Comparing the latent structure of ATHINA Test among young children and older adults: A preliminary study

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The ATHINA Test

- The ATHINA Test for the Diagnosis of Learning Difficulties (Paraskevopoulos, Kalantzi-Azizi, & Giannitsas, 1999) is an individually-administered psycho-educational diagnostic instrument for children between the ages of 5 and 9.

- Being multi-thematic, the ATHINA Test (AT) is designed to provide teachers or other specialists with a detailed description of a child’s current state in key areas of development.

- It can also identify deficit areas which might prevent the child from meeting school learning requirements and need special intervention.

- The development of the ATHINA Test was based on two other instruments: the Illinois Test of Psycholinguistic Abilities- ITPA (Kirk, McCarthy, & Kirk, 1968) and the Aston Index, a comprehensive battery for screening and diagnosing language difficulties (Newton & Thomson, 1982).
As stated by its constructors (Paraskevopoulos, et al., 1999) the ATHINA Test can be used:

- for the planning and implementation of appropriate individualized instruction to students in need.

- It can also serve as a tool for students’ initial psychological evaluation which will help to identify children who need to be referred for systematic diagnostic assessment.

- Finally, it is a handy tool for collecting research data.
The content of the AT

The ATHINA Test consists of 15 subtests, in the form of psychometric scales, which evaluate, both, the level and rate of a child’s development in 5 discrete cognitive domains:

- cognitive ability
- auditory and visual memory
- completion of representations
- grapho-phonological awareness, and
- neuropsychological maturation.
The AT standardized scores allow for a reading of a child’s performance from two different perspectives:

- The perspective of interpersonal individual differences, by determining whether an examinee’s level of development correlates with his / her chronological age, comparing performance between children of the same age.

- The perspective of intrapersonal individual differences. The subscales of the ATHINA Test are designed to allow for comparisons between them, identifying discrepancies in various skills that reflect strengths and weaknesses within the same person.
The construction of the AT was completed in 7 years, through a three-stage process:

- **Construction of a preliminary version of the subscales.** At that stage, the particular goal and form of each subscale was determined and the items were produced.
- **Pilot study,** during which, the preliminary version of the test was administered to a sample of 500 children.
- **Final study,** during which, the final version was administered to a sample of 660 kindergarten and first – to fourth-grade elementary school children. The sample was proportionally representative of two sexes and of all age groups from the start of the fifth year until the end of the 9th.
Reliability

- Reliability measurements were calculated from the AT standardization sample.

- The constructors of AT (Paraskevopoulos, et al., 1999) report internal consistency estimates for the subscales ranging from .80 for the younger and the older groups of age up to .90 for the intermediate groups of age.
The AT is divided into fifteen (15) subtests, fourteen (14) core and one (1) supplemental, which assess a wide range of abilities in motor, perceptual, cognitive and psycholinguistic domains.

As research findings suggest, the aforementioned domains are highly related to difficulties faced by children, to meet the school learning requirements. (Fuchs, Compton, Fuchs, et al., 2012; Melby – Lervag, Lyster, & Hulme, 2012).
The AT subscales I

- **Mental ability**
  - Language Analogies
  - Pattern Copying
  - Vocabulary
- **Grammatical and auditory completions**
  - Sentence Completions
  - Word Completions
- **Auditory and Visual Memory**
  - Digit Span
  - Picture Memory
  - Pattern Memory
  - Memory of Common Sequences
The AT subscales II

- **Grapho – Phonological Awareness**
  - Grapheme Discrimination
  - Phoneme Discrimination
  - Phoneme Synthesis

- **Neuropsychological Maturation**
  - Visual – Motor Coordination
  - “Right – Left” Perception
  - Lateralization
Use of the AT test in the present study

All the participants in the present study completed a brief version of the ATHINA test in order for an estimate of their overall cognitive functioning to be provided. The inclusion of the six subscales described here was made on the basis of the following criteria:

- Measurement of general cognitive ability
- Tasks’ similarity to the other measures used in the study, namely the Raven’s Educational CPM, the Children’s Category Test 1 and the Mini Mental State Examination.
The AT subscales that were used in the present study

- The first three mentioned subscales are administered in the order verbal scale-practical scale-verbal scale, and they assess the child’s language and visuo-cognitive development.

- Combined with the two memory subscales allow for an estimate of the general cognitive ability.

- The sixth subscale was administered for the purposes of an estimate of the participants’ neuropsychological maturation.
The AT subscales that were used in the present study

- **Language Analogies**: Language analogies consist of 32 pairs of sentences. Each pair contains four meanings that are connected with each other (e.g. shape) and form an analogy expressed in words. For each pair of sentences, the first sentence is complete while the second is incomplete (e.g. the table is square, the sun is ... ). The participant’s task is to find the missing word in this second sentence. Every correctly answered item results in 1 point. **It is a test of verbal concept formation, which reflects a child’s abstract verbal classification abilities.**
Pattern Copying: The participant is presented with 3 geometrical patterns that vary in difficulty. The correct pattern copying requires increasing visuo-conceptual maturity with every pattern. The drawings are scored by three morphological characteristics:

a. general resemblance to standard,

b. shape orientation,

c. equality of different parts.

Each drawing is scored 0-3 points.
- **Vocabulary**: It consists of 20 items – words, both concrete and abstract, for which the subject needs to give a definition. They vary in difficulty from the simplest to more difficult words. Each answer is scored 0-2 points depending on the accuracy of the definition. **This test assesses word knowledge, language development and long-term memory.**

- **Digit span**: It includes 16 items - sequences of numbers that gradually get longer. Participants are given the sequences orally and are asked to repeat them as heard. Correctly repeated items are given a score of 2 or 1, at first or second attempt, respectively. **It is a test of short – term phonological memory.**
- **Memory of Common Sequences:** This is a supplemental subscale in the AT test. The child is asked to name parts of sequences encountered in everyday life (days of week, months of year, etc.). Every correctly answered item results in 1 point.

- **“Right – Left” Perception (neuropsychological maturation)** 2 items in form of instructions to be executed by the participants indicating whether they can distinguish and orientate accordingly the right and left "side" of the body, either their own (direct perception), or the examiner’s (“mirror” perception). Every correctly answered item results in 1 point.
Because of the relatively small sample size of each group, analyses were not run at the item level.

Instead, Confirmatory factor analysis was conducted to examine the factor structure of the AT for every group of the sample, using summed scores of each one of the six observed variables (subscales of the AT).
Statistical Analysis

- The covariance matrix was based on the following six total scores (measured variables):
  - total raw score for the Language Analogies subscale (LA),
  - total raw score for the Pattern Copying subscale (PC),
  - total raw score for the Vocabulary subscale (V),
  - total raw score for the Digit Span subscale (DS),
  - total raw score for the Memory of Common Sequences subscale (MCS), and
  - total raw score for the “Right – Left” Perception subscale (R-LP).
Confirmatory factor analysis was conducted in EQS Version 6.1 (Bentler, 2005) and performed on the five covariance matrices, which stemmed from the total sample and each one of the four groups of participants, using the Maximum Likelihood (ML or ML ROBUST) estimation method.

- The Wald test was used to test the need for the estimated parameters and to suggest a more restricted model.
Initially, we tested the one-factor CFA in the total sample (Model A).
Confirmatory factor analysis fully verified the one-factor structure -based on 6 measured variables/summed items- of AT for the total sample:

\[ \chi^2 (9, N = 243) = 15.006, p = .09, \chi^2/df = 1.67, \text{CFI} = .99, \text{SRMR} = .02, \text{RMSEA} = .05 \text{ (CI}_{90\%} .00 - .10) \].

According to the suggestions of the Wald test all the parameters’ loadings of the Model A were statistically significant.
Thus, we derived one factor (latent variable), that probably explains the variance of participants’ performance on AT.
For the total sample, Cronbach’s α coefficient was .82.
Testing latent structure of the AT in the subsample of new-old adults

- In order to compare the latent structure in AT between the four groups of the sample, we, then, tested the one-factor CFA model in the group of new-old adults (Model B1).
- Confirmatory factor analysis fully verified the one-factor structure - based on 6 latent variables/summed items - of the AT for the group of new-old adults.
- $[\chi^2 (9, N = 118) = 12.574, p = .18, \chi^2/df = 1.40, CFI = .98, SRMR = .05, RMSEA = .06 (CI_{90\%} .00 - .13)].$
- According to the suggestions of the Wald test all the parameters’ loadings of the Model B were statistically significant except for the residual of one of the measured variables, namely the residual of the total raw score for the Language Analogies subscale ($p = .54$).
Testing latent structure of the AT in the subsample of new-old adults

- Thus, we derived one factor (latent variable), that probably explains the variance of the new – old adults’ performance on the 6 subscales of the AT test that were used in the present study.

- For the group of new – old adults, Cronbach’s α coefficient was .68.
Figure 1. The underlying structure of the single g latent factor in the total sample and in the subsample of new - old adults (standardized solution).

*All loadings drawn indicate significant associations (p < 0.05). **e = measurement error
Testing Latent structure of the AT in the subsample of elementary students

• Then, we tested the aforementioned one-factor CFA model in the group of first- to second-grade elementary school students (Model C1).
• Confirmatory factor analysis did not verify the one-factor model, in which the six measured variables loaded on one factor, for the group of elementary school students (Model C1), although the indices were excellent.
  \[\chi^2 (9, N = 56) = 4.575, \ p = .87, \ \chi^2/df = .51, \ CFI = 1.00, \ SRMR = .04, \ RMSEA = .00 (CI_{90\%} .00 - .08)\].
• According to the suggestions of the Wald test all the parameters’ loadings of the Model C1 were statistically significant except for one of the measured variables, namely the total raw score for the “Right – Left Perception” subscale \(p = .32\).
Consequently, we tested in the group of elementary students a one-factor structure model in which five of the six measured variables loaded on one factor (Model C2). Model C2 was verified:

\[ \chi^2 (5, \, N = 56) = 4.127, \, p = .53, \, \chi^2/df = .83, \, CFI = 1.00, \, SRMR = .04, \, RMSEA = .00 \text{ (CI}_{90\%} \, .00 - .17) \].

According to the suggestions of the Wald test all the parameters’ loadings of the Model C2 were statistically significant.

For the group of first- to second- grade elementary school students, Cronbach’s \( \alpha \) coefficient was .71.
Then, we tested the CFA model, in which the six measured variables loaded on one factor, in the group of old-old adults (Model D1).

Confirmatory factor analysis did not verify the model, in which the six measured variables loaded on one factor, for the group of old-old adults (Model D1). There was a warning that “test results may not be appropriate due to condition code”.

Consequently, we tested in the group of old-old adults the CFA model that was verified for the group of first- to second- grade elementary school students. In this Model (D2) five measured variables (with the exception of the total raw score for the “Right – Left” Perception subscale) loaded on one factor.
Testing latent structure of the AT in the subsample of old – old adults

- A unidimensional model in which five of the six measured variables loaded on one factor (Model D2), was verified:
  - $\chi^2(5, \, N = 27) = 1.093, \, p = .95, \, \chi^2/df = .22, \, CFI = 1.00, \, SRMR = .03, \, RMSEA = .00$ (Cannot compute boundary of Confidence Interval).
- According to the suggestions of the Wald test, all the parameters of the Model D2 were statistically significant, except for the residual of one of the measured variables, namely the residual of the total raw score for the “Language Analogies” subscale ($p = .95$).
Testing latent structure of the AT in the subsample of old – old adults

- For the group of old – old adults, Cronbach’s α coefficient was .72.

- The comparison of the CFA Model C2 with the Model D2 indicates a similar latent structure in AT for first- to second- grade elementary school students and old-old adults.
Figure 2. The underlying structure of the single g latent factor in the subsamples of elementary school students and old-old adults (standardized solution).

*All loadings drawn indicate significant associations ($p < 0.05$). **e = measurement error
Finally, we tested the one-factor CFA model in the group of kindergarten students (Model E1).

Confirmatory factor analysis did not verify the one-factor model, in which the six measured variables loaded on one factor, for the group of kindergarten students (Model E1), although the indices were good.

\[ \chi^2 (9, N = 42) = 9.476, p = .39, \chi^2/df = 1.05, CFI = .97, SRMR = .09, RMSEA = .04 (CI_{90\%} .00 - .18)\]
Testing latent structure of the AT in the subsample of Kindergarten students

- According to the suggestions of the Wald test the parameters’ loadings of the Model E1 were statistically significant except for three of the six measured variables, namely,
  - the total raw score for the “Right – Left” Perception subscale ($p = .84$),
  - the total raw score for the Memory of Common Sequences subscale ($p = .63$), and
  - the total raw score for the Pattern Copying subscale ($p = .47$).
Consequently, we tested in the group of kindergarten students a one-factor structure model in which the remainder three of the six measured variables loaded on one factor (Model E2).

According to its indices $[\chi^2(0, N = 42) = 0.00, p = \text{undefined}, \text{NFI} = 1.00]$, it seemed that Model E2 should be considered as just-identified and fits the data better than Model E1 of this set of analysis.
Testing latent structure of the AT in the subsample of Kindergarten students

- However, confirmatory factor analysis did not verify the one-factor model, in which the three measured variables loaded on one factor (Model E2), for the group of kindergarten students, because, according to the suggestions of the Wald test, the variance of the single latent variable (factor) was not found to be statistically significant ($p = .06$).

- Thus, we did not derive one factor, that could explain the variance of the kindergarten students’ performance on AT.

- For the group of kindergarten students, Cronbach’s $\alpha$ coefficient was .54.
Conclusion

- For the group of kindergarten students the existence of a single latent g-factor measured by ATHINA Test was not confirmed, since its variance was not found to be statistically significant.

- This finding seems to be consistent with previous ones indicating that the factor solutions of [R] Educational CPM are stabilized after the age of 5-6 (Fajgelj, et al., 2010. Papantonioiu et al., 2015).
Conclusions

To summarize,

• The comparison of the CFA Model C2 with Model D2 indicates a similar pattern of structure in AT for first- to second-grade elementary school students and old-old adults.

• Additionally, the comparison of the CFA Model B with Model C2 and D2 indicates a different pattern of structure in AT between new-old adults, on the one hand, and elementary school students and old-old adults, on the other.
Conclusions

The unidimensional structure of the AT test, that was observed in the present study in the groups of elementary school students and old-old adults, is possible to indicate a qualitative change,

- perhaps, a lack, or a delay in the acquisition of certain skills that reflect neuropsychological maturation (in first– to second– grade elementary school students),
- and a start of disorganization or decline of neuropsychological functioning in old–old adults compared to new–old adults.
However, in order for the applicability of the ATHINA Test to be assessed in Greek older adults, normative data have to be provided for this population.
References

Thank you for your attention!