**The Structure of Language Abilities and Language Disabilities[[1]](#footnote-1)**

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MATAL is a computer-based test battery for the diagnosis of learning disabilities (LD) in applicants to higher education institutions and in currently enrolled students. MATAL was developed by NITE in cooperation with the Council of Higher Education in Israel (CHE), as part of an endeavor to develop policy and procedure for standardizing and regulating the diagnosis of LD in higher education and thus facilitating the provision of test accommodations. The MATAL Assessment Tools include: 20 tests (54 performance measures) which assess the following skills: reading, writing, numeracy, attention, memory and visual perception. Of the 20 tests, 11 are used to diagnose language deficiencies, mostly those pertaining to reading and writing.

Since 2007, over 8,000 persons have been diagnosed as LD by means of MATAL. The data yielded constitute a unique opportunity to examine the relationships between basic and higher language skills and to uncover the structure of both academic language skills and basic cognitive language skills.

To achieve this goal, a factor analysis was applied to performance scores of 2,652 persons who applied for LD diagnosed by the means of MATAL test-battery. The factor analysis was applied once to all 54 performance measures and again to 31 performance measures of 11 language tests. The factors obtained in both analyses were interpreted according to the variables loaded on them. The correlation between the factors and their correlations with a general verbal ability score were also examined.

**Introduction**

In a typical clinical situation, a battery of 10-20 achievement and cognitive tests is administered to a given client. Since each test may produce several performance scores, a few dozen such scores are typically produced. The final diagnosis of learning disability (LD), taking into account the performance scores, along with personal information (e.g., medical and learning history), is ultimately a subjective clinical judgment. One way to improve this process is to combine performance scores into theoretically meaningful and empirically-based categories of skills or abilities.

Moreover, the superiority of statistical models over clinical models in decision-making has long been established by research in the field (e.g., Dawes, Faust and Meehl, 1993; Meehl, 1954).

The main objective of this study is to map the underlying structure of academic and cognitive language skills used for the diagnosis of reading and writing learning disabilities. More specifically the study aims to -

* analyze the factorial structure of the performance scores on language tests used for the diagnosis of disabilities in reading and writing
* combine the performance scores of the language tests into empirically-based and theoretically meaningful skill categories
* examine the relationships among the skill categories
* examine the relationships between the skill categories and IQ measures
* examine the diagnostic efficacy of the skill-categories in the diagnosis of disabilities in the language domain (dyslexia & dysgraphia).

**Method**

*Participants*

Participants were2,652 applicants to tertiary education and students who applied for LD diagnosed by means of the MATAL test-battery. About 85% of the participants were diagnosed with at least one learning disability. 563 participants of the main sample participated in MATAL’s second validation study and rich background information was collected and coded for them, including IQ scores obtained on the Wechsler intelligence tests that were available for 291 of the 563 participants. The IQ scores were derived from LD diagnostic reports provided by the participant while applying for a MATAL LD diagnosis*.*

*Tools*

MATAL – a computer-based test battery for the diagnosis of LD in applicants to higher education institutions and in currently enrolled students.[[2]](#footnote-2) (MATAL, 2007)
MATAL assessment tools include 20 tests (54 performance scores) which assess abilities in six main domains: reading, writing, numeracy, attention, memory and visual perception (Ben-Simon & Inbar Wiess, 2012). The tests can be classified into three categories: (1) achievement tests assessing basic academic skills such as reading writing and the ability to carry out simple calculations; (2) cognitive tests assessing basic process underlying the abovementioned academic skills; and (3) tests assessing general cognitive skills such as: attention, memory and visual perception. Of the 20 tests, 11 are used to diagnose language deficiencies, mostly those pertaining to reading and writing.

*Analysis*

A two stage Factor Analysis (FA) was applied to 53 performance scores on 19 of the 20 MATAL tests[[3]](#footnote-3). The analysis was carried out in three stages.

In stage 1, an exploratory factor analysis was applied to all 53 performance scores. Two methods were used to examine the data structure: principal component analysis (PCA) and factor analysis with oblique rotation. Next, factor scores were computed for all participants on the principle factor (factor 1 in the PCA).
In stage 2, hierarchal factor analysis was applied to the residual scores were computed for the 53 performance scores, controlling for scores on the principal factor. This stage also involved application of the two analysis methods (PCA and oblique rotation).

In stage 3, both exploratory and hierarchal factor analysis were applied, once again using the PCA and oblique rotation methods. However, in this stage, the analyses were applied to 25 performance scores on the ten language tests only. The hierarchal factor analysis controlled for the principal factor scores computed in stage 1.

**Results**

*Stage 1; confirmatory FA applied to all performance scores*

The exploratory PCA applied to the 53 performance scores on MATAL tests yielded 13 factors ( EV>1.0) that explain 65% of the variance. Figure 1 shows the EV obtained on the exploratory FA for the PCA and oblique rotation methods. A salient principal factor explaining 23% of the variance was obtained by the PCA. 44 of the 53 performance scores were loaded on this factor (loading >.25) relating to participants' performance on all domains assessed by MATAL (reading, writing, numeracy, attention, memory and visual perception). This result indicates the existence of what may be termed a general learning disability factor (LD g-factor). The LD g-factor resembles, in many ways, the g-factor – a [general factor of human mental abilities](http://en.wikipedia.org/wiki/General_intelligence_factor) (intelligence) discovered by Spearman in the early 1920s and acknowledged by the professional community since then.

Figure 1: EV of the first 13 factors obtained on the exploratory FA using the PCA and oblique rotation\* methods

Figure 1: EV of the first 17 factors obtained on the hierarchal FA using the PCA
 and oblique rotation methods

To test the hypothesis that the LD g-factor is merely a manifestation of the g-factor, scores on the LD g-factor were correlated with IQ scores obtained on the Wechsler intelligence tests by 291 participants.

Table 1 gives the mean and SD of the IQ scores and their correlations with the LD g-factor scores. Low to moderate correlations were observed between LD g-factor and IQ scores: .26 for the verbal scale, .24 for the performance scale and .32 for the IQ score. These results indicate that the LD g-factor does not reflect intelligence. Given the nature of the tests included in MATAL it is suggested that while the g-factor is a [general factor of human higher-order mental abilities](http://en.wikipedia.org/wiki/General_intelligence_factor) (processes) the LD g-factor is a general factor of human basic processes. The fact that most MATAL tests assess basic cognitive process supports this assertion.

Table 1: Mean and SD of IQ scores and their correlations with LD g-factor (N=291)

|  |  |  |  |
| --- | --- | --- | --- |
|  | Verbal scale | Performance scale | IQ |
| Mean (SD) | 104 (10.5) | 110 (12.0) | 107 (10.3) |
| Corr. | .26 | .24 | .32 |

*Stage 2; hierarchal FA applied to all performance scores*

Figure 2 shows the EV of the first 17 factors (EV>1.0) obtained on the hierarchal FA with the PCA and the oblique rotation methods. Results show a marked decrease in the size of the principal factor, indicating that most of the variance common to all 53 performance scores was indeed controlled for.

*Stage 3; exploratory and hierarchal FA applied to the language tests*

Six of the 13 factors obtained on the exploratory FA factors were associated with language skills. To examine the factorial structure of the language tests, an exploratory factor analysis was applied to the 25 performance scores on these tests. The PCA yielded six factors (EV>1.0) that explain 66% of the variance. To further differentiate the factors, the data was subjected to oblique rotation. Figure 3 shows the EV obtained for the six factors for both methods of analysis (PCA and oblique rotation). Table 2 reports the loadings of the 25 language scores on the six factors.

An interpretation of the scores' loadings indicated the following skill categories: (1) naming; (2) phonological decoding; (3) text comprehension-accuracy; (4) text comprehension-RT; (5) orthographic memory; and (6) verbal fluency.

Hierarchal FA applied to the 25 language performance scores, while controlling for the LD-g-factor, yielded 8 factors. The first six factors were identical to the factors obtained on the exploratory FA. The additional two factors were: 'phonological awareness' and syntactic awareness (RT).

Figure 4 shows the EV of the eight factors (EV>1.0) obtained on the hierarchal FA. It is interesting to note that the distributions of the EVs obtained by the PCA and the oblique rotation methods are fairly similar, indicating that most of the variance common to the language tests is explained by the LD g-factor.

Table 2: Factor analysis of MATAL's language tests with oblique rotation

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Test & performance score | Cognitivefunction | Naming | Phonological decoding | Text comp. accuracy | Text comp. RT | Ortho-graphic memory | Verbal fluency |
| RAN (numbers) | Naming | 1.00 | .00 | .00 | .00 | .00 | .00 |
| RAN (objects) | Naming | .99 | .00 | .00 | .00 | .00 | .01 |
| RAN (letters) | Naming | .98 | .00 | .00 | .00 | .00 | .00 |
| Vocal text reading (RT) | Phonological decoding | .63 | .02 | .03 | .02 | .03 | .00 |
| Dictation | Writing pace | .48 | .00 | .00 | .00 | .30 | .00 |
| Non-word Reading(Identification) | Phonological decoding  | .00 | 1.00 | .01 | .00 | .01 | .00 |
| Non-word Reading (production) | Phonological decoding | .00 | .86 | .02 | .00 | .04 | .00 |
| Non-word Reading (production) - RT | Phonological decoding  | .11 | .69 | .00 | .02 | .00 | .00 |
| Non-word Reading(Identification) - RT | Phonological decoding  | .06 | .71 | .00 | .04 | .00 | .00 |
| Phonemic Deletion - RT | Phonological awareness | .04 | .61 | .00 | .05 | .00 | .03 |
| Phonemic Deletion | Phonological awareness | .00 | .56 | .11 | .00 | .03 | .03 |

Table 2 (cont.): Factor analysis of MATAL's language tests with oblique rotation

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Test & performance score | Cognitivefunction | Naming | Phonological decoding | Text comp. accuracy | Text comp. RT | Ortho-graphic memory | Verbal fluency |
| Listening Comprehension (English) |  | .00 | .00 | 1.00 | .00 | .00 | .00 |
| Listening Comprehension (English |  | .00 | .02 | .90 | .01 | .00 | .00 |
| Reading Comprehension |  | .05 | .01 | .66 | .01 | .00 | .02 |
| Syntactic Awareness |  | .10 | .06 | .37 | .00 | .04 | .02 |
| Listening Comprehension (English) - RT |  | .00 | .00 | .00 | 1.00 | .00 | .00 |
| Reading Comprehension English - RT |  | .00 | .01 | .00 | .90 | .00 | .00 |
| Reading Comprehension - RT |  | .09 | .00 | .06 | .54 | .00 | .00 |
| Dictation | Morpho-phonological spelling errors | .01 | .02 | .00 | .00 | 1.00 | .00 |
| Dictation | Handwriting | -.01 | .00 | -.05 | .00 | .93 | .00 |
| Dictation | Homophonic spelling errors | .00 | .04 | .02 | .00 | .86 | .00 |
| Vocal text reading | Phonological decoding | .00 | .06 | .06 | .00 | .75 | .00 |
| Verbal Fluency | Semantic cue | .02 | .00 | .00 | .00 | .00 | 1.00 |
| Verbal Fluency | Phonological cue | .00 | .01 | .01 | .00 | .00 | .98 |
| Syntactic Awareness |  | .26 | .02 | .04 | .23 | .00 | .01 |

Figure 3: EV of the first six language factors obtained on the exploratory FA with
 the PCA and oblique rotation methods

Figure 4: EV of the first 8 language factors obtained on the hierarchal FA with
 the PCA and oblique rotation methods

To examine the relationships among the language skill categories, inter-factor correlations were computed for the six factors obtained on the exploratory FA (see table 3). Significant yet moderate correlations (.10-.42) were observed for 13 of the 15 factor pairs. However, inter- factor correlations decreased substantially when the LD g-factor was controlled for.

Table 3: Inter-factor correlations of the language factors obtained on the exploratory
 FA with oblique rotation (N=2652)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|   | Naming | Phono-logical decoding | Text comp. accuracy | Text comp. RT | Ortho-graphic memory |
| Phonological decoding | .37 |  |  |  |   |
| Text comprehension - accuracy | .31 | .41 |  |  |   |
| Text comprehension - RT | .41 | .27 | .31 |  |   |
| Orthographic memory | .21 | .42 | .32 | .10 |  |
| Verbal fluency | .32 | .22 | .32 | .17 | .10 |

To examine the relationship between the language skill categories and IQ measures, the factor scores were correlated with IQ scores. Table 4 presents these correlations. Significant low to moderate correlations (.13-.41) were observed between the six language factors and IQ scores. As expected, higher correlations were observed with the verbal scale (.12-.45) than with the performance scale (.07-.23). The highest correlations with IQ were observed for the *reading comprehension (accuracy)* factor (.41) and for the *verbal fluency* factor (.36) both assessing relatively higher-order cognitive skills.

Table 4: Correlations between the language factors and IQ scores (N=291)

|  |  |  |  |
| --- | --- | --- | --- |
|   |  Verbal scale | Performance scale | IQ score |
| Naming | .12 | .18 | .20 |
| Phonological decoding | .21 | .\*08 | .18 |
| Text comprehension - accuracy | .45 | .23 | .41 |
| Text comprehension - RT | .21 | .10\* | .16 |
| Orthographic memory | .17 | .07\* | .13 |
| Verbal fluency | .41 | .23 | .36 |

\* Non significant correlations

**Summary**

The study analyzed the underlying structure of academic and cognitive language skills used for the diagnosis of learning disability in general, and reading and writing disabilities in particular. To this end, exploratory and hierarchal factor analyses were applied to 53 performance scores obtained by 2,652 persons who applied for LD diagnosed by means of the MATAL test-battery. The factor analyses were applied once to all 53 MATAL performance scores and again to 25 performance scores on ten language tests. The exploratory factor analysis applied to all MATAL performance scores indicated the existence of a principal factor that capitalizes on all the skills assessed by MATAL (reading, writing, numeracy, attention, memory and visual perception). This factor was interpreted as a general learning disability factor (LD g-factor) reflecting the efficiency of carrying out basic cognitive processes. Low to moderate correlations were observed between this factor and IQ scores.

Exploratory, followed by hierarchal, factor analyses applied to the performance scores of the language tests categorized six language skills: naming, phonological decoding, text comprehension-accuracy, text comprehension-RT, orthographic memory and verbal fluency. The study also examined the relationships among the language skill categories and the relationships between them and IQ.

**References**

Ben-Simon, A. & Inbar-Weiss, N. (2012). *MATAL Test Battery for the Diagnosis of Learning disabilities:* *User Guide*. Jerusalem: National Institute for testing and evaluation and the Council for Higher Education (Hebrew).

Dawes, R. M., Paust, D. & Meehl, P. (1993). Statistical Prediction Versus Clinical Prediction: Improving What Works. In: G. Keren, & C. Lewis. *A Handbook for Data Analysis in the Behavioral Sciences.* pp. 351-368. Lawrence Erlbaum Associates.

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**Appendix 1: MATAL Assessment Tools: Tests and Questionnaires**

| **Diagnostic tools**  | **Skill/Function** | **Task description** | **Performance measures** |
| --- | --- | --- | --- |
| **Background Questionnaire** |
| **Language (reading & writing)**  |
| **Vocal Text Reading** | Phonological decoding | Vocal reading of a non-vocalized text | * Accuracy
* RT
 |
| **Non-word Reading** (production) | Phonological decoding | Vocal reading of vocalized non-words | * Accuracy
* RT
 |
| **Non-word Reading**(Identification) | Phonological decoding & lexical retrieval | Identification of a non-word that sounds like a common word in Hebrew  | * Accuracy
* RT\*
 |
| **Phonemic Deletion** | Phonological awareness | Phonemic deletion in non-words | * Accuracy
* RT
 |
| **Phonemic Count** | Phonological awareness | Phoneme count in non-words | * Accuracy
* RT
 |
| **Dictation** | Grapho-motor efficiencySpelling | Writing a text vocalized by the computer | * Handwriting
* Writing pace
* Homophonic spelling errors
* Morpho-phonological spelling errors
 |
| **Rapid Automatic Naming (RAN)** | Lexical retrieval | Rapid naming of objects, letters and numbers | * Naming rate
 |
| **Verbal Fluency** | Lexical retrieval | Words retrieval by phonological cue and by semantic cue | * Number of words retrieved in each category
 |
| **Syntactic Awareness** | Syntactic awareness / Mastery of syntax | Reading a complex sentence with irregular syntax and then identifying a very short sentence which has a similar meaning. | * Accuracy
* RT
 |
| **Reading Comprehension** | Reading comprehension | Reading 3 passages and answering 30 MC questions | * Accuracy
* RT
 |
| **English Reading Comprehension**  | Reading comprehension in 2nd language  | Sentence completion | * Accuracy
* RT
 |
| **English Listening Comprehension** | Listening comprehension in 2nd language  | Sentence completion | * Accuracy
* RT
 |

| **Diagnostic tools**  | **Skill/Function** | **Task description** | **Performance measures** |
| --- | --- | --- | --- |
| **Attention** |  |  |  |
| **Continuous Performance Task (CPT)** | Sustained attention | Responding to a two- dimensional target stimuli (shape & color)  | * Omissions
* Commissions in 1st part
* Commissions in 2nd part
* RT
* Variability of RT
 |
| **Attentional Network (ANT)** | * Alerting attention
* Orienting of attention
* Executive attention
* Sustained attention
 | Determining the direction (left/right) of a target symbol (arrow) presented with or without various cues | * Accuracy
* RT
* Executive attention
* Alerting attention
* Orienting of attention
 |
| **ADHD self-report questionnaire** | * Attention difficulties in adulthood & childhood
* Impulsivity and hyperactivity in adulthood & childhood
 | Self-reporting of behavioral symptoms | * Attention in adulthood
* Impulsivity- hyperactivity in adulthood
* Attention in childhood
* Impulsivity- hyperactivity in childhood
 |
| **Mathematics / Numeracy** |
| **Computational Automaticity** | Retrieval of simple arithmetic facts  | Judging the correctness of simple arithmetic equations | * Accuracy
* RT
 |
| **Procedural Knowledge** | Mastery of basic arithmetic procedures | Judging the correctness of arithmetic equations | * Accuracy
* RT
 |
| **Number Sense** | Number-line representation | Determining which of two number values presented on a number-line is located at the correct point.  | * Accuracy
* RT
* Distance-related accuracy
 |
| **Memory** |
| **Auditory Verbal Memory**  | Short-term memoryLong-term memory | Free recall of words from a given listIdentification of words from a previously presented word list  | * Immediate recall
* Delayed recall
* Delayed recognition
 |
| **Visual Perception** |
| **Visual Perception: parallel processing** | Spatial perception | Discrimination between two spatial frequencies presented simultaneously  | * JND threshold
 |
| **Visual Perception: temporal processing** | Working memory Visual perception | Discrimination between two spatial frequencies presented one after the other | * JND threshold
 |

1. Paper presented at the IAEA 38th annual conference, Astana, Kazakhstan (October, 2012). [↑](#footnote-ref-1)
2. MATAL was developed by NITE in cooperation with the Council of Higher Education in Israel (CHE), as part of an endeavor to develop policy and procedure for standardizing and regulating the diagnosis of LD in higher education, thus facilitating the provision of test accommodations. [↑](#footnote-ref-2)
3. The Phonemic Count Tests was excluded from the analysis due to poor diagnostic effect. [↑](#footnote-ref-3)