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Multilingual Evaluation of Executive Functions and Reading Predictors with a novel digital tool: Insights from a Sample of 7-8-Year-Olds

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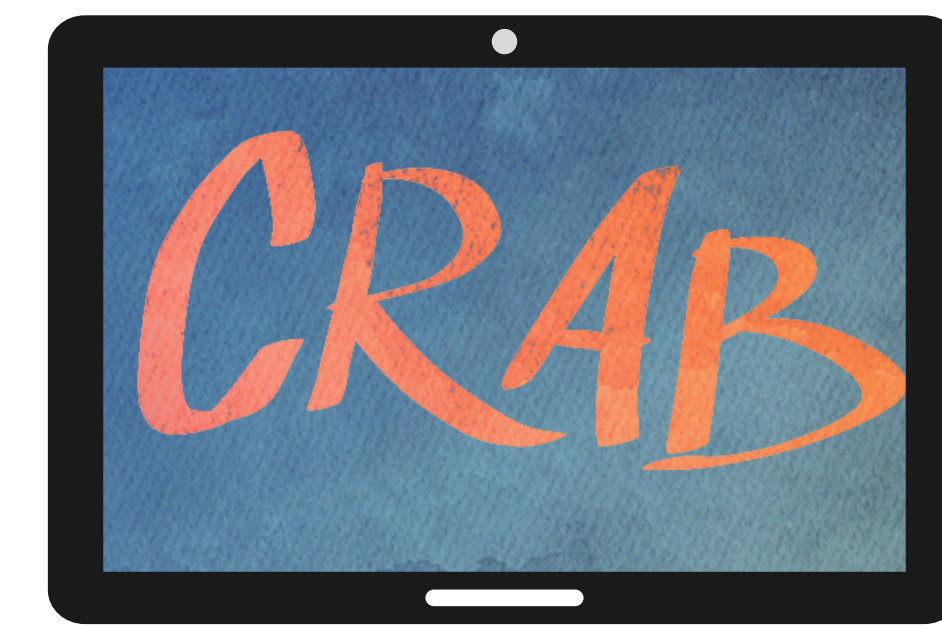
¹University of Geneva ²University of Zurich ³University of Paris Cité ⁴Aix-Marseille University ⁵NCCR Evolving Language *equal contributing

INTRODUCTION

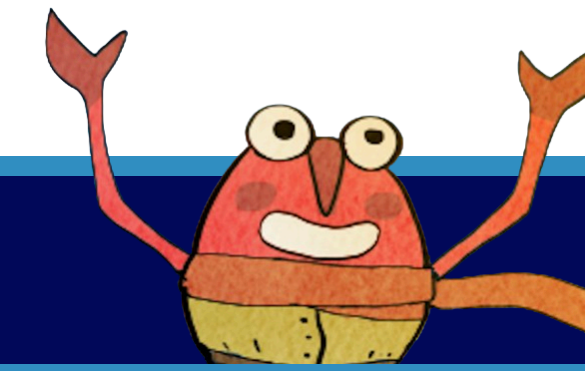
THEORETICAL BACKGROUND

- Accurately modeling **individual differences in reading ability** requires data from large, diverse, and representative samples (Yeatman et al., 2022).
- However, standard clinical reading assessments, which involve paper-and-pencil tasks, are **time-consuming** and prone to **errors**.
- Reading relies on language abilities such as **phonological awareness** (Pennington, 2006), as well as **executive functions** like working memory capacity and attentional control.
- Additionally, the relative weight of these mechanisms is thought to vary **across languages**, calling for cross-linguistic assessment tools (Landerl et al., 2019; Lallier & Carreiras, 2018).

→ To improve reading assessments, **innovative digital tools** are needed that encompass diverse samples and cross-linguistic perspectives.



Computerized Reading-related Assessment Battery



METHOD

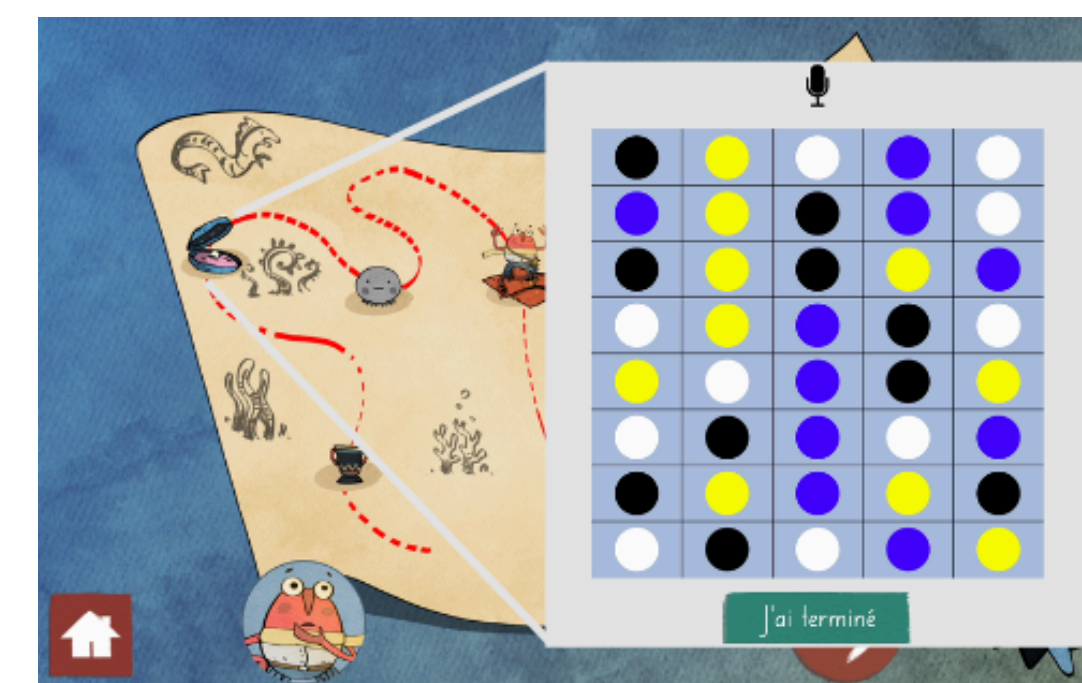
PARTICIPANTS

French N = 154 Age = 7.5

Italian N = 157 Age = 7.5

COMPUTERIZED ASSESSMENT BATTERY

- In class **collective** assessment
- **Tablet-based** with **headphones**
- **2 languages:** French and Italian
- **3 versions:** Pre, Post, Follow-up
- About 2 experimenters for 15 children
- **11 gamified tasks**
- Automated, aided and unaided practice using automated speech recognition (ASR) in 5 tasks
- Adaptive algorithm using ASR in the digit span task



Left: one of the three maps where each icon corresponds to a task as well as the path to reach the final treasure.
Right: the color RAN task which requires speech recognition.

Want to see a practice trial demo?



ASSESSMENT TASKS (selected)

Cognitive	Skills	Main Outcome	Descriptive		
			median	mean	SD
<ul style="list-style-type: none"> • Digit span Backward <ul style="list-style-type: none"> ◦ Forward ◦ Backward • Corsi span <ul style="list-style-type: none"> ◦ Forward ◦ Backward • Barrage <ul style="list-style-type: none"> ◦ 30s ◦ 120s • Multiple Object Tracking (MOT) 	Working memory	Digit Span: FORWARD	ASR fail	ASR fail	ASR fail
		Digit Span: BACKWARD	3	2.64	0.88
		Corsi Span: FORWARD	4	4.11	1.09
		Corsi Span: BACKWARD	4	3.74	1.23
	Attentional Control	Number targets found: at 30s	11.00	11.17	2.63
		Number targets found: at 120s	19.33	18.92	1.09
		Accuracy	0.61	0.62	0.14

RESULTS

	MOT	Barrage 120s	Barrage 30s	Corsi BACK	Corsi FRWD
Digit BACK	0.06 ns	0.03 ns	0.00 ns	0.17 *	0.21 **
Corsi FRWD	0.15 *	0.12 ns	0.06 ns	0.31 ***	
Corsi BACK	0.16 *	0.23 ***	0.18 **		
Barrage 30s	0.07 ns	0.63 ***			
Barrage 120s	0.04 ns				

Highest correlations as expected:

- 2 Barrage measurements
- 3 Span measurements
- Corsi BACK with Attention demanding tasks (MOT and Barrage)

Language-Related	Skills	Main Outcome	Descriptive			
			median	mean	SD	
<ul style="list-style-type: none"> • Vocabulary • Color RAN 	Receptive vocabulary	Rate Correct Score	31.57	31.72	7.00	
		Lexical access	Total Completion Time	51.02	51.42	11.66
<ul style="list-style-type: none"> • Phoneme Deletion <ul style="list-style-type: none"> ◦ WORD ◦ PSEUDOWORD • Visual Orthographic <ul style="list-style-type: none"> ◦ LETTER ◦ SYMBOL 	Phonological awareness	Accuracy: WORD	1.38	1.25	0.56	
		Accuracy: PSEUDOWORD	1.22	1.12	0.54	
		Orthographic processing	D' : LETTER*	1.98	2.00	0.99
			D' : SYMBOL*	1.43	1.50	1.03

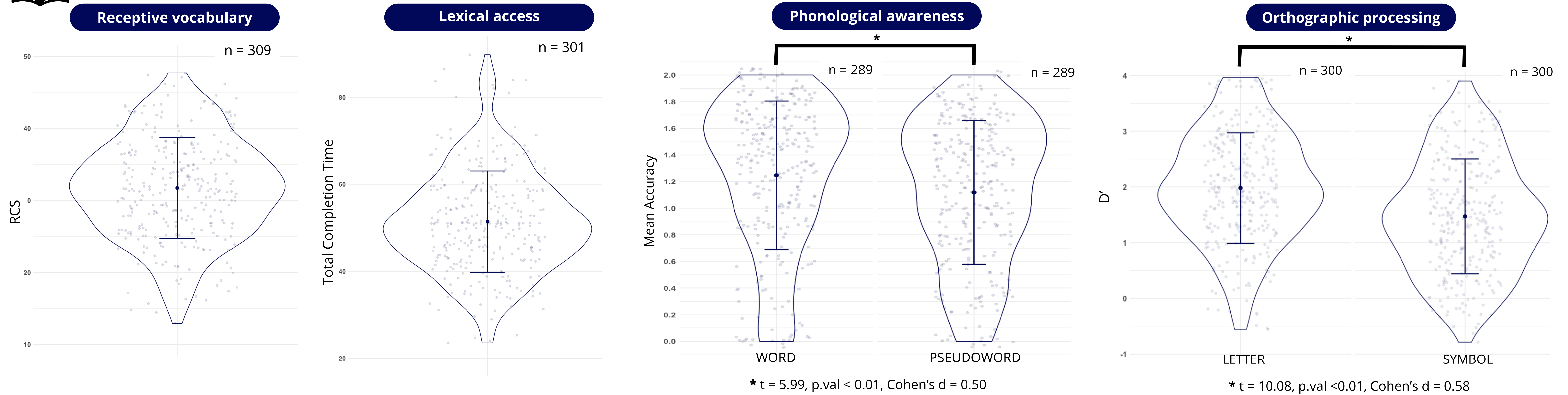
* Different Correct = Hit, Different Incorrect = Miss

	Ortho SYMBOL	Ortho LETTER	PhonDel PSEUDO	PhonDel WORD	RAN
Vocabulary	0.11 ns	0.11 ns	0.15 *	0.12 ns	0.21 **
RAN	0.10 ns	0.14 *	0.20 **	0.15 *	
PhonDel WORD	0.23 ***	0.30 ***	0.74 ***		
PhonDel PSEUDO	0.19 **	0.19 **			
Ortho LETTER	0.62 ***				

Highest correlations as expected:

- 2 Phoneme deletion measurements
- 2 Visual-ortho measurements
- Visual-ortho with Phoneme deletion
- RAN with PhonDel WORD > PSEUDO
- RAN with Vocabulary

DISTRIBUTIONS



CONCLUSION

- **Efficiency and Automation:** CRAB overcomes the constraints of resource-intensive, in-person reading assessments by providing an **efficient and automated tool**.
- **Cross-Language Research:** It enables **effective research** into the linguistic and cognitive mechanisms underlying reading ability **across different languages**.
- **Reliability of Data Collection:** The automated data collection is generally reliable.
 - The Digit Span task, which relies on Automatic Speech Recognition (ASR) during test trials, is an exception.
- **Future Improvements:** More work is needed to improve the ASR model or redesign the Digit Span task to enhance overall reliability.



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