Cognitive predictors of children's language acquisition

Ashley Blake[1], Ewa Dąbrowska[1,2], Nick Riches[3]
[1]University of Birmingham; [2]Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen; [3]Newcastle University

INTRODUCTION

Question:

How do different cognitive abilities predict differences in children's linguistic development?

We investigate four cognitive predictors in children with:

- ❖ **Typically developing language (language typical: LT), and**
- ❖ **children with language difficulties (developmental language disorder: DLD):**

Cognitive predictors:
- **non-verbal intelligence**
- **working memory**
- **speed of automatization**
- **implicit learning**

Language measures:
- **Grammar**
- **Vocabulary**
- **Syntactic complexity and fluency measures**

METHODS

Individual differences design, comprising:
- children with typically developing language (language typical: LT)
- children with language difficulties (developmental language disorder: DLD)

97 participants:
- 73 language typical children: 45 males, 28 females. Mean age: 8;1 (range 7;0 - 9;9)
- 24 children with DLD: 13 males, 11 females. Mean age: 8;3 (range: 6;9 - 10;8)

Hybrid method of data collection:
- Children received a Tower of Hanoi puzzle in the post in advance of the first session.
- 3 online sessions.

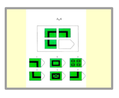
Session 1:

Children completed the Multiple-trial Tower of Hanoi task (MToH):

- 25 trials of the MToH
- 5 trials – secondary task

Sessions 2 and 3:

Children completed language and cognitive tasks:

Session 2		Session 3	
	**Narrative task** 'Frog, Where Are You? (Mayer, 1969)		**The British Picture Vocabulary Scale 3** (Dunn, Dunn & Styles, 2009)
	**Test for the Reception of Grammar** (Bishop, 2003)		**Ravens Coloured Progressive Matrices** (Raven, 1995)
	**Expository Discourse** (see Nippold, Hesketh, Duthie & Mansfield, 2005)		**Backwards Colour Span Task** (Riches, 2012)
	**Recalling sentences sub-test: CELF-5** (Wiig, Semel & Secord, 2013)		**Embedded triplets' task** (adapted from Arciuli & Simpson, 2012)

LEXICAL DIVERSITY AND FLUENCY MEASURES

Speech samples were transcribed, coded and analyzed in CLAN (MacWhinney, 2000). Audio files were analyzed in Praat (Boersma & Weenink, 2022) using the Syllable Nuclei script v.2 (de Jong & Wempe, 2009) for fluency measures.

We averaged narrative and spontaneous speech data to form composite measures of:

- Syntactic complexity
- Fluency

RESULTS

Descriptive statistics and effect sizes (Cohens *d*) are reported in table 1.

	Mean LT	SD LT	Mean DLD	SD DLD	Cohen's *d*	*p*-value
Cognitive measures						
Non-verbal IQ	29.10	4.23	21.71	5.26	1.63	***
Working Memory	14.63	2.89	10.42	2.63	1.47	***
CV	0.04	0.04	0.06	0.05	-0.53	.
Implicit learning %	50.88	9.08	50.18	4.54	0.08	0.06
Language measures						
Receptive grammar (blocks)	16.53	4.55	7.58	3.45	3.74	***
Productive grammar	50.30	15.15	22.71	8.94	2.95	***
Receptive vocabulary	125.00	21.21	93.04	12.81	1.97	***
Productive vocabulary	35.10	8.62	29.38	8.99	0.68	**
Subordination index	1.23	0.12	1.10	0.06	1.31	***
MLU morphemes	8.61	1.85	6.58	1.18	1.24	***
Speech rate	2.74	0.48	2.27	0.42	1.08	***

Table 1. Descriptive statistics (Mean and SD) and Cohens-d
(Inferential statistics are based on raw scores)

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The measure of the speed of automatization (CV) is expressed as a coefficient of variation (calculated by dividing the SD by the mean number of moves), where automatization reflects a decrease in the coefficient of variation (following Segalowitz & Segalowitz, 1993). Strongly automatized behaviours show very little within-participation variation.

Logistic regression was used to analyze the relationship between language difficulties (language typical, coded as '0" and language difficulties (DLD), coded as "1"), and four cognitive predictors: non-verbal IQ, working memory, implicit learning, and two measures of the speed of automatization: co-efficient of variation and difference in moves. (All independent variables were scaled).

The final model is presented in table 2, with a visualisation in figure 1.

Logistic regression

(language_difficulties ~ NVIQ + WM + CV)

McFadden's R^2 = 0.49

term	odds ratio	estimate	std.error	statistic	p.value
(Intercept)	0.11	-2.19	0.49	-4.49	***
NVIQ	0.33	-1.12	0.37	-2.98	**
WM	0.16	-1.83	0.58	-3.15	**
CV	2.05	0.72	0.33	2.19	*

Table 2. Logistic regression
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

RESULTS (continued)

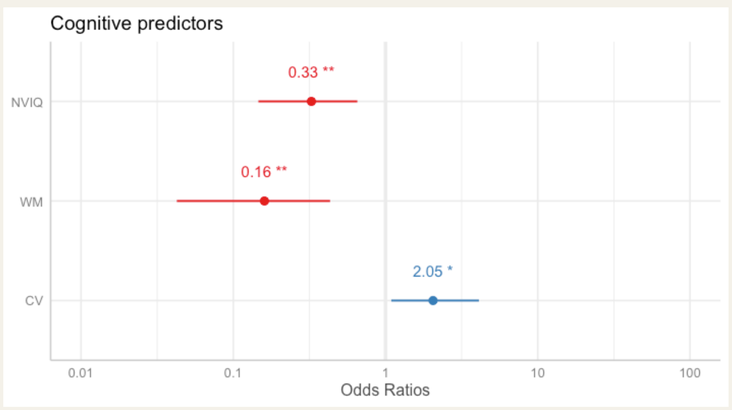


Figure 1

DISCUSSION

- The two groups show significant differences in cognitive abilities and language measures, as shown in table 1.
- Implicit learning did not predict performance on linguistic tasks. Most children performed at chance, which could reflect that the task was not sensitive enough to capture this effect. As this is a longitudinal study, this measure will be repeated, with an adaptation of the task.
- Our results show that cognitive predictors of non-verbal intelligence, working memory and the speed of automatization (CV) are strong predictors of language outcomes, as shown in table 2/figure 1.
- Children with language difficulties show a higher coefficient of variation which indicates slower automatization on the MToH task. This could suggest difficulties with proceduralization, as previous literature has shown.

TAKE HOME MESSAGE

Non-verbal IQ, working memory, and automatization are significant predictors of language outcomes.

Children with language difficulties show slower automatization as reflected in the MToH task.

REFERENCES

Bishop, D. 2003. *Test for reception of grammar: TROG-2: manual*. London: Pearson.
Boersma, P. Weenink, D. (1992–2022): Praat: doing phonetics by computer [Computer program]. Version 6.2.09, retrieved 15 February 2022 from https://www.praat.org.
de Jong, N.H., Wempe, T. (2009) Praat script to detect syllable nuclei and measure speech rate automatically. *Behavior Research Methods* **41,** 385–390 (2009)
Arciuli, J. & Simpson, I. C. 2012. Statistical learning is related to reading ability in children and adults. *Cognitive Science*, 36(2), 286-304.
Dunn, L. M., Dunn, D. M., & Styles, B. 2009. *British Picture Vocabulary Scale* - 3 (3rd ed). London: GL Assessment Ltd.
MacWhinney, B. (2000). *The CHILDES project: Tools for analyzing talk: Transcription format and programs*, Vol. 1. *(3rd ed.).* Lawrence Erlbaum Associates Publishers.
Mayer, M. (1969). *Frog, where are you?.* New York: Dial Books for Young Readers.
Nippold, M. A., Hesketh, L. J., Duthie, J. K. & Mansfield, T. C. 2005. Conversational versus expository discourse. *Journal of Speech, Language, and Hearing Research. 48*(5):1048-64.
Raven J.C. (1995). *Coloured Progressive Matrices Sets A, Ab, B. Manual Sections 1 & 2.* Oxford Psychologists Press; Oxford, UK: 1995.
Riches, N. G. 2012. Sentence repetition in children with specific language impairment: an investigation of underlying mechanisms. *International Journal of Language & Communication Disorders*, *47*(5), 499–510.
Segalowitz, N.S. & Segalowitz, S. J. (1993). Skilled performance, practice, and the differentiation of speed-up from automatization effects: Evidence from second language word recognition. *Applied Psycholingusitics, 14*, 369-385.
Wiig, E. H., Semel, E. & Secord, W. A. (2013). *Clinical Evaluation of Language Fundamentals–5th edn. (CELF-5).* Bloomington, MN: NCS Pearson.

CONTACT INFORMATION

a.r.blake@bham.ac.uk
@ashleyrblake
https://www.ashley-blake.com