Print Exposure and Online Sentence Processing Among Older Adults

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Rationale

• Reading is an important activity for maintaining intellectual capacity and exercising cognitive abilities across the lifespan.

• Studies have shown that *print exposure* (PE), the degree of habitual engagement in reading, can explain the positive age-related relationships with crystallized abilities such as vocabulary and declarative knowledge among older adults (Stanovich et al., 1995).

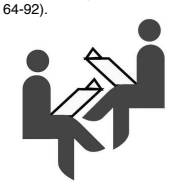
• Higher PE is associated with facilitation in word-level processes among both child and younger adult readers (e.g., Chateau & Jared, 2000). However, less is known about the role of PE in the continued building of skilled reading over the life span.

• In the current study, we examine the effects of PE on online measures of word decoding, lexical access, and textbase integration among older readers.

Methods

Participants

• 150 community dwelling older adults (Mean age = 72, Range = 64-92).



Measures and Procedure

• *Exposure to Print.* The Author Recognition Test (ART; Stanovich & West, 1989). Participants were given a checklist with authors and foils, and asked to select the authors. The overall score is calculated by subtracting the number of foils identified from the number of authors correctly identified.

• *Verbal Ability.* The ETS-Advanced Vocabulary and Extended Range Vocabulary Test (Ekstrom et al., 1976). For each item, participants are asked to choose the correct synonym of a target word from a list of five possible words.

• *Verbal Working Memory (vWM).* The loaded reading span task (Stine & Hindman, 1994). Participants read a series of sentences for immediate true/false judgments, and then reported the last word of each sentence in sets of increasing size. The score was the maximum set size with accurate recall.

• *Reading Task.* Sets of 24 two-sentence passages were presented to each participant to read word-by-word in an individual laboratory session.

Results

• Advancing age was associated with marginally lower vWM and lower levels of PE. PE was highly related to both measure of verbal ability as well as education, and vWM (see Table 1).

• In subsequent analyses, the two vocabulary measures were combined into one verbal ability composite for each subject (α = .89).

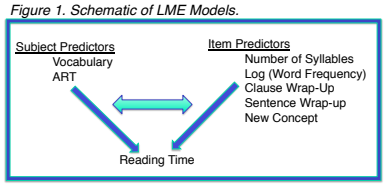
Table 1. Correlations Between Age, Education, Verbal Working Memory, Verbal Ability, and Print Exposure

	M (SE)	Age	Ed	vWM	VocEx	VocAdv
Age	72.30 (.65)					
Ed	15.40 (.22)	.01				
vWM	3.92 (.08)	-.14†	.15†			
VocEx	14.35 (.39)	.02	.49**	.22*		
VocAdv	9.81 (.31)	.05	.45**	.16*	.82**	
ART	10.20 (.43)	-.17*	.30**	.20*	.62**	.62**

Effects of Print Exposure on Online Measures of Text Encoding

• Word-by-word reading times were submitted to analysis using linear mixed effects (LME) models with cross-random effects for subjects and items. This allows us to simultaneously model predictors of subject and item variance and their interactions (see Fig.1) without biased estimates (Quene & van den Bergh, 2007).

Figure 1. Schematic of LME Models.



• We entered predictors of reading time hierarchically in 3 models. Predictors were centered. Reading times were log transformed to correct for skew. Estimates and standard errors for each model are presented in Table 2.

Table 2. Estimates and Standard Errors From Cross Random Effects Models

	Model 1		Model 2		Model 3	
	B	SE	B	SE	B	SE
Intercept	6.49	.0389***	6.76	.0662***	6.69	.0787***
Item Predictors						
Syll	.0489	.0095***	.0683	.0111***	.0683	.0110***
logWF	-.0510	.0006***	-.0577	.0070***	-.0058	.0070***
IntSB	.0396	.0149**	.0638	.0187***	.0638	.0187***
SB	.4785	.0279***	.4579	.0392***	.4579	.0329***
NC	.0578	.0167***	.0835	.0199***	.0853	.0199***
Subject Predictors						
ART	—	—	-.0255	.0054***	-.0188	.0007**
Vocab	—	—	—	—	-.0557	.0350†
Cross Effect Interactions						
ARTxSyll	—	—	-.0019	.0005***	-.0019	.0005***
ARTxlogWF	—	—	6E-04	5E-04*	6E-04	.0003*
ARTxIntSB	—	—	.0023	.0001*	.0023	.0001*
ARTxSB	—	—	.0028	.0016ns	.0021	.0016ns
ARTxNC	—	—	-.0024	.0010**	-.0023	.0011**
-2 Log Likelihood	64428.5_A		63063.1_B		63060.6_B	

Note. ns = non-significant, p > .10; †p < .10; *p < .05; **p < .01; *** p< .001. Subscripts denote significant differences in model fit (a lower value is better).

• Individuals with higher vocabulary had higher PE scores (Stanovich & West, 1989; also, see Table 1) and it is possible that verbal ability may be a stronger determiner of resource allocation (Stine-Morrow et al., 2008) than print exposure.

• Examining effects of PE that are independent of verbal ability constitutes a very conservative test (Chateau & Jared, 2000).

• The final model represents the unique effects of PE on online reading comprehension even after it was "robbed of some of its rightful variance" (pg. 265; Cunningham & Stanovich, 1991).

Model 1. Resource Allocation: Predictors of Word Reading Time

In Model 1, we included only item-level predictors of reading time:

Table 3. Item-level Predictors of Reading Time

Text Variable	Theoretical Processes
Syll	Orthographic decoding
Log(WF)	Lexical access
IntSB	Conceptual wrap-up at clause boundaries
SB	Conceptual wrap-up at sentence boundaries
NC	Immediate processing of new conceptual information

Note. Syll= number of syllables; Log(WF)= log word frequency; IntSB= intrasentence (clause) boundary; SB= sentence boundary; NC= new concept.

• All parameters in this model were significant. On average, more time is allocated to words that are more orthographically complex, that are lower in word frequency, that introduce new concepts, and at integration sites (i.e., wrap-up at clause and sentence boundaries; Stine-Morrow et al., 2008).

Model 2. Print Exposure Differences in Resource Allocation

• In Model 2, we added cross effect interactions between PE and each of the five item-level predictors.

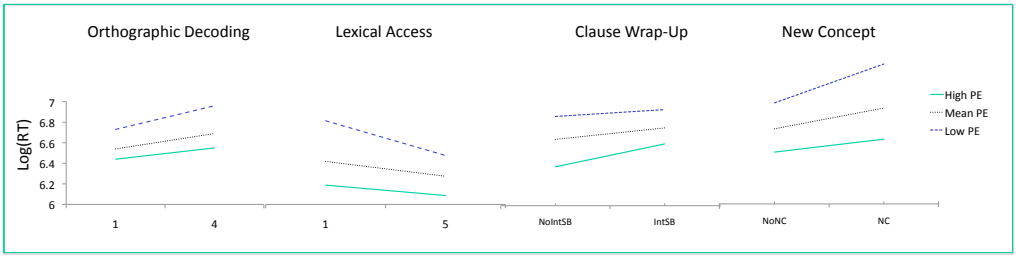
• All but one interaction parameter in this model was significant (ARTxSB, *p = .20*; though it was tending in the correct direction).

• Older adults with higher print exposure were facilitated in orthographic processing, lexical access, and textbase processing.

Model 3. Unique Effects of Print Exposure

• If verbal ability is responsible for the relationships between PE and resource allocation, then adding this to the model should reduce or eliminate the significant interactions found in Model 2. However, all parameters from Model 2 remained significant and were largely unchanged when this variable was added, suggesting that PE had unique effects on attentional engagement during reading: high levels of PE engendered more efficient orthographic decoding and lexical access and more effort to semantic integration processes (see Figure 2).

Figure 2. Partial Effects Plots of Interactions in Model 3 at Conditional Levels of PE (Low PE = Mean - 1SD; Mean PE; High PE = M+1SD).



Conclusions

• Our findings suggest that habitual engagement with reading is related to an effective allocation policy (see Stine-Morrow et al., 2008) among older adults

• Older readers with higher levels of PE were facilitated in word level processing. This freed up resources to be available for higher-level textbase processes (Long, Johns, & Morris, 2007) such as processing of new concepts and increased intrasentence wrap-up.

• The increased efficiency of component reading processes that comes with greater exposure to print contributes to maintaining and improving skilled reading, even among older readers.

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