Development of a screening tool for children prior to school entrance

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The present study describes the development, application and validation of the A' TEST, a screening tool administered individually to kindergarten children to determine their school preparedness. The A' TEST evaluates six cognitive domains (abstract thinking, critical reasoning, language skills, visual perception, visual motor skills and organizational skills). It was administered to 2002 preschool children, and validated through comparison with well-established classification systems. Also, in order to examine the predictive value of the A' TEST, 201 of the examined children were reevaluated by their teachers two years after initial assessment. Analysis provided evidence of structure, convergent, concurrent and discriminant validity and reliability, as well as predictive validity. Overall, the A' TEST predicted that 9.1% of the children were not school-ready, giving a 98.5% correct prediction when compared with the teachers' evaluations two years later. In conclusion, the A' TEST is a valid and appropriate screening tool for school readiness.

Key words: school readiness, screening, learning difficulties, validation.

The transition to school is an important milestone in the developmental course of young children[1]. For a smooth transition from kindergarten to school, children need to be prepared to learn. The concept of preparedness for school entry is often referred to as school readiness[2-4]. School readiness has been conceptualized as a multifaceted construct that includes, but is not limited to, preliteracy and prenumeracy skills. Furthermore, it involves important factors such as cognition, language, health, motor skills, behavior and socio-emotional status[5,6]. These fundamental factors facilitate children's socialization, communication and engagement in both structured and unstructured activities[7,8]. Even though there is no universal definition of school readiness, general agreement is commonly seen regarding the relationship between a smooth transition into school and early academic success[9].

Traditionally, chronological age has served as the criterion for school entry. However, age sets only a minimum eligibility requirement, rather than being a measure of readiness per se. Indeed, preschoolers are heterogeneous due to variability in preschool duration and in the types of programs offered by different preschools. Therefore, children are not uniformly prepared to follow a standardized curriculum, and the use of chronological age as a measure of readiness is unreliable. Indeed, research indicates that chronological age alone is not sufficient for predicting later school performance[10]. In fact, children's readiness for school comprises five dimensions: physical health, socio-emotional development, approaches to learning, language and cognitive development[11].

Screening measures, which vary greatly from country to country, are widely used to detect children who are at risk for educational difficulties[12]. The Phelps Kindergarten Readiness Scale (PKRS) focused on three domains (verbal, perceptual and auditory) that were correlated with later academic achievement[13]. The Miller Assessment for Preschoolers (MAP) and the Pediatric Examination of Educational

Readiness (PEER) are similar assessment tools used for early identification of children with developmental disabilities[14]. Although scores from these exams cover socio-emotional and behavioral domains, in addition to cognitive and literacy abilities, their predictive value has been questioned due to the non-negligible number of false negative results obtained[15,16].

The importance of early identification of these children is based on several factors: first, early intervention programs may influence the child's later academic and social achievements; second, developmental processes are more flexible in young children; and third, there exists the possibility for prevention of secondary problems, i.e., social and emotional difficulties[17-19]. Certainly, screening alone is not sufficient, and further assessment may be necessary to ultimately determine appropriate placement or instruction for a child[20].

Although the use of screening tools for determining the readiness of children to enter school is prevalent and likely to continue[21], such tests are frequently criticized, and their use as a criterion to establish school preparedness is controversial[22]. For example, it has been suggested that screening methods should not exclude children from programs for which they are legally eligible; instead, they should only be used to identify those children needing educational assistance. Unbiased, ethical practice would involve accepting the entire spectrum of children into the educational system, identifying any special needs that they may have, and offering them the best possible opportunity to grow and learn. Also, it is imperative that schools be well prepared to adopt approaches that will accommodate individual differences, rather than operating under the assumption that children enter school with homogeneous skills[4]. For these reasons, the concept of school readiness is shifting away from the viewpoint that the child must fit the rigid expectations of the school, and the notion that successful school experiences require mutual adaptability and individualized educational instruction is emerging[23,24].

While measures have predominantly focused on the importance of cognitive skills and emergent literacy with regard to later academic achievement, other dimensions of readiness have received less attention[25]. It has been suggested that assessment of readiness for school should encompass not only cognitive and literacy abilities, but also aspects of the socio-emotional and behavioral domains[13,26], such as getting along with others, attitudes toward oneself and others, persistence in tasks, and engaging in conversation and cooperation. Thus, school readiness procedures should shift their emphasis toward using a multidimensional approach[27].

Children who enter school ready to learn are expected to achieve more academically[21]. Longitudinal research findings have demonstrated that early math, reading and attention skills are important predictors of later academic success[2,28-30]. However, less research has been conducted on early socio-emotional development, and its association with future academic outcomes and school adjustment[29,31]. Recent studies, nonetheless, support the significance of social and emotional aspects, both as indicators and as predictors of later school success[5,32].

A very important skill inherent in the process of learning is visual perception. Visual perception is the ability to process and organize visual information from the environment. A more practical definition of visual perception is the capacity to interpret or give meaning to what is seen. This definition includes recognition, insight and interpretation at the higher levels of the central nervous system of what is seen[33]. Most children are able to integrate these abilities by the time they start school. This is important, because approximately three-quarters of all classroom learning is visual. A child with even mild visual-perceptual difficulties will struggle with learning in the classroom and, often, in other areas of life. One of the instruments used for assessing children's visual perceptual strengths and weaknesses is the TVPS-R[34], along with its newer version, the TVPS-3[35]. It includes the following subtests: visual discrimination, visual memory, visual-spatial relationships, form constancy, visual sequential memory, visual figure-ground and visual-closure[36]. Another recently developed tool is the Developmental Test of Visual Perception-2nd Edition (DTVP-2)[37]. Statistically significant correlations between the DTVP-2 and TVPS-3 total scale scores and subscale scores were found. Internal consistency of items

for the DTVP-2 and TVPS-3 total scores was >0.80, and internal consistency of items for the subscale scores was >0.70. The DTVP-2 exhibited evidence of convergent validity with the TVPS-3[38]. Similar results were found when assessing learners with learning difficulties[39].

Another important area associated with vision and learning is visual motor skills: the use of vision and the hands to perform tasks. Examples of this are writing and drawing. The TVMS-3 measures how well individuals can coordinate and visually guide fine-motor movements by asking individuals to reproduce 39 increasingly complex geometric designs[40]. Nine types of errors are identified: incorrect closures; incorrect angles; line quality; line lengths; line connections; modification of size or part; addition or deletion of a part; rotation or reversal; and shape overlap. By analyzing these errors, the therapist gets a detailed evaluation of visual motor skills. When used in conjunction with a visual perception test, the TVMS-3 can differentiate visual-motor and perceptual impairments, although visual perception and visual motor skills are usually significantly correlated[41]

Notwithstanding the abundance of screening tools for children prior to school entrance, no such tool had been developed in Greece, and none of the existing ones had been translated into the Greek language. The aim of this study was to develop and validate the A' TEST: a comprehensive school readiness tool to be administered individually to Greek children prior to school entrance.

Material and Methods

Sample

The sample consisted of 2002 preschool children recruited from 80 kindergartens in the Athens area. Kindergartens were selected using simple random sampling from a registry provided by the Greek Ministry of Education. The study sample consisted of 1069 (53.4%) boys and 933 (46.6%) girls, with a mean age of 5.8 years old (range: 5.2–6.2 years), who would start going to school the following year.

Instruments

Test of Visual-Perceptual Skills-Revised (TVPS-R) and Test of Visual Motor Skills-3 (TVMS-3)

The TVPS-R and TVMS-3 were assessed by an experienced pediatric occupational therapist, with individual scores reported for every child. These scores were also transformed into five ordinal categories, the first three being underachievers, i.e., children with severe, mild and possible difficulties, and the other two, achievers (medium and high).

The A' TEST (see Appendix A)

The selection and implementation of the items included in the A' TEST involved focus group discussions by members of the Child Developmental Assessment Unit of the Medical School of the University of Athens, who had considerable clinical experience.

The verbal subtest is an overall measure of the child's ability to reason verbally. It assesses children's ability to listen to a question, draw upon information learned from both formal and informal education, reason through an answer and express their thoughts aloud.

Table I. Classification of Children According to Their A' TEST Score Subscales in Absolute Numbers and Percentages.

	Critical reasoning	Language skills	Abstract thinking	Visual perception	Visual motor skills	Organizational skills
Severe difficulty	38 (1.9%)	30 (1.5%)	68 (3.4%)	38 (1.9%)	12 (0.6%)	
Mild difficulty	100 (5.0%)	120 (6.0%)	60 (3.0%)	130 (6.5%)	110 (5.5%)	
Possible difficulty	54 (2.7%)	48 (2.4%)	130 (6.5%)	166 (8.3%)	70 (3.5%)	164 (8.2%)
Medium achiever	1564 (78.2%)	1590 (79.5%)	1434 (71.7%)	1504 (75.2%)	1172 (58.6%)	1476 (73.8%)
Advanced achiever	242 (12.1%)	216 (10.8%)	310 (15.5%)	164 (8.2%)	638 (31.9%)	358 (17.9%)

Table II. Mean Scores ± Standard Deviations of the A' TEST Visual Perception and Visual Motor Skills Subscales and the TVPS-R and TVMS-3 Tests According to the Gender of Study Participants; Gender Comparisons of the Means with the Independent Samples t-test.

Subscale	Boys	Girls	p (t-test)
Visual perception (A' test)	12.65±2.32	13.09±2.45	<0.01
TVPS-R	6.64±1.33	6.85±1.43	<0.01
Visual motor skills (A' test)	9.55±1.98	10.03±2.01	<0.01
TVMS-3	19.05±4.07	19.52±4.73	<0.01

Abstract thinking: This part of the test consists of 3 questions asking how two objects are alike/similar regarding their use. E.g., How are a pencil and a marker alike?

Critical reasoning: This consists of 3 questions about social situations or common concepts of right/wrong. This task assesses children's ability to examine a problem and find solutions. E.g., Why should young children not play with knives?

Language skills: This consists of 3 questions involving sentence completion. The examinee is given an unfinished sentence and asked to find the missing word based on the sentence's content. Each sentence involves clues that lead to a specific word. This part of the test assesses working memory and children's language ability with respect to choosing the right form of a word to complete a sentence. E.g., In the morning there is light; at night there is.....?

Scores assigned to answers in the verbal subtest ranged from 0 to 2: two for the right answer without help; one for the right answer with encouragement from the examiner, as indicated in the test's instruction manual; and zero for the wrong answer or no answer.

Visual perception: Children are given rows of symbols and target symbols, and asked to mark whether or not the target symbols appear in each row.

Visual motor skills: Children are asked to copy 5 shapes, in order to assess their drawing accuracy and spatial perception skills.

Organizational skills: This part of the test consists of 3 cards describing a short story. It assesses children's ability to focus their attention and quickly scan, discriminate between and sequentially order visual information. It requires planning ability.

As in the case of the TVPS-R and TVMS-3, the scores for each subtest were transformed into five ordinal categories (severe difficulty, mild difficulty, possible difficulty, medium achievers and high achievers). Additionally, based on the scores of all the subtests, the children were categorized into two major groups corresponding to the values of a binary variable characterizing their school readiness (yes/no). At the same time, the kindergarten teachers were requested to fill out an evaluation form for each child (see Appendix B), based on which the conclusion about the teacher's opinion was reached. This was a binary decision as to whether a child was school ready or not.

Two years later, in order to examine the predictive value of the A' TEST, 10% of the original sample (200 children) were randomly invited for evaluation by their teachers, with parental consent. The random selection followed this pattern: 30 of the randomly invited children belonged to the group originally characterized as not being school ready, and the rest (170 children) were randomly selected from among those originally characterized as school ready. The teacher's evaluation (see Appendix C) also led to a binary decision as to whether the child

Table III. Sensitivity, Specificity, PPV and NPV of the A' TEST Evaluation with Respect to the Kindergartens Teachers' Evaluations.

	Estimated value	95% confidence interval	
		Lower	Upper
Sensitivity	79.4%	72.5%	85.0%
Specificity	97.7%	96.3%	98.3%
Positive predictive value	77.0%	69.8%	82.6%
Negative predictive value	98.0%	97.2%	98.6%

Table IV. Sensitivity, Specificity, PPV and NPV of the A' TEST Evaluation with Respect to the Schoolteachers' Evaluations two Years Later.

	Estimated value	95% confidence interval	
		Lower	Upper
Sensitivity	93.3%	76.5%	98.8%
Specificity	99.4%	96.3%	99.9%
Positive predictive value (PPV)	96.6%	80.4%	99.8%
Negative predictive value (RHV)	98.8%	95.4%	99.8%

had learning difficulties or not. The reason why the reevaluation was performed two years rather than one year after the child's entry into primary school was twofold: first, to allow for the child to fully adapt to the new school conditions, and second, to allow for the schoolteacher to form a comprehensive assessment of the child.

Statistical analysis

The structure validity of the A' TEST was assessed with exploratory factor analysis (EFA) using the principal components approach. Kaiser-Meyer-Olkin (KMO) values >0.5 indicate robust estimation. The Kaiser criterion (eigenvalue >1) was used in order to determine the number of extracted components to be retained for further analysis, while varimax rotation was applied to the extracted components in order to increase their interpretability. The convergent and discriminant validity was confirmed with confirmatory factor analysis (CFA). Confirmatory fit indices (CFI) >0.90 and root mean square error of approximations (RMSEA) <0.10 indicated good model fit. Cronbach's α reliability coefficient was calculated as a measure of internal consistency. According to Nunnaly's criterion, a Cronbach's α value >0.7 defines an acceptable consistency between the examined items.

Continuous variables were presented as mean ± standard deviation (SD) and between-group differences were tested with the independent samples t-test and their correlations with Pearson's correlation coefficient. Statistical significance was set at 0.05. Ordinal and binary categorical variables were presented as absolute frequencies and percentages. Chi-square tests were applied to test the homogeneity of their distributions. Kendall's tau-c was calculated to examine the level of agreement between categorical variables.

Finally, cross-tabulation of binary variables resulted in 2x2 contingency tables, yielding absolute frequencies of true positives (TP), true negatives (TN), false positives (FP) and false negatives (FN), from which calculations produced the values of sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) with their 95% confidence intervals (CI).

Results

Structure, convergent and discriminant validity and reliability of the A' TEST

Exploratory factor analysis using the principal components approach applied to the original 21 items extracted six components that explained 76% of the total variability. The items that entered into each of the six components perfectly matched the constructs of the six subtests (structure validity). When Confirmatory Factor Analysis (CFA) was applied, the goodness-of-fit of the 6-component model confirmed (CFI=0.895 and RMSEA=0.033) the theoretical construct of the A' TEST school readiness dimensions to the sample data (convergent and discriminant validity). Finally, Cronbach's α reliability coefficient for the A' TEST was 0.84, revealing very good internal consistency of the included items.

Classification of children with the A' TEST

In general, the different A' TEST subsets showed a similar pattern of distribution (Table I). More than 50% of children were classified as medium achievers in all A' TEST subsets. In five of the six subsets, almost 90% of children were medium or advanced achievers. However, when the children in each subtest were divided into two groups (children with and without learning difficulties), significant differences were observed.

As figure 1 shows and as is proven by the chi-square test of homogeneity ($p<0.01$), the proportion of children who had difficulty in performing the tasks varied significantly between the different tests. Specifically, with

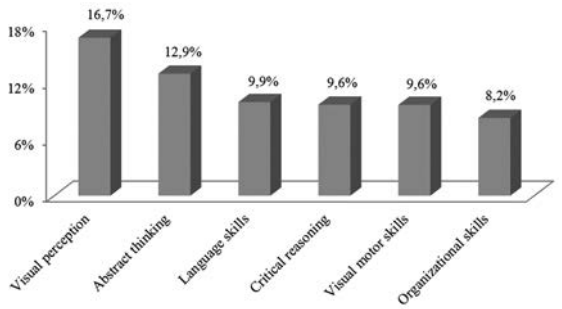

Fig. 1. Proportion of children who encountered difficulty in performing the tasks in the six subtests.

regard to visual perception skills the proportion of non-achievers was as high as 16.7%, and for abstract thinking the proportion was 12.9%. For the other four subtests the proportion was below 10%.

Concurrent validity of the A' TEST

Pearson's coefficient between visual perception as measured by the A' TEST and by the TVPS-R was r=0.90 (p<0.001), and between visual-motor coordination results from the A' TEST and the TVMS-3 was r=0.60 (p<0.001). Moreover, Kendall's tau-c showed a very good level of agreement in the classification between achievement levels in both tests. Specifically, Kendall's tau–c between the TVPS-R and A' TEST visual perception subscales was 0.88, and between the TVMS-3 and A' TEST visual-motor coordination subscales was 0.92.

Furthermore, a sensitivity analysis revealed the stability of the A' TEST visual perception and visual motor skills subtests, finding the same patterns of statistically significant differences between the two genders as the TVPS-R and TVMS-3 (see table II).

Overall, of the 2002 children examined, the A' TEST predicted that 182 (9.1%) of them were not school ready and that the other 1820 (90.9%) were school ready. Comparison between children's school readiness levels (yes/no) according to the A' TEST and the kindergarten teachers' evaluations also demonstrated a high level of accuracy in the detection of potential learning problems in children. Importantly, using the A' TEST, we detected overall readiness levels that were almost identical to those obtained through teacher evaluations. Indeed, Kendall's tau-c coefficient was 0.94, corresponding to the high level of observed agreement between the two procedures. Of the 182 children predicted by the A' TEST to have learning difficulties, teachers confirmed this prediction for 139 children (TP) and disagreed in 42 cases (FP). Likewise, of the 1820 children predicted by the A' TEST not to have learning difficulties, teachers confirmed this prediction for 1784 children (TN) and disagreed in 36 cases (FN), giving a total of 78 (3.9%) cases in which there was disagreement. From the above, the corresponding indices, shown in table III, were calculated, which confirmed the high level of agreement of the A' TEST with the kindergarten teachers' evaluations.

Predictive validity of the A' TEST

The predictive value of the A' TEST was measured in a sample of 200 children who were re-assessed by their teachers two years after initial examination. Teacher evaluations were compared to the A' TEST results in order to estimate the predictive sensitivity and specificity of the instrument. Of the 30 children predicted by the A' TEST to have learning difficulties, teachers confirmed this prediction for 29 children (TP) and disagreed in only one case (FP). Likewise, of the 170 children predicted by the A' TEST not to have learning difficulties, teachers confirmed this prediction for 168 children (TN) and disagreed in only 2 cases (FN), giving in total only 3 (1.5%) false predictions. From the above, the corresponding indices, shown in table IV, were calculated, which confirmed the high level of accuracy of the A' TEST in the primary detection of children with learning difficulties.

Discussion

The present study describes the development, application and validation of the A' TEST, a screening tool administered individually to children prior to school entry. The A' TEST is an easily applied tool that examines a comprehensive range of cognitive skills in children in order to determine their readiness for school entry.

The current findings showed that the A' TEST is a valid and appropriate screening tool for school readiness, with evidence of structure, convergent, concurrent and discriminant validity and reliability, as well as predictive validity. The A' TEST demonstrated high levels of accuracy in detecting children with learning disabilities (concurrent validity) and very good internal consistency (reliability). The cognitive subsets of

the A' TEST that related to visual-perceptual skills and visual-motor skills correlated very well with the standardized TVPS-R and TVMS-3 scales. The A' TEST also showed a high correlation with the kindergarten teachers' evaluations for determining school readiness. Moreover, in children who were evaluated by their schoolteachers two years after initial assessment, the A' TEST demonstrated almost perfect predictive validity for detecting children with learning difficulties. The high positive and negative predictive values bear the strongest evidence for the necessity of utilizing the A' TEST as a standard screening procedure for Greek children prior to school entrance. The aim of course is not segregation but its exact opposite, i.e., identification of children who may encounter potential difficulties in school so that they may be assisted to integrate seamlessly with the rest of the class.

Nonetheless, it is important to emphasize that the A' TEST is to be utilized solely as a screening measure that may identify children who require more comprehensive evaluation. The main limitation of this study is that it is not truly multi-domain, inasmuch as it does not incorporate an overall behavioral characteristics checklist or screening for attention-deficit hyperactivity disorder (ADHD)-like symptoms. Also, although the children were checked for auditory and visual acuity, this examination was not comprehensive. Bearing in mind that it has been shown that uncorrected refractive errors were connected with school failure[42], it must be conceded that unidentified refractive errors may be a confounding factor in the assessment of visual perception.

To the best of our knowledge, this is the first attempt in Greece to screen preschool children for school readiness, and to use such a large sample. Overall, in the current sample, the A' TEST shows 9.1% of children examined as not being school ready. Practically the same percentage was indicated by the kindergarten teachers' evaluations. This is an alarming proportion, especially in view of the finding that almost all of these predicted cases turned out to be, according to the schoolteachers' evaluations after two years, children with learning difficulties. Even more disturbing is the fact that in the area of visual perception—crucially important for children who are about to attend school, bearing in mind that learning is very much centered on vision—this proportion rises to 16.7%. Abstract thinking also seems to require special attention. These issues need to be addressed as early as possible.

In conclusion, the A' TEST is proven to be an appropriate screening tool for school readiness, with evidence of structure, convergent, concurrent and discriminant validity and reliability, as well as predictive validity in detecting children with learning difficulties. School professionals can use the A' TEST with confidence to screen children entering school.

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