

# Impact of Poverty on Brain Development, Executive Function, and Literacy in Rural Cocoa Communities in Côte d'Ivoire



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## INTRODUCTION

In many rural communities in Ivory Coast, children are confronted with a number of challenges to optimal developmental and academic outcomes: child cocoa labor, poor access to quality education, and family poverty. The impact of poverty on child development, including brain function, is well documented<sup>4</sup>.

Executive functions (EFs; inhibition, working memory, cognitive flexibility)<sup>1</sup> are crucial components of cognitive development that support a child's academic outcomes, including literacy<sup>2,3</sup>. EFs are supported by the development of the prefrontal cortex (PFC).

**Specific Aim:** To understand the development of EFs and patterns of neural activation in the prefrontal cortex (PFC) that support academic outcomes (i.e. literacy) in children growing up with complex and multidimensional poverty in rural cocoa communities in Ivory Coast.

## METHODS

**Participants.** 46 children (3rd, 5th grade) aged 7-14 years (M=10.54, SD=1.53) in central and southern Côte d'Ivoire (Adzopé, Tiébissou)

**Literacy Assessment** (Yopp et al., 1995; Woodcock et al., 2001)

Task	Example
<b>Letter Decoding</b>	100 letters/letter combinations (e.g. E, ch, B) in one minute
<b>Word Reading</b>	50 words (e.g. tu, il, vol) in one minute
<b>Nonword Reading</b>	50 nonwords (e.g. ja, zi, vof) in one minute

**Family SES, Child Labor, and Anthropomorphic Measures**

Based on USAID Early Grade Reading Assessment and Tulane University Survey of Child Labor in West African Cocoa Growing Areas (2015)

Measures socioeconomic status, family literacy resources, child involvement in cocoa agriculture (i.e. heavy load portage, burning of trees, etc.) and other domestic and economic activities. As well as BMI z-scores from weight, height, and mean upper arm circumference (MUAC).

**Executive Function Tasks<sup>5</sup>**

Task	Example
Working Memory: List Sorting	
Inhibitory Control: Flanker	
Cognitive Flexibility: Rule Switch	

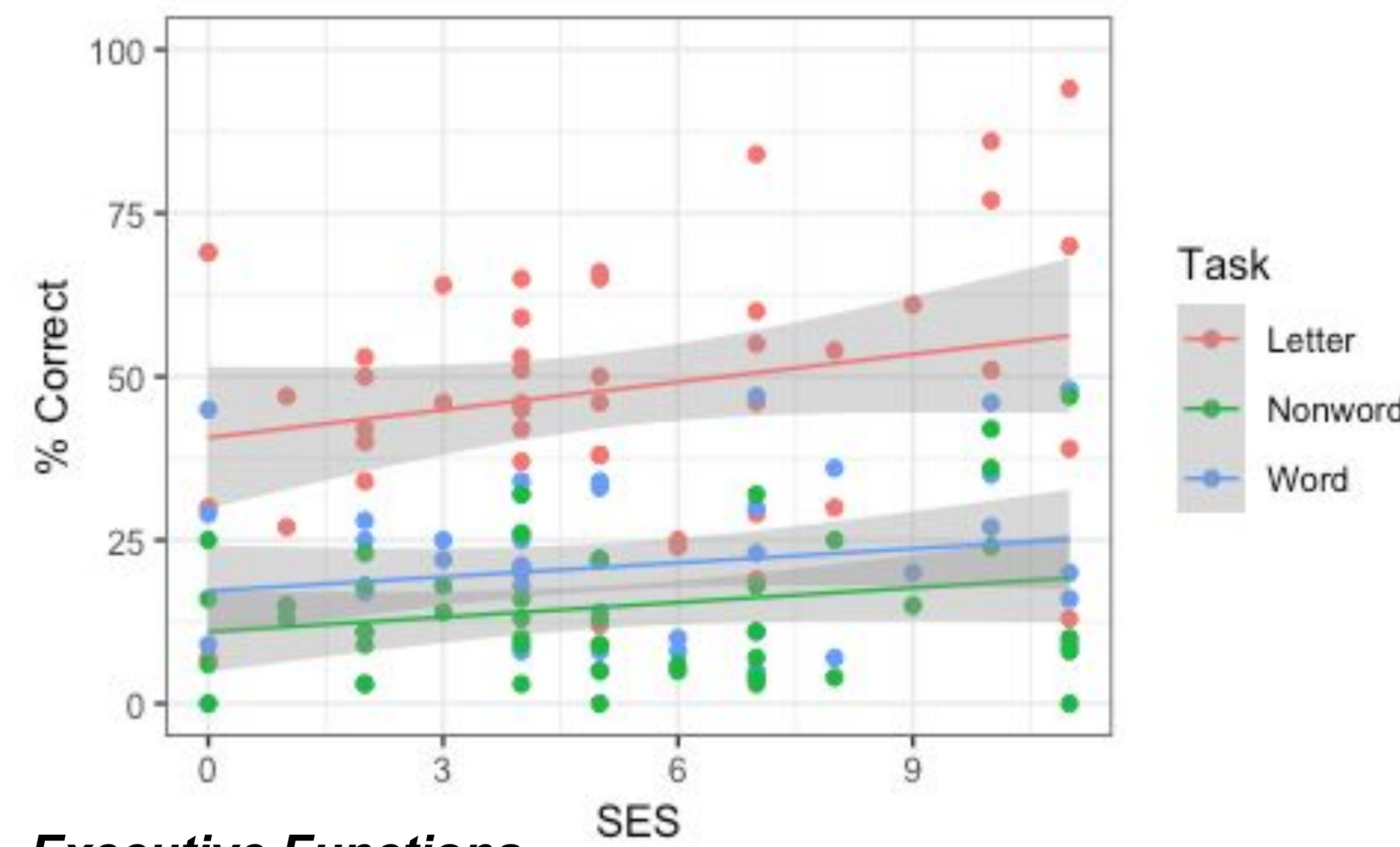
**Field fNIRS Neuroimaging<sup>6</sup>**

Neural activation patterns measured for cognitive flexibility task  
 Block design: Switch, Repeat  
 Contrast: Switch v Repeat  
 Analysis: NIRS-SPM

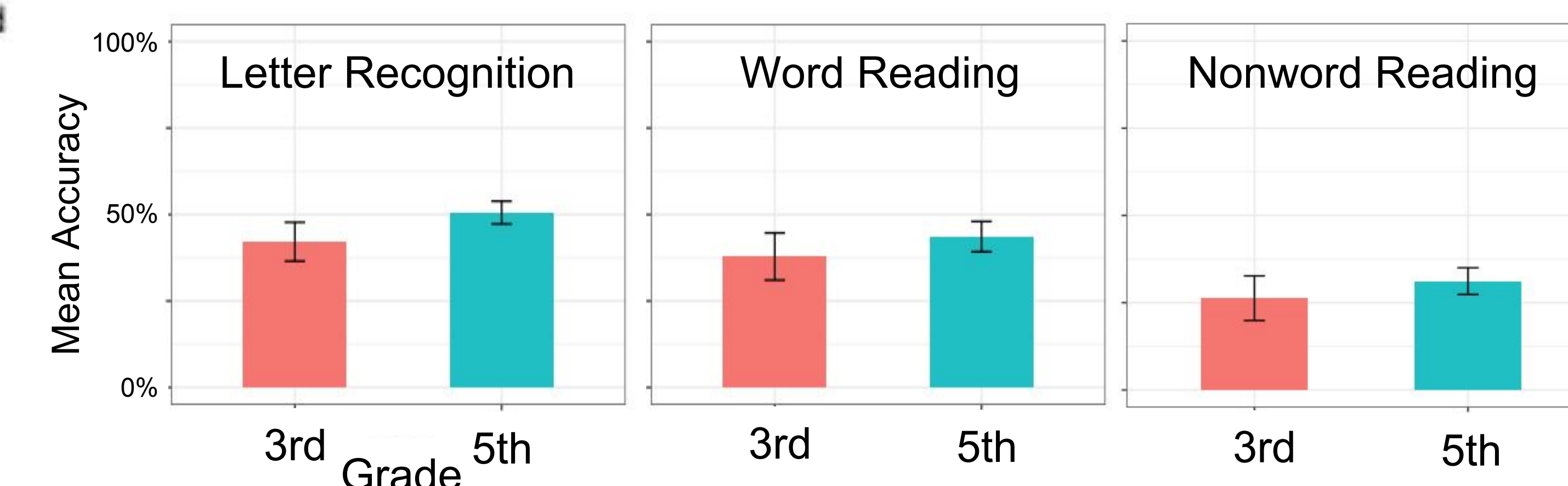


## BEHAVIORAL RESULTS

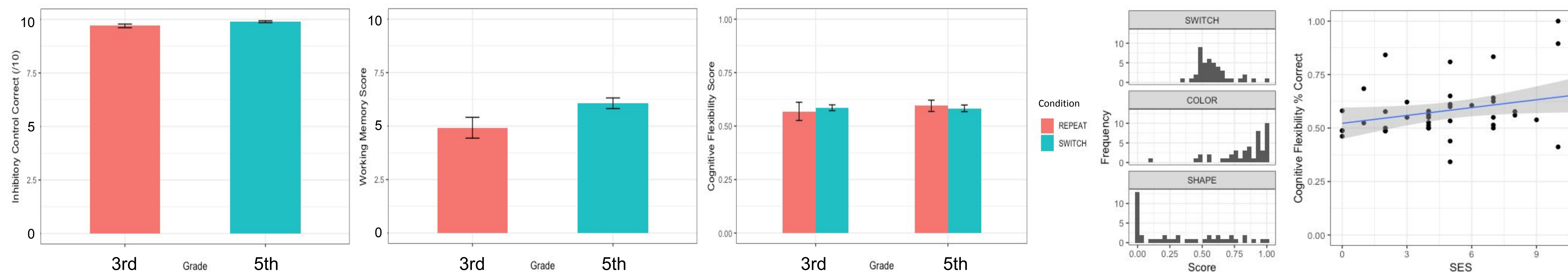
**Reading Measures and Socioeconomic Characteristics**



Household Characteristics	Total M (SD) or %
Household SES (asset index of 15 items)	5.17 (3.23)
Labor on cocoa plantation (number of activities of 24 items)	4.74 (7.09)
Hazardous cocoa labour (Y/N)	28%
Other economic activities (number of activities 10 items)	3.78 (2.02)
Domestic work (number of activities of 8 items)	4.87 (1.6)
Parent can read (Y/N)	67%
Child has a book at home (Y/N)	35%



**Executive Functions**



**Inhibitory Control:** Ceiling performance

**Working Memory:** 5th graders showed better performance (b=1.92, SE=1.04, t(27)=1.84, p= 0.08)

**Cognitive Flexibility:** Chance performance. However, histograms indicate high individual variance. Higher SES children showed better cognitive flexibility task scores (b=0.02, SE=0.01, t(28)=1.84, p= 0.08)

## DISCUSSION

**Reading.** Overall reading scores were poor. On average, children were able to read about 50% of the items in the letter and word reading tasks, and approximately 30% of the items on the nonword reading tasks. Indeed, age, child labor, anthropometric measurements and phonological awareness (French and local language) have an impact on literacy.

**Household SES.** Statistics indicate that most children lacked many resources in the home (e.g. books, running water, etc.).

**Executive Functions.** Behavioral results from our cognitive flexibility task showed poor accuracy scores, which related to SES.

**Neuroimaging.** SES predicted PFC engagement (DLPFC, VLPFC) during the cognitive flexibility task. PFC activation predicted all reading outcomes.

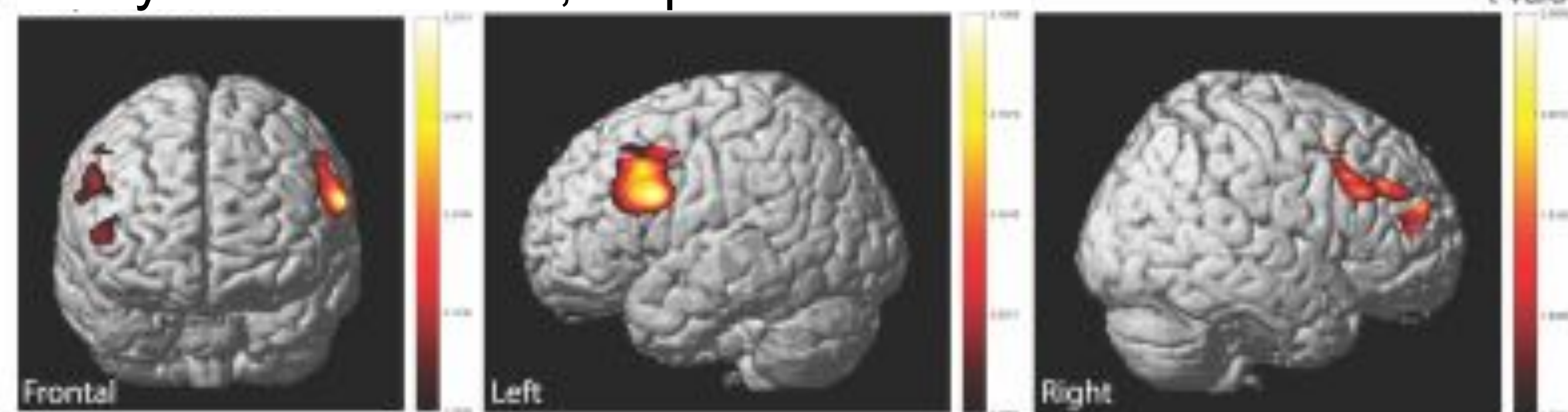
## CONCLUSION

Exposure to poverty (including hazardous labor) impacts children's brain development and executive functions, which support literacy.

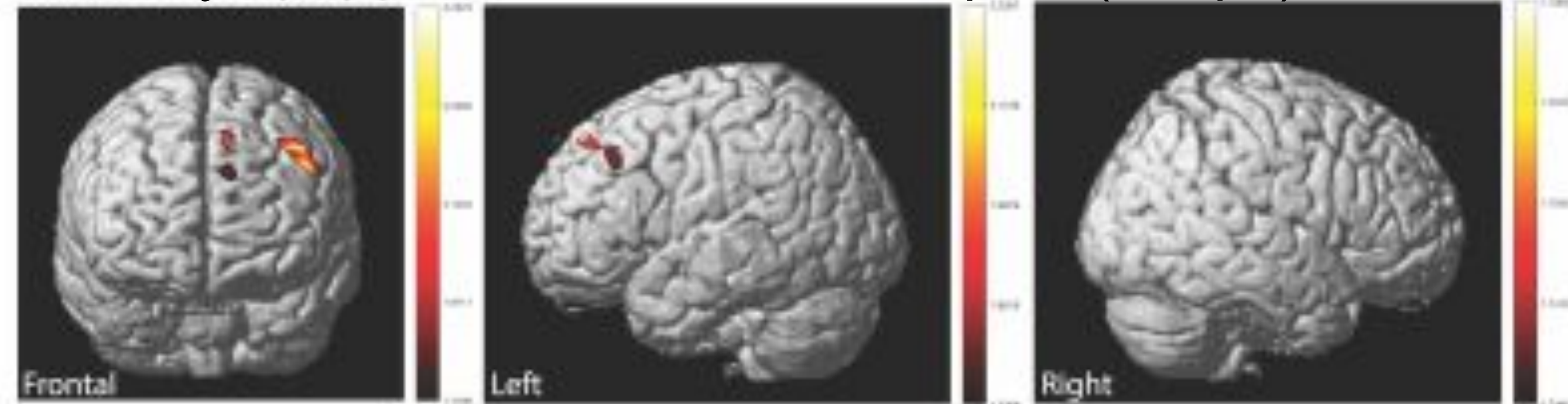
Understanding the complex relationships between impoverished environments, brain development and learning outcomes provides new insights into children's learning pathways and the development of reading in various context.

## NEUROIMAGING RESULTS

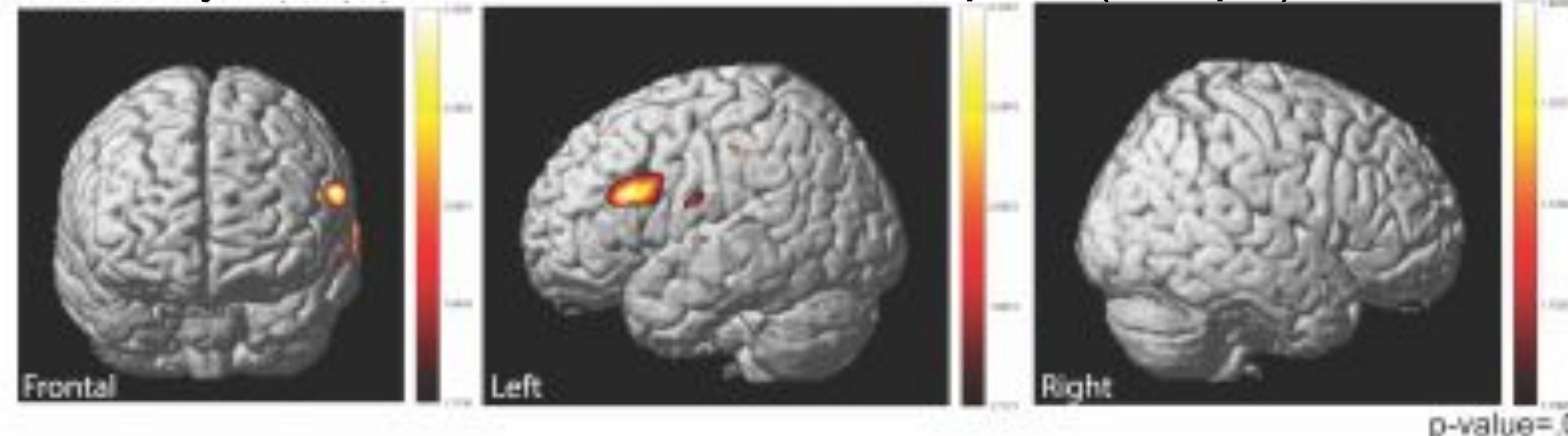
7-9 year old children, Repeat > Switch



10-11 year old children, Switch > Repeat (Shape)



12-14 year old children, Switch > Repeat (Shape)



**Brain-Behavior Correlation**

Predictor	Letter	Word	Nonword
	$\beta$ (SD)	$\beta$ (SD)	$\beta$ (SD)
Age	-4.002*** (1.06)	-1.809*** (0.64)	-1.821 (0.53)
Gender	-5.298 (3.48)	-1.059 (2.1)	-1.282 (1.76)
SES	1.359* (0.52)	0.756* (0.32)	0.537 (0.26)
BMI	-3.063 (1.85)	-3.592** (1.12)	-2.864** (0.94)
Cocoa Labor	0.677** (0.24)	0.468** (0.14)	0.543 (0.12)
Haz. Labor (Y/N)	2.136 (0.47)	1.107** (0.29)	-3.743 (1.05)
Eco. Labor	-0.072** (1.14)	-0.033*** (0.70)	-0.112 (0.56)
Dom. Labor	-3.193 (1.39)	-0.792* (0.86)	-0.024 (0.71)
Phono. Aware.	1.104*** (0.2)	1.12*** (0.12)	0.819 (0.1)
Vocab.	0.04*** (0.41)	-0.486* (0.25)	-0.429 (0.21)
Working Memory	1.35*** (0.4)	0.799*** (0.24)	0.524** (0.2)
Cognitive Flexibility	0.807 (1.09)	-1.458 (1.35)	0.732 (2.20)
L. DLPFC	-586.901** (200.32)	-242.05* (120.86)	-196.80 (101.22)
R. DLPFC	-933.277* (427.39)	-278.58 (257.86)	187.464 (215.95)
L. IFG	1273.236*** (368.4)	485.91* (222.27)	242.451 (186.14)
R. IFG	-25.447 (47.7)	0.40 (28.78)	42.738 (24.1)

**DLPFC and IFG Activation Predicted by Demographic and SES Factors**

Predictor	L. DLPFC	R. DLPFC	R. DLPFC	L. IFG
	std. $\beta$ (SE)	std. $\beta$ (SE)	std. $\beta$ (SE)	std. $\beta$ (SE)
Age	-0.151 (0.09)	-0.129 (0.09)	-0.149 (0.09)	-0.0147 (0.09)
Gender	-0.453 (0.20) *	-0.402 (0.20) *	-0.450 (0.20) *	-0.447 (0.20) *
BMI	0.104 (0.10)	0.081 (0.09)	0.101 (0.10)	0.100 (0.09)
SES	-0.197 (0.10) *	-0.209 (0.10) *	-0.202 (0.10) *	-0.204 (0.10) *
Cocoa Labor	0.126 (0.10)	0.089 (0.10)	0.121 (0.10)	0.118 (0.10)

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