Psychological Test and Assessment Modeling, Volume 61, 2019 (3), 263-283

Validity of the Anadolu-Sak Intelligence Scale in the identification of gifted students

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Abstract

Anadolu-Sak Intelligence Scale (ASIS) is the first intelligence scale developed and normed in Turkey. In this study, the concurrent validity of the ASIS was investigated. A total of 98 gifted and 232 average students were administered the ASIS. Gifted students' mean IQ (135) on the ASIS was found to be above the traditional cutoff (130 IQ). ASIS general intelligence index was the best predictor of giftedness, followed by the Fluid Reasoning Index, the Crystalized Knowledge Index and the Memory Capacity Index. Correlations between the ASIS indexes and academic achievement in math, science, language and social studies for average students were high, ranging from .50 to .83. The General Intelligence Index had the highest correlations with academic achievement in all the subjects with a mean correlation of .81 at the fourth grade and .75 at the fifth grade. Results provided strong support for the validity of the ASIS in relation to academic achievement and giftedness.

Keywords: Anadolu-Sak Intelligence Scale, ASIS, gifted children, identification

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Note. This research was supported by the Anadolu University Scientific Research Projects Office (Grant No: 1504E151).

Introduction

The origin of the contemporary intelligence testing is acknowledged to start with Alfred Binet and Simon's test of intelligence in the early 19th century (Wasserman, 2012). The 1911 revision of this test was translated to Turkish by Alaeddin Govsa in 1915 (Govsa, 1915) before Terman adapted and revised it in the United States. Since the first translation of Binet's test in Turkish, numerous intelligence tests have been translated and adapted in Turkey, such as Wechsler Intelligence Scale for Children-Revised, Stanford Binet L-M, Cognitive Assessment System, Raven's Progressive Matrices, Wechsler Nonverbal Scale of Ability, Wechsler Primary and Preschool Scale of Intelligence, Kaufman Brief Intelligence Test, Leiter International Performance Scale, and most recently Wechsler Intelligence Scale for Children-IV. In the last 100 years, researchers in Turkey have had sufficient experience and scientific knowledge on intelligence testing, but they have not developed their own intelligence tests that fit Turkish Culture and geography. The Anadolu-Sak Intelligence Scale (ASIS) is the first test of intelligence developed, standardized and normed in Turkey (Sak et al., 2016).

Even though the main purpose of the Binet test was to identify children with an intellectual risk, its methodology has been used in most measurement practices of intelligence (Machek & Plucker, 2003). Starting with Terman's adaptation and revision of the Binet test (1916), intelligence tests have become the primary instrument in measuring giftedness. During the past decades, scientific research on intelligence and intelligence testing have led new theoretical and technical advances in the development of intelligence tests, such as the use of the Cattell-Horn-Carroll model as a theoretical framework, and the continuous norming to obtain age-adjusted scores (Lenhard et al., 2018; Schneider & McGrew, 2012).

Although intelligence tests are criticized as being a traditional method to identify gifted students, the use of intelligence tests is still the prevalent method in the identification of gifted students for a number of reasons. First, high intelligence is considered to be the primary component of giftedness. For example, in the United States, 90 % of state definitions of giftedness (McClain & Pfeiffer, 2012) and 99.5 % of school districts' definitions (Callahan, Moon & Oh, 2017) include intellectual giftedness. In line with definitions, 32 % of the states require schools to use intelligence tests in the identification of gifted students (McClain & Pfeiffer). In Turkey, IQ scores are accepted as the single criteria of intellectual giftedness by the Ministry of Education (Sak, 2018). Second, the predictive power of intelligence tests as a single or joint criteria in identifying gifted students has been investigated extensively and proven to be sufficiently strong. Gifted students' mean scores reported in manuals of major intelligence tests were found to be significantly higher than average students' scores (e.g., Ehrler & McGhee, 2008; Kaufman & Kaufman, 2004; Naglieri, Das, & Goldstein, 2014; Roid, 2003; Wechsler, 2014). Third, intelligence tests have a long research history, providing ample scientific evidence for their validity and reliability. Indeed, intelligence is one of the best researched and understood constructs in psychology (Coaley, 2010; Gottfredson & Saklofske, 2009; Warne, 2016). Last, the widespread use of intelligence tests over 100 years created a strong social acceptance and trust for test users.

Contemporary intelligence tests measure higher-order thinking skills and cognitive processes that underlie giftedness. Most essential components of giftedness, such as verbal and visual reasoning and learning, are objectively measured by intelligence tests. Scientific theories of giftedness and research on gifted children show that gifted students share extraordinary characteristics, such as verbal fluency, rich vocabulary, high analytical ability, superior reasoning and logic, high perceptual discrimination, high memory capacity, abstract thinking, and cognitive flexibility (Davis, Rimm, & Siegle, 2011; Geake, 2008; Krisel, 2012) that can be measured by intelligence tests. General ability measured by intelligence tests is one of the prime elements in major theories of giftedness, such as Renzulli's three-ring conception of giftedness and Gagne's differentiated model of giftedness and talent (Gagne, 2003; Renzulli, 2005; see theories in Sternberg & Davidson, 2005). In addition, cultural conceptions of giftedness share common elements, such as reasoning, memory, and perceptual flexibility (Phillipson & McCann, 2007) that are measured by intelligence tests. Similar to other intelligence tests, the ASIS measures several components of intelligence providing evidence about whether a child is gifted or not. In this article, we review the ASIS, present research on its reliability and validity, and then we report our current research study on its criterion validity.

Anadolu-Sak Intelligence Scale

The ASIS is an individually administered test of intelligence for ages 4 to 12 (Sak et al., 2016). The average testing time ranges from 25 to 50 minutes for the full battery, depending on a child's age and test performance. The test was developed using the Cattell-Horn-Carroll (CHC) three-layered hierarchical model of intelligence (McGrew, 2009; Schneider & McGrew, 2012). It provides a three-factor solution (fluid reasoning, crystalized knowledge, and short-term memory) according to the CHC model. The Fluid Reasoning Index (FRI) or G_f includes Visual-Spatial Analogy and Visual Flexibility subtests. The Crystalized Knowledge Index (CKI) or G_c consists of Words-Meanings and Verbal Analogy subtests. The Short-Term Memory Index (SMI) or G_{sm} includes Verbal Short-Term Memory, Visual Span Memory and Visual-Spatial Pattern Memory subtests.

The test provides an additional two-factor solution for the assessment of intelligence for practical uses. The two-factor solution provides verbal IQ and nonverbal IQ indexes, each of which takes 20 minutes for administration. In addition, the ASIS can be administered as a brief battery providing an IQ screening consisting of a verbal (verbal analogies) and a nonverbal subtest (words and meanings), which takes 10 minutes. The General Intelligence Index (GIQ) derives from the administration of seven subtests, the Verbal Intelligence Index is obtained from the three verbal subtests and the Nonverbal Intelligence Index derives from the four nonverbal subtests. The verbal and nonverbal intelligence indexes were specifically factor-confirmed for a practical use to identify gifted children for special education programs based on their performance in verbal or nonverbal domains. The ASIS includes high-end items developed to assess varying levels of giftedness.

Crystalized Knowledge Index

This index consists of two subtests. *Verbal Analogies (VAN) subtest* is a measure of comprehension and verbal reasoning. Items of this subtest were developed using a theoretical framework for structure-mapping and a taxonomy of meronymic relations (Gentner, 1983; Winston, Chaffin, & Herrmann, 1987). Although this subtest involves reasoning, a component of fluid reasoning, it also requires general knowledge and vocabulary to solve analogy problems. More difficult items require advanced vocabulary and general knowledge. *Words and Meanings (WOM) subtest* primarily measures language development and vocabulary knowledge. It also measures comprehension of sentences and understanding words in context. Vocabulary knowledge at the conceptual level is a prime sign of language development and intelligence (Deak, 2014). In the subtest, the examinee is read aloud a sentence and asked to think of a word that could be used in place of a word in the sentence, which can be a synonym or a word with a similar meaning. Some sentences have clues to figure out word meanings.

Fluid Reasoning Index

This index includes two subtests. *Visual-Spatial Analogies (VISA)* has the same theoretical framework with the Verbal Analogies subtest (Gentner, 1983; Winston, Chaffin, & Herrmann, 1987), and therefore measures similar cognitive processes, but through using visual stimuli. Contrary to verbal analogies which involve vocabulary knowledge and language development, solving analogy problems in this subtest does not rely on previously learned knowledge. This subtest consists of 2x2 and 2x3 matrices, measuring nonverbal inductive reasoning through visual-spatial analogies. The examinee is required to examine conceptual relationships to discover how geometric shapes or figures are interrelated and then figure out what completes a matrix. *Visual Flexibility (VIF)* is a measure of visual-spatial ability to solve problems related to spatial relations, visualization, perceptual flexibility, perceptual discrimination, rescaling (Bennett & Warren, 2002), and mental rotation (Cooper, 1975; Takano, 1989). This subtest contains two types of items. The first type is a simple rotation of two-dimensional shapes. The examinee chooses among others which rotated shape fills a hole in a larger shape. The second type of item includes size rescaling of rotated two-dimensional shapes. The examinee is prompted to choose a correctly rescaled and rotated form of a larger shape.

Short-Term Memory Index

The Short-Term Memory index includes three subtests measuring working memory, pattern memory, and verbal short-term memory. *Visual Span Memory (VSM)* is a measure of visual span memory, sequential processing, and working memory. It assesses the capacity to encode information, hold it actively in the primary memory and immediately reproduce stimuli in the same order it is presented (Schneider & McGrew, 2012). Retaining serial order is a critical capacity for a variety of activities (Baddeley, 2012), such as reading and writing. The examinee is shown figures (triangle, square, star, etc.) in a certain order on a line for five seconds and then asked to recall the correct order among several options within 30 seconds. The floor items start with two figures in order and the most difficult item includes nine figures in order. *Visual-Spatial Design Memory* (VSPM) measures the capacity for visual-spatial short term memory. This subtest has two types of items. The first type requires the recall of figures or designs made of triangles on a grid of 2x1, 2x2, 2x3, 3x3, and the like. Both the figure and its location on the grid should be recalled correctly. The stimuli are shown for five seconds and the examinee is required to find the correct option among several within 30 seconds. The second type includes spatial items which include dots on or between two, three or four lines, similar to musical note lines. The examinee has to remember the location of dots. The administration is similar to the grid items. *Verbal Short-Term Memory (VSTM)* measures memory for verbally presented material. This is a short story recall test. A short story recall test measures short-term memory if it does not require delayed recall or multiple exposures (Schneider & McGrew, 2012). A 116-word story is read aloud by the examiner which takes about 50 seconds. Immediately after the story is read, the examiner asks verbal questions about the story. The child is required to recall specific facts, procedures and episodes. Facts include numbers, colors, names, quantity, location, and time.

Validity

Construct Validity. The factorial structure of the ASIS was investigated using Explanatory Factor Analysis (EFA) in a pilot study and Confirmatory Factor Analysis (CFA) in the norm study. Because ASIS was developed based on a theoretical framework provided by CHC model (McGrew, 2009; Schneider & McGrew, 2012), we tested the factorial structure of ASIS to find out whether it fit the CHC three-stratum hierarchical model. EFA was conducted with data collected from 679 children in a pilot study (Sak et al., 2016). Because responses on the ASIS record form are coded as 1 and 0, EFA was conducted from tetraconic correlation matrix (Olson, 1979; Baglin, 2014) using FACTOR program (Lorenzo-Seva & Ferrando, 2006). EFA results showed that all the ASIS subtests were highly and positively associated with a general intelligence factor g, explaining 41.68 % of the total variance with subtest factor loadings ranging from .50 to .79. Although the ASIS g factor was quite strong, a two-factor solution with a higher-order factor g and a three-factor solution with a higher-order factor g were also investigated. Two-factor and three-factor solutions seemed to be more interpretable and psychologically sensible in which the two-factor solution accounted for 54.78 % of the total variance and the three-factor solution accounted for 65.51 % of the total variance.

CFA was conducted as a further investigation of the structure of abilities measured by the ASIS (Sak et al., 2016). Two-factor and three-factor models revealed by explanatory results provided good explanations of the ASIS subtest interrelationships. We tested two models, one with three-factor solution (fluid reasoning, crystalized knowledge, and short-term memory) and another with two-factor solution (verbal intelligence and non-verbal intelligence). Using CFA results, the relative fit of two specified models were compared: 1) A three-factor model placing all vocabulary and verbal analogy subtest scores on the Crystalized Knowledge Index, visual-spatial analogy and visual flexibility subtests on the Fluid Reasoning Index and verbal short term memory, visual span memory and visual-spatial design memory subtest on the Short-Term Memory Index (g is a measure of verbal, nonverbal and memory abilities); 2) A two-factor model placing all verbal scores on the Verbal Intelligence Index and all nonverbal scores on the Non-verbal Intelligence Index (g is a measure of verbal and nonverbal abilities). CFA was conducted using the covariance matrix of normative sample. The two models were compared according to statistics including comparative fit index (CFI), non-normed Fit index (NNFI), root mean square error of approximation (RMSEA) and standardized root mean square residuals (SRMR). CFA results revealed that both of the models were plausible. Fit statistics tended to be slightly better for model 1 positing a three-factor model (G_c, G_f, and G_{sm}). This model yielded higher CFI and NNFI statistics, both exceeding .98 and lower RMSEA and SRMR. RMSEA was found as .060 for model 1 and .067 for model 2; and SRMR was found as .014 for model 1 and .017 for model 2. These findings suggest that ASIS subtests appear to fit as expected according to the hierarchical model of CHC on which ASIS was developed.

Developmental trends. Because intelligence grows rapidly in the early years (Chen & Siegler, 2000), age differentiation is used as a major criterion in the validation of intelligence tests. Intelligence test scores (raw scores) are expected to increase with advancing age (Anastasi & Urbina, 1997). Similar to age, years of schooling correlate with intelligence. In order to examine the developmental validity of the ASIS, children's raw scores in the norm sample were correlated with age and grade (Sak et al., 2016). Correlations ranged from .72 (grade and Fluid Reasoning Index) to .86 (age, grade and General Intelligence Index) for index scores. As expected, subtest correlations were relatively lower, ranging from .50 (grade and visual flexibility) and .51 (age and visual flexibility) to .83 (age and vocabulary). Index correlations are uniformly large (Cohen, 1988), typically exceeding .70 and demonstrating that raw scores of the ASIS increase with age and grade in a relatively constant manner across composite scores, providing developmental evidence for the validity of the ASIS.

Face validity. Being objectively valid is not sufficient for an intelligence test for use in practical settings, rather, it also needs high acceptance by test users. Face validity refers to what a test measures from the point of view of examinees, examiners, or administrators who decide on its use (Anastasi & Urbina, 1997). Perceptions of test users about a particular intelligence test determine their decisions whether to use it or choose another intelligence test to assess a child's intelligence. However, the content of the test is not the only criterion that influences a test user's decision. Other factors, such as easiness in administration, scoring and interpretation and item stimulation for children, affect a test user's decision. This may be called *social validity* of intelligence tests which also comprises face validity (Sak et al., 2016). The face validity of the ASIS was investigated through administering a 40-item questionnaire to 32 trained testers. The questionnaire consisted of items addressing content efficiency, simplicity for administration, simplicity for learning and interpretation and preference. Descriptive analyses yielded a high satisfaction rate with all components. For example, the following items had the highest mean scores: *ASIS measures intelligence; conversion of raw scores into standard scores is easy; administration of ASIS is easy; ASIS manual is sufficient to interpret scores.*

Correlations with other intelligence tests and measures. The validity of the ASIS was investigated using other intelligence tests as well. These tests included the UNIT (Universal Nonverbal Intelligence Test), the nonverbal index of the RIAS (Reynolds Intellectual Assessment System II), WISC-R (Wechsler Intelligence Scale for Children-Revised), and LEITER (Leiter International Performance Scale-Revised). Because UNIT and RIAS did not have a norm in Turkey, only raw scores were used in correlational analyses. Correlations between the general intelligence index of the ASIS and general indexes of other scales were as follows: .78 with the UNIT, .82 with the RIAS (Dulger, 2018) .74 with the LEITER and .88 with WISC-R (DSE, 2017). In another study, the relation of the ASIS scores with humor production ability was investigated (Arslan, 2018). Correlations between the ASIS indexes and humor production ability ranged from .73 to .82, with the General Intelligence Index having the highest relation, followed by the Crystalized Knowledge Index, the Memory Capacity Index and the Fluid Reasoning Index.

Discrimination among special groups is an evidence of criterion-related validity of intelligence tests (Anastasi & Urban, 1997). ASIS was administered to clinically identified children with intellectual disability (N = 48), autism (N= 32), learning disability (N= 89), attention-deficit hyperactivity disorder (N = 102) and gifted students (N = 95) (Cirik, 2018; DSE, 2017; Sozel, 2017). The range of the ASIS scores for these groups were found to be similar to those of clinical groups reported in research on other intelligence tests (e.g., Bracken & McCallum, 1998; Ehrler & McGhee, 2008; Kaufman & Kaufman, 2004; Naglieri, Das, & Goldstein, 2014; Roid, 2003; Wechsler, 2014). For example, the mean score of children with learning disability was 85 for general IQ, 92 for crystalized knowledge and fluid reasoning and 83 for short-term memory. Similarly, children with attention-deficit hyperactivity disorder (ADHD) had lower scores than the normative group. The mean of their general IQ was 82, the means of crystalized knowledge and fluid reasoning were 90 and the mean of short-term memory was 80. Children with autism spectrum disorder had lower scores than the learning disability and the ADHD group. Their mean scores were measured as 63 for general IQ, 74 for crystalized knowledge, 80 for fluid reasoning and 68 for short-term memory (Cirik). Children with intellectual disability had even lower scores. This group scored 47 on general intelligence, 59 on crystalized knowledge, 58 on fluid reasoning and 54 on short-term memory (Sozel).

In addition, two studies were carried out with gifted samples. The first study involved 95 students who were identified as gifted (at or above 130 IQ) using the Wechsler Nonverbal Scale of Ability (WNSA) for gifted education centers run by the Ministry of Education. While they were attending the Centers, they were administered the ASIS to find out how many of these students were also identified as gifted by the ASIS (DSE, 2017). Their mean IQ was measured as 134.75 on the WNSA and 135.14 on the ASIS. The ASIS general intelligence index correctly predicted 71.5 % of these students. The general intelligence index together with the nonverbal index correctly identified 79.05 % of gifted students. In the second study, 43 students who were identified to be gifted using the ASIS and who were attending an enrichment center for the gifted were administered Raven's Standard Progressive Matrices Test (Bildiren, 2018). These students scored an average of 95.5 percentile on the Raven's test. Overall, these results show a strong evidence for the concurrent validity of the ASIS for special education groups.

Reliability

Three types of reliability of the ASIS index and subtest scores were investigated. *Internal consistency* was examined for all age groups (N = 4641) in the standardization sample (Sak et al., 2016). The internal consistency of scores was analyzed using Cronbach's coefficient alpha as the ASIS is a power test. Consistency of scores for the total sample ranged from .97 to .99 for the indexes. The Nonverbal IQ had the lowest coefficient (.97) and the General Intelligence Index had the highest value (.99). Coefficients for the subtests ranged from .81 (verbal-short term memory) to .97 (verbal analogies). The median alpha reliability estimate was .97 for the indexes and .90 for the subtests. Internal consistency analysis by age also showed high reliability estimates, with the lowest consistency (.85) for age 4 and the highest consistency (.98) for age 11. Reliability coefficients by gender also were found to be sufficiently high in a sample of 255 children (Tamul, 2017). The lowest index coefficients were .88 for girls and .84 for boys. The highest coefficients were .97 for girls and .95 for boys.

The test-retest reliability of the ASIS was investigated to assess the consistency of the scores over a period of three weeks (Tamul, 2017). The sample (N = 55) included children aged 5 through 11 years. Correlations between the two administrations were corrected for attenuation (Murphy & Davidshofer, 1988). Coefficients were found to be of sufficient magnitude, providing evidence for the stability of the scores. Correlations ranged from .88 (Nonverbal Index) to .98 (Fluid Reasoning Index) for the indexes and from .66 (visual-spatial design memory) to .85 (visual-spatial analogies) for subtests. A practice effect was evident for all the scores; that is, all the means of the second administration were higher than the means of the first testing.

Last, *interscorer reliability* was investigated to explore whether examinees' scores changed as a result of estimating raw scores and converting raw scores into standard scores by different examiners. Interscorer errors can result from improper application of standard scoring procedures. Seven trained examiners of the ASIS rescored subtest scores in 228 record forms (Tamul, 2017). Correlations between the scorers were .99 for visual-spatial analogies and visual flexibility and 1.00 for the other subtests. These results provide strong evidence for the high reliability of the ASIS scoring procedures.

Current study

Prior research on the validity of the ASIS included construct validity, face validity, developmental validity by age and grade, discrimination validity for special education groups and criterion validity as a relation between ASIS scores and other intelligence tests. The current study involved an investigation of the validity of the ASIS in terms of its relation to academic achievement and its power to predict gifted students who were identified by a combination score of several criteria and were attending a gifted education program. Intelligence and academic achievement are different but strongly correlated constructs (Gottfredson, 2005; Macintosh, 1998) and because of this correlation, intelligence is used as one of the primary predictors of academic achievement (Deary, Strand, Smith, & Fernandes, 2007; Gustafsson & Undheim, 1996; Jensen, 1998; Watkins, Lei, & Canivez, 2007). Due to a theoretical link between academic achievement and intelligence, academic achievement has been used as one of the most prevalent criteria in validating intelligence tests. For example, almost all major intelligence tests are validated against academic achievement as reported in their manuals (e.g., Bracken & McCallum, 1998; Ehrler & McGhee, 2008; Kaufman & Kaufman, 2004; Naglieri, Das, & Goldstein, 2014; Roid, 2003; Wechsler, 2014). Furthermore, intelligence is found to be a powerful predictor of achievement in mathematics, reading, science and social sciences (Lohman, 2005) because academic achievement is partially a result of learning and learning ability is related to intelligence.

Because most conceptions of giftedness include intelligence or general ability as a component of giftedness (see scientific and cultural conceptions of giftedness in Phillipson & McCain, 2007; Sternberg & Davidson, 2005), a precise measure of giftedness is essential evidence for the validity of intelligence tests. Indeed, definitions of giftedness in the early twentieth century were made based solely on the intelligence construct and giftedness was defined as high intelligence with varying levels (Hollingworth, 1926). Therefore, gifted children are expected to score significantly higher on intelligence tests than do average and above average children. Besides high scores, the proportion of gifted children correctly identified by a particular intelligence test is an important evidence for the concurrent validity of this intelligence test. The current study explores two research questions addressing two types of criterion validity of the ASIS: 1) How does the ASIS correctly identify gifted children who are identified by a joint score of two tests? 2) How are children's ASIS scores related to their academic achievement?

Method

Participants

Participants included two volunteer samples. A gifted sample was used for investigating the concurrent validity of the ASIS. The second sample included students with varying levels of intelligence but not identified as gifted (who will be called average students in the rest of the text) and was used to examine the relationship of the ASIS scores with academic achievement. The first sample was composed of 98 gifted students who were participating the education programs of the Center for Research and Practice for High Ability Students (EPTS) at Anadolu University in Turkey. These students were attending fifth (f = 21; m = 35) and sixth grade (f = 19; m = 23) in 30 different schools within the city of Eskisehir. They were identified through the standard identification and admission processes of the EPTS (Sak, 2011, 2016). The admission decision was made based on students' performance on the Test of Mathematical Talent (TMT) (Sak et al., 2008) and

Creative-Scientific Ability Test (Bermejo, Ruiz-Melero, Esparza, Ferrando & Pons, 2016; Ayas & Sak, 2014; Sak & Ayas, 2013). The second sample included 232 students, of whom 68 (f = 32; m = 36) were attending fourth grade at a primary school and 164 (f = 83; m = 81) were attending fifth grade at a middle school in the city of Eskisehir. Fourth graders came from three classrooms; fifth graders came from six classrooms. The ASIS General IQ of this group was quite heterogeneous, ranging from 61 to 141 with a mean of 100.62 and a standard deviation of 17.48.

Instruments

The ASIS was the primary instrument in the study. It was reviewed before. Besides the ASIS, grades (end-of-year-grades) in language (reading and writing), mathematics, science and social studies in fourth and fifth grades were used as criterion measures. Students' performance in all courses in the fourth grade was graded by their classroom teachers as all the courses are taught by classroom teachers in the primary school. Because courses are taught by subject teachers in middle school, students were graded by subject teachers in each course in the fifth grade. Language grades included a combination of reading and writing performance in Turkish. Grading systems in primary and middle schools was the same, with a minimum grade of 1 and a maximum grade of 100.

Data collection and analysis

The ASIS was administered to gifted students by eight trained testers at the EPTS Center on the weekends. Each student was individually tested in a room designed for testing. Average students were individually tested by seven trained testers in a room assigned for testing in their schools during the weekdays. Each student was pulled out from the classroom for testing. Each testing lasted about 40 minutes.

In order to examine the relationship of the ASIS scores with academic achievement, average students' grades in language (Turkish), math, science and social studies were correlated with their scores on the ASIS. A separate correlational analysis (Pearson Product-Moment Correlation) was carried out for fourth and fifth graders because students' achievement was graded by classroom teachers in the primary school, whereas it was graded by course teachers in middle school. Descriptive analysis was carried out for the gifted sample and the percentage of this sample falling at or above 130 IQ, 127 IQ (130 – Standard Error of Measurement) and 120 IQ was estimated to investigate the concurrent validity of the ASIS. Three cutoff scores were used (130 IQ, 127 IQ and 120 IQ) as the ASIS score at 130 IQ has a standard error of measurement of +-3 and as 120 IQ is widely accepted to be a border for superiority.

Results

Concurrent validity: Profile of gifted students

Gifted students' scores on the ASIS are presented in table 1. Their mean general intelligence (GIQ) was found to be 135.34 which is over the traditional cutoff score "130 IQ" for giftedness. Their scores ranged from 114 to 158, with a standard deviation of 10.61, which is lower than the standard deviation of the norm group (SD = 15). This finding shows that the sample is rather homogenous in terms of general intelligence. Further analysis showed that 64.3% of gifted students scored at or above 130 general IQ, 75.5% of them scored at or above 127 IQ and 90% scored at or above 120 IQ.

Index-level analyses showed that gifted students had the highest and lowest individual score on the Fluid Reasoning Index (lowest = 90, highest = 160), with the highest standard deviation (SD = 13.70) whereas they had the highest mean score on the Nonverbal Intelligence Index (M = 132.84) and the lowest mean score on the Short-Term Memory Index (M = 127.43). Tests of paired differences between the General Intelligence Index, the Crystalized Knowledge Index, the Fluid Reasoning Index, and the Short-Term Memory Index showed that all the differences between the General Intelligence Index and the other three indexes were significant, whereas differences between the other three indexes were insignificant. The highest difference was found between the General Intelligence Index and the Short-Term Memory Index; $t(97) = 8.78$, $p < .001$.

Table 1:
Gifted Students' ASIS Scores

Indexes*	Minimum	Maximum	Mean	SD
General Intelligence Index	114	156	135.34	10.61
Crystalized Knowledge Index	104	158	129.04	11.63
Fluid Reasoning Index	90	160	131.38	13.70
Short-Term Memory Capacity	103	153	127.43	11.47
Verbal IQ	104	157	128.47	10.99
Nonverbal IQ	96	158	132.84	12.62
Subtest Scores**				
Visual Span Memory	39	85	61.58	9.27
Verbal Analogies	48	86	69.01	7.26
Visual Flexibility	35	91	66.24	10.71
Visual-Spatial Analogies	44	82	67.77	7.58
Verbal Short-Term Memory	45	80	61.23	8.57
Visual-Spatial Design Memory	40	79	65.61	7.13
Words and Meanings	42	85	64.68	9.21

Note. *IQ scores; **t scores.

Subtest-level analyses showed that gifted students had the highest mean score on the Verbal Analogies Subtest (M = 69.01), with one of the lowest standard deviations, followed by the Visual-Spatial Analogies Subtest (M = 67.77). On the other hand, their lowest score was on the Verbal Short-Term Memory Subtest (M = 61.23), followed by the Visual Span Memory Subtest (M = 61.58). They had the lowest and highest individual scores on the Visual Flexibility Subtest (Lowest = 35; Highest = 91), with the highest standard deviation (SD = 10.71).

Further analyses of paired differences at the subtest level showed that 15 differences of 21 comparisons were significant at 0.01 significance level with the lowest effect size of 0.24 and the highest effect size of 0.72. The following paired differences were not significant: Visual Span Memory-Verbal Short-Term Memory, Verbal Analogies-Visual Spatial Analogies, Visual Flexibility-Visual Spatial Analogies, Visual Flexibility-Visual Spatial Design Memory, Visual Flexibility-Words and Meanings, and Visual Spatial Design Memory-Words and Meanings.

Criterion validity: Relation to academic achievement

Table 2 presents descriptive statistics of academic achievement and the ASIS General Intelligence for 232 average students attending fourth and fifth grades. The ASIS General IQ of this group was quite heterogeneous, ranging from 61 to 141 with a mean of 100.62 and a standard deviation of 17.48 for the total sample. Grade means for the four courses were between 70 and 82. Minimum and maximum grades ranged from low 30s to 100. As seen in the table, similar to variance in general intelligence, variance was sufficiently high in all courses in both grades, with the highest variance in mathematics,

Table 2:
Descriptive Statistics for Academic Achievement and ASIS Scores by Grade

		Scores			
Grade	Variable	Minimum	Maximum	Mean	SD
4	ASIS General IQ	61	139	101.88	15.93
	Mathematics	40.30	98.10	71.06	19.09
	Language	40.60	98.10	74.73	16.69
	Social Studies	42.00	98.40	79.24	14.72
	Science	41.60	99.00	82.59	14.08
5	ASIS General IQ	66	141	100.10	18.10
	Mathematics	32.40	100.00	73.73	17.52
	Language	35.30	98.91	76.68	15.80
	Social Studies	40.50	97.95	78.53	15.01
	Science	40.60	99.50	73.91	16.13

that allowed researchers to carry out correlational analyses between academic achievement and the ASIS scores.

Correlational findings are presented in table 3 and 4. There were significant correlations between all the ASIS indexes and grade in all the courses at .01 significance level in both the fourth and fifth grade. The General Intelligence Index had the highest correlations with grade in all the courses regardless of grade level, ranging from high .70s to low .80s in the fourth grade and from low .70s to low .80s in the fifth grade. The mean correlation was .78. Next, the Crystalized Knowledge Index and the Verbal IQ had the highest correlations with grade (minimum = .70; maximum = .80), with both of them having a mean correlation of .75. Next, the Fluid Reasoning Index and the Nonverbal IQ had the highest correlations with grade (minimum = .59; maximum = .71), with a mean correlation of .64. Compared to the other indexes, the Short-Term Memory Index had the lowest correlations with grade, ranging from .50 to .71, with a mean correlation of .59.

Table 3:
Correlations between ASIS Scores and Academic Achievement for Fourth-Grade Students

	Courses				
ASIS Scores	Math	Language	Social Studies	Science	Index Mean
General Intelligence Index	.82**	.83**	.81**	.77**	.81
Crystalized Knowledge Index	.72**	.80**	.78**	.76**	.77
Fluid Reasoning Index	.69**	.63**	.61**	.58**	.63
Short-Term Memory Capacity	.71**	.64**	.59**	.57**	.63
Verbal IQ	.73**	.81**	.79**	.76**	.77
Nonverbal IQ	.71**	.64**	.62**	.59**	.64
Mean correlation	*.73*	*.73*	*.70*	*.67*	*.71*
Visual Span Memory	.60**	.52**	.52**	.50**	.54
Verbal Analogies	.68**	.71**	.71**	.68**	.70
Visual Flexibility	.33**	.30*	.35**	.34**	.33
Visual-Spatial Analogies	.68**	.62**	.58**	.55**	.61
Verbal Short-Term Memory	.43**	.41**	.41**	.41**	.42
Visual-Spatial Design Memory	.60**	.53**	.46**	.45**	.51
Words and Meanings	.68**	.79**	.77**	.74**	.75
Mean correlation	.57	.55	.54	.52	.55

Note. * $p < .05$; ** $p < .01$.

Table 4:
Correlations between ASIS Scores and Academic Achievement for Fifth-Grade Students

	Courses				
ASIS Scores	Math	Language	Social Studies	Science	Index Mean
General Intelligence Index	.76**	.70**	.71**	.81**	.75
Crystalized Knowledge Index	.72**	.69**	.71**	.78**	.73
Fluid Reasoning Index	.70**	.62**	.60**	.71**	.66
Short-Term Memory Capacity	.59**	.52**	.50**	.61**	.56
Verbal IQ	.72**	.70**	.71**	.79**	.73
Nonverbal IQ	.68**	.60**	.57**	.70**	.64
Mean correlation	*.69*	*.64*	*.64*	*.73*	*.68*
Visual Span Memory	.41**	.38**	.35**	.43**	.39
Verbal Analogies	.68**	.62**	.65**	.72**	.67
Visual Flexibility	.55**	.48**	.43**	.56**	.51
Visual-Spatial Analogies	.67**	.61**	.61**	.70**	.65
Verbal Short-Term Memory	.47**	.46**	.47**	.50**	.46
Visual-Spatial Design Memory	.40**	.31**	.28**	.40**	.35
Words and Meanings	.70**	.69**	.71**	.77**	.72
Mean correlation	*.55*	*.51*	*.50*	*.58*	*.54*

Note. ** $p < .01$.

Correlations between the ASIS scores and grade varied by course and year. First, correlations between the ASIS scores and grade in science were slightly higher in the fifth grade than in the fourth grade. Mean correlations were .65 and .59 respectively. Contrary to this finding, correlations between the ASIS scores and grade in mathematics, social sciences and language were higher in the fourth grade than in the fifth grade. Second, the Crystalized Knowledge Index was more related to academic achievement in all the subject areas than the Fluid Reasoning Index. Mean correlations for these indexes were .77 and .63 for the fourth grade and .73 and .66 for the fifth grade respectively. Third, the ASIS Verbal IQ had a higher correlation with academic achievement in all the courses than the Nonverbal IQ did. Index means were .77 and .64 for the fourth grade and .73 and .64 for the fifth grade respectively. Last, the Short-Term Memory Index was seemingly more related to mathematics achievement than to academic achievement in the other courses.

Subtest-level analyses showed that all the correlations between the ASIS subtest scores and grade in the four courses were statistically significant. Correlations ranged from low to strong with the lowest correlation between the Visual-Spatial Design Memory and social studies (r = .28) and the strongest correlation between the Words and Meanings subtest and language (r = .79). The Words and Meanings and the Verbal Analogies subtests had the highest mean correlations with grade in all the courses in the fourth and fifth grade (r = .75, .72, and .70, .67, respectively) followed by the Visual-Spatial Analogies subtest (r = .61 and .65). Grade had the lowest mean correlation with the Visual Flexibility subtest in the fourth grade (.33) and with the Visual-Spatial Design Memory subtest in the fifth grade (.35). Overall, knowledge and reasoning subtests had higher correlations with grade than memory subtests did.

Discussion

The present study provides a strong support for the criterion validity of the ASIS in terms of how its scores are related to academic achievement and giftedness. Academic achievement and special education groups are frequently used in the validation of intelligence tests (e.g., Kaufman & Kaufman, 2004a; Naglieri, Das, & Goldstein, 2014; Roid, 2003; Wechsler, 2014) because one of the most important purposes of intelligence tests is to identify students who can benefit from differentiated instruction or special education.

In the current study, gifted students scored exceptionally higher than the norm sample of the ASIS. Their mean IQ on the ASIS is 135, which is significantly higher than the traditional cutoff score (130 IQ) which is still commonly accepted as an entry point for many gifted education programs using intelligence tests as a major identification tool (Hunsaker, 2012; Johnsen. 2004). The efficiency of the ASIS in identifying gifted students is comparable to other major intelligence tests. For example, mean IQs of gifted children reported in the manuals of major intelligence tests are 130 IQ in the Primary Test of Nonverbal Intelligence (Ehrler & McGhee, 2008), 123.7 IQ in the Stanford Binet 5 (Roid, 2003), 120.1 IQ in the Kaufman Assessment Battery for Children II (Kaufman & Kaufman, 2004a), 119.5 in the Reynolds Intellectual Assessment Scales II (Reynolds & Kamphaus, 2015), 116.5 in the Universal Nonverbal Intelligence Test (Bracken & McCallum, 1998), 115 IQ in the Kaufman Brief Intelligence Test II (Kaufman & Kaufman, 2004b), and 112.9 in the Cognitive Assessment System II (Naglieri, Das & Goldstein, 2014).

Besides mean IQ, the proportion of students identified as gifted is also important to evaluate the validity of an intelligence test because a few outliers in a gifted sample can escalate the mean score of the group. A majority of the gifted sample (75.5%) of this study scored at or above 127 IQ (lower boundary of standard error of measurement). The mean IQ of a group of gifted students randomly drawn from a certain population or selected for a particular gifted education setting is influenced by a number of factors, such as types of assessment (traditional or alternative), ability (general or domain-specific) and instruments (objective or subjective) used in identification and cutoff level on ability (130 IQ or less) for identification. The sample of this study was identified based on their performance on the Mathematical Ability Test and Creative Scientific Ability Test. That is, students are gifted in math and science. A perfect match between the classification of the ASIS and the EPTS identification should not be expected due to partial overlap in ability, assessment types and the cutoff score. Further, even though two intelligence tests possess the same theoretical framework, their assessment results do not converge perfectly due to differences in their psychometric qualities, such as differences in norms, subtests, items, instruction, and method of administration. Some tests are only visual-spatial and some are both verbal and visual-spatial. Two tests with the same theoretical framework place varying level of emphasis on the same construct such as reasoning, working memory, verbal ability, or visual-spatial ability. For example, almost 50% of the subtests of the UNIT measures memory (Bracken & McCallum, 1998) whereas 25% of the RIAS involves the measurement of memory (Reynolds & Kamphaus, 2015). In fact, memory components of some tests are not included in the full-scale score as in the RIAS. As a result, IQ score of an individual on different intelligence tests can vary to some degree.

According to the results of this study, the strength of each ASIS index in predicting giftedness is not the same. The ASIS general intelligence index is a better predictor of giftedness than all the other indexes and subtest scores. The Fluid Reasoning Index is a stronger predictor of giftedness than the Crystalized Knowledge Index and the Short-Term Memory Index. Likewise, the Nonverbal IQ is a stronger predictor of giftedness than the Verbal IQ. At the subtest level, gifted students performed seemingly better on reasoning and knowledge subtests and relatively lower on memory subtests. Lower memory mean resulted from relatively lower performance on the Visual-Span Memory and the Verbal Short-Term Memory subtests. The relatively lower mean on the memory component is reminiscent of the lower mean of gifted children found on the memory subtests of other intelligence tests (e.g., Bracken & McCallum, 1998; Kaufman & Kaufman, 2004a; Roid, 2003). That is, the ASIS profile of gifted students is similar to that of gifted students reported in other intelligence tests.

The results of this study show that ASIS scores are highly related to academic achievement in language, math, science, and social studies. All the correlations between the ASIS general intelligence index and grade in math, science, language and social studies are at or above .77 which is comparable to most major intelligence tests. Here, we report correlations compiled from the manuals of the intelligence tests. For instance, the CAS II general index has a correlation of .46, .61, .63, and .67 with grade in writing, language, reading and math respectively (Naglieri, Das & Goldstein, 2014). Correlations between the RIAS II and grade in writing, language, reading and math are .60, .64, .65, and .67 respectively (Reynolds & Kamphaus, 2015). Correlations between the KABC II general index and math and reading grades are .69 and .72 (Kaufman & Kaufman, 2004a). The PTONI's correlations with grade in reading, language and math are .37, .43, and .56 (Ehrler & McGhee, 2008). The SB5 general index has correlations with grade in writing, reading, language and math at .53, .67., 77. and .79 level respectively (Roid, 2003). In general, all the intelligence tests reviewed here have a correlation of at least .30 with academic achievement. Only a few intelligence tests' correlations with academic achievement are above .70.

Analyses of the relationship between academic achievement and the ASIS scores showed that the degree to which the ASIS indexes are related to academic achievement in math, science, language and social studies varied by the index and the subject, with the ASIS general intelligence index having the highest correlations with academic achievement in all the courses in both fourth and fifth grade. The average correlation between the ASIS general intelligence index and academic achievement (.81 for the fourth grade and .75 for the fifth grade) aligns with the expected mean correlation of .60 between intelligence and academic achievement (Sattler, 1988). Next, the correlations for the Verbal IQ and the Crystalized Knowledge Index are notable, having higher correlations than the Non-verbal IQ and the Fluid Reasoning Index with academic achievement. The Short-Term Memory Index has a relatively lower correlation with academic achievement than the other indexes. Higher correlations between verbal intelligence and academic achievement and relatively lower correlations between working memory and academic achievement are reported for other intelligence tests as well (e.g., Reynolds & Kamphaus, 2015; Roid, 2003).

In conclusion, the ASIS shows consistent relationships with a variety of external variables including academic achievement and measure of giftedness. The ASIS general intelligence index is a stronger predictor of giftedness and academic achievement than the verbal, nonverbal and memory indexes. Thus, it is strongly advised to use the general index in the identification of gifted children. The findings obtained in this study provide a strong support for the concurrent validity of the ASIS in identifying gifted children. Future work on the ASIS should include a comparative study of the performance of gifted and average children identified using the ASIS to investigate its predictive validity in the long run.

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