A comparison of models for formulating computerized diagnoses of learning disabilities using the MATAL system

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Introduction

MATAL is a computer-based test battery for the diagnosis of learning disabilities (dyslexia, dysgraphia, and dyscalculia) and ADHD for applicants to higher education institutions and for currently enrolled students.

MATAL consists of 2 questionnaires and 20 tests (tasks) in the following domains: language, quantitative functioning, attention, memory, visual perception and general processing speed.

MATAL produces two types of diagnosis for each of the four disabilities:

- Computerized diagnosis – Produced using a logistic regression model based on the individual's performance in MATAL diagnostic tools. This diagnosis classifies reading, writing, numeric ability, and attention functions into two levels: adequate / inadequate.
- Clinical diagnosis – Generated by an expert clinician based on a wide variety of information sources, including the individual's performance on MATAL.

The purpose of this study is to assess the accuracy of three approaches to constructing prediction equations for the four clinical groups. All three approaches use logistic regression as classifiers with the factor scores as predictors, and differ mainly in the dataset(s) used for training and testing.

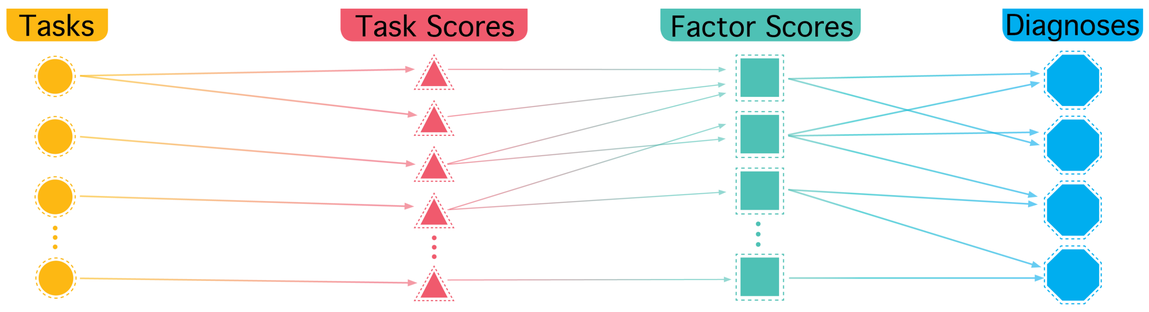
Data

The datasets used are:

- **Norm Sample** – 508 participants with no learning disabilities or ADHD, whose performance was used to establish national norms for the MATAL tasks
- **Revalidation sample** – 563 participants who took a MATAL-based diagnosis between 2008 and 2011. For each disability, this sample was divided into two subgroups:
- Clinical group – consists of individuals diagnosed with the relevant disability ($y = 1$) : dyslexia ($n = 285$), dysgraphia ($n = 255$), dyscalculia ($n = 131$), ADHD ($n = 313$)
- Non-Clinical group - consists of individuals with no diagnosis of the relevant disability ($y = 0$)

Methods

- Each of the 22 tasks yields 2-5 scores, totaling up to 54 task scores Standardized task scores ($z_1, \dots, z_{54}$) were calculated using the norm sample data
- 10 factor scores ($f_1, \dots, f_{10}$) were calculated using $z_1, \dots, z_{54}$
- Diagnosis produced by 4 logistic regression models ($M^1, \dots, M^4$), one for each disability, using $f_1, \dots, f_{10}$ as predictors.



The three approaches compared, based on the above datasets, were Full Mix, Partial Mix and VR Only:

Group \ Approach	Full Mix		Partial Mix		VR Only	
	Train	Test	Train	Test	Train	Test
Norm Sample	✓	✓	✓			
Non-Clinical	✓	✓	✓	✓	✓	✓
Clinical	✓	✓	✓	✓	✓	✓

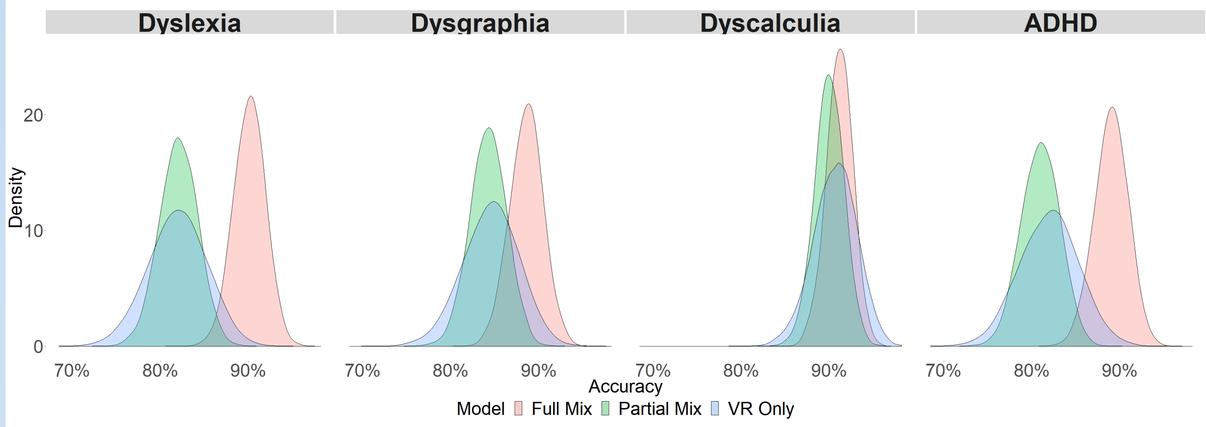
Comparison

For each approach j and disability k, 10,000 iterations were carried out. For each iteration i:

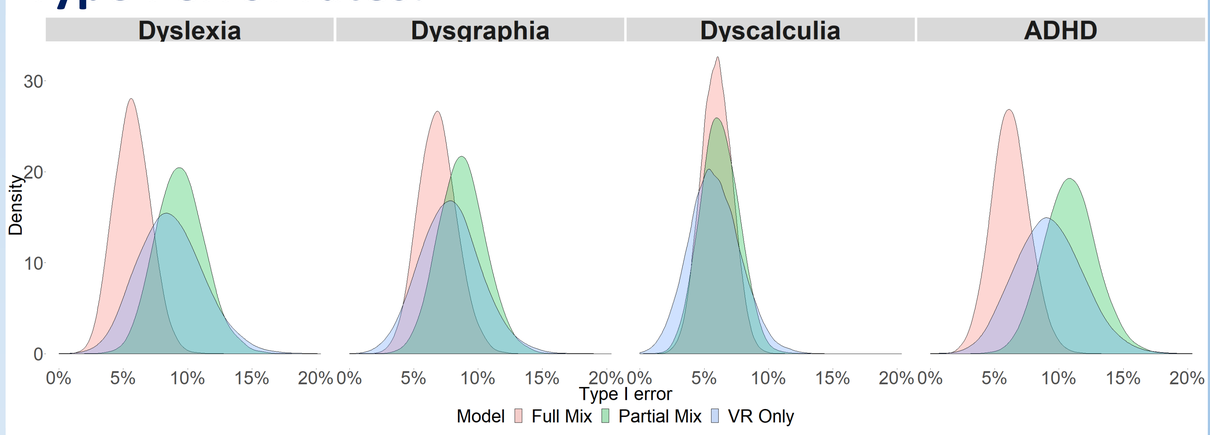
- The data was split using a 4:1 ratio (train:test) while keeping a constant morbidity rate
- An optimal cutoff point (probability) was fit for $M_{i,j}^k$
- Accuracy ($\hat{y}_{i,k}^{test} = y_{i,k}^{test}$) rate, type I error rate and type II error rate were calculated, using the clinical diagnoses as criterion $\left(y_{i,k}^{test}\right)$

Results

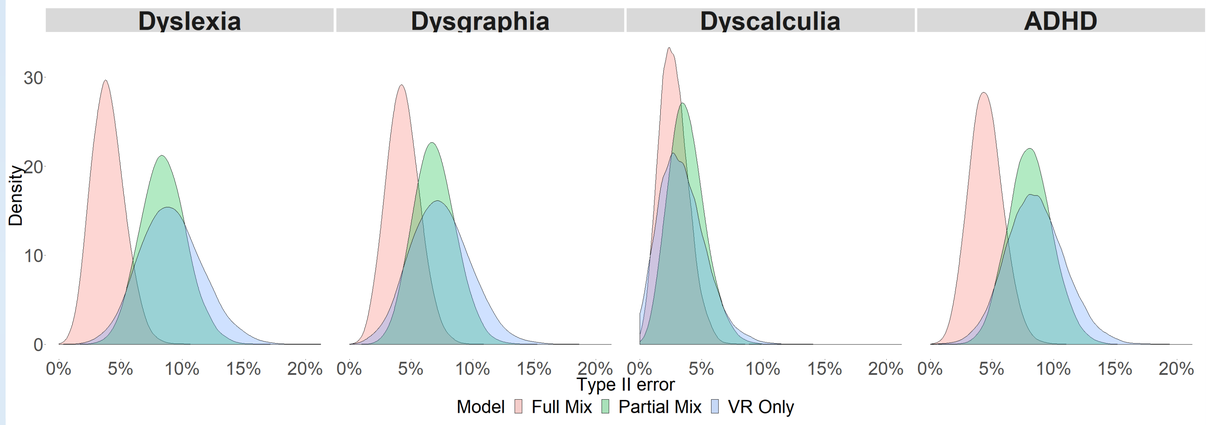
Accuracy rates by approach:



Type I error rates:



Type II error rates:



Mean intercept values by approach:

Approach \ Disability	Dyslexia	Dysgraphia	Dyscalculia	ADHD
VR Only	-3.65	-3.54	-5.97	-3.50
Partial Mix	-4.68	-4.67	-6.39	-5.19
Full Mix	-4.54	-4.47	-6.35	-4.79

Conclusions & Applications

1. The Full Mix approach has achieved, on average, the highest level of accuracy and the lowest level of type II errors
2. The addition of the Norm group samples yields a model with a wider domain for the sigmoid function, which in turn resembles a better explanation of the observed phenomenon
3. During the development of the latest MATAL version, new computerized diagnosis prediction equations were built using the Full Mix approach

References

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4. Ben-Simon, A., Kleper, D. & Saka, N. (In writing). *The Factorial Structure of the Cognitive Functioning Assessed by MATAL for the Diagnosis of Learning Disabilities and ADHD.* Jerusalem: The National Institute for Testing & Evaluation.

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