Differential Contribution of Executive Functions to Reading Across Development: Insights from Older Emergent Readers in Rural Côte D'Ivoire

Joelle Hannon[1], Faryal Khan[3], Kaja Jasińska[1,2,3]*

University of Delaware, Haskins Laboratories, University of Toronto *senior author

Introduction

Executive functions (i.e. working memory, inhibitory control, cognitive flexibility) **play a crucial role in reading development (**Blankenship et al., 2019). However, little is known about how executive functions supports emergent reading across development. In rural Côte d'Ivoire, children start schooling, and therefore learning to read, at different ages (UNESCO, 2017).

Here we ask, **do executive functions differently predict reading for younger versus older children?** Because executive functions continue to develop into late childhood and beyond, we predict that executive functions more strongly support reading development in older emergent readers.

Methods and Materials

Executive Functions-

(AMES; Sulik et al., 2020)

Heart & Flowers

Inhibitory Control
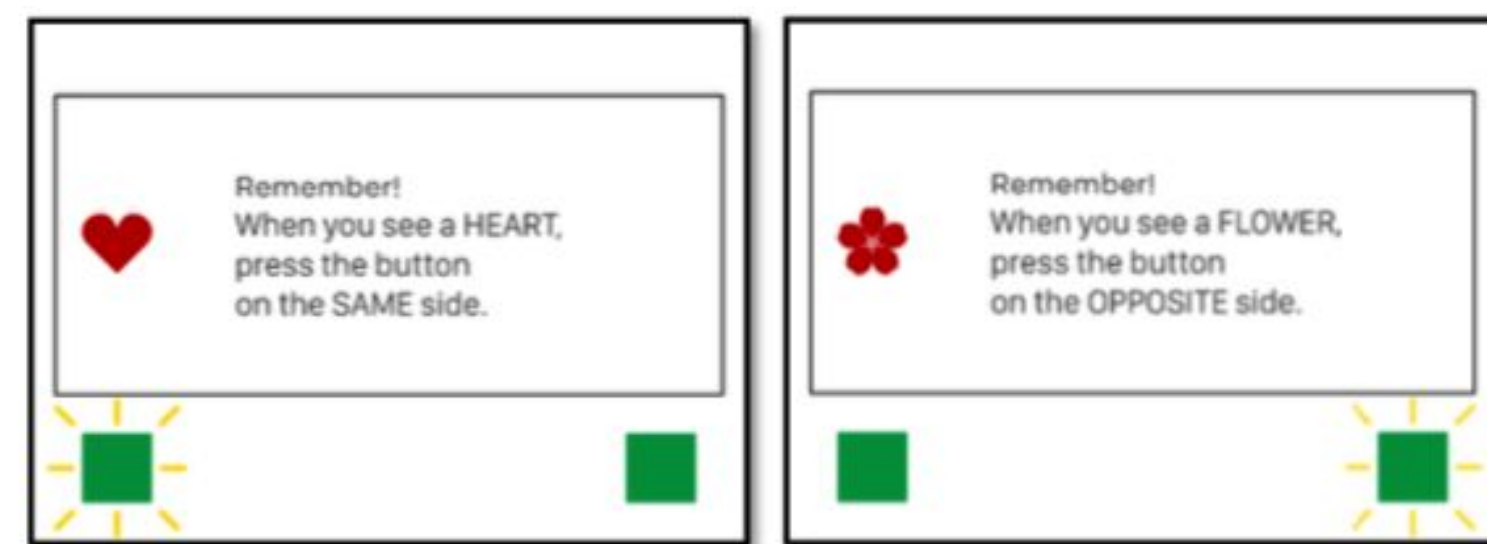for trials in which the flower appeared children were instructed to touch the square on the opposite side

Figure 1. Example of the Hearts & Flowers task

Cognitive Flexibility
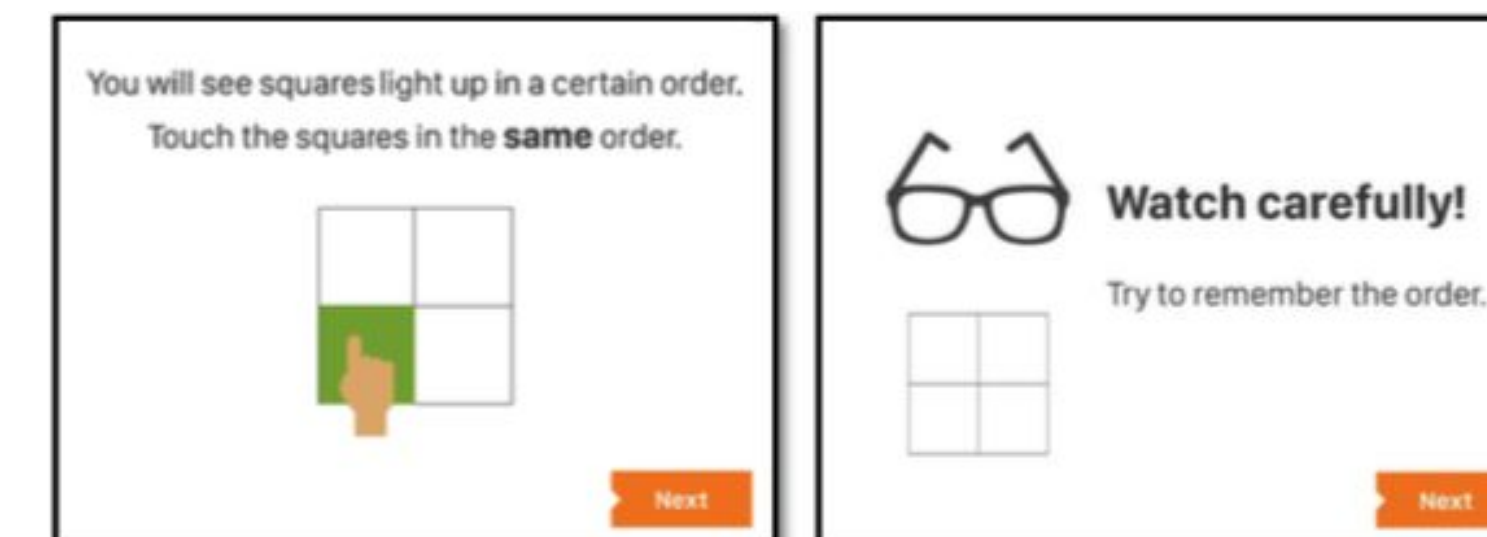mixed trials in which children needed to apply one rule for flowers and a different rule for hearts.

Figure 2. Example of the working memory task

Working memory
Children were presented with squares flashing on a grid and were asked to repeat the pattern of where the squares appeared. They were also asked to respond with the reverse pattern for some trials. Forward and backward trails were averaged together.

Literacy Assessments-
(RTI International, 2009; Gove & Wetterberg, 2011)

Reading
- 100 letters & letter combinations
- 50 common French words
- 50 Non-Word Read

Participants

One thousand thirty seven 5th grade children (ages 7-16 years; M= 11, SD= 1.46) participated in executive functions and literacy assessments.
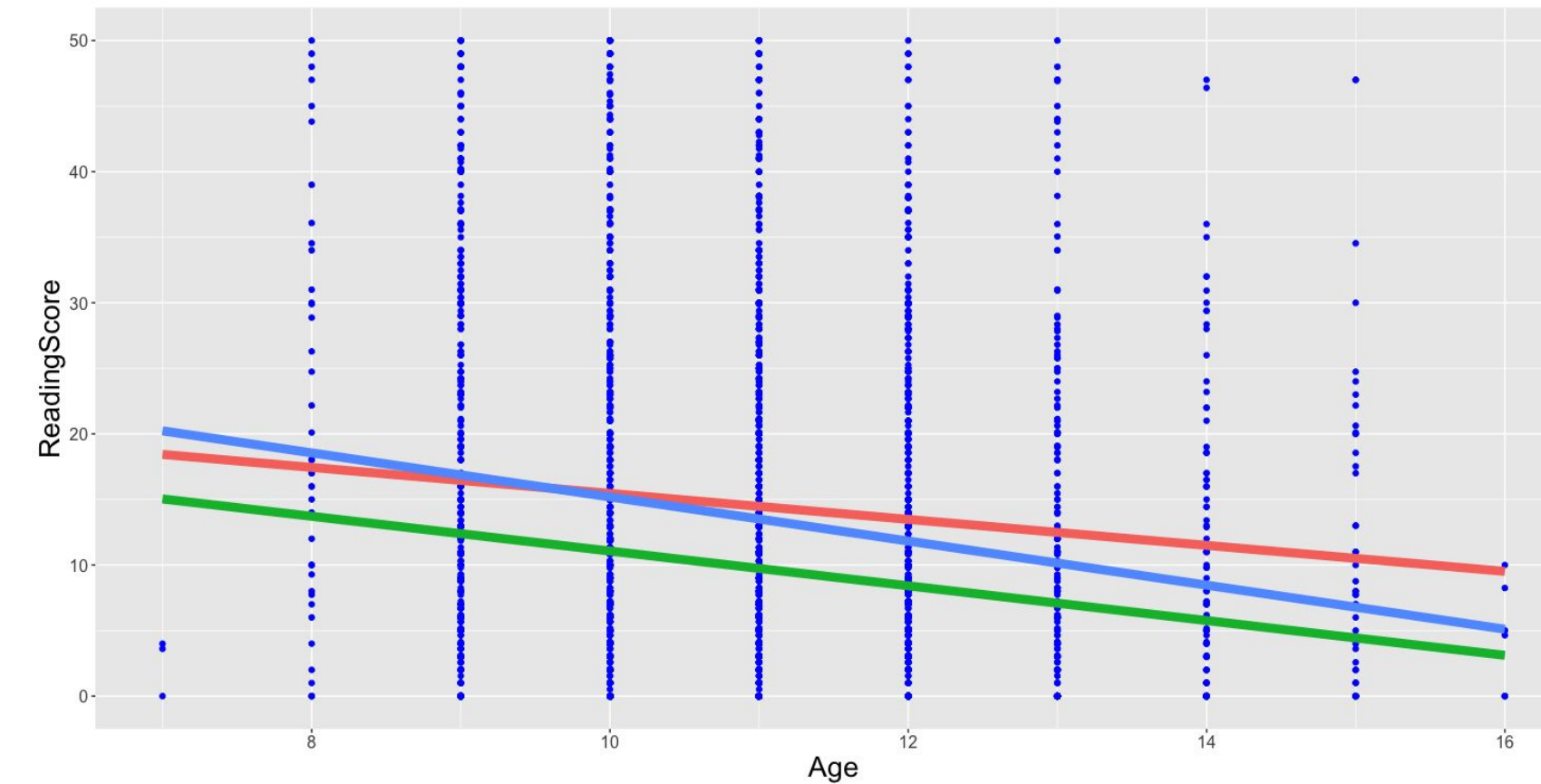
References

1. Blankenship, T. L., Slough, M. A., Calkins, S. D., Deater-Deckard, K., Kim-Spoon, J., & Bell, M. A. (2019). Attention and executive functioning in infancy: Links to childhood executive function and reading achievement. Developmental Science, doi:http://dx.doi.org.myaccess.library.utoronto.ca/10.1111/desc.12824
2. Gove, A., & Wetterberg, A. (Eds.) (2011). The Early Grade Reading Assessment: Applications and interventions to improve basic literacy. RTI Press. RTI Press Book No. BK-0007-1109 https://doi.org/10.3768/rtipress.2011.bk.0007.1109
3. UNESCO (2017). More Than One-Half of Children and Adolescents Are Not Learning Worldwide. http://uis.unesco.org/sites/default/files/documents/fs46-more-than-half-children-not-learning-en-2017.pdf. (Accessed on 30 June 2021).
4. Sulik, Michael J., Jenna E. Finch, and Jelena Obradović. "Moving beyond executive functions: Challenge preference as a predictor of academic achievement in elementary school." Journal of Experimental Child Psychology 198 (2020): 104883.
5. RTI International and Sprenger-Charolles, L. (2009). EGRA (Early Grade Reading Assessment Toolkit): Adapatation pour les pays francophones (Manuel pour l'évaluation des compétences fondamentales en lecture).

Results

Reading Scores for Children Across Ages

Older children were poorer readers and age was correlated with reading measures but not executive functioning measures. There was, however, a significant interaction for age and cognitive flexibility across each reading test (letter, word, and non-word).

Figure 3: Plot for reading scores for each age; Letter Reading ■, Word Reading ■, Non-Word Reading ■

Executive Functioning Scores for Children Across Ages

Cognitive Flexibility   Inhibitory control   Working Memory

Figure 4: Plot for executive function scores for each age.

Correlations of Measures

Table 1

Means, standard deviations, and correlations with confidence intervals

Variable	M	SD	1	2	3	4	5	6
1. Age	11.00	1.46						
2. Letter Reading	28.07	21.52	-.13** [-.19, -.07]					
3. Word Reading	13.51	15.42	-.16** [-.22, -.10]	.79** [.77, .81]				
4. Non-Word Reading	9.72	12.85	-.15** [-.21, -.09]	.76** [.73, .78]	.94** [.93, .94]			
5. Working Memory	4.11	2.06	-.02 [-.08, .04]	.18** [.12, .24]	.18** [.12, .24]	.18** [.12, .24]		
6. Cognitive Flexibility	0.86	0.16	.03 [-.04, .09]	.09** [.03, .15]	.03 [-.03, .09]	.05 [-.01, .11]	.28** [.23, .34]	
7. Inhibitory Control	0.85	0.16	-.00 [-.07, .06]	.12** [.06, .18]	.09** [.03, .15]	.09** [.03, .15]	.26** [.21, .32]	.44** [.39, .49]

*Note. M and SD are used to represent mean and standard deviation, respectively. Values in square brackets indicate the 95% confidence interval for each correlation. The confidence interval is a plausible range of population correlations that could have caused the sample correlation (Cumming, 2014). * indicates p < .05. ** indicates p < .01.*

Moderation of Age on the Relation between Reading and Executive Functions

Table 2: Executive functions on Letter Reading

Predictor	b	b 95% CI [LL, UL]	sr²	sr² 95% CI [LL, UL]	Fit
(Intercept)	82.51*	[17.96, 147.07]			
Age	-6.38*	[-12.19, -0.58]	.00	[-.00, .01]	
Cognitive Flexibility	-90.78*	[-162.27, -19.28]	.01	[-.00, .01]	
Working Memory	3.37	[-1.85, 8.59]	.00	[-.00, .01]	
Inhibitory Control	37.29	[-27.88, 102.46]	.00	[-.00, .01]	
Inhibitory Control : Age	-2.51	[-8.31, 3.28]	.00	[-.00, .00]	
Cognitive Flexibility : Age	8.39*	[1.99, 14.79]	.01	[-.00, .02]	
Working Memory : Age	-0.17	[-0.64, 0.30]	.00	[-.00, .00]	
					R² = .059** 95% CI[.03,.08]

Table 3: Executive functions on Word Reading

Predictor	b	b 95% CI [LL, UL]	sr²	sr² 95% CI [LL, UL]	Fit
(Intercept)	43.72	[-2.75, 90.20]			
Age	-3.32	[-7.49, 0.85]	.00	[-.00, .01]	
Cognitive Flexibility	-68.91**	[-120.13, -17.70]	.01	[-.00, .02]	
Working Memory	2.26	[-1.31, 5.82]	.00	[-.00, .01]	
Inhibitory Control	45.58	[-1.03, 92.20]	.00	[-.00, .01]	
Inhibitory Control : Age	-3.53	[-7.68, 0.61]	.00	[-.00, .01]	
Cognitive Flexibility : Age	5.78*	[1.20, 10.36]	.01	[-.00, .01]	
Working Memory : Age	-0.09	[-0.41, 0.23]	.00	[-.00, .00]	
					R² = .068** 95% CI[.04,.09]

Table 4: Executive functions on Non-Word Reading

Predictor	b	b 95% CI [LL, UL]	sr²	sr² 95% CI [LL, UL]	Fit
(Intercept)	24.90	[-13.71, 63.52]			
Age	-1.96	[-5.43, 1.52]	.00	[-.00, .01]	
Cognitive Flexibility	-46.46*	[-89.06, -3.86]	.00	[-.00, .01]	
Working Memory	2.23	[-0.71, 5.17]	.00	[-.00, .01]	
Inhibitory Control	35.89	[-3.76, 75.54]	.00	[-.00, .01]	
Inhibitory Control : Age	-2.83	[-6.37, 0.70]	.00	[-.00, .01]	
Cognitive Flexibility : Age	4.03*	[0.21, 7.84]	.00	[-.00, .01]	
Working Memory : Age	-0.11	[-0.37, 0.15]	.00	[-.00, .00]	
					R² = .062** 95% CI[.03,.09]

Interaction of Age and Cognitive Flexibility for Reading

Predicted values of Letter Reading

Figure 5. Plot for the interaction between Cognitive flexibility and age on letter reading

Predicted values of Word Reading
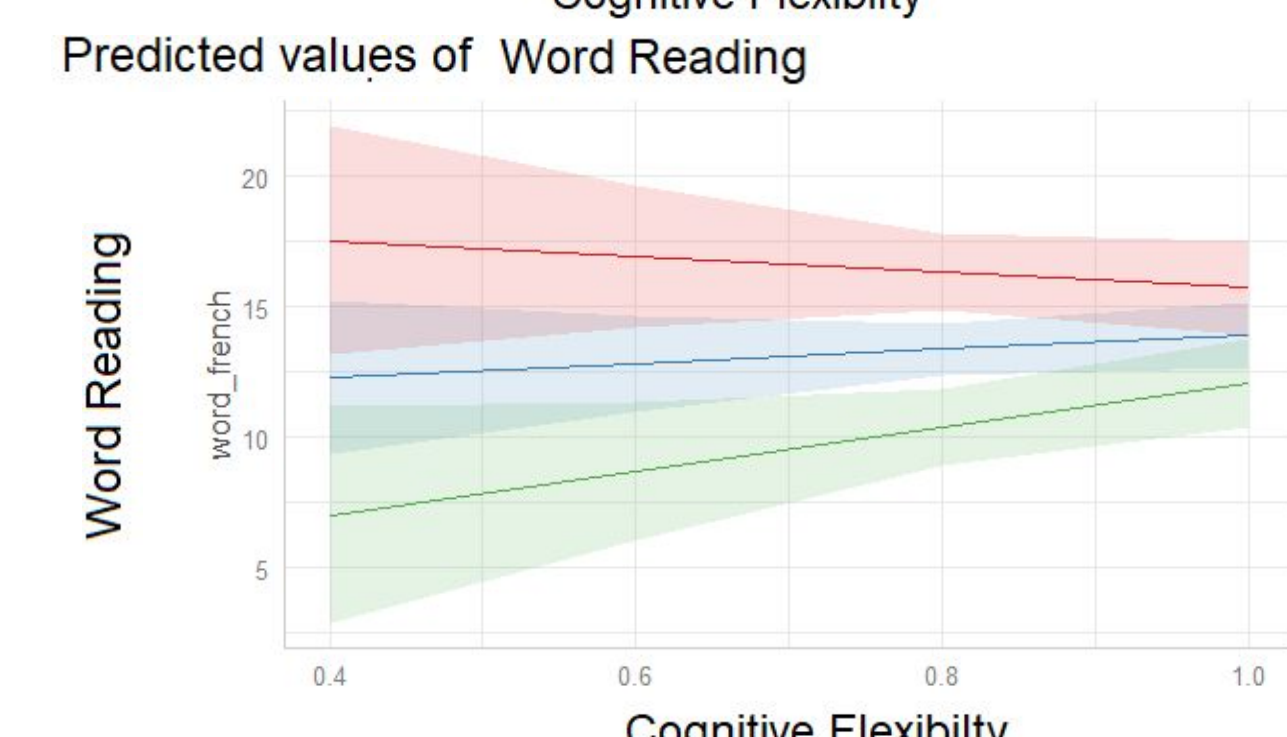
Figure 6. Plot for the interaction between Cognitive flexibility and age on word reading
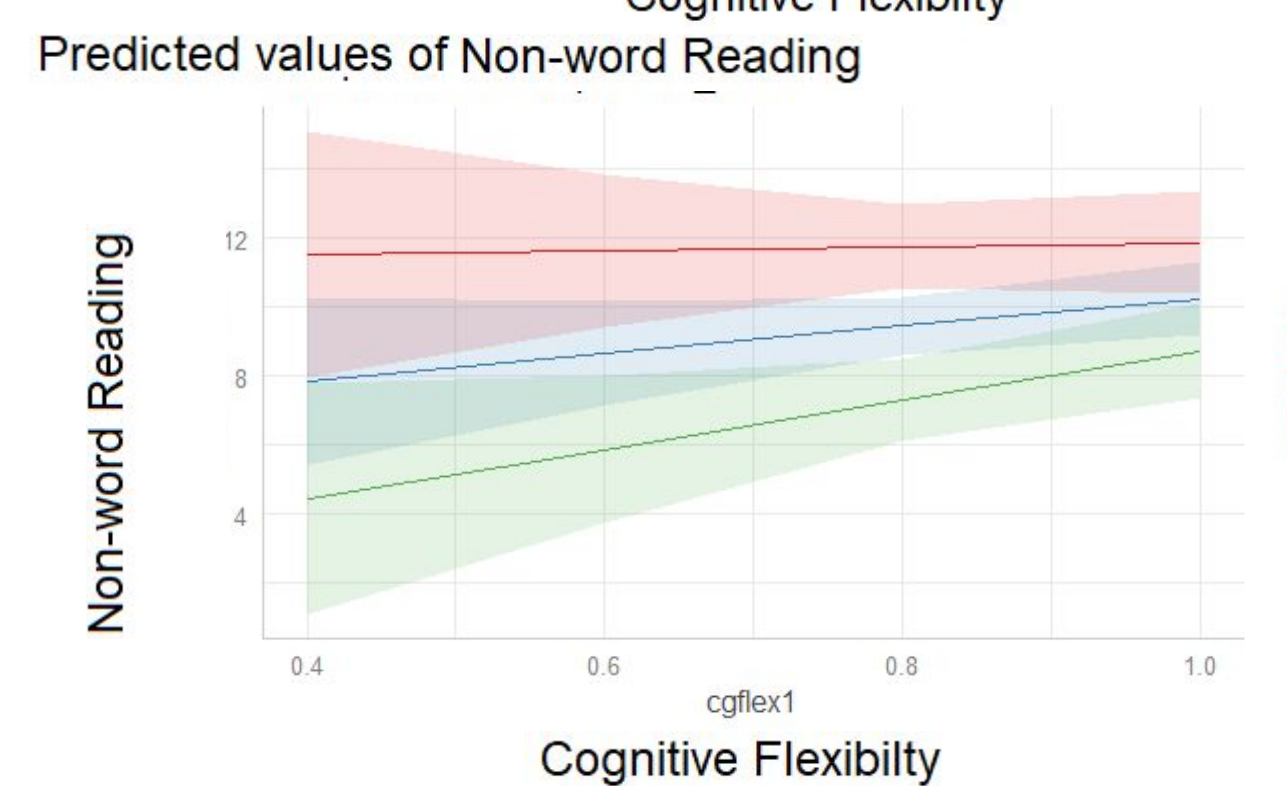
Predicted values of Non-word Reading

Figure 7. Plot for the interaction between Cognitive flexibility and age on non-word reading

Discussion

We find a main effect of cognitive flexibility for reading, **we also observed a significant interaction between age and cognitive flexibility**.

Simple slopes analysis revealed that **Executive functions more strongly predicted reading in older versus younger children.**

Conclusions

The association between executive functions and reading varied across ages, specifically, **Cognitive Flexibility predicted reading in older, but not younger children, supporting our hypothesis**.

Our results suggest that more mature executive functions in older children may facilitate learning to read.

Future Directions

How do we leverage the support of these cognitive abilities for older emergent readers?

What role does socioeconomic status play in the relationship between age and reading?

Contact: Joelle Hannon ◇ University of Delaware ◇ Email: johannon@udel.edu