,76)} = 7.23$, $p < 0.01$; Y≥M, $F_{(1,76)} = 3.67$, $p < 0.10$
- No group differences for **FFD** or **pRO**

Regardless of literacy skill, middle-aged adults were relatively less likely than the young to regress out from target words in the weakly constraining condition compared to the unexpected condition. This Age interaction patterned the same way as for pRO but did not reach significance. Relative to high-literacy adults, there was a trend for low-literacy adults to show differentially longer RPDs when the target word was unexpected; this reached conventional levels of significance only when the unexpected condition was contrasted with the expected condition (collapsed across strong and weak constraints).

Fig. 3

Fig. 4
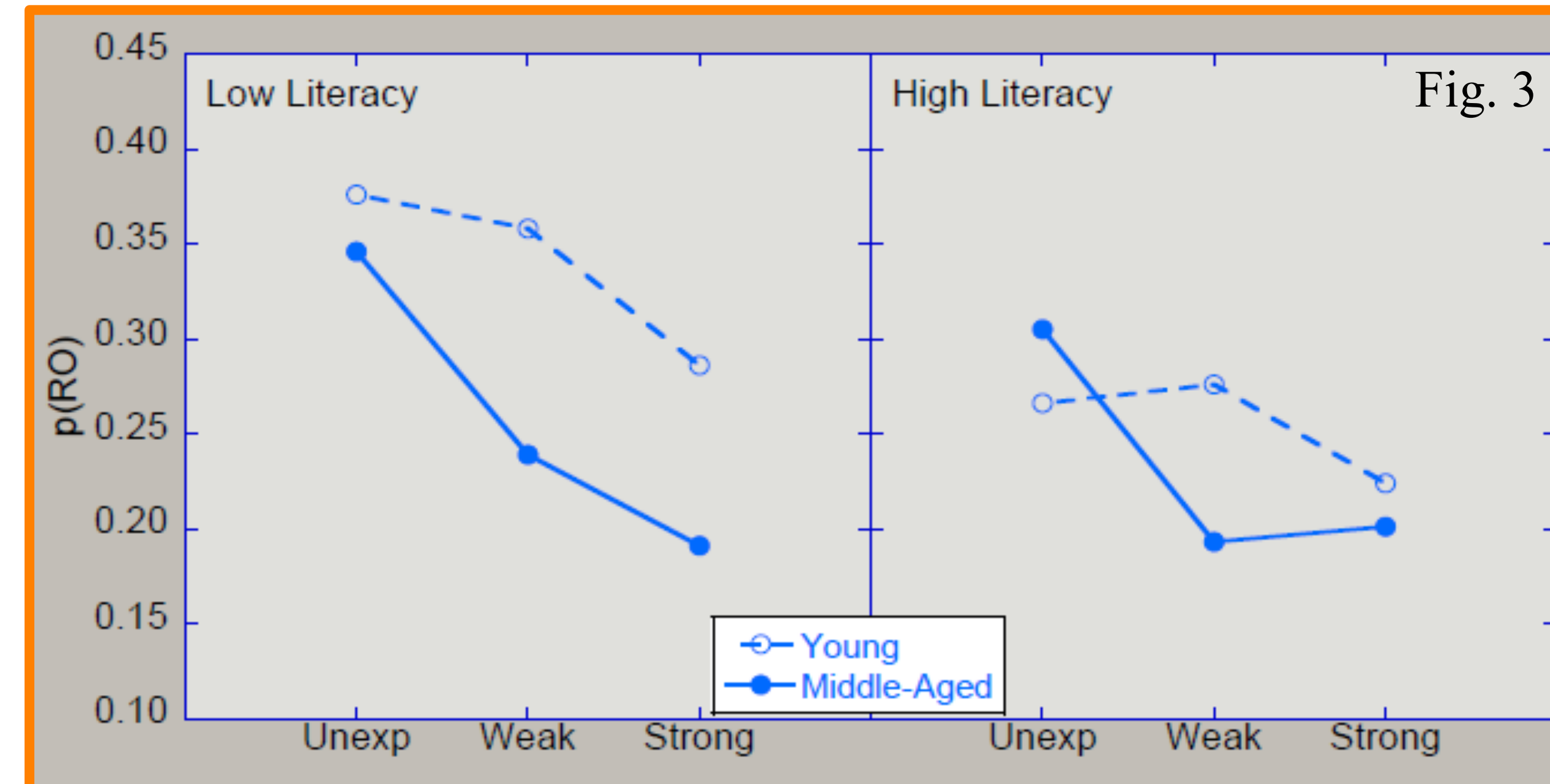
- **Expectancy X Age interaction**, $F_{(2,76)} = 5.49$, $p = 0.01$
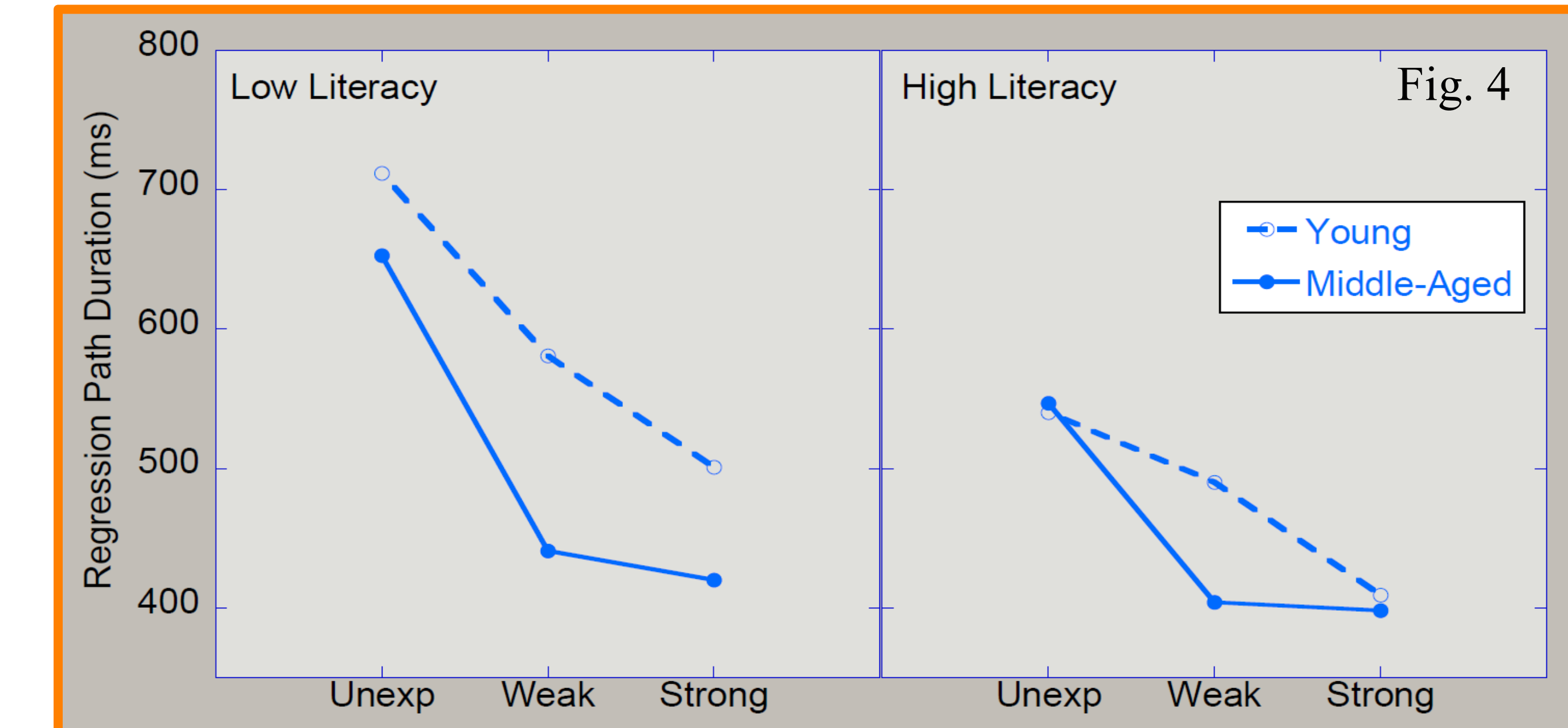
- **Expectancy (U, W, S) X Age interaction**, $F_{(2,76)} = 2.75$, $p < 0.1$
- **Expectancy (U, W, S) X Literacy interaction**, $F_{(2,76)} = 2.71$, $p < 0.1$
- **Expectancy (U, Exp) X Literacy interaction**, $F_{(1,76)} = 4.57$, $p < 0.05$

Conclusions

- Regardless of age or literacy levels, readers allocate extra effort to process words that are unexpected (Figure 1).
- Regardless of age, adults with lower literacy skills allocate more effort than higher literacy adults to resolve meaning for concepts that are unexpected (Figures 3 & 4).
- Middle-aged readers, regardless of literacy level, allocate differentially less effort to resolving meaning when the context is weakly constraining relative to the unexpected condition (Figures 3 & 4), which may alternately reflect:
  - an advantage in the use of more subtle contextual cues, or
  - insufficient attentional allocation to resolve meaning in this condition (consistent with the comprehension data).
- The dissociation of the effects of constraint and expectancy on comprehension and eye-gaze, respectively, highlights the value of using both online and offline measures of reading.

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