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Multigroup Confirmatory Factor Analysis of U.S. and Italian Children's Performance on the PASS Theory of Intelligence as Measured by the Cognitive Assessment System

Jack A. Naglieri
University of Virginia and Devereux Center for Resilient Children

Stefano Taddei
University of Florence

Kevin M. Williams
Multi-Health Services, Toronto, Ontario, Canada

This study examined Italian and U.S. children's performance on the English and Italian versions, respectively, of the Cognitive Assessment System (CAS; Naglieri & Conway, 2009; Naglieri & Das, 1997), a test based on a neurocognitive theory of intelligence entitled PASS (Planning, Attention, Simultaneous, and Successive; Naglieri & Das, 1997; Naglieri & Otero, 2011). CAS subtest, PASS scales, and Full Scale scores for Italian (N = 809) and U.S. (N = 1,174) samples, matched by age and gender, were examined. Multigroup confirmatory factor analysis results supported the configural invariance of the CAS factor structure between Italians and Americans for the 5- to 7-year-old (root-mean-square error of approximation [RMSEA] = .038; 90% confidence interval [CI] = .033, .043; comparative fit index [CFI] = .96) and 8- to 18-year-old (RMSEA = .036; 90% CI = .028, .043; CFI = .97) age groups. The Full Scale standard scores (using the U.S. norms) for the Italian (100.9) and U.S. (100.5) samples were nearly identical. The scores between the samples for the PASS scales were very similar, except for the Attention Scale (d = 0.26), where the Italian sample's mean score was slightly higher. Negligible mean differences were found for 9 of the 13 subtest scores, 3 showed small d-ratios (2 in favor of the Italian sample), and 1 was large (in favor of the U.S. sample), but some differences in subtest variances were found. These findings suggest that the PASS theory, as measured by CAS, yields similar mean scores and showed factorial invariance for these samples of Italian and American children, who differ on cultural and linguistic characteristics.

Keywords: intelligence, neuropsychology, cross-cultural, cognitive assessment system, PASS theory

The measurement of intelligence across country and cultural boundaries has been a topic of interest since Binet's first tests were adapted for use outside of France. Practitioners and researchers around the world who want to use any test developed in a different country need to know if an adapted version of a test has acceptable psychometric characteristics, especially validity. Cross-cultural adaptation of intelligence tests in different countries has been complicated by the verbal and quantitative sections of traditional IQ tests, which require, for example, knowledge of words and arithmetic skills. Simple translations of a vocabulary test can be difficult, particularly when frequency of word usage may vary from language to language and because word knowledge is related to quality of education (Harris & Llorente, 2005). Educational attainment also varies by socioeconomic status, race, and ethnicity (e.g., Hispanic children in the United States are more likely than non-Hispanic Whites children to have parents who did not earn a high school diploma; Ramirez & de la Cruz, 2002). Although it may be important to have language and quantitative skills to be successful in academic settings, assessment of intelligence using tests with verbal and quantitative content can present a barrier for those with limited knowledge of any language as well as limited math skills (Naglieri, 2008b). One way to measure ability while reducing the role of verbal and quantitative test questions is to use nonverbal tests of general intelligence (e.g., Bracken & McCallum, 1997; Wechsler & Naglieri, 2006). Although nonverbal measures of general ability have good validity and avoid the problem of academically related content found in traditional IQ tests (see Bracken, 2009; Naglieri & Brunnert, 2009; Roid, 2009), their use for diagnosis and instructional planning is limited.

Traditional verbal, quantitative, and nonverbal IQ concepts are well entrenched in psychology and education (Matarazzo, 1992), yet some researchers and theoreticians have recently argued that intelligence is better conceptualized on the basis of neuropsycho-

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Jack A. Naglieri, Curry School of Education, University of Virginia, and Devereux Center for Resilient Children; Stefano Taddei, Department of Psychology, University of Florence, Florence, Italy; Kevin M. Williams, Multi-Health Services, Toronto, Ontario, Canada.

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Correspondence concerning this article should be addressed to Kevin M. Williams, Public Safety Division, Multi-Health Systems, 3770 Victoria Park Avenue, Toronto, ON M2H 3M6, Canada. E-mail: jnaglieri@gmail.com or kevin.williams@mhs.com

logical processes (Ceci, 2000; Fagan, 2000; Naglieri & Otero, 2011; Sternberg, 1988). Using a processing based approach to the way ability is conceptualized and measured would offer several advantages (e.g., Das, 2002; Fagan, 2000; Naglieri, 2002; Sternberg, 1988). First, processing tests avoid achievement-like verbal and quantitative test questions found on traditional IQ tests, making them more appropriate for assessment of culturally and linguistically diverse populations (Fagan, 2000; Suzuki & Valencia, 1997). Second, a processing approach could allow for early detection of disabilities that predate academic failure, have better diagnostic utility, and provide a way to better understand children's disabilities (Ceci, 2000). Third, a cognitive processing approach could have instructional relevance (Naglieri, 2011; Naglieri & Conway, 2009). Fourth, although there is considerable evidence for the validity of general intelligence (see Jensen, 1998), a multidimensional theory of neuropsychological processes could provide a more comprehensive view of ability (Naglieri, 2005; Sternberg, 1988).

Suzuki and Valencia (1997) described the Planning, Attention, Simultaneous, and Successive (PASS) theory of intelligence and the Cognitive Assessment System (CAS; Naglieri & Das, 1997) as "an innovative approach to traditional intelligence assessment that assesses a broader spectrum of abilities than has been previously available in IQ testing" (Suzuki & Valencia, 1997, p. 1111). The PASS theory described by Naglieri and Das (1997, 2005b) is a view of intelligence that is based on the neuropsychological work of A. R. Luria (1966, 1973, 1980, 1982) and is composed of four neuropsychological processes. The first ability is Planning, which is a mental activity that provides cognitive control; use of processes, knowledge, and skills; intentionality; organization; and self-monitoring and self-regulation. The essence of the construct of Planning ability and tests to measure it is that they provide a novel problem-solving situation when a previously acquired strategy is absent. This is the hallmark of the concept of executive function (Hayes, Gifford, & Ruckstuhl, 1996) and is closely aligned with the definition of frontal lobe functioning provided by Goldberg (2001), because it includes self-regulation, skillful and flexible use of strategies, allocation of attention and memory, response inhibition, goal setting, self-monitoring, and self-correction (also see Eslinger, 1996).

Attention is conceptualized (Naglieri & Das, 2005b) as an ability to demonstrate focused, selective, sustained, and effortful activity over time and resist distraction. Focused attention involves directed concentration toward a particular activity, selective attention is important for the inhibition of responses to distracting stimuli, and sustained attention refers to the variation of concentration over time. This construct was conceptualized and operationalized similarly to the attention work of Schneider, Dumais, and Shiffrin (1984) and Posner and Boies (1971), particularly the selectivity aspect of attention, which relates to intentional discrimination between stimuli.

Simultaneous ability is a cognitive process that provides a person the ability to integrate stimuli into interrelated groups or a whole (Naglieri & Das, 2005b). Simultaneous tasks typically have strong spatial aspects for this reason but can involve both nonverbal and verbal content as long as the task requires the integration of information into groups. The construct of simultaneous processing is conceptually related to the examination of visual-spatial reasoning particularly found in progressive matrices tests such as those originally developed by Penrose and Raven (1936) and is now included in nonverbal scales of intelligence tests, such as the Wechsler Nonverbal Scale of Ability (Wechsler & Naglieri, 2006) and the Stanford-Binet (5th ed.; Roid, 2003), as well as the simultaneous processing scale of the Kaufman Assessment Battery for Children (2nd ed.; Kaufman & Kaufman, 2004).

Successive ability is a psychological process that involves working with stimuli in a specific serial order (Naglieri & Das, 2005b), including the perception of stimuli in sequence and the linear execution of sounds and movements. For this reason, successive processing is involved with phonological analysis and the syntax of language and has been experimentally related to the concept of phonological skills and reading decoding failure (Das, Naglieri, & Kirby, 1994). Successive ability is similar to the concept of sequential processing included in the K-ABC2 (Kaufman & Kaufman, 2004) and tests that require recall of serial information, such as Digit Span Forward.

Originally proposed by Das, Kirby, and Jarman (1979), the PASS theory was operationalized by the CAS in 1997 and has undergone considerable evaluation. For example, there have been several studies comparing race and ethnic groups. Naglieri, Rojahn, Matto, and Aquilino (2005) found a difference between White and African American children in the United States of 4.8 IQ points (in favor of Whites) when demographic variables were controlled. They also found similar correlations between the PASS scores on the CAS and achievement for African Americans (.70) and Whites (.64). Similarly, Naglieri, Rojahn, and Matto (2007) compared PASS scores for Hispanic and White children in the United States and found that the groups differed by 6.1 points using unmatched samples, 5.1 with samples matched on basic demographic variables, and 4.8 points when demographics differences were statistically controlled. They also reported that the correlations between CAS scores with achievement did not differ significantly for the Hispanic and White samples. Naglieri, Otero, DeLauder, and Matto (2007) compared scores obtained on the CAS when administered in English and Spanish to bilingual children referred for academic difficulties. The children earned similar Full Scale scores on the English (M = 84.6) and Spanish (M = 87.6) versions of the CAS, and the scores from the two versions were highly correlated (r = .96). These small differences suggest that ability may be more equitably assessed across race and ethnic groups with a neuropsychologically based measure of ability, and, at the same time, the PASS scores are strongly related to academic performance.

Naglieri and Rojahn (2004) examined another important validity issue: the relationships between the PASS and reading, writing, and math scores from the Woodcock–Johnson Tests of Achievement—Revised (WJ-R; Woodcock & Johnson, 1989) scores, using a representative sample of 1,559 students aged 5–17 years. They found a correlation between the CAS Full Scale with the WJ-R Skills cluster (Letter-Word Identification, Applied Problems, and Dictation) of .71 for the entire sample. Naglieri, Goldstein, Iseman, and Schwebach (2003) compared the Wechsler Intelligence Scale for Children (3rd ed.; WISC-III; Wechsler, 1991) to the CAS with achievement for a sample of children aged 6–16 years who were referred for evaluation because of learning problems. The CAS Full Scale score correlated .83 with the achievement scores, compared with .63 for the WISC-III Full Scale IQ, suggesting that both test scores were strongly related to achievement. These two studies provide evidence that the PASS constructs are relevant to academic performance.

There has been international interest in measuring the PASS theory using other versions of the CAS. For example, adapted and translated editions of the instrument were published in Italy in 2005 (Taddei & Naglieri, 2005) and Japan (Naglieri & Das, 2006a), Korea (Naglieri & Das, 2006b), and Norway (Naglieri & Das, 2006c) in 2006. There are also research versions in Spanish (see Naglieri, Otero, et al., 2007) and Dutch (Van Luit & Kroesbergen, 1998). Van Luit, Kroesbergen, and Naglieri (2005) found that Dutch children with attention-deficit disorder earned PASS scores that were similar to those earned in several studies conducted in the United States (Naglieri, 2003; Naglieri & Das, 1997; Naglieri et al., 2003): low scores in Planning with higher scores on the other three PASS scales. Importantly, the control group (N = 51) had a CAS Full Scale score of 100.4 using the U.S. norms, suggesting that the instrument could have utility across cultural groups. The initial results from the Dutch study, in combination with the studies of the race and ethnic groups conducted in the United States supported Suzuki and Valencia's (1997) suggestion that the PASS theory may have utility across diverse cultural and linguistic settings.

This study had two main purposes. First, we examined the configural invariance of the CAS factor structure between Italians and Americans based on the Italian and U.S. norms, respectively. Second, we examined the practical question of the similarity of PASS scores, as measured by the CAS, for children and adolescents in the United States and Italy. We compared the means and standard deviations as well as the factorial invariance between a large sample of Italian children and adolescents and a U.S. sample with similar characteristics by age and gender using the U.S. norms. Using the U.S. norms as a reference point allowed for a less complex comparison than using raw scores, because several of the CAS subtest scores are based on the combination of more than one scorable component (e.g., number correct, time, number of false detections), and the means and standard deviations are more easily compared than raw scores. Our overall goal was to further evaluate Suzuki and Valencia's (1997) and Fagan's (2000) suggestion that measuring intelligence from a processing theory could yield small differences between groups that differ in cultural and linguistic backgrounds. Finally, we are responding to Suzuki and Valencia's (1997) calls for research involving diverse populations on the PASS theory. To achieve these goals we utilized the standardization samples for the U.S. and Italian versions of the CAS (scoring all children using the U.S. norms), which offer the advantages of large sample sizes that were developed to be representative of the context within which they are used.

Method

Participants

The participants in this study were 1,983 children and adolescents who were tested during the standardization phases of the U.S. (N = 1,174) and Italian (N = 809) versions of the Cognitive Assessment System (Naglieri & Das, 1997, 2005a, respectively). Both original standardization samples are more fully described in their respective test manuals (Naglieri & Das, 1997, 2005a). Students from the original U.S. standardization sample who matched the Italian sample (which was composed of students aged 5, 6, 7, 9, 11, and 13 years) and gender (approximately 50% of each) were included in this study. As shown in Table 1, approximately equal numbers and males and females were included in both samples. The U.S. sample was diverse and similar to the U.S. population characteristics on the basis of geographic region, parental educational levels, race, and ethnicity variables (see Table 2).

The Italian sample used to create norms for the adaptation of the Italian version of the CAS was composed of children and adolescents at specific ages (5, 6, 7, 9, 11, and 13 years) tested from spring 2002 to spring 2005 in 34 schools distributed around Italy (see Table 3). A total of 984 cases were obtained: 809 cases for the normative sample and the remaining subjects for research studies. The sample was mainly selected from the area of Tuscany, with some portion from other sections of Italy (north, central, and southern). School administrators were contacted in these regions, and once approval was given classes were randomly selected, and parental permission was obtained for all students in those classes. Considerable effort was made to obtain variability on the basis of socioeconomic characteristics of the region, different educational settings, and location of residence (e.g., central or peripheral areas of cities, urban or rural settings). The sample (see Tables 1 and 3) included participants attending public schools from central (78.2%) and, in smaller numbers, from northern (6.8%) and southern (15.0%) Italy. There was no significant difference, $F(1, 806) = 2.19$, $p = .11$, between the mean scores of 100.5 (SD = 13.2), 101.2 (SD = 11.9), and 103.1 (SD = 11.6) earned by these subsamples, respectively. The sample included cases of foreign subjects (6%) drawn from 32 schools in 11 provinces from nine regions of the country. Similar numbers of boys and girls were obtained (overall 50.4% girls and 49.6% boys), with a slight female predominance at age of 5.

Measures

Cognitive Assessment System, U.S. Edition. The CAS (Naglieri & Das, 1997) is a multidimensional measure of intelligence

Table 1
Description of the Italian and U.S. Samples by Age in Years and Gender

	Girls		Boys		
Age in years	*n*	%	*n*	%	Total *n*
Italian sample					
5	56	62.2	34	37.8	90
6	95	51.4	90	48.6	185
7	65	44.8	80	55.2	145
9	85	52.5	77	47.5	162
11	50	44.2	63	55.8	113
13	57	50.0	57	50.0	114
Total	408	50.4	401	49.6	809
U.S. sample					
5	117	48.8	123	51.3	240
6	140	50.0	140	50.0	280
7	141	50.2	140	49.8	281
9	90	48.6	95	51.4	185
11	45	46.9	51	53.1	96
13	44	47.8	48	52.2	92
Total	577	49.1	597	50.9	1,174

Table 2
Description of the U.S. Sample by Region, Parental Education, Race, and Ethnicity (N = *1,174*)

Variable	*n*	%	U.S. %
Region of United States			
Midwest	283	24.1	25.2
Northeast	219	18.7	18.7
South	403	34.3	34.2
West	269	22.9	21.9
Total	1,174	100.0	100.0
Parental education level			
Less than high school	231	19.7	20.3
High school graduate	334	28.4	28.5
Some college	340	29.0	28.7
College graduate	269	22.9	22.5
Total	1,174	100.0	100.0
Race			
White	901	76.7	76.9
Black	153	13.0	13.5
Other	120	10.2	9.6
Total	1,174	100.0	100.0
Ethnicity			
Hispanic	130	11.1	11.4
Non-Hispanic	1,044	88.9	88.6
Total	1,174	100.0	100.0

based on a neuropsychological framework called the Planning, Attention, Simultaneous, and Successive (PASS) theory (see Naglieri, 1999; Naglieri & Conway, 2009; Naglieri & Das, 1997), which is grounded in the work of A. R. Luria (1966, 1973, 1980, 1982). A standard score with a mean of 100 and standard deviation of 15 is provided for each ability score (Planning, Attention, Simultaneous, and Successive) and a Full Scale score. Twelve individual subtests (three per PASS Scale) are set to have a standard score of 10 and standard deviation of 3. The 12 subtests comprise the Standard Battery, and the Basic Battery is made up of two subtests per PASS scale. The internal reliability coefficients for the Standard Battery scales based on the U.S. sample are as follows: Planning = .88, Attention = .88, Simultaneous = .93, Successive = .93, and Full Scale = .96. For summaries of the research on CAS see Naglieri (2005a) and Naglieri and Conway (2009). The scales are described in the following (for further explanation, see Naglieri, 1999).

Planning scale. The Planning scale includes three subtests: Matching Numbers, Planned Codes, and Planned Connections. In the Matching Numbers subtest, children are presented four pages containing eight rows of numbers. The child is instructed to underline the two numbers that are the same. The items were constructed so that children can apply strategies to find the match, such as by examining the last number as opposed to the first number (e.g., 143, 134, 144, 410, 143, 131). The Planned Codes subtest contains two pages, each with a distinct set of codes (e.g., A = OX; B = XX; C = OO) and empty boxes arranged in seven rows and eight columns. At the top of each page is a legend that contains the codes. The child is told to write the code beneath each corresponding letter. The letters are organized on the page in either a vertical or diagonal arrangement, giving the child the opportunity to use a plan, or strategy, of filling in all the A codes, then the B codes, and so forth. In the Planned Connections subtest the child is instructed to connect numbers in sequences that appear in a quasirandom order (e.g., 1–2-3). This is similar to the Trails test often used in neuropsychological assessment (Lezak, 1995). For the last two items, the child connects numbers and letters in sequential order, alternating between numbers and letters (e.g., 1-A-2-B). Children use various strategies to solve this task, such as scanning the page for the next number or letter, lifting the hand to better see the page, and looking back to the previous step to more easily know what comes next. For a complete list of the strategies used by children on all the Planning tests see Naglieri and Das (1997), and for further discussion of strategy use see Winsler and Naglieri (2003) and Winsler, Naglieri, and Manfra (2006).

Attention scale. The Attention scale is composed of the Expressive Attention, Number Detection, and Receptive Attention subtests. For Expressive Attention, children 5 to 7 years old are presented with pictures of animals arranged in rows. Animals that are typically small are drawn to appear large and large are drawn to appear small. The child is told to say the *real* size of the animal (e.g., if a butterfly was drawn to appear large, the child would respond "small"). Children 8 years and older are given three pages to complete, much like the well-known Stroop test (Lezak, 1995). For the first page, the child reads color words (i.e., "blue," "yellow," "green," and "red"). The words are presented in a quasirandom order. On the second page, the child is instructed to name the colors of a series of rectangles printed in colors that corresponded to page one. On the third page, each color word is printed in a different ink color than the color the word's name (e.g., the word "red" would appear in blue ink). The Number Detection subtest requires children to find the target stimuli (e.g., the numbers 1, 2, and 3, printed in an open font) among many distracters (e.g., the same numbers printed in a different font). This test is modeled after the work of Schneider, Dumais, and Shiffrin (1984) on selective attention. The Receptive Attention subtest contains two pages: For the first page, targets are letters that are physically the same (e.g., BB but not Bb), and for the second page, targets are letters that have the same name (e.g., Bb but not Ab). This test was modeled after the attention research of Posner and Boies (1971).

Table 3
Description of the Italian Sample by Region and City

Region	*n*	%
North	55	6.8%
Alessandria	31	56.4%
Milan	1	1.8%
Modena	23	41.8%
Central	633	78.2%
Ancona	49	7.7%
Florence	551	87.0%
Latina	26	4.1%
Pesaro	4	0.6%
Perugia	3	0.5%
South	121	15.0%
Catanzaro	90	74.4%
Bari	25	20.7%
Naples	6	5.0%
Total	809	100.0%

Simultaneous scale. The Simultaneous scale is composed of the subtests Nonverbal Matrices, Verbal Spatial Relations, and Figure Memory. Nonverbal Matrices is a traditional progressive matrix test, like those published by Raven (1947) and Naglieri (1997, 2008a), that includes items that have a variety of shapes and geometric designs that are interrelated through spatial or logical organization. For each item the child is required to decode the relationships and choose the best of six possible answers that completes the matrix. The Verbal Spatial Relations subtest measures the comprehension of logical and grammatical descriptions of spatial relationships. The child is presented with six drawings, arranged in a specific spatial manner, and a printed question. Then the child is told to identify which of the six drawings best answers the question. A typical item may be, "Which picture shows a square above a circle?" with six options that include these shapes and others in various spatial arrangements. This test was based on the concept that simultaneous processing underlies the understanding of what Luria (1982) described as logical and grammatical relationships and is measured by the Token Test (Lezak, 1995). For Figure Memory the child is presented with a two- or three-dimensional geometric figure for 5 s and then is presented with a response page, with the original geometric figure embedded in a larger, more complex geometric pattern, and is asked to identify the original design. This test was modeled after the work of Graham and Kendal (1960).

Successive scale. The Successive scale is composed of Word Series, Sentence Repetition, and Sentence Questions subtests. In Word Series, the examiner reads the child a series of words and then asks them to repeat the words in the same order. This subtest uses the following nine single-syllable, high-frequency words: "book," "car," "cow," "dog," "girl," "key," "man," "shoe," and "wall." Word Series is similar to other tests that are used to evaluate memory for sequences (e.g., Digit Span forward). For Sentence Repetition the child is read sentences aloud and is asked to repeat each sentence exactly as presented. The sentences are composed of color words (e.g., "The blue yellows the green"), which reduces semantic meaning from the sentences. The Sentence Questions subtest uses the same type of sentences that are used in the sentence repetition subtest: however, now the child is read a sentence and asked a question about it. For example, the examiner reads "The blue yellows the green" and asks the child "Who yellows the green?" The correct answer is "the blue." Both Sentence Repetition and Sentence Questions were developed following Luria's (1966, 1982) explanation of how successive processing underlies a child's understanding of the syntactic organization of language.

Cognitive Assessment System, Italian Edition. The Italian version of the CAS (CAS-I; Naglieri & Das, 2005a) includes all of the subtests that comprise the U.S. version. The items that involved language (Verbal Spatial Relations, Word Series, Sentence Repetition, Sentence Questions, Speech Rate) and administration directions were carefully translated and adapted by a team of four researchers in Italy (see Taddei & Naglieri, 2005), who translated the English to Italian and discussed that translation; then a native English-speaking researcher, also fluent in Italian, translated the text back to English and any issues were resolved. This version was administered to the 809 participants in this study by trained examiners and used to develop Italian norms (see Taddei & Naglieri, 2005, for more information on the methods used to generate the normative tables). The standard scores reported here for the CAS-I were those obtained from the raw score to standard score conversion tables for the U.S. standardization sample, not the Italian normative tables.

Data Analysis and Results

The cross-cultural stability of the CAS factor structure between Italian and American samples was assessed through multigroup confirmatory factor analysis (MGCFA) using Amos 18.0 (Arbuckle, 2009). The factor structure was evaluated using typical MGCFA procedures and standards (see Baumgartner & Steenkamp, 1998; Billiet, 2002; Byrne, Shavelson, & Muthén, 1989; Jöreskog, 1971; Steinmetz, Schmidt, Tina-Booh, Wieczorek, & Schwartz, 2009). These procedures involve establishing cross-group constraints and evaluating models with increasingly restricted parameters. Specifically, an unconstrained model is first tested to establish configural invariance. Subsequent tests constrain various factors to be equal, including measurement weights, measurement intercepts, and measurement residuals to examine metric invariance, strong invariance, and strict invariance, respectively.

The general factor model we tested is displayed in Figure 1. Each of the four PASS abilities are represented as latent variables that were allowed to covary and are manifested in their respective CAS subtest scores. The models were then tested using maximum-likelihood estimation, with the root-mean-square error of approximation (RMSEA; Browne & Cudeck, 1993; Steiger & Lind, 1980) evaluated for model fit. Kenny (2011) stated that "RMSEA is currently the most popular measure of model fit" and is "now reported in virtually all papers that use CFA" (see his Root Mean Square Error of Approximation [RMSEA] section). Among the reasons for its popularity, Cheung and Rensvold (2002) demonstrated that RMSEA was the only fit index among 20 alternatives that was unaffected by model complexity. The RMSEA's standardized and known distributional properties are also often cited as further beneficial features (e.g., Hancock & Freeman, 2001; Kelley & Lai, 2011). Other fit indices, such as the chi-square test, have been demonstrated to be inappropriate for sample sizes of 400 or more (see Kenny, 2011), as is the case with our samples, and were therefore not considered. Given the differences in the CAS subtests across ages (i.e., the Speech Rate subtest given to children 5 to 7 years old is replaced with the Sentence Questions subtest for children 8 to 17 years old), it was necessary to separate the samples into these two age groups prior to analysis. In these samples, we conducted successively stricter tests of configural, metric, strong, and strict invariance.

MGCFA results for each age group are displayed in Table 4. In the 5- to 7-year-old sample, results supported configural invariance of the CAS factor structure between Italians and Americans based on an RMSEA value of .038 (90% CI = .033; .043), which was below the frequently established criterion of .06 for good model fit (Hu & Bentler, 1999). This result suggests the same model structure exists in both groups. The subsequent test of metric invariance was also supported (RMSEA = .039, 90% confidence interval [CI] = .034, .044), suggesting that the CAS subtests measure the PASS abilities similarly (i.e., a similar metric) between groups. The RMSEA value for strong invariance suggested reasonable fit (.077; 90%

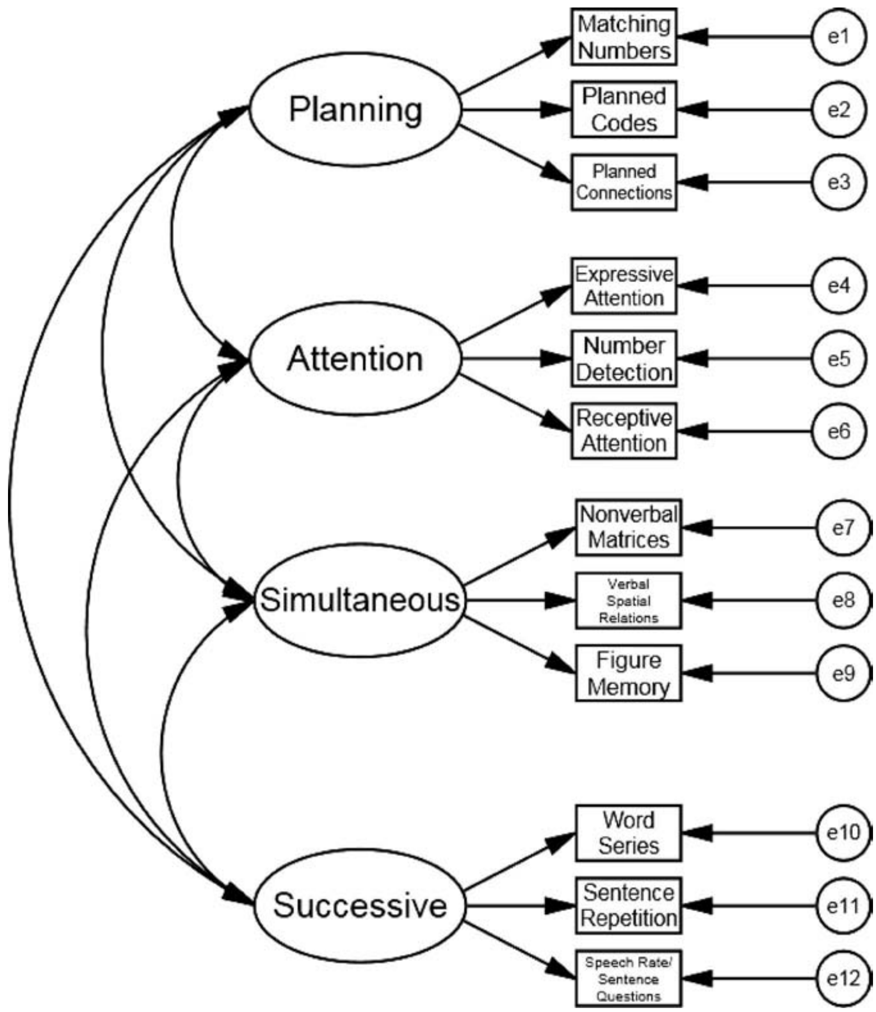

Figure 1. Cognitive Assessment System factor structure tested through multigroup confirmatory factor analysis.

CI = .072, .082) based on the guidelines suggested by Browne and Cudeck (1993; i.e., RMSEA < .08). This result suggests there are no differences between groups in the means of the specific CAS subtests. Finally, the test of strict invariance also demonstrated reasonable fit (RMSEA = .073; 90% CI = .069, .077), suggesting similar reliabilities of CAS scores between groups.

Table 4
Multigroup Confirmatory Factor Analysis Results for the CAS Factor Structure Between Italian and American Children

Invariance test	5–7 years (N = 1,221) RMSEA	5–7 years (N = 1,221) 90% CI	8–17 years (N = 762) RMSEA	8–17 years (N = 762) 90% CI
Configural invariance	.038	.033, .043	.036	.028, .043
Metric invariance	.039	.034, .044	.035	.028, .042
Strong invariance	.077	.072, .082	.059	.053, .066
Strict invariance	.073	.069, .077	.063	.057, .068

Note. CAS = Cognitive Assessment System; RMSEA = root-mean-square error of approximation (Browne & Cudeck, 1993); CI = confidence interval. Guidelines for interpreting good and reasonable model fit are RMSEA < .06 and RMSEA < .08, respectively (Browne & Cudeck, 1993; Hu & Bentler, 1999).

In the 8- to 17-year-old sample, results also supported configural invariance between Italians and Americans as the RMSEA (.036; 90% CI = .028, .043) value surpassed the criterion for good model fit. Furthermore, the tests of metric invariance (RMSEA = .035; 90% CI = .028, .043) and strong invariance (RMSEA = .059; 90% CI = .053, .066) also showed good fit, with reasonable fit found for the test of strict invariance (RMSEA = .063; 90% CI = .057, .068). Importantly, for both age groups, none of the RMSEA confidence intervals included .10, which is the guideline for poor model fit (Browne & Cudeck, 1993; Hu & Bentler, 1999). Collectively, these results provide support for the similarity of the CAS model structure, subtest metrics, mean scores, and reliabilities between Italian and American 8- to 17-year-olds.

Our second examination of the performance of the U.S. and Italian samples involved comparing the subtest scores, PASS scales, and Full Scale standard scores for the Italian and U.S. samples *using the U.S. norms.* We examined means, standard deviations, *d*-ratios and variance ratios for each subtest and all of the scales the CAS yields. Comparisons across the samples were described with *d*-ratios calculated using Cohen's (1988) formula:

$$\frac{(X_{Italian} - X_{US})}{\sqrt{\left[\left(n_{Italian} \times SD^2_{Italian} + n^2_{US} \times SD^2_{US}\right)/\left(n_{Italian} + n_{US}\right)\right]}}$$

These *d*-ratios were described as small (0.2 to 0.49), medium (0.5 to 0.79), and large (0.8 and greater) by Cohen (1988). The means and standard deviations of Italian children on the CAS subtests, four PASS constructs of intelligence, and the Full Scale are provided in Table 5. There were some significant but small differences between the Italian and U.S. children on about one quarter of the subtests. There were small differences (e.g., *d*-ratios of 0.39 to 0.44) for Planned Connections, Figure Memory, and Expressive Attention. The Italian children were lower on Planned Connections but higher than the U.S. children on Figure Memory and Expressive Attention. A significant, $F(1, 1981) = 246.2$, $p < .01$, difference ($d = 0.92$) was found for Speech Rate, a subtest only given to children aged 5 to 7 years. The Italian children likely performed poorly on Speech Rate ($M = 7.6$) because of the differences between the lengths of the words used in the items. The test score is based on the time it takes the child to repeat, for example, the words "Red—Green—Blue" 10 times. In English each of these is a single syllable word, making the entire string three syllables in length. In Italian, however, the item becomes "Rosso—Blu—Verde", which is five syllables in length. We suspect that this difference resulted in longer performance times for the Italian children in contrast to the U.S. children. This finding is consistent with findings on the Wechsler Intelligence Scale for Children (3rd ed.; Wechsler, 1991; see Georgas, Weiss, DeVijver, & Saklofske, 2003) and has been recognized as far back as 1926 (Broody, 1926). The possible reasons for the small Italian/U.S. differences for the other three subtests are less clear and require further verification and experimentation.

There was a nonsignificant difference, $F(1, 1981) = 2.3$, $p > .10$, between the CAS Full Scale mean scores earned by the Italian and U.S. samples (*d*-ratio $= 0.03$ and the two scores differed by only four tenths of a standard score) when both samples were evaluated using the U.S. norms. This finding suggests that the translation and adaptation of the CAS into Italian was accomplished with little overall effect of culture and language on the Full Scale scores. There were also negligible differences between nearly all of the separate PASS scales, which are also presented in Table 5. Only the Attention scale standard score showed a significant, $F(1, 1981) = 32.2$, $p < .01$, difference with a small *d*-ratio (.26); in this case the Italian children scored about one quarter of a standard deviation higher than the U.S. sample. This slight difference appears to be related to a single subtest (Expressive Attention), which had a *d*-ratio of 0.44 in favor of the Italian sample. Interestingly, the Expressive Attention test requires the child to identify the color a word is printed and as with Speech Rate, two rather than three syllable words are used. In this case, however, the results were different; the time taken to respond was low making the standard score higher relative to the U.S. sample. This finding requires further examination but taken as a whole, these results suggest that the PASS abilities appear to be robust to differences in the language and culture of the two groups of students to which they were administered.

We next compared Italian and U.S. score variances across by calculating variance ratios (Feingold, 1992). As seen in Table 4,

Table 5
*Means and SDs for Italian Children (*N = 809*) on the CAS Subtests and PASS and Full Scales Using U.S. Norms and d-Ratio Comparisons to U.S. Sample (*N = 1,174*), Matched by Age*

	Italian			U.S.							
Subtests and scales	*M*	*SD*	*n*	*M*	*SD*	*n*	*F*	*p*	*d*-ratio		Variance ratio
CAS subtests											
Matching Numbers	9.8	2.9	809	10.1	3.0	1,163	2.9	.09	−0.09	T	1.06
Planned Codes	10.1	2.6	809	10.2	3.0	1,163	0.2	.63	−0.03	T	1.15
Planned Connections	9.0	2.5	809	10.1	3.0	1,163	69.9	<.01	−0.39	S	1.17
Nonverbal Matrices	10.0	2.7	809	10.2	3.0	1,163	1.2	.28	−0.06	T	1.08
Verbal Spatial Relations	10.0	3.1	809	10.3	2.8	1,163	3.2	<.01	−0.09	T	0.90
Figure Memory	11.6	2.9	809	10.3	3.0	1,163	95.7	<.01	0.44	S	1.01
Expressive Attention	11.3	2.6	809	10.1	3.0	1,163	94.3	<.01	0.44	S	1.16
Number Detection	10.4	2.8	809	10.1	2.9	1,163	9.1	<.01	0.13	T	1.06
Receptive Attention	10.2	2.9	809	10.1	2.9	1,163	0.8	.36	0.03	T	1.02
Word Series	10.2	2.7	809	10.1	3.0	1,163	1.2	.28	0.04	T	1.12
Sentence Repetition	10.5	2.4	809	10.2	2.9	1,163	4.8	.03	0.09	T	1.20
Speech Rate (ages 5–7 years)	7.6	2.3	420	10.2	3.0	801	246.2	<.01	−0.92	L	1.32
Sentence Questions (ages 8–17 years)	10.5	2.6	389	10.0	3.1	373	5.3	.02	0.17	T	1.20
CAS composite scales											
Planning	97.7	13.4	809	100.5	15.4	1,174	18.1	<.01	−0.19	T	1.15
Simultaneous	103.0	13.9	809	101.1	14.1	1,174	9.3	<.01	0.14	T	1.01
Attention	104.2	13.7	809	100.6	14.4	1,174	32.2	<.01	0.26	S	1.05
Successive	99.0	12.5	809	100.5	14.5	1,174	5.1	.02	−0.11	T	1.16
Full Scale	100.9	12.9	809	100.5	14.8	1,174	2.3	.13	0.03	T	1.14

Note. CAS = Cognitive Assessment System; PASS = Planning, Attention, Simultaneous, and Successive. U.S. sample *N*s vary due to missing data. Designations for *d*-ratios are as follows: T = trivial (<.2), S = small (.2), M = medium (.5), and L = large (.8). For all *F* values the *df*s are 1,1981, except for Speech Rate (1, 1219) and Sentence Questions (1,762).

several of the subtest variance ratios, met Feingold's (1992) suggestion that a value of 1.10 or greater can be considered meaningful in size. Two of the Planning tests (Planned Codes and Planned Connections), one subtest on the Attention scale (Expressive Attention), and all Successive subtests had lower variances for the Italian sample. Similarly, the CAS Full Scale, Planning and Successive scale variances just met Feingold's criteria. These findings suggest that there was some restriction in the range of scores for the Italian sample.

Discussion

There were two main goals of this study. First, we examined the cross-cultural stability of the CAS factor structure between Italian and American samples using multigroup confirmatory factor analysis and found support for the similarity of the CAS model structure, subtest metrics, mean scores, and reliabilities between Italian and American samples. Second, we studied Italian and American student's scores on the Italian and U.S. versions of the CAS, which was used to operationalize the PASS abilities. To do so we studied mean score differences and PASS score variability between two samples using the U.S. raw score to standard score conversion tables. Our findings suggest that there were small mean score differences between the performance of U.S. and Italian children on the PASS constructs, but some tests did show variance differences (smaller values for the Italian sample). The two versions of the CAS, which were used to measure PASS theory, yielded findings that differed minimally on the overall PASS and Full Scale scores. In total, the factorial results support the similarity of factor structures of the CAS for Italian and American samples, suggesting that the CAS subtests measure the PASS neurocognitive abilities similarly between groups, and there was considerable similarity in mean PASS scale standard scores across the groups.

The findings of this study suggest that Suzuki and Valencia (1997) and Fagan (2000) may have been correct when they argued that a theory of intelligence based on assessment of neuropsycholoigcally defined constructs may have advantages over traditional IQ tests, and, in particular, they may be more appropriate for use across cultural and linguistic populations. Our findings are also consistent with previous cross-cultural research on the PASS theory, as measured by the CAS, in the Netherlands (Van Luit et al., 2005) and with studies with bilingual Spanish speaking children (Naglieri, Otero, et al., 2007). These findings provide support for utility of the PASS theory as operationalized by the CAS U.S. and Italian versions as a tool that has potential for application across cultures and countries.

This study, like any other, has limitations that should be considered. First, the comparison of the Italian and U.S. samples was limited by differences in the basic demographics of the samples. Whereas there is adequate evidence that the U.S. sample is representative of the U.S. population on the basis of geographic region, parental education, race, and ethnicity, the Italian sample may not be as representative of that country as a whole. The Italian sample included participants from various locations in Italy, but it was mainly composed of students from the central region. Despite the fact that there were no significant differences between the scores earned by the participants from the different regions of Italy, more adequate sampling across that country would be preferred. We also do not know if the Italian sample represents the country on the basis of parental education levels, even though efforts were made to have a diverse sample along this demographic variable.

Taken as a whole, the findings presented here suggest that the theoretical structure of the CAS was invariant across these samples and that the U.S. and Italian versions of the CAS yield similar mean scores across cultures and language groups across most of the subtests and PASS scales. Future research should be conducted to compare PASS scores across groups from different countries and cultures. It would also be important to replicate studies with the CAS that have been conducted in the United States involving children with attention- deficit disorders and learning disabilities (Naglieri & Conway, 2009). Initial reports suggest that Italian children with attention-deficit/hyperactivity disorder (Taddei, Contena, Caria, Venturini, & Venditti, 2011; Taddei & Venditti, 2010) and those with learning disabilities (Taddei, Chillè, & Venturini, 2006; Taddei, Venditti, & Cartocci, 2009) have the similar PASS profiles to those reported by Naglieri (2009). Researchers should also more fully examine PASS data of this type for bias; replicate studies of gender differences; and examine internal reliability coefficients and relationships to achievement. In conclusion, these findings indicate that the PASS theory, as operationalized by the CAS may provide a useful tool for cross-cultural research in intelligence.

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