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The Validity and Reliability Study of TONI-3 Test for 14-17 Aged Children

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ABSTRACT

Introduction: Since there are not enough scales to evaluate the cognitive performance of adolescents in Türkiye, the aim of this study is to conduct a reliability and validity study of the Test of Nonverbal Intelligence-3 (TONI-3) for individuals aged between 14 and 17.

Methods: A total of 566 children between the ages of 14–17 were included in the study. A form of TONI-3 test was administered to all participants. Test-retest and parallel form application were made for reliability analyses, and Raven Standard Progressive Matrices Test (RSPM) and Naglieri Nonverbal Ability Test (NNAT-I) tests were applied for validity analyses.

Results: It has been found that the TONI-3 Test has a high reliability with an average reliability coefficient of 0.92. It was determined that there was a high, positive and significant relationship between Form A and Form B of the TONI-3 Test (r=0.76, p<0.01). The correlation coefficient between the scores was found to be 0.83 between the first application of the TONI-3 test and the test repeated after 4 weeks. A high, positive and significant correlation was found between TONI-3 Test, RSPM Test and NNAT-I (r=0.69, p<0.01; r=0.81, p<0.01).

Conclusion: This study revealed evidence of the reliability and validity of the TONI-3 test between the ages of 14–17. This is the first study of the TONI-3 test in this age group. It is thought that clinicians can practically evaluate cognitive abilities in children who are clinically referred to or determined to have behavior disorders at school through this test.

Keywords: Adolescents, standardization, TONI-3, validity and reliability

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INTRODUCTION

Intelligence tests, which can be applied in the mother tongue of students, may cause language-related problems in the assessment of intelligence due to cultural differences (1,2). Nonverbal intelligence tests, on the other hand, are designed to eliminate the bias stemming from language, cultural and socioeconomic differences (3,4). Nonverbal intelligence tests are preferred to measure intelligence when it comes to hearing impairment, autism spectrum disorder, learning disability, and language impairment (1,5–7). It is also used in the diagnosis of children whose mother tongue is not the language of that country and gifted children from low socioeconomic background (8,9).

The Test of Nonverbal Intelligence-3 (TONI-3), which is one of the nonverbal intelligence tests and widely used in the world, also distinguishes itself from more traditional intelligence tests by offering a language-independent management option (10,11). The TONI-3 is a nonverbal, language-independent test with minimal motor requirements. It predicts intellectual competence by evaluating an individual's ability to solve new abstract/figural problems (10,12). In validation studies conducted with the TONI-3 test, significant relationships were found with various other tests. In validation studies, the TONI-3 test demonstrated significant relationships with several other assessments, including the Leiter International Performance Scale –revised (13), the Matrix Reasoning subtest (14) of the Wechsler Adult Intelligence Scale-III, and the Analogical Reasoning subscale (15) of the Universal Nonverbal Intelligence Test. Additionally, moderate positive correlations were observed between the TONI-3 test and the four main indexes of the Wechsler Intelligence Scale for Children, 4th ed. (WISC-IV) (10,13–15).

Nevertheless, it is crucial to note that the observed correlations highlight the TONI-3 test's moderate proficiency in assessing nonverbal cognitive abilities within the specified indexes. Additionally, these correlations

Highlights

- **TONI-3 has high reliability with an average reliability coefficient of 0.92.**
- **The correlation coefficient between TONI-3 Form A and Form B total scores is 0.76.**
- **TONI-3 scores were not significantly different between genders..**
- **The correlation coefficient between TONI-3 and RSPM total scores is 0.69.**
- **The correlation coefficient between TONI-3 and NNAT-I total scores is 0.81.**

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likely reflect shared variance, which represents common underlying factors related to general cognitive ability.

The reliability and validity study of the TONI-3 Test for the age of 7–11 in Türkiye was carried out by Korkmaz et al., (2018) and the test has begun to be used in the national literature (16–18). Since there are not enough scales to evaluate the cognitive performance of adolescents in Türkiye, especially in clinical studies, the aim of this study is to study the reliability and validity of the TONI-3 Test between the ages of 14–17. Thus, clinical psychiatrists, psychologists and specialists will be able to make a rough clinical definition (15).

METHODS

Samples

The population of the research consists of 55,860 children attending secondary education in Aydin (19). In order to determine the sample of the research, 1 science high school, 1 qualified Anatolian high school, 1 address-based Anatolian high school and 2 vocational high schools in Efeler district were selected. The research was carried out with children studying in these designated schools. Since statistical methods based on correlation analysis were used in this study, it was considered important to conduct a sampling study 10 times the number of items in order to obtain more accurate results (20). The TONI-3 Test consists of 45 items to be administered to the participants in the 6–89 age group, and the sample group of the study consisted of a total of 566 children aged 14–17, taking into account possible data losses and parametric test criteria.

Participants

Considering the sociodemographic characteristics of the children participating in the study, it was seen that 281 (49.6%) girls and 285 (50.4%) boys took part. According to age distribution, it was determined that 147 children (26%) were 14 years old, 153 children (27%) were 15 years old, 148 children (26.1%) were 16 years old, and 118 (20.8%) were 17 years old. According to their education level, 193 (34.1%) of the children are 9th grade, 152 (26.9%) are 10th grade, and 221 (39%) are 11 th grade.

Data Collection Tools

Test of Nonverbal Intelligence-3 (TONI-3): Brown et al. (1997), an aptitude test consisting of 45 items, TONI-3 is used to evaluate the general mental abilities of individuals between the ages of 6–89. In the standardization study in the United States, the Cronbach Alpha internal consistency reliability coefficients for the A and B forms of the test ranged from 0.89 to 0.97 (11). Its adaptation and standardization in Türkiye were carried out by Korkmaz et al. (2018) in a sample of 631 children aged 6–11. In this study, the Kuder-Richardson -20 internal consistency reliability coefficient for formula A of TONI-3 was found between 0.86 and 0.95, and between 0.90 and 0.93 for Form B (18).

Raven Standard Progressive Matrices Test (RSPM): The Turkish adaptation and standardization of RSPM, which was developed by Raven & Court (1993) to measure general ability and visual-spatial perception (21), was performed by Şahin and Söyle (1993) in a sample of 2277 children aged 6–15 years. has been carried out (22). The two-half reliability of the test for the whole sample was found to be 0.91, and the correlation between the subtests was found to vary between 0.58 and 0.95.

Naglieri Nonverbal Ability Test (NNAT-I): Developed by Jack Naglieri in 2003, NNAT-I is a 72-item nonverbal ability test used in participants aged 5–17 years to assess their reasoning skills. In the standardization study in the United States, as a result of internal consistency reliability analyzes for age groups, the Cronbach Alpha internal consistency reliability coefficients of the test were found to be between 0.89 and 0.95. NNAT-I has an average reliability coefficient of 0.91 (9). Its adaptation and standardization in Türkiye were carried out by Kavruk and Bildiren (2022) on children aged 5–9 years. The Cronbach Alpha coefficients were found to be between 0.80 and 0.88, and the average reliability coefficient was determined to be 0.88. Reliability for Form B was calculated as 0.93 for participants aged 5–9 years, and high correlations (0.87, 0.88) were obtained in test-retest analyzes (23).

Data Collection

The data of the study were collected between March 2023 and June 2023. In accordance with the application instructions of the TONI-3 test, the application was carried out in groups of 20 people in one session. The average test time was between 25 and 30 minutes. The data collection process was carried out on Form A of the TONI-3 test and Form B was administered to 51 children at 5-day intervals to examine its correlation with Form B. In addition, test-retest was applied to 81 children who were administered TONI-3 test at 4-week intervals. For validity analysis, RSPM Test was applied to 116 children and NNAT-I test was applied to 42 children in one week.

Statistical Analysis

To analyze the gathered data statistically, numerical and percentage distributions were employed to identify the descriptive characteristics of the children. To assess the measurement tool's reliability, evaluations were conducted on test-retest reliability, parallel form reliability, and reliability coefficient based on age. Gender's impact on TONI-3 scores was determined using the T-Test, while the one-way analysis of variance (ANOVA) was utilized to explore potential differences between TONI-3 scores and age groups. In terms of validity analysis, the Pearson Product Moments formula was applied to calculate the correlation levels between the TONI-3 Test, Raven Standard Progressive Matrices Test, and Naglieri Nonverbal Ability Test.

Ethical approval for this study was obtained from the Aydin Adnan Menderes University Educational Research Ethics Committee dated February 2, 2023 with protocol number 2023/002.

RESULTS

The objective of this study is to assess the TONI-3 Test's efficacy in measuring cognitive abilities in children within the 14–17 age range. Furthermore, the study aims to establish the psychometric properties of this assessment tool. For this purpose, reliability and validity analyzes were carried out and the findings were presented in tables.

Table 1 presents the reliability coefficients calculated for different age ranges, along with the corresponding standard errors. The results indicate that the TONI-3 Test exhibits high reliability, with an average reliability coefficient of 0.92.

When Table 2 is examined, the average score was found to be 33.15 in the first application of TONI-3, while the average score was found to be 34.02 after 4 weeks of application. The correlation coefficient between the scores was calculated as 0.83 between the first application and the test re-application after 4 weeks (Table 2). These results show that the TONI-3 Test gives consistent results over time and age.

As a result of the examination of Table 3, it was determined that the average of the TONI-3 Test for Form A was 33.15, and the average of B Form was 26.25. When the differences between Form A and Form B were examined, it was found that the mean standard score difference was 0.35. It is observed that there is a high, positive and significant correlation between Form A and Form B of TONI-3 Test ($r=0.76$, $p<0.01$). The correlation coefficient between the total scores of the two forms was calculated as 0.76.

Upon examining Table 4, it was observed that there was no significant difference in TONI-3 scores based on gender (t (564)=0.242, p>0.01).

According to the findings presented in Table 5, a significant difference was observed between TONI-3 scores and calendar ages (F (3,562)=4.445, p<0.01). Post-hoc analysis using the Scheffe test revealed that the TONI-3 scores of 17-year-old children ($\bar{x}$=35.31) were significantly higher than those of 14-year-olds ($\bar{x}$=32.20) and 15-year-olds ($\bar{x}$=32.71). Conversely, no significant difference was observed between the 17-year age group and the other age groups assessed.

As a result of the examination of Table 6, it was determined that the average of the TONI-3 Test was 33.15, the average of the RSPM Test was 47.78, and the average of the NNAT-I Test was 52.79. A strong, positive, and statistically significant correlation was observed between the TONI-3 Test and the RSPM Test (r=0.69, p<0.01). The total scores of the two tests yielded a correlation coefficient of 0.69, indicating a high level of association. Similarly, a strong, positive, and statistically significant correlation was found between the TONI-3 Test and the NNAT-I Test (r=0.81, p<0.01). The total scores of these two tests displayed a correlation coefficient of 0.81, suggesting a substantial relationship between them.

Table 1. Cronbach Alpha coefficients by age

Age	N	Cronbach alpha coefficient	SE_E
14 age	147	0.91	4.5
15 age	153	0.91	4.5
16 age	148	0.93	3.97
17 age	118	0.92	4.24
Toplam	566	0.92	4.24

Standard estimation errors were calculated using the following formula:
$SE_E = 15\sqrt{1 - r_{xx}}$ (r_{xx})

Table 2. Test-retest reliability

	N	$\bar{x}$	SS	r
TONI-3 (First application)		33.15	8.00	
Re-test (4 weeks)	81	34.02	6.60	0.83**

TONI-3: Test of Nonverbal Intelligence-3
**: p<0.01

Table 3. Parallel form reliability

	N	$\bar{x}$	SS	r
TONI-3 (A Form)		33.15	8.00	0.76**
TONI-3 (B Form)	51	26.25	7.65	

TONI-3: Test of Nonverbal Intelligence-3
**: p<0.01

Table 4. T-test results of TONI-3 scores by gender

Gender	N	$\bar{x}$	s	Sd	t	p
Girl	281	33.09	8.19	564	1.17	0.242
Boy	285	33.84	7.16			

Table 5. Descriptive statistics of TONI-3 scores by calendar age

Yaş	N	$\bar{x}$	SS
14 age	147	32.20	7.74
15 age	153	32.71	7.40
16 age	148	34.03	8.05
17 age	118	35.31	7.16

Table 6. Correlation of TONI-3 with RSPM and NNAT-I

	N	$\bar{x}$	SS	r
TONI-3		33.15	8.00	
RSPM	116	47.78	6.10	0.69**
NNAT-I	42	52.79	11.77	0.81**

NNAT-I: Naglieri Nonverbal Ability Test; RSPM: Raven Standard Progressive Matrices Test; TONI-3:Test of Nonverbal Intelligence-3
**: p<0.01

DISCUSSION

In the research, the reliability and validity of the TONI-3 nonverbal intelligence test for participants between the ages of 14–17 was made and a norm table was prepared for this age range. According to the reliability and validity analyzes obtained, data indicating that the test would be applicable in this age range was determined.

In our study, Cronbach's alpha reliability coefficient of TONI-3 Test, test-retest method and parallel form reliability were applied for internal consistency within the scope of reliability analyzes of the Scale. The Cronbach's alpha coefficient was 0.91 for 14 and 15 years, 0.93 for 16 years, 0.92 for 17 years, and 0.92 for all ages. In the internal consistency analyzes of Brown et al.'s (1997) TONI-3 test, Cronbach's alpha reliability coefficient was found to be between 0.89 and 0.97 between the ages of 6–89 (11). Korkmaz et al., (2018) found that the internal consistency reliability coefficients were 0.86–0.95 in the 7–11 age range. In the study of Biller and Korkmaz on gifted children, the Cronbach alpha internal consistency reliability coefficient was found to be 0.92 (18). Similar to previous studies, it can be said that the reliability coefficients were high in our study. Brown et al., (1997) reliability coefficients in the test-retest study were 0.90, Korkmaz et al. (2018) was found to be 0.65 in their study. Considering the test-retest reliability coefficient of 0.85 in our study, it reveals that TONI-3 test scores are stable over time. In addition, the parallel form reliability coefficient of 0.76 also supports the time invariance of the test in parallel with other studies (11,18).

In order to test whether the TONI-3 test measures the same construct regarding intelligence, the relationship between the RSPM and the NNAT-I was analyzed and convergent relationships were determined between the tests. A recent study in Brazil showed a correlation of 0.62 between the TONI-3 test and the SnijdersOomen Nonverbal Ability test, and 0.53 degrees between the Colored Progressive Matrices Test (CPM) (24). Again, in a study conducted in India, it was revealed that the TONI-3 test has moderately convergent validity to the CPM test (r=0.48) and has a more successful construct validity than the CPM Test in dividing intelligence into groups (25). In the national nonverbal intelligence test development study of Bildiren et al., (2021), a 0.67 degree correlation was found between the TONI-3 test and the developed nonverbal intelligence test (16). In a recent study to determine the relationship between the knowledge of computational thinking that emerges in the context of general problem solving and the TONI-3 test, a similarly moderate relationship was found (26). In Kavruk and Bildiren's (2022) NNAT-I norm study, TONI-3 was preferred for criterion validity and a moderate correlation was found between the NNAT-I and TONI-3 test in this study. Korkmaz et al., (2018) showed a 0.79 degree correlation between RSPM and TONI in the TONI-3 7–11 age norm study. Considering the validity results of the RSPM and NNAT-I tests and current studies, it is seen that the TONI-3 test provides important evidence for its validity in the 14–17 age group. This result can be attributed to the fact that all three tests are language-independent, focus on figure-based problem solving, evaluate fluent intelligence, and provide one-dimensional measurement.

The fact that TONI-3 test does not differ according to gender shows parallelism with similar studies. Brown et al., (1997) did not differ according to gender in the test development stage. Again, Korkmaz et al. (2018), no difference was found in TONI-3 test scores according to gender. This result is not unique to the TONI-3 test. The NNAT-I test did not reveal a gender difference in the American norm study. Likewise, in Kavruk and Bildiren's 5–9 age NNAT-I test reliability and validity study, no significant difference was found between NNAT-I scores according to gender. The same result is valid for the CPM test, which is another nonverbal ability test. In the study conducted by Bildiren et al., (2017) in the 4–6 age group, CPM test scores did not differ according to gender (27). The results of our study and other studies show that intelligence measured by nonverbal tests does not differ according to gender. According to this result, it can be said that when the TONI-3 test is preferred in clinical evaluations, the test can be applied regardless of gender.

It is seen that TONI-3 test scores differ according to age levels in our study. Average scores increase with increasing age. However, it is seen that the 17age group differs significantly compared to the 14 and 15 age groups. There may be different reasons for this result. Foremost, the fact that the number of age groups was a certain number may have caused this result. Another reason may be related to the adolescence period. In a study conducted by Ramsden et al. (2011), the researchers investigated the relationship between fluctuations in measured intelligence and brain development using neuroimaging techniques. Their findings indicated that both verbal and nonverbal intelligence can experience fluctuations, either increasing or decreasing, during the teenage years (28). The study highlighted the potential for an individual's intellectual capacity, relative to their peers, to change during adolescence. It was suggested that unexpected declines in intelligence observed in various age groups may be specifically associated with adolescence.

Due to its language and cultural independence, the TONI-3 test can serve as a valuable tool for predicting cognitive processes and evaluating the cognitive abilities of individuals from diverse linguistic and cultural backgrounds. It is particularly useful for identifying gifted individuals across various cultures and language groups, assessing individuals with hearing impairments, language or speech disorders, and identifying individuals with intellectual disabilities. The TONI-3 test finds extensive application in both individual and group settings, making it advantageous for student screening purposes.

As a result, nonverbal ability assessments provide an alternative opportunity to determine the performance of children with linguistic, physical, auditory and cultural differences. Nonverbal cognitive ability tests are designed to assess general cognitive abilities. They employ procedures that minimize or eliminate the need for receptive and expressive language skills in test-takers. These tests are commonly utilized in clinical evaluations to evaluate individuals' cognitive functioning.

The TONI-3 test is a nonverbal intelligence test preferred in the literature among nonverbal intelligence tests. Our study revealed evidence of the reliability and validity of the TONI-3 test between the ages of 14–17. This is the first study of the TONI-3 test in this age group. Clinicians can practically assess cognitive ability in children who are clinically referred or determined to have conduct disorder at school with this test. However, due to the one-dimensional approach of cognitive ability, it is recommended to perform a more comprehensive assessment such as Wecshler intelligence scales for a comprehensive assessment with this test. Analyzing verbal, numerical and nonverbal intelligence together will provide a more accurate assessment.

Ethics Committee Approval: Ethical approval for this study was obtained from the Aydin Adnan Menderes University Educational Research Ethics Committee dated February 2, 2023 with protocol number 2023/002.

Informed Consent: Informed consent was obtained from both the participating children and their parents.

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