Information Foraging among Younger and Older Adults Depends on Abilities and Memory Self-Efficacy

Xiaomei Liu[1], Jessie Chin[2], Wai-Tat Fu[1], Daniel G. Morrow[1] & Elizabeth A. L. Stine-Morrow[1]

[1]University of Illinois Urbana-Champaign, [2]University of Waterloo

RATIONALE

Age differences in text memory have been related to both cognitive and motivational factors (Stine-Morrow et al., 2006, 2008). However, very little is known about how these factors influence performance in a reading ecology where readers can self-regulate and choose among multiple texts. Using an Information Foraging framework (Liu et al., 2016; Pirolli & Card, 1999), we contrasted the contributions of ability and memory self-efficacy (MSE) to age differences in performance in reading ecologies that placed differential demands on speeded processing and degrees of self-regulation: **Foraging Condition** - Readers learned about a topic by selecting texts and regulating time allocation within an overall time limit ("free reading" condition to operationalize "typical" performance); **Control Condition** - Readers learned about a topic from texts in which the order and timing of presentation were determined a priori ("time constraint" condition to operationalize "optimal" performance).

METHOD

- Participants: Age groups were matched in verbal ability, but there was a small but significant difference in education level. Younger adults also scored higher on fluid ability and MSE, which remained when education levels was controlled (cf. **Table 1**). Education was controlled in all subsequent analyses.

Table 1. Sample characteristics.

		Young (N=20)	Old (N=22)	*t*	*r*(x,Age.Ed)
Age	M(SE)	28.8 (1.6)	73.5 (1.3)		
	Range	20 - 40	61 - 81		
ED	M(SE)	14.8 (0.3)	13.7 (0.4)	2.3*	
	Range	12 - 16	12 - 16		
MSE	M(SE)	114.1 (4.6)	96.9 (0.1)	3.1**	-.55**
Fluid Ability	M(SE)	0.5 (0.1)	-0.5 (0.1)	6.4**	-.76**
Ep Memory	M(SE)	0.2 (0.2)	-0.1 (0.2)	1.4	
Speed	M(SE)	0.7 (0.2)	-0.6 (0.1)	5.7**	
Reasoning	M(SE)	21.5 (0.7)	12.2 (1.2)	6.1**	
WM	M(SE)	0.6 (0.2)	-0.5 (0.1)	4.7**	
Verbal Ability	M(SE)	0.2 (0.1)	-0.1 (0.1)	1.4	-.22
Vocab	M(SE)	8.7 (0.6)	8.7 (0.8)	0.1	
Reading Fluency	M(SE)	87.2 (3.1)	77.4 (3.3)	2.1*	
Verbal Fluency	M(SE)	47.6 (3.4)	43.1 (2.1)	1.2	

MSE, measured by Change and Capacity subscales from Metamemory in Adulthood Questionnaire (Dixon et al., 1988).
Ep Memory = Episodic Memory, a standardized composite of delayed recall, retention, and recognition scores from Hopkins Verbal Learning Test – Revised.
WM = Working Memory, a standardized composite score of Reading Span and Listening Span tasks.
Fluid ability and Verbal ability are estimated as standardized composites of component measures (Cronbach's α = .73 and .84, respectively).

Table 2. Sample Texts.

	Topic Cue	Text
Marie Curie	Danger	Her work-related papers are still radioactive, and those who wish to consult them must wear protective clothing.
	Wedding	Instead of wearing a bridal grown, she wore a dark blue dress, which served her for many years as a laboratory outfit.
	Religion	Raised by a Catholic mother and an atheist father, she became agnostic after her mother's death.
Williams Shakespeare	Marriage	At the age of 18, he married Anne Hathaway, who was 8 years his senior and the daughter of a local farmer.
	Missing	There is no record of his activities between 1585 and 1592, but some think he was fleeing prosecution for deer poaching.
	Death	At the age of 52, he died after signing his will, which he began by describing himself as being in "perfect health."

Notes. †p<.1; *p<.05; **p<.01)

- Materials and Procedure
  - Participants learned biographical information about six historical individuals (Curie, Newton, Dickinson, Shakespeare, Mother Teresa, Gandhi) by reading short texts about each person (cf. **Table 2** for examples).
  - Reading was done on electronic tablets (**Figure 1**) with the goal to learn as much information as possible, under two conditions:
    - *Foraging*: Readers selected texts about an individual based on topic cues, with freedom allocate time to each passage as desired; overall time was matched with that of the Control condition.
    - *Control*: Texts were presented in a random order, with presentation time systematically controlled (RT = 500 + x (# propositions), where x was increased or decreased by 75ms per proposition across trials)), providing data for recall performance across a range of presentation times.

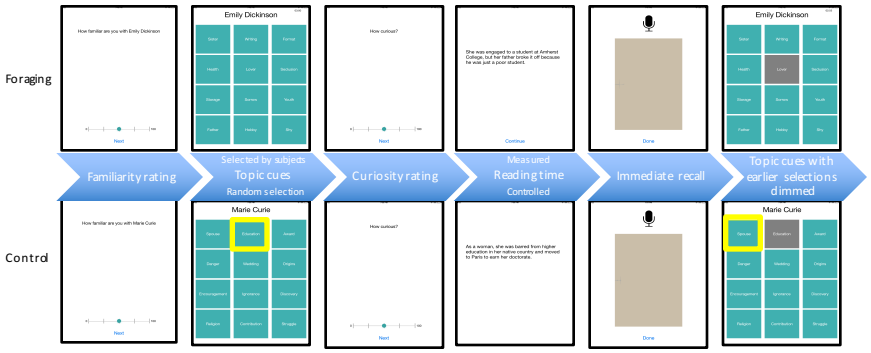

Figure 1. Reading Procedure on iPad.

- Estimating Information Uptake Rate and Recall Performance
  - Control condition: optimal uptake rate and maximum recall were estimated for each participant by fitting the data to an the exponential function, $PR t = a - a e^{-rt}$, where PR(t) = proportion propositions recalled at time t, a = asymptotic recall, and r = rate. The point of optimal information uptake was defined as the point at which the tangent $PR'(t) = .05$ intersected with PR(t) (**Figure 2**).
  - Foraging condition: typical uptake rate was estimated for each participant as the proportion propositions recalled per unit time allocated across the condition, and typical recall was defined as mean sentence proportion of propositions recalled.
  - Because uptake rates were positively skewed, they were analyzed with a natural log transform.

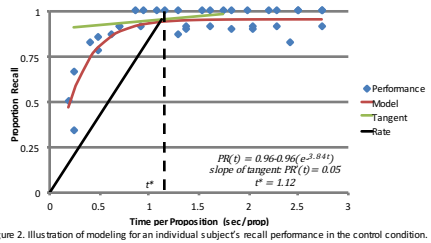

Figure 2. Illustration of modeling for an individual subject's recall performance in the control condition.

RESULTS

- Information uptake rate was higher in the Foraging than in the Control condition (**Figure 3**, left), but memory performance was better in the Control than the Foraging condition (**Figure 3**, right). Across conditions, compared to younger adults, older adults showed lower uptake rates and recall, which did not differ with reading condition.

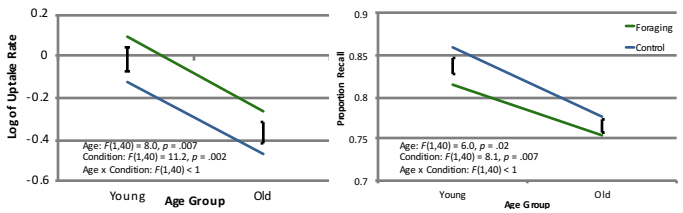

Figure 4. Mean immediate recall and rate of information uptake as a function of age and condition. Standard errors of differences are represented by vertical bars.

- Regardless of condition, fluid ability and MSE were generally positive predictors for both uptake rate and recall; verbal ability specifically predicted rate of uptake but not recall (**Table 3**).
- However, a regression analysis (**Table 4**) suggested these variables contributed differentially to age effects depending on condition. This analysis confirmed that verbal ability supports uptake rate regardless of the reading ecology, but the impact of individual differences in motivation varied with ecology, with MSE predicting uptake rate in the Foraging condition, but recall performance in the Control condition. When these individual differences were partialled out, age was no longer a significant predictor.

Table 3. Correlations between measures of reading performance and individual differences controlling for education level.

Measures	Foraging LogRate	Foraging Recall	Control LogRate	Control Recall
Age	-.55**	-.36*	-.39*	-.39*
MSE	.60**	.32†	.42**	.49**
Fluid Ability	.60**	.43**	.57**	.46**
Verbal Ability	.56**	.14	.59**	.26

Table 4. Standardized betas from linear regressions predicting uptake rate and immediate recall in foraging and control conditions controlling for education level.

Condition	Variable	Age Alone	Model				
			Fluid	Verbal	MSE	Age	Adj Rsq
Foraging	LogRate	-0.46**	0.21	0.35**	0.34*	-0.13	.55
	Recall	-0.28†	0.44	-0.08	0.18	0.05	.13
Control	LogRate	-0.35*	0.41†	0.40*	0.19	0.09	.43
	Rate	-0.39*	0.40	0.02	0.37*	0.12	.25

CONCLUSION

- The combination of a fast information uptake rate and low recall in the Foraging condition, relative to the Control, suggests the use of a satisficing strategy among younger and older adults in free reading conditions.
- Verbal ability supports faster information uptake regardless of the reading ecology.
- Memory self-efficacy contributed more to performance metrics that are more compatible with demands of the ecology (i.e., encoding accuracy under time limitations and satisficing in free reading; cf. Stine-Morrow et al., 2006).
- Age-associated changes in cognition and motivational factors can contribute differentially to reading performance depending on the ecology in which reading is engaged.

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Request for more info to xliu85@illinois.edu.