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Abstract

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Key words: Cuban children; Neuropsychological battery; Neurodevelopment; Assessment.

INTRODUCTION

The evaluation of neuropsychological functioning in early childhood is of paramount importance. Childhood is a crucial developmental stage for human beings, as it lays the foundational neurological and maturational groundwork for development in the early years of life. The development of the brain during these early years significantly impacts both mental and physical health, as well as lifelong (Treviño et al., 2021). Adversity and toxic stress experiences in early childhood can lead to lifelong impairments in learning, behavior, and physical and mental health (Shonkoff, 2010, 2012). Brain systems responsible for emotional regulation, memory, and executive function - which include the prefrontal cortex and other brain regions where circuits for attention, impulse control, and higher-order cognitive skills are developed well into adulthood - are particularly vulnerable. Significant adversity before birth or during early childhood can contribute to increased neural susceptibility to damage from repeated stressors later in life, particularly in vulnerable populations. Although remediation is possible at any age, outcomes are more favorable when detection and intervention occur earlier. Achieving this requires neuropsychological assessments during childhood using reliable and adapted instruments, particularly for executive functions, as well as targeted interventions addressing these functions (Shonkoff & Garner, 2012).

Despite the importance of this issue, few neuropsychological assessment batteries are currently available for use with Spanish-speaking children and adolescents (Arango-Lasprilla, 2015; Guardia-Olmos et al., 2015; Rosselli-Cock et al., 2004). We often see batteries designed for other cultures and languages that, when translated and applied in Spanish-speaking countries, fall short of the necessary standards and psychometric requirements

(Arango-Lasprilla, 2015; Rosselli-Cock et al., 2004). In the absence of appropriately adapted tests, children with risk factors sometimes do not undergo the clinical and neuropsychological screening that would allow us to differentiate between healthy children and those with developmental delays (Poveda-Pulla et al., 2021). This can have major implications, as children who are in need of specialized intervention may not receive it, resulting in cognitive, behavioral, or learning disorders (Poveda-Pulla et al., 2021).

The shortcomings of neuropsychological assessment instruments in Latin America were analyzed in a recent study (Arango-Lasprilla et al., 2017). The study surveyed the opinions of neuropsychologists from 17 Latin American countries (including Cuba) on issues related to their profession. In all, 62% of respondents highlighted the lack of normative data for local populations, while nearly half cited the lack of cultural adaptation and the high cost of these instruments (Arango-Lasprilla et al., 2017).

In order to overcome the shortcomings in the field of neuropsychological evaluation in Latin America, considerable efforts have been made in recent years to obtain normative data in children and develop neuropsychological batteries adapted to this particular context. For an obvious example of this, we need look no further than special issues such as the 2017 issue of the journal *NeuroRehabilitation*. This issue featured the adaptations of 10 neuropsychological tests and published normative data for a sample of 6,030 healthy children and adolescents between 6 and 17 years old from 10 Spanish-speaking countries (including Cuba) (Arango-Lasprilla & Rivera, 2017).

Another important battery is the ENI (*Evaluación Neuropsicológica Infantil* (or Neurological Assessment of Children in English); Matute et al., 2007), which was the first neuropsychological battery developed in Latin America for a sample of Spanish-speaking children. Designed for children between the ages of 5 and 16, it assesses eleven cognitive domains. The ENI-2 is now commercially available (Matute et al., 2013) and is theoretically and psychometrically robust, but it is expensive and takes three to four hours to administer.

In the Cuban sample, we found the B-PREA-R test, which assesses nine cognitive domains in pre-school children. There are validity evidences of this tool with 300 children between the ages of 4 and 6 in the province of Cienfuegos, and its purpose is the early identification of children with cognitive developmental delays before they start school (Ramírez-Benítez et al., 2022).

The Computerized Battery for Neuropsychological Evaluation of Children (BENCI; Cruz-Quintana et al., 2013) is particularly important in the context of the development of neuropsychological batteries for children and adolescents. This battery is the result of several international cooperation projects focused on neurodevelopmental protection. The priority for these projects has been the development of culturally adapted, reliable, and valid assessment instruments (Cruz-Quintana et al., 2022). The BENCI is designed for children aged 6 to 18 and assesses the following cognitive domains: Processing Speed, Visuomotor Coordination, Attention, Language, Memory, and Executive Function. It is available in a standardized, computerized format. Data capture is straightforward and reliable (correct answers, errors, and reaction time), and the parameters can be configured to tailor tests to the target sample. It consists of 13 tests with an estimated completion time of approximately 60-70 minutes. The battery is user-friendly and its appealing design makes it easy to create personalized reports and databases. It is a freely available, tablet-based battery with a good track record in assessing neurodevelopment in the overall child sample (Burneo-Garcés et al., 2019; Cruz-Quintana et al., 2013; Fasfous et al., 2015; Fernández-Alcántara et al., 2022) and in clinical samples, such as preterm children (García-Bermúdez et al., 2019).

The BENCI has been tested in a large sample of Ecuadorian children, showing differences between those with a lower socioeconomic status and those with a medium socioeconomic status (Burneo-Garcés et al., 2019). Evidence of validity and reliability has been found in Arabic-speaking samples in Morocco (Fasfous et al., 2015) and Palestine (Fasfous et al., 2021), as well as in Kenya (Maina et al., 2019; Rachel et al., 2023). A five-factor structure, following Diamond's model of executive function (2013) has been tested in Moroccan children, showing good fit statistics (Fasfous et al., 2015). Finally, preliminary data on its validity in Spanish children aged nine to eleven have recently been published, showing a positive association with other neuropsychological tests assessing the same domains as the BENCI (Fernández-Alcántara et al., 2022).

Given these characteristics, as well as the lack of available instruments for assessing development in the Cuban population, the validation of the BENCI could prove extremely valuable for analyzing the neurodevelopment of Cuban children and the way it is influenced by certain psychosocial variables. We believe that validating this test is of great interest, as it stands out compared to previously reviewed instruments by allowing the assessment of a broader age range (6 to 18 years, compared to the B-PREA-R, which is limited to preschool children), in less time (60–70 minutes compared to the 3–4 hours required by the ENI), and free of charge (unlike the other cited tests, which require payment). Furthermore, this test was reviewed by experts in Cuban language and culture prior to its application to ensure its cultural adaptation.

The main aim of the present study was to analyze the reliability and validity (convergent, differential and construct) of the BENCI battery in a sample of Cuban children aged 6 to 18 years old.

METHODS

Participants

The study involved 1,714 Cuban children, 777 boys and 937 girls, between the ages of 6 and 18 years old. The participants came from the provinces of Cienfuegos (municipalities of Cienfuegos, n=1238 and Cumanayagua, n=360) and Havana (municipality of Marianao, n=116). The province of Cienfuegos is in the central part of Cuba and Havana in the western part, and they are two municipalities representative of the island's population. Educational levels in Cuba are divided into Elementary (first to sixth grade - 6 to 11 years old), High School (seventh to ninth grade - 12 to 14 years old) and Pre-University (tenth to twelfth grade - 15 to 18 years old). Participants were recruited from three Elementary schools (two from Cienfuegos and one from Havana), two High schools (one from Cienfuegos and one from Cumanayagua) and three Pre-university schools (one from Cienfuegos, one from Cumanayagua and one from Havana). Schools were selected by Cuban educational institutions based on the representation criteria of the students in Cuba. According to teachers and parents in the initial interviews, all of the children did not have any psychiatric or neuropsychological disease. The data were collected between 2022 and 2023. Of the total sample, 134 were selected to conduct the validity study and 59 to conduct the reliability study. Table 1 shows the distribution of the sample by sex, academic level, and geographic area. Regarding parent's SES, Table 2 shows parent's educational level stratified by municipalities. -

INSERT TABLES 1 AND 2 ABOUT HERE-

Inclusion criteria were: a) being students at the selected centers, and b) having informed consent from their legal guardians. Exclusion criteria were: a) failure to complete all the tests included in the protocol, and b) have a diagnosis of a neurodevelopment condition (ADHD, learning disability, etc) reported by teachers or parents.

Measures

a) Objective tests completed by children

2.2.1. The *BENCI Computerized Battery for Neuropsychological Evaluation of Children* (Cruz-Quintana et al., 2013). This battery, which uses electronic devices to present and record the subject's responses, assesses the main neuropsychological domains: Processing Speed, Visuomotor Coordination, Attention, Memory, Language, and Executive Function. The test can be administered quickly and its duration varies depending on the number of functions to be assessed (it can be administered in its entirety or by selecting specific tests) and the age of the person being assessed. The maximum duration of the test is 75 minutes. It consists of 13 tests that can be used separately or in combination, depending on the purpose of the assessment. It can be administered to children as young as 6 years of age ~~(~~(see Table 3)- (a comprehensive description of the BENCI, including instructions and illustrative images for each test, is provided in the supplementary material). About the general presentation of the battery, the BENCI features a simple and intuitive graphical interface, designed for users of various ages. The icons are large and easily identifiable, while the color scheme is soft to avoid distractions. On-screen instructions are brief and precise, minimizing confusion (see supplementary material for examples of the tests). The application allows for adjustments to test parameters, including the number of stimuli presented, the number of trials, and the duration of stimulus presentation on the screen. The selection of these parameters should be tailored to the evaluation objectives and the characteristics of the sample. The BENCI is designed to be administered under supervision. It should be used in a controlled environment, such as a clinical or educational setting.

-INSERT TABLE 3 ABOUT HERE-

The 13 tests and the parameters selected for each test are detailed below:

1. Simple Reaction Time. This involves pressing any key as quickly as possible every time a cross (+) appears on the screen. Number of trials: 100. Presentation time: 500 milliseconds. Interval between stimuli: 2000 milliseconds. Parameters recorded: Reaction Time (RT), measured in milliseconds (ms).

2. Visuomotor Coordination (A). This involves pressing the numbers or elements that appear jumbled up on the screen in ascending order or according to a prescribed sequence. Number of stimuli: 15. Parameters recorded: RT (ms).

3.Alternate Visuomotor Coordination (B). This involves pressing the numbers and elements from two separate series, which are jumbled up on the screen, in alternate and ascending order. Number of stimuli: 15. Parameters recorded: RT (ms).

4. Continuous Performance Test (CPT). Blocks of letters (trails) appear on the screen one after the other. Participants have to press a key every time the specified stimulus appears (e.g., an A after an X). All other letters are distractors. Three blocks of 100 trials per block with a presentation time of 500 msg and an inter-stimulus interval of 2000 msg are presented. Parameters recorded: correct answers.

5. Verbal Memory. The participant listens to the same sequence of words three times (Verbal Memory trial 1, Verbal Memory trial 2 and Verbal Memory trial 3). At the end of each sequence, the participant must repeat aloud all the words that they can remember. Number of stimuli: 9. Parameters recorded: correct answers.

Verbal Memory (Delayed test). Twenty minutes after the end of the Verbal Memory Test, the participant must repeat aloud all the words that they can remember from the list given in the test. Parameters recorded: correct answers.

Verbal Memory (Recognition test). Immediately after the previous test, the participant listens to a set of words, half of which are from the list presented in the Verbal Memory test. The participant must indicate whether each of the words is on that list. Parameters recorded: correct answers.

6. Visual Memory. Images of common objects are presented and then the participant must verbally recall all the pictures they remember. Parameters recorded: correct answers.

Visual Memory (Delayed test). Twenty minutes after the Visual Memory Test is completed, the participant is asked to verbally recall all of the images they remember from those presented in the test. Parameters recorded: correct answers.

Visual Memory (Recognition test). Immediately after the previous test, various images are shown, many of which appeared in the Visual Memory test. For each image, the person must indicate if it was one of those shown in the aforementioned task. Presentation time: 2000 milliseconds. Parameters recorded: correct answers.

7. Verbal Comprehension (Images). Participants are shown a set of images belonging to a particular category (e.g., animals). They then receive verbal instructions asking them to select an image that meets the conditions specified (type of animal, position, activity it can perform, and/or color: e.g., "touch the frog next to the dog"). Number of ~~instructions~~trials: 10. Parameters recorded: correct answers.

Verbal Comprehension (Figures). This is similar to the previous test, but involves images of geometric shapes (circles, triangles, and squares: small, medium, and large) of different colors. Participants must select those that meet the conditions specified (shape, size, position, and/or color: e.g., "touch a small blue circle"). Number of ~~instructions~~trials: 10. Recorded parameters: correct answers.

8. Phonetic Fluency. A letter is given and the participant is asked to list all the words they know beginning with that letter. F Letter. Response time: 60 seconds. Parameters recorded: correct answers. ~~Time: 60 seconds.~~

9. Working Memory. Participants listen to mixed sequences of numbers and colors and then have to repeat the numbers and colors stated; first the numbers in ascending order and then the colors, or vice-versa. Parameters recorded: correct answers.

10. Abstract Reasoning. A series of logical sequences are displayed on the screen. Participants have to select the item that completes the displayed sequence. Parameters recorded: RT (ms) and correct answers.

11. Semantic Fluency. Participants are given a semantic category (colors or animals) and are asked to list all the items they know belonging to that category. Time: 60 seconds. Parameters recorded: correct answers.

12. Inhibition: Go/No-go. Two items appear alternately on the screen. In the first phase, the participant must press a key when one item appears. Then, after hearing a tone signaling the transition to the second phase or halfway through the test, the participant must press a key when the other item appears. Parameters recorded: RT (ms) and correct answers.

13. Planning: Amusement park. The goal is to go on as many rides as possible in the allotted time with the money provided. Each ride has a different price and duration, and the same ride may not be chosen twice in a row. Parameters recorded: number and variety of rides visited.

In order to analyze the evidence of convergent validity the following tests were used:

2.2.2. Forward and Backward Digit Span Subtest (WISC-V. Wechsler, 2015). In the first part of this task, the subject is asked to repeat a sequence of numbers in the same order as they are said by the evaluator (forward), and then in the second part they have to repeat the sequence in reverse order (backward). In both cases, the number of digits to be repeated increases with each attempt. This subtest primarily assesses attention, working memory, cognitive flexibility, and auditory discrimination. Its internal consistency in a Spanish sample has been found to range from .88 to .93, depending on the test (Wechsler, 2015).

2.2.3. Raven's Progressive Matrices Test (Raven, 1989). This is a non-verbal intelligence test. Solving progressively difficult matrix problems involves cognitive functions such as attention and perception, inductive reasoning, fluid intelligence, general visual intelligence, classification ability, spatial ability, simultaneous processing, and working memory. This test has demonstrated evidence of convergent validity and reliability (with an internal consistency of .90) (~~Sanchez~~ Sánchez & Pirela, 2009).

2.2.4. Luria Neuropsychological Diagnostic Battery - Initial (Manga & Ramos, 2006). We used the version adapted to the Cuban context by Ramírez-Benítez et al. (2013). This is an instrument designed to identify neuropsychological alterations in children. This battery assesses motor skills, executive functions, language abilities, processing speed, and both verbal and non-verbal memory. For this study we used the battery's three memory tests, where the ~~student~~ participant listens to the same sequence of words three times (Luria trial 1, Luria trial 2 and Luria trial 3) and after each trial, the participant repeats the words ~~they~~ s/he recalls. Internal consistency values indicate that the instrument is reliable (.82).

b) Completed by the parents

2.2.5. BRIEF-2 Behavioral Rating Inventory of Executive Function (Gioia et al., 2015). We used the Spanish adaptation by Maldonado et al. (2017). This test assesses executive function using nine clinical scales (Inhibition, Self-monitoring, Flexibility, Emotional control, Initiative, Working memory, Planning and organization, Task monitoring, and Organization of materials), three general indexes (Behavioral regulation index, Emotional regulation index, and Cognitive regulation index) and a global index of executive function. It also includes three validity scales (Infrequency, Inconsistency, and Negativity). This test is completed by the child's parents and/or guardians. The test has good convergent and differential validity indices. The Cronbach's alpha coefficient has a mean value of .86 (Maldonado et al., 2017).

Procedure

First of all, approval was sought and obtained from the Research Ethics Committees of the University of Granada (Registration No. 2098/CEIH/2021) and the University of Cienfuegos "Carlos Rafael Rodríguez" (Resolution No. 85). Meetings were then scheduled with the regional directors of education in the provinces of Cienfuegos and Havana to request their cooperation and to select the participating schools. The next step was to hold meetings with the principals and teachers of the participating schools to explain the objectives of the study and enlist their cooperation. Teachers notified families and asked fathers, mothers, or legal guardians to sign an informed consent form authorizing the children's participation.

The evaluators were students and faculty from the Universities of Cienfuegos and Havana, who had been trained in the use of the assessment protocol. They were coordinated by a researcher from the project team. The assessments took place on school premises during regular school hours. Each assessment was conducted on a one-to-one basis and lasted approximately 90 minutes. A subsample of 134 participants also completed the validation tests during the same session. The tests used for the validation process were selected based on previous studies with the BENCI (Burneo-Garcés et al., 2017) and were previously validated in a Cuban sample (Ramírez-Benítez et al., 2013). According to information from previous studies (Fasfous et al., 2015), fifteen days after the initial assessment, a subsample of 59 participants were retested using the BENCI to calculate test-retest reliability.

The order in which the tests were administered was the same for all participants and, for the neuropsychological tests, followed the recommendations made by Lezak et al. (2004).

Statistical Analysis

Reliability was analyzed by means of test-retest measures using the intraclass correlation coefficient (ICC) and internal consistency using Cronbach's alpha. The analysis of convergent validity involved the calculation of Pearson correlations between the BENCI tests and other tests assessing similar domains. To analyze the differential validity of the BENCI, we conducted a between-groups analysis of variance (ANOVA) to assess how participants performed by sex and educational level (independent variable) on all the BENCI tests (dependent variable). Given the need for multiple comparisons, the Bonferroni correction was applied to reduce the probability of a type I error, establishing the significance threshold at $\leq .002$ for ANOVA. We conducted a *post hoc* analysis using the Bonferroni correction. Finally, to examine the factorial structure of the BENCI, we first performed an exploratory factor analysis (EFA) employing maximun likehood and varimax rotation followed by a confirmatory factor analysis (CFA) using the maximum likelihood (ML) estimator. We evaluated model fit using the Comparative Fit Index (CFI) and the Tucker-Lewis Index (TLI), the values of which must exceed .90. The root mean square error of approximation (RMSEA) was also calculated, with values of at least less than .08 required for a good fit (Hu & Bentler, 1995). All analyses were performed with the SPSS program (version 22.0) and the Jamovi program for the EFA and the CFA.

RESULTS

3.1. Reliability: test-retest and internal consistency

For the reliability analyses, a subsample of 59 children participated, with the distribution shown in Table 4. Specifically, 4 children aged 6 years (2 boys and 2 girls), 8 children aged 7 years (3 boys and 5 girls), 7 children aged 8 years (5 boys and 2 girls), 10 children aged 9 years (5 boys and 5 girls), 5 children aged 10 years (2 boys and 3 girls), 2 children aged 11 years (1 boy and 1 girl), 4 children aged 12 years (4 boys and 0 girls), 3 children aged 13 years (0 boys and 3 girls), 4 children aged 14 years (1 boy and 3 girls), 3 children aged 15 years (1 boy and 2 girls), 5 children aged 16 years (1 boy and 4 girls), and 4 children aged 17 years (2 boys and 2 girls).

INSERT TABLE 4 ABOUT HERE

In terms of test-retest reliability, Table 5 shows the intraclass correlation coefficients (ICC) for each test in the battery and the Pearson correlations obtained from a subsample of 59 participants. As can be seen in table 5, the coefficients range from .136 to .782. Following the guidelines reported by Ko and Li (2016), ~~Good~~ good measure~~s~~ (scores between 0.75 and 0.9) ~~equal to or greater than .6)~~ was obtained for Reasoning (ICC= 0.782); moderate measures (scores between 0.5 and 0.75) were obtained for Alternate Visuomotor Coordination (ICC= 0.661), ~~Reasoning (ICC= .782),~~ Phonetic Fluency (ICC= 0.677), ~~and~~ Working Memory (ICC= 0.603)~~.~~, Visuomotor Coordination (ICC= 0.554), Verbal Memory Trial 2 (ICC= 0.505), Verbal Memory (Delayed test) (ICC=0.518), Visual Memory (Recognition test) (ICC= 0.531), Semantic Fluency (ICC= 0.576), and Simple Reaction Time (ICC= .597); and poor measures (scores values <0.5) were obtained for Continuous Performance Test (ICC=0.323), Verbal Memory Trial 1 and Trial 3 (ICC=0.339, ICC=0.384) ~~Sufficient/adequate measures (scores between .4 and .599) were obtained for Visuomotor Coordination (ICC= .554), Verbal Memory Trial 2 (ICC= .505), Verbal Memory (Delayed test) (ICC= .518),~~ Visual Memory Immediate and ~~(~~Delayed test~~)~~ (ICC=0.387, ICC = 0.486), Verbal Comprehension Figures and Images (ICC=0.136, ICC=0.260) and Planning (ICC=0.175). ~~Visual Memory (Recognition test) (ICC= .531), Semantic Fluency (ICC= .576), and Simple Reaction Time (ICC= .597).~~

-INSERT TABLE 5 ABOUT HERE-

For the analysis of internal consistency, Cronbach's alpha was calculated, yielding good values for the Reasoning task (α = .878) and adequate values for the Reaction Time (α = .748), Semantic Fluency (α =.731), Phonetic Fluency (α=.808), Visuomotor Coordination (α=.739), Alternate Visuomotor Coordination (α=.796) and Working Memory α = .753) tasks. However, they were notably low for Verbal Comprehension (Figures) (α=.239) and Planning (α=.297)~~.~~ and moderate to low in the remaining tasks as shown in table 5.

3.2. Validity Analysis:

3.2.1. Convergent validity

In terms of convergent validity, results from the subsample of 134 subjects found significant positive correlations between the BENCI scores and the other neuropsychological tests. The distribution of this subsample is shown in Table 6. Specifically, 11 children aged 6 years participated (5 boys and 6 girls), 12 aged 7 years (5 boys and 7 girls), 17 aged 8 years (9 boys and 8 girls), 12 aged 9 years (8 boys and 4 girls), 10 aged 10 years (5 boys and 5 girls), 14 aged 11 years (7 boys and 7 girls), 4 aged 12 years (2 boys and 2 girls), 8 aged 13 years (1 boy and 7 girls), 12 aged 14 years (2 boys and 10 girls), 10 aged 15 years (5 boys and 5 girls), 22 aged 16 years (4 boys and 18 girls), 1 aged 17 years (1 boy and 0 girls), and 1 aged 18 years (1 boy and 1 girl).

INSERT TABLE 6 ABOUT HERE

These correlations were observed (see Table 7) between the BENCI Verbal Memory Trial 2 and the Luria Trial 2 (r= .247, p<.01) as well as between the Verbal Memory Trial 3 and the Luria Trial 3 (r=.295, p<.01). Significant positive correlations were also found between the Verbal Delayed Memory test and the Delayed Luria (r=.217, p<.05), between the Reasoning test and Raven's Matrices (r=.781, p<.01), and between the Working Memory test and both the WISC-V Digit Span Forward (r=.182, p<.05) and Backward tasks (r=.296, p<.01). A significant negative correlation was found between the Working Memory test and the BRIEF-2's working memory tasks (r=-.269, p<.01).

- INSERT 7 ABOUT HERE-

3.2.2. Differential validity

In order to determine the differential validity of the BENCI, we analyzed the differences in neuropsychological performance of the participants in the different tests according to their level of education, sex and its interaction. As shown in Table 8, there are significant differences between elementary school, high school, and pre-university children across all of the neuropsychological variables. As the *post hoc* analyses show, these differences indicate that higher-grade children outperform lower-grade children (see Table 8 and supplementary material). Table 8 shows that at each stage of education, performance in the tests of Visuomotor Coordination, Alternate Visuomotor, Reasoning, ~~Semantic Fluency,~~ Phonetic Fluency, and Working Memory is significantly better than at the previous stage (p < .002). Performance at the high school and pre-university levels is similar and in both cases significantly better than at the elementary level in Continuous Performance Test, Verbal Memory Trial 1; Verbal Delayed Memory; Visual Immediate and ~~,~~ Delayed~~, and Recognition~~ Memory; Verbal Comprehension of Figures and Images; the hit rate of the Go-no-go task and Simple Reaction Time. ~~In Verbal Memory Trial 2 and Planning, there are no significant differences between elementary and high school, but both groups perform significantly below pre-university levels. Significant differences were found between the elementary and pre-university groups in Verbal Memory Trial 3.~~ Regarding the differences in sex and the interactions between sex and education we found statistically significant differences in the

Simple Reaction Time by Sex, where boys performed better than girls. Other effects that were below the statistical threshold used for multiple comparisons (p > .002 ~~in all cases~~) are included in Table 8. ~~, we found that boys performed better on the Simple Reaction Time, Verbal Memory Trial 2, and Semantic Fluency, Reasoning, and Working Memory tasks. In contrast, girls outperformed boys on the Planning Task. Additionally, we identified three significant interactions. The results indicate that elementary school boys perform worse than girls on the Visual Recognition Memory and Verbal Comprehension of Figures tasks, while high school boys perform worse than girls on the Phonetic Fluency task.~~.

- INSERT TABLE 8 ABOUT HERE-

3.2.3. Construct validity

We based our evaluation of the structure of the BENCI battery on the model fit reported in the Moroccan-Arabic adaptation by Fasfous et al. (~~2014~~2015). Considering the potential cultural differences between samples, we first conducted an exploratory factor analysis (EFA). The sample size was adequate based on the discretion of Kaiser-Meyer-Olkin value (KMO= .821) and the Bartlett's test of sphericity (χ^2 (91)= 4634, p < .001). The analysis identified a total of four main factors: 1) inhibition, 2) fluency, 3) flexibility and reasoning, and 4) memory (see Table 9). Since these results were consistent with the version Arabic version of the BENCI and that the flexibility tasks had negative loadings on the factor, we decided to include them as a separate dimension in the confirmatory factor analysis (CFA) and test a five-factor model: Inhibition, Flexibility, Fluency, Reasoning, and Memory. The variables in both analysis include both correct answers and errors, with the hit rate calculated for blocks 1 to 4 in the case of the Go/No-Go task (hits/(hits+omission errors)). The results of the confirmatory model revealed adequate model fit indices (see Figure 1): X^2 (67) = 216, p < .001, CFI=.968, TLI= .957, RMSEA= .036 (CI 90%= .030, .041).

-INSERT TABLE 9 AND FIGURE 1 ABOUT HERE-

DISCUSSION

The main objective of this research was to analyze the psychometric properties of the BENCI in a Cuban sample of children and adolescents. The results obtained showed good reliability and validity indices. This means that the BENCI is a suitable test for assessing neurodevelopment in the Cuban population between the ages of 6 and 18.

Firstly, the data obtained for reliability are adequate and comparable to those found in studies using the BENCI in Moroccan-Arabic (Fasfous et al., 2015) and Kenyan (Rachel et al., 2023) samples. In the Cuban sample, good or ~~adequate~~ moderate ICCs were obtained in ~~11~~ 10 of the battery's 18 subtests, particularly in Reasoning, Alternate Visuomotor Coordination~~, Reasoning,~~ and Working Memory. These subtests have also yielded good or excellent ICCs in other samples where there are evidences of validity for the BENCI (Fasfous et al., 2015; Rachel et al., 2023). ~~Good~~ Moderate ICCs ~~were~~ was also obtained for Phonetic Fluency in the Cuban sample. This data has not been found in other non-Spanish speaking samples. This may be due to the phonetic characteristics of Spanish that distinguish it from other languages, where the BENCI has been tested. ICCs were low for Continuous Performance Test, Verbal Memory Trials 1 and 3, Visual Memory Immediate and Delayed test, Planning (a finding also reported in the Moroccan-Arabic sample by Fasfous et al. (2015)) and for Verbal Comprehension (Figures and Images). ~~This~~ These results could be due to the fact that the sample used for the test-retest analysis consisted of 59 students out of the total sample. Moreover, the 15-day interval between the two tests may have facilitated learning and increased familiarization with the tasks, potentially influencing the indices obtained.

In terms of internal consistency, ~~good~~ good or adequate indices were found for seven of the battery's tests: Reasoning task, reaction time, semantic and phonetic fluency, visuomotor coordination, alternative visuomotor coordination and working memory. However, internal consistency for verbal comprehension (figures) and planning w~~as~~ere notably low and moderate to low in the remaining tasks. These findings could be explained by the diversity of items within some of the tasks or by variations in the difficulty levels of certain items within each task. In the case of planning, the result stands in contrast to findings from other samples (Fasfous et al., -2015; Rachel et al., 2023), where the planning task demonstrated high internal consistency. This discrepancy may be attributable to the cultural and linguistic variations observed across the different samples.

With reference in the first instance to convergent validity, the results of the BENCI in a Cuban sample provide evidence of its validity. The data show statistically significant relationships between cognitive domains evaluated by the BENCI and other similar neuropsychological tests previously shown to be effective in assessing the cognitive functions examined in this study (de Jong, 2023; Pind et al., 2003; Ramírez-Benítez et al., 2013) although the correlation coefficients were low to moderate in some cases. This may be attributable to the analyses being conducted on a subsample of participants with varying ages. For example, we found a high correlation between Verbal Memory assessed using the BENCI and the Luria battery; between the Reasoning test and Raven's Matrices; and between the Working Memory test and the WISC-V Forward and Backward Digit Span and BRIEF-2 Working Memory tests. These findings suggest that the BENCI is a valid test for assessing these cognitive domains in the Cuban population. Similar data have been obtained when validating the test in other settings. The data obtained in this study are similar to those found in the Kenyan sample, where a significant high correlation was found between the BENCI tests that assess Reasoning, Memory, and Inhibition and culturally specific neuropsychological tests (Rachel et al., 2023). Furthermore, of all the tests used, the strong correlation found between the Reasoning test and Raven's Matrices is comparable to the findings of the preliminary validation in the Spanish sample, which showed statistically significant relationships between this variable and the Toni-2 (Fernández-Alcántara et al., 2022).

In terms of differential validity, the battery has demonstrated the ability to discriminate between different levels of education. The results show significant differences between elementary, high school, and pre-university children for most of the neuropsychological variables. These differences indicate that children in higher grades outperform those in lower grades. The data obtained confirm the BENCI's ability to assess neurodevelopment in children from the early stages of education to more advanced levels. This finding is consistent with the data reported in the validation of the battery in Arabic-speaking samples in Morocco and Palestine (Fasfous et al., 2015;~~ and~~ 2021) where the BENCI showed that it was able to differentiate children by age. This feature has also been verified in Ecuadorian (Burneo-Garcés et al., ~~2018~~2019) and Spanish (Fernández-Alcántara et al., 2022) samples.

In terms of the factorial structure of the BENCI, the results of this study are consistent with previous adaptations (Fasfous et al., 2015; Rachel et al., 2023), identifying a model with an adequate fit for five key aspects of executive function: Inhibition, Flexibility, Fluency, Reasoning, and Memory. In addition, the factor loadings indicate higher values, with only the Alternate Visuomotor errors having values below .30, whereas in previous studies four tests had low factor loadings (Fasfous et al., 2015).

CONCLUSIONS

In conclusion, the reliability and validity data provided indicate that the BENCI is a reliable, valid, and culturally adapted neurodevelopmental assessment instrument. First and foremost, the BENCI is presented as a tool that can address the lack of culturally adapted neuropsychological instruments in Latin America. However, its ability to effectively discriminate between clinical and non-clinical populations requires validation in future research. The BENCI is adapted and free of charge, overcoming the difficulty of using expensive evaluation tools in emerging countries such as Cuba (Cruz-Quintana et al., 2022). Secondly, the BENCI is a valid and reliable tool for neurodevelopmental research. This is important because neurodevelopmental research is particularly relevant in resource-poor countries such as Cuba, which have less funding to allocate to education and child protection (Saforcada, 2006). In such contexts, the availability of suitable neurodevelopmental assessment tools and procedures is a major step forward, as it allows for the evaluation and detection of possible deficiencies affecting the neurodevelopment of Cuban children and adolescents. Thirdly, a number of features of the test make it ideally suited for use in the neuropsychological assessment of children and adolescents. These features include: its short administration time compared to other batteries (Matute et al., 2007); its user-friendly tablet-based design; customizable parameters to suit the target sample; the option to store personal information for each individual; and the ability to export data to spreadsheets for later analysis (Cruz-Quintana et al., 2022). It also requires minimal training and can be used in clinical, educational, and research contexts. Fourth, this validation of the BENCI in a Cuban sample has been possible thanks to an international development cooperation project between Spain and Cuba, and serves to underline the importance of such initiatives and the implications of the findings for the target population.

This study provides further evidence of its validity, as already demonstrated in other countries and cultures, such as Ecuador (Burneo-Garces et al., 2018), Kenya (Rachel et al., 2023), Morocco (Fasfous et al., 2015), Palestine (Fasfous et al., 2021), and Spain (Fernández-Alcántara et al., 2022). In the present ~~research~~study, there ~~was~~were some differences between boys and girls~~,~~ in tests such as Simple Reaction Time, as well as interactions between sex and educational level that ~~doesn't~~did not reach the statistic threshold used for multiple comparisons. Although previous studies using the BENCI have not analyzed differences by sex, futures~~s~~ research is needed in order to study the role of gender in its interaction with age and socioeconomi~~cal~~c status (Burneo-Garces et al., 201~~8~~9). The BENCI is therefore an extremely valuable neuropsychological assessment tool, in whatever context.

The main limitations of the study include the fact that the IQ of the participants was not controlled for. Furthermore, we were not able to ensure a homogeneous sample size across the different municipalities and educational levels. On the other hand, future research should include clinical samples to assess the discriminant validity of the battery. Furthermore, the small sample size used in both the test-retest and convergent validity studies may have influenced some of the results obtained. To reiterate, our main conclusion is that the BENCI has ~~demonstrated~~ shown good ~~reliability and validity~~evidence of reliability and validity ~~evidences~~ in the neuropsychological assessment in a Cuban sample of children and adolescents~~s sample~~. As such, it can be considered a reference for neuropsychological and neurodevelopmental assessment in Cuba.

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Title:

Validation of the Computerized Battery for Neuropsychological Evaluation of Children (BENCI) in a Cuban sample.

Abstract

The aim of this research was to analyze the reliability and validity of the Computerized Battery for Neuropsychological Evaluation of Children (BENCI) in a Cuban population of children and adolescents. The study involved 1,714 Cuban students between the ages of 6 and 18 who were divided into three groups according to their level of education (Elementary: 6 to 11 years old; High School: 12 to 14 years old; and Pre-University: 15 to 18 years old). All participants were evaluated using the BENCI with some also undergoing additional neuropsychological testing. The BENCI evaluates the following cognitive domains: processing speed, visuomotor coordination, attention, memory, language, and executive functions. The results showed that the BENCI has good test-retest reliability indices and high internal consistency values in Reasoning, Reaction Time, and Working Memory. In terms of validity, the data revealed significant correlations between the BENCI tests and other neuropsychological tests assessing similar cognitive functions. The BENCI also has discriminative validity, as it was found that performance on the tests varies according to the level of education of those being evaluated. In terms of construct validity, confirmatory factor analysis showed that the fit indices for the executive functions dimension of the BENCI are adequate. The data show that the BENCI is a reliable and valid instrument for assessing neurodevelopment in Cuban children and adolescents. Since this is the first neuropsychological test of its kind to be validated in the Cuban population, this finding is of particular importance.

Key words: Cuban children; Neuropsychological battery; Neurodevelopment; Assessment.

INTRODUCTION

The evaluation of neuropsychological functioning in early childhood is of paramount importance. Childhood is a crucial developmental stage for human beings, as it lays the foundational neurological and maturational groundwork for development in the early years of life. The development of the brain during these early years significantly impacts both mental and physical health, as well as lifelong (Treviño et al., 2021). Adversity and toxic stress experiences in early childhood can lead to lifelong impairments in learning, behavior, and physical and mental health (Shonkoff, 2010, 2012). Brain systems responsible for emotional regulation, memory, and executive function - which include the prefrontal cortex and other brain regions where circuits for attention, impulse control, and higher-order cognitive skills are developed well into adulthood - are particularly vulnerable. Significant adversity before birth or during early childhood can contribute to increased neural susceptibility to damage from repeated stressors later in life, particularly in vulnerable populations. Although remediation is possible at any age, outcomes are more favorable when detection and intervention occur earlier. Achieving this requires neuropsychological assessments during childhood using reliable and adapted instruments, particularly for executive functions, as well as targeted interventions addressing these functions (Shonkoff & Garner, 2012).

Despite the importance of this issue, few neuropsychological assessment batteries are currently available for use with Spanish-speaking children and adolescents (Arango-Lasprilla, 2015; Guardia-Olmos et al., 2015; Rosselli-Cock et al., 2004). We often see batteries designed for other cultures and languages that, when translated and applied in Spanish-speaking countries, fall short of the necessary standards and psychometric requirements

(Arango-Lasprilla, 2015; Rosselli-Cock et al., 2004). In the absence of appropriately adapted tests, children with risk factors sometimes do not undergo the clinical and neuropsychological screening that would allow us to differentiate between healthy children and those with developmental delays (Poveda-Pulla et al., 2021). This can have major implications, as children who are in need of specialized intervention may not receive it, resulting in cognitive, behavioral, or learning disorders (Poveda-Pulla et al., 2021).

The shortcomings of neuropsychological assessment instruments in Latin America were analyzed in a recent study (Arango-Lasprilla et al., 2017). The study surveyed the opinions of neuropsychologists from 17 Latin American countries (including Cuba) on issues related to their profession. In all, 62% of respondents highlighted the lack of normative data for local populations, while nearly half cited the lack of cultural adaptation and the high cost of these instruments (Arango-Lasprilla et al., 2017).

In order to overcome the shortcomings in the field of neuropsychological evaluation in Latin America, considerable efforts have been made in recent years to obtain normative data in children and develop neuropsychological batteries adapted to this particular context. For an obvious example of this, we need look no further than special issues such as the 2017 issue of the journal *NeuroRehabilitation*. This issue featured the adaptations of 10 neuropsychological tests and published normative data for a sample of 6,030 healthy children and adolescents between 6 and 17 years old from 10 Spanish-speaking countries (including Cuba) (Arango-Lasprilla & Rivera, 2017).

Another important battery is the ENI (*Evaluación Neuropsicológica Infantil* (or Neurological Assessment of Children in English); Matute et al., 2007), which was the first neuropsychological battery developed in Latin America for a sample of Spanish-speaking children. Designed for children between the ages of 5 and 16, it assesses eleven cognitive domains. The ENI-2 is now commercially available (Matute et al., 2013) and is theoretically and psychometrically robust, but it is expensive and takes three to four hours to administer.

In the Cuban sample, we found the B-PREA-R test, which assesses nine cognitive domains in pre-school children. There are validity evidences of this tool with 300 children between the ages of 4 and 6 in the province of Cienfuegos, and its purpose is the early identification of children with cognitive developmental delays before they start school (Ramírez-Benítez et al., 2022).

The Computerized Battery for Neuropsychological Evaluation of Children (BENCI; Cruz-Quintana et al., 2013) is particularly important in the context of the development of neuropsychological batteries for children and adolescents. This battery is the result of several international cooperation projects focused on neurodevelopmental protection. The priority for these projects has been the development of culturally adapted, reliable, and valid assessment instruments (Cruz-Quintana et al., 2022). The BENCI is designed for children aged 6 to 18 and assesses the following cognitive domains: Processing Speed, Visuomotor Coordination, Attention, Language, Memory, and Executive Function. It is available in a standardized, computerized format. Data capture is straightforward and reliable (correct answers, errors, and reaction time), and the parameters can be configured to tailor tests to the target sample. It consists of 13 tests with an estimated completion time of approximately 60-70 minutes. The battery is user-friendly and its appealing design makes it easy to create personalized reports and databases. It is a freely available, tablet-based battery with a good track record in assessing neurodevelopment in the overall child sample (Burneo-Garcés et al., 2019; Cruz-Quintana et al., 2013; Fasfous et al., 2015; Fernández-Alcántara et al., 2022) and in clinical samples, such as preterm children (García-Bermúdez et al., 2019).

The BENCI has been tested in a large sample of Ecuadorian children, showing differences between those with a lower socioeconomic status and those with a medium socioeconomic status (Burneo-Garcés et al., 2019). Evidence of validity and reliability has been found in Arabic-speaking samples in Morocco (Fasfous et al., 2015) and Palestine (Fasfous et al., 2021), as well as in Kenya (Maina et al., 2019; Rachel et al., 2023). A five-factor structure, following Diamond's model of executive function (2013) has been tested in Moroccan children, showing good fit statistics (Fasfous et al., 2015). Finally, preliminary data on its validity in Spanish children aged nine to eleven have recently been published, showing a positive association with other neuropsychological tests assessing the same domains as the BENCI (Fernández-Alcántara et al., 2022).

Given these characteristics, as well as the lack of available instruments for assessing development in the Cuban population, the validation of the BENCI could prove extremely valuable for analyzing the neurodevelopment of Cuban children and the way it is influenced by certain psychosocial variables. We believe that validating this test is of great interest, as it stands out compared to previously reviewed instruments by allowing the assessment of a broader age range (6 to 18 years, compared to the B-PREA-R, which is limited to preschool children), in less time (60–70 minutes compared to the 3–4 hours required by the ENI), and free of charge (unlike the other cited tests, which require payment). Furthermore, this test was reviewed by experts in Cuban language and culture prior to its application to ensure its cultural adaptation.

The main aim of the present study was to analyze the reliability and validity (convergent, differential and construct) of the BENCI battery in a sample of Cuban children aged 6 to 18 years old.

METHODS

Participants

The study involved 1,714 Cuban children, 777 boys and 937 girls, between the ages of 6 and 18 years old. The participants came from the provinces of Cienfuegos (municipalities of Cienfuegos, n=1238 and Cumanayagua, n=360) and Havana (municipality of Marianao, n=116). The province of Cienfuegos is in the central part of Cuba and Havana in the western part, and they are two municipalities representative of the island's population. Educational levels in Cuba are divided into Elementary (first to sixth grade - 6 to 11 years old), High School (seventh to ninth grade - 12 to 14 years old) and Pre-University (tenth to twelfth grade - 15 to 18 years old). Participants were recruited from three Elementary schools (two from Cienfuegos and one from Havana), two High schools (one from Cienfuegos and one from Cumanayagua) and three Pre-university schools (one from Cienfuegos, one from Cumanayagua and one from Havana). Schools were selected by Cuban educational institutions based on the representation criteria of the students in Cuba. According to teachers and parents in the initial interviews, all of the children did not have any psychiatric or neuropsychological disease. The data were collected between 2022 and 2023. Of the total sample, 134 were selected to conduct the validity study and 59 to conduct the reliability study. Table 1 shows the distribution of the sample by sex, academic level, and geographic area. Regarding parent's SES, Table 2 shows parent's educational level stratified by municipalities.

INSERT TABLES 1 AND 2 ABOUT HERE-

Inclusion criteria were: a) being students at the selected centers, and b) having informed consent from their legal guardians. Exclusion criteria were: a) failure to complete all the tests included in the protocol, and b) have a diagnosis of a neurodevelopment condition (ADHD, learning disability, etc) reported by teachers or parents.

Measures

a) Objective tests completed by children

2.2.1. The *BENCI Computerized Battery for Neuropsychological Evaluation of Children* (Cruz-Quintana et al., 2013). This battery, which uses electronic devices to present and record the subject's responses, assesses the main neuropsychological domains: Processing Speed, Visuomotor Coordination, Attention, Memory, Language, and Executive Function. The test can be administered quickly and its duration varies depending on the number of functions to be assessed (it can be administered in its entirety or by selecting specific tests) and the age of the person being assessed. The maximum duration of the test is 75 minutes. It consists of 13 tests that can be used separately or in combination, depending on the purpose of the assessment. It can be administered to children as young as 6 years of age (see Table 3) (a comprehensive description of the BENCI, including instructions and illustrative images for each test, is provided in the supplementary material). About the general presentation of the battery, the BENCI features a simple and intuitive graphical interface, designed for users of various ages. The icons are large and easily identifiable, while the color scheme is soft to avoid distractions. On-screen instructions are brief and precise, minimizing confusion (see supplementary material for examples of the tests). The application allows for adjustments to test parameters, including the number of stimuli presented, the number of trials, and the duration of stimulus presentation on the screen. The selection of these parameters should be tailored to the evaluation objectives and the characteristics of the sample. The BENCI is designed to be administered under supervision. It should be used in a controlled environment, such as a clinical or educational setting.

-INSERT TABLE 3 ABOUT HERE-

The 13 tests and the parameters selected for each test are detailed below:

1. Simple Reaction Time. This involves pressing any key as quickly as possible every time a cross (+) appears on the screen. Number of trials: 100. Presentation time: 500 milliseconds. Interval between stimuli: 2000 milliseconds. Parameters recorded: Reaction Time (RT), measured in milliseconds (ms).

2. Visuomotor Coordination (A). This involves pressing the numbers or elements that appear jumbled up on the screen in ascending order or according to a prescribed sequence. Number of stimuli: 15. Parameters recorded: RT (ms).

3.Alternate Visuomotor Coordination (B). This involves pressing the numbers and elements from two separate series, which are jumbled up on the screen, in alternate and ascending order. Number of stimuli: 15. Parameters recorded: RT (ms).

4. Continuous Performance Test (CPT). Blocks of letters (trails) appear on the screen one after the other. Participants have to press a key every time the specified stimulus appears (e.g., an A after an X). All other letters are distractors. Three blocks of 100 trials per block with a presentation time of 500 msg and an inter-stimulus interval of 2000 msg are presented. Parameters recorded: correct answers.

5. Verbal Memory. The participant listens to the same sequence of words three times (Verbal Memory trial 1, Verbal Memory trial 2 and Verbal Memory trial 3). At the end of each sequence, the participant must repeat aloud all the words that they can remember. Number of stimuli: 9. Parameters recorded: correct answers.

Verbal Memory (Delayed test). Twenty minutes after the end of the Verbal Memory Test, the participant must repeat aloud all the words that they can remember from the list given in the test. Parameters recorded: correct answers.

Verbal Memory (Recognition test). Immediately after the previous test, the participant listens to a set of words, half of which are from the list presented in the Verbal Memory test. The participant must indicate whether each of the words is on that list. Parameters recorded: correct answers.

6. Visual Memory. Images of common objects are presented and then the participant must verbally recall all the pictures they remember. Parameters recorded: correct answers.

Visual Memory (Delayed test). Twenty minutes after the Visual Memory Test is completed, the participant is asked to verbally recall all of the images they remember from those presented in the test. Parameters recorded: correct answers.

Visual Memory (Recognition test). Immediately after the previous test, various images are shown, many of which appeared in the Visual Memory test. For each image, the person must indicate if it was one of those shown in the aforementioned task. Presentation time: 2000 milliseconds. Parameters recorded: correct answers.

7. Verbal Comprehension (Images). Participants are shown a set of images belonging to a particular category (e.g., animals). They then receive verbal instructions asking them to select an image that meets the conditions specified (type of animal, position, activity it can perform, and/or color: e.g., “touch the frog next to the dog”). Number of trials: 10. Parameters recorded: correct answers.

Verbal Comprehension (Figures). This is similar to the previous test, but involves images of geometric shapes (circles, triangles, and squares: small, medium, and large) of different colors. Participants must select those that meet the conditions specified (shape, size, position, and/or color: e.g., “touch a small blue circle”). Number of trials: 10. Recorded parameters: correct answers.

8. Phonetic Fluency. A letter is given and the participant is asked to list all the words they know beginning with that letter. F Letter. Response time: 60 seconds. Parameters recorded: correct answers.

9. Working Memory. Participants listen to mixed sequences of numbers and colors and then have to repeat the numbers and colors stated; first the numbers in ascending order and then the colors, or vice-versa. Parameters recorded: correct answers.

10. Abstract Reasoning. A series of logical sequences are displayed on the screen. Participants have to select the item that completes the displayed sequence. Parameters recorded: RT (ms) and correct answers.

11. Semantic Fluency. Participants are given a semantic category (colors or animals) and are asked to list all the items they know belonging to that category. Time: 60 seconds. Parameters recorded: correct answers.

12. Inhibition: Go/No-go. Two items appear alternately on the screen. In the first phase, the participant must press a key when one item appears. Then, after hearing a tone signaling the transition to the second phase or halfway through the test, the participant must press a key when the other item appears. Parameters recorded: RT (ms) and correct answers.

13. Planning: Amusement park. The goal is to go on as many rides as possible in the allotted time with the money provided. Each ride has a different price and duration, and the same ride may not be chosen twice in a row. Parameters recorded: number and variety of rides visited.

In order to analyze the evidence of convergent validity the following tests were used:

2.2.2. Forward and Backward Digit Span Subtest (WISC-V. Wechsler, 2015). In the first part of this task, the subject is asked to repeat a sequence of numbers in the same order as they are said by the evaluator (forward), and then in the second part they have to repeat the sequence in reverse order (backward). In both cases, the number of digits to be repeated increases with each attempt. This subtest primarily assesses attention, working memory, cognitive flexibility, and auditory discrimination. Its internal consistency in a Spanish sample has been found to range from .88 to .93, depending on the test (Wechsler, 2015).

2.2.3. Raven's Progressive Matrices Test (Raven, 1989). This is a non-verbal intelligence test. Solving progressively difficult matrix problems involves cognitive functions such as attention and perception, inductive reasoning, fluid intelligence, general visual intelligence, classification ability, spatial ability, simultaneous processing, and working memory. This test has demonstrated evidence of convergent validity and reliability (with an internal consistency of .90) (Sánchez & Pirela, 2009).

2.2.4. Luria Neuropsychological Diagnostic Battery - Initial (Manga & Ramos, 2006). We used the version adapted to the Cuban context by Ramírez-Benítez et al. (2013). This is an instrument designed to identify neuropsychological alterations in children. This battery assesses motor skills, executive functions, language abilities, processing speed, and both verbal and non-verbal memory. For this study we used the battery's three memory tests, where the participant listens to the same sequence of words three times (Luria trial 1, Luria trial 2 and Luria trial 3) and after each trial, the participant repeats the words s/he recalls. Internal consistency values indicate that the instrument is reliable (.82).

b) Completed by the parents

2.2.5. BRIEF-2 Behavioral Rating Inventory of Executive Function (Gioia et al., 2015). We used the Spanish adaptation by Maldonado et al. (2017). This test assesses executive function using nine clinical scales (Inhibition, Self-monitoring, Flexibility, Emotional control, Initiative, Working memory, Planning and organization, Task monitoring, and Organization of materials), three general indexes (Behavioral regulation index, Emotional regulation index, and Cognitive regulation index) and a global index of executive function. It also includes three validity scales (Infrequency, Inconsistency, and Negativity). This test is completed by the child's parents and/or guardians. The test has good convergent and differential validity indices. The Cronbach's alpha coefficient has a mean value of .86 (Maldonado et al., 2017).

Procedure

First of all, approval was sought and obtained from the Research Ethics Committees of the University of Granada (Registration No. 2098/CEIH/2021) and the University of Cienfuegos "Carlos Rafael Rodríguez" (Resolution No. 85). Meetings were then scheduled with the regional directors of education in the provinces of Cienfuegos and Havana to request their cooperation and to select the participating schools. The next step was to hold meetings with the principals and teachers of the participating schools to explain the objectives of the study and enlist their cooperation. Teachers notified families and asked fathers, mothers, or legal guardians to sign an informed consent form authorizing the children's participation.

The evaluators were students and faculty from the Universities of Cienfuegos and Havana, who had been trained in the use of the assessment protocol. They were coordinated by a researcher from the project team. The assessments took place on school premises during regular school hours. Each assessment was conducted on a one-to-one basis and lasted approximately 90 minutes. A subsample of 134 participants also completed the validation tests during the same session. The tests used for the validation process were selected based on previous studies with the BENCI (Burneo-Garcés et al., 2017) and were previously validated in a Cuban sample (Ramírez-Benítez et al., 2013). According to information from previous studies (Fasfous et al., 2015), fifteen days after the initial assessment, a subsample of 59 participants were retested using the BENCI to calculate test-retest reliability.

The order in which the tests were administered was the same for all participants and, for the neuropsychological tests, followed the recommendations made by Lezak et al. (2004).

Statistical Analysis

Reliability was analyzed by means of test-retest measures using the intraclass correlation coefficient (ICC) and internal consistency using Cronbach's alpha. The analysis of convergent validity involved the calculation of Pearson correlations between the BENCI tests and other tests assessing similar domains. To analyze the differential validity of the BENCI, we conducted a between-groups analysis of variance (ANOVA) to assess how participants performed by sex and educational level (independent variable) on all the BENCI tests (dependent variable). Given the need for multiple comparisons, the Bonferroni correction was applied to reduce the probability of a type I error, establishing the significance threshold at $\leq .002$ for ANOVA. We conducted a *post hoc* analysis using the Bonferroni correction. Finally, to examine the factorial structure of the BENCI, we first performed an exploratory factor analysis (EFA) employing maximun likehood and varimax rotation followed by a confirmatory factor analysis (CFA) using the maximum likelihood (ML) estimator. We evaluated model fit using the Comparative Fit Index (CFI) and the Tucker-Lewis Index (TLI), the values of which must exceed .90. The root mean square error of approximation (RMSEA) was also calculated, with values of at least less than .08 required for a good fit (Hu & Bentler, 1995). All analyses were performed with the SPSS program (version 22.0) and the Jamovi program for the EFA and the CFA.

RESULTS

3.1. Reliability: test-retest and internal consistency

For the reliability analyses, a subsample of 59 children participated, with the distribution shown in Table 4. Specifically, 4 children aged 6 years (2 boys and 2 girls), 8 children aged 7 years (3 boys and 5 girls), 7 children aged 8 years (5 boys and 2 girls), 10 children aged 9 years (5 boys and 5 girls), 5 children aged 10 years (2 boys and 3 girls), 2 children aged 11 years (1 boy and 1 girl), 4 children aged 12 years (4 boys and 0 girls), 3 children aged 13 years (0 boys and 3 girls), 4 children aged 14 years (1 boy and 3 girls), 3 children aged 15 years (1 boy and 2 girls), 5 children aged 16 years (1 boy and 4 girls), and 4 children aged 17 years (2 boys and 2 girls).

INSERT TABLE 4 ABOUT HERE

In terms of test-retest reliability, Table 5 shows the intraclass correlation coefficients (ICC) for each test in the battery and the Pearson correlations obtained from a subsample of 59 participants. As can be seen in table 5, the coefficients range from .136 to .782. Following the guidelines reported by Ko and Li (2016), good measure (scores between 0.75 and 0.9) was obtained for Reasoning (ICC= 0.782); moderate measures (scores between 0.5 and 0.75) were obtained for Alternate Visuomotor Coordination (ICC= 0.661), Phonetic Fluency (ICC= 0.677), Working Memory (ICC= 0.603), Visuomotor Coordination (ICC= 0.554), Verbal Memory Trial 2 (ICC= 0.505), Verbal Memory (Delayed test) (ICC=0.518), Visual Memory (Recognition test) (ICC= 0.531), Semantic Fluency (ICC= 0.576), and Simple Reaction Time (ICC= .597); and poor measures (scores values <0.5) were obtained for Continuous Performance Test (ICC=0.323), Verbal Memory Trial 1 and Trial 3 (ICC=0.339, ICC=0.384) Visual Memory Immediate and Delayed test (ICC=0.387, ICC = 0.486), Verbal Comprehension Figures and Images (ICC=0.136, ICC=0.260) and Planning (ICC=0.175).

-INSERT TABLE 5 ABOUT HERE-

For the analysis of internal consistency, Cronbach's alpha was calculated, yielding good values for the Reasoning task (α = .878) and adequate values for the Reaction Time (α = .748), Semantic Fluency (α =.731), Phonetic Fluency (α=.808), Visuomotor Coordination (α=.739), Alternate Visuomotor Coordination (α=.796) and Working Memory α = .753) tasks. However, they were notably low for Verbal Comprehension (Figures) (α=.239) and Planning (α=.297) and moderate to low in the remaining tasks as shown in table 5.

3.2. Validity Analysis:

3.2.1. Convergent validity

In terms of convergent validity, results from the subsample of 134 subjects found significant positive correlations between the BENCI scores and the other neuropsychological tests. The distribution of this subsample is shown in Table 6. Specifically, 11 children aged 6 years participated (5 boys and 6 girls), 12 aged 7 years (5 boys and 7 girls), 17 aged 8 years (9 boys and 8 girls), 12 aged 9 years (8 boys and 4 girls), 10 aged 10 years (5 boys and 5 girls), 14 aged 11 years (7 boys and 7 girls), 4 aged 12 years (2 boys and 2 girls), 8 aged 13 years (1 boy and 7 girls), 12 aged 14 years (2 boys and 10 girls), 10 aged 15 years (5 boys and 5 girls), 22 aged 16 years (4 boys and 18 girls), 1 aged 17 years (1 boy and 0 girls), and 1 aged 18 years (1 boy and 1 girl).

INSERT TABLE 6 ABOUT HERE

These correlations were observed (see Table 7) between the BENCI Verbal Memory Trial 2 and the Luria Trial 2 (r= .247, p<.01) as well as between the Verbal Memory Trial 3 and the Luria Trial 3 (r=.295, p<.01). Significant positive correlations were also found between the Verbal Delayed Memory test and the Delayed Luria (r=.217, p<.05), between the Reasoning test and Raven's Matrices (r=.781, p<.01), and between the Working Memory test and both the WISC-V Digit Span Forward (r=.182, p<.05) and Backward tasks (r=.296, p<.01). A significant negative correlation was found between the Working Memory test and the BRIEF-2's working memory tasks (r=-.269, p<.01).

- INSERT 7 ABOUT HERE-

3.2.2. Differential validity

In order to determine the differential validity of the BENCI, we analyzed the differences in neuropsychological performance of the participants in the different tests according to their level of education, sex and its interaction. As shown in Table 8, there are significant differences between elementary school, high school, and pre-university children across all of the neuropsychological variables. As the *post hoc* analyses show, these differences indicate that higher-grade children outperform lower-grade children (see Table 8 and supplementary material). Table 8 shows that at each stage of education, performance in the tests of Visuomotor Coordination, Alternate Visuomotor, Reasoning, Phonetic Fluency, and Working Memory is significantly better than at the previous stage ($p < .002$). Performance at the high school and pre-university levels is similar and in both cases significantly better than at the elementary level in Continuous Performance Test, Verbal Memory Trial 1; Verbal Delayed Memory; Visual Immediate and Delayed Memory; Verbal Comprehension of Figures and Images; the hit rate of the Go-no-go task and Simple Reaction Time. Regarding the differences in sex and the interactions between sex and education we found statistically significant differences in the Simple Reaction Time by Sex, where boys performed better than girls. Other effects that were below the statistical threshold used for multiple comparisons ($p > .002$) are included in Table 8.

- INSERT TABLE 8 ABOUT HERE-

3.2.3. Construct validity

We based our evaluation of the structure of the BENCI battery on the model fit reported in the Moroccan-Arabic adaptation by Fasfous et al. (2015). Considering the potential cultural differences between samples, we first conducted an exploratory factor analysis (EFA). The sample size was adequate based on the discretion of Kaiser-Meyer-Olkin value (KMO= .821) and the Bartlett's test of sphericity (χ^2 (91)= 4634, $p < .001$). The analysis identified a total of four main factors: 1) inhibition, 2) fluency, 3) flexibility and reasoning, and 4) memory (see Table 9). Since these results were consistent with the version Arabic version of the BENCI and that the flexibility tasks had negative loadings on the factor, we decided to include them as a separate dimension in the confirmatory factor analysis (CFA) and test a five-factor model: Inhibition, Flexibility, Fluency, Reasoning, and Memory. The variables in both analysis include both correct answers and errors, with the hit rate calculated for blocks 1 to 4 in the case of the Go/No-Go task (hits/(hits+omission errors)). The results of the confirmatory model revealed adequate model fit indices (see Figure 1): X^2 (67) = 216, $p < .001$, CFI=.968, TLI= .957, RMSEA= .036 (CI 90%= .030, .041).

-INSERT TABLE 9 AND FIGURE 1 ABOUT HERE-

DISCUSSION

The main objective of this research was to analyze the psychometric properties of the BENCI in a Cuban sample of children and adolescents. The results obtained showed good reliability and validity indices. This means that the BENCI is a suitable test for assessing neurodevelopment in the Cuban population between the ages of 6 and 18.

Firstly, the data obtained for reliability are adequate and comparable to those found in studies using the BENCI in Moroccan-Arabic (Fasfous et al., 2015) and Kenyan (Rachel et al., 2023) samples. In the Cuban sample, good or moderate ICCs were obtained in 10 of the battery's 18 subtests, particularly in Reasoning, Alternate Visuomotor Coordination and Working Memory. These subtests have also yielded good or excellent ICCs in other samples where there are evidences of validity for the BENCI (Fasfous et al., 2015; Rachel et al., 2023). Moderate ICCs was also obtained for Phonetic Fluency in the Cuban sample. This data has not been found in other non-Spanish speaking samples. This may be due to the phonetic characteristics of Spanish that distinguish it from other languages, where the BENCI has been tested. ICCs were low for Continuous Performance Test, Verbal Memory Trials 1 and 3, Visual Memory Immediate and Delayed test, Planning (a finding also reported in the Moroccan-Arabic sample by Fasfous et al. (2015)) and for Verbal Comprehension (Figures and Images). These results could be due to the fact that the sample used for the test-retest analysis consisted of 59 students out of the total sample. Moreover, the 15-day interval between the two tests may have facilitated learning and increased familiarization with the tasks, potentially influencing the indices obtained.

In terms of internal consistency, good or adequate indices were found for seven of the battery's tests: Reasoning task, reaction time, semantic and phonetic fluency, visuomotor coordination, alternative visuomotor coordination and working memory. However, internal consistency for verbal comprehension (figures) and planning were notably low and moderate to low in the remaining tasks. These findings could be explained by the diversity of items within some of the tasks or by variations in the difficulty levels of certain items within each task. In the case of planning, the result stands in contrast to findings from other samples (Fasfous et al., 2015; Rachel et al., 2023), where the planning task demonstrated high internal consistency. This discrepancy may be attributable to the cultural and linguistic variations observed across the different samples.

With reference in the first instance to convergent validity, the results of the BENCI in a Cuban sample provide evidence of its validity. The data show statistically significant relationships between cognitive domains evaluated by the BENCI and other similar neuropsychological tests previously shown to be effective in assessing the cognitive functions examined in this study (de Jong, 2023; Pind et al., 2003; Ramírez-Benítez et al., 2013) although the correlation coefficients were low to moderate in some cases. This may be attributable to the analyses being conducted on a subsample of participants with varying ages. For example, we found a high correlation between Verbal Memory assessed using the BENCI and the Luria battery; between the Reasoning test and Raven's Matrices; and between the Working Memory test and the WISC-V Forward and Backward Digit Span and BRIEF-2 Working Memory tests. These findings suggest that the BENCI is a valid test for assessing these cognitive domains in the Cuban population. Similar data have been obtained when validating the test in other settings. The data obtained in this study are similar to those found in the Kenyan sample, where a significant high correlation was found between the BENCI tests that assess Reasoning, Memory, and Inhibition and culturally specific neuropsychological tests (Rachel et al., 2023). Furthermore, of all the tests used, the strong correlation found between the Reasoning test and Raven's Matrices is comparable to the findings of the preliminary validation in the Spanish sample, which showed statistically significant relationships between this variable and the Toni-2 (Fernández-Alcántara et al., 2022).

In terms of differential validity, the battery has demonstrated the ability to discriminate between different levels of education. The results show significant differences between elementary, high school, and pre-university children for most of the neuropsychological variables. These differences indicate that children in higher grades outperform those in lower grades. The data obtained confirm the BENCI's ability to assess neurodevelopment in children from the early stages of education to more advanced levels. This finding is consistent with the data reported in the validation of the battery in Arabic-speaking samples in Morocco and Palestine (Fasfous et al., 2015; 2021) where the BENCI showed that it was able to differentiate children by age. This feature has also been verified in Ecuadorian (Burneo-Garcés et al., 2019) and Spanish (Fernández-Alcántara et al., 2022) samples.

In terms of the factorial structure of the BENCI, the results of this study are consistent with previous adaptations (Fasfous et al., 2015; Rachel et al., 2023), identifying a model with an adequate fit for five key aspects of executive function: Inhibition, Flexibility, Fluency, Reasoning, and Memory. In addition, the factor loadings indicate higher values, with only the Alternate Visuomotor errors having values below .30, whereas in previous studies four tests had low factor loadings (Fasfous et al., 2015).

CONCLUSIONS

In conclusion, the reliability and validity data provided indicate that the BENCI is a reliable, valid, and culturally adapted neurodevelopmental assessment instrument. First and foremost, the BENCI is presented as a tool that can address the lack of culturally adapted neuropsychological instruments in Latin America. However, its ability to effectively discriminate between clinical and non-clinical populations requires validation in future research. The BENCI is adapted and free of charge, overcoming the difficulty of using expensive evaluation tools in emerging countries such as Cuba (Cruz-Quintana et al., 2022). Secondly, the BENCI is a valid and reliable tool for neurodevelopmental research. This is important because neurodevelopmental research is particularly relevant in resource-poor countries such as Cuba, which have less funding to allocate to education and child protection (Saforcada, 2006). In such contexts, the availability of suitable neurodevelopmental assessment tools and procedures is a major step forward, as it allows for the evaluation and detection of possible deficiencies affecting the neurodevelopment of Cuban children and adolescents. Thirdly, a number of features of the test make it ideally suited for use in the neuropsychological assessment of children and adolescents. These features include: its short administration time compared to other batteries (Matute et al., 2007); its user-friendly tablet-based design; customizable parameters to suit the target sample; the option to store personal information for each individual; and the ability to export data to spreadsheets for later analysis

(Cruz-Quintana et al., 2022). It also requires minimal training and can be used in clinical, educational, and research contexts. Fourth, this validation of the BENCI in a Cuban sample has been possible thanks to an international development cooperation project between Spain and Cuba, and serves to underline the importance of such initiatives and the implications of the findings for the target population.

This study provides further evidence of its validity, as already demonstrated in other countries and cultures, such as Ecuador (Burneo-Garces et al., 2018), Kenya (Rachel et al., 2023), Morocco (Fasfous et al., 2015), Palestine (Fasfous et al., 2021), and Spain (Fernández-Alcántara et al., 2022). In the present study, there were some differences between boys and girls in tests such as Simple Reaction Time, as well as interactions between sex and educational level that did not reach the statistic threshold used for multiple comparisons. Although previous studies using the BENCI have not analyzed differences by sex, future research is needed in order to study the role of gender in its interaction with age and socioeconomic status (Burneo-Garces et al., 2019). The BENCI is therefore an extremely valuable neuropsychological assessment tool, in whatever context.

The main limitations of the study include the fact that the IQ of the participants was not controlled for. Furthermore, we were not able to ensure a homogeneous sample size across the different municipalities and educational levels. On the other hand, future research should include clinical samples to assess the discriminant validity of the battery. Furthermore, the small sample size used in both the test-retest and convergent validity studies may have influenced some of the results obtained. To reiterate, our main conclusion is that the BENCI has shown good evidence of reliability and validity in the neuropsychological assessment in a Cuban sample of children and adolescents. As such, it can be considered a reference for neuropsychological and neurodevelopmental assessment in Cuba.

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Table 1. Distribution of the sample according to sex, age, academic level and municipalities

Academic Level and ages	Municipality of Cienfuegos (Cienfuegos province) n = 1238 (72.2%)		Municipality of Cumanayagua (Cienfuegos province) n = 360 (21%)		Municipality of Marianao (Havana province) n = 116 (6.8%)	
TOTAL SAMPLE=1714	Boys	Girls	Boys	Girls	Boys	Girls
Elementary n = 651 (37.98%)	303	307	-	-	16	25
6 years	28	43			1	3
7 years	46	46			-	3
8 years	61	51			5	8
9 years	62	56			3	2
10 years	39	42			5	3
11 years	67	69			2	6
Mean age (SD)	9.05 (1.78)	8.86 (1.83)			9.23 (1.48)	9.23 (2.01)
High School n = 433 (25.26%)	165	157	54	51	1	5
12 years	52	44	-	-	1	5
13 years	56	61	16	16	-	-
14 years	57	52	38	35	-	-
Mean age (SD)	13.53 (.94)	13.52 (.97)	13.97 (.66)	14 (.69)	12 (.0)	12 (.0)
Pre-university n = 630 (36.76%)	109	197	108	147	21	48
15 years	39	63	16	21	4	2

16 years	35	82	59	100	12	37
17 years	25	39	32	23	4	7
18 years	10	13	1	3	1	2
Mean age	16.42	16.21	16.34	15.44	16.09	16.19
(SD)	(.87)	(.83)	(.53)	(1.18)	(.76)	(.57)

Table 2. Parent´s educational level stratified by municipalities

	Father's Educational Level				Mother's Educational Level			
	1	2	3	4	1	2	3	4
Municipality of Cienfuegos (Cienfuegos province)	0.44%	9.15%	50.73%	39.68%	0.24%	6.09%	48.39%	45.28%
Municipality of Cumanayagua (Cienfuegos province)	0%	0.69%	62.76%	36.55%	0.7%	0%	65.53%	33.79%
Municipality of Marianao (Havana province)	0%	15.63%	57.82%	26.55%	0%	10.96%	52.05%	36.99%

Note. 1. Elementary. 2. High School. 3. Pre-university. 4. University

Table 3. Domains, areas, and tasks that make up the BENCI.

Domain	Area	BENCI Task
Processing Speed		Simple Reaction Time
Visuomotor coordination		Visuomotor Coordination
Attention	Sustained	Continuous Performance Test (CPT)
Memory	Verbal Visual	Verbal Memory Test (short and long term) Visual Memory Test (short and long term)
Language	Comprehension Production	Verbal Comprehension (Images and Figures) Semantic and Phonetic Fluency
Executive Function	Updating	Working Memory Abstract Reasoning Semantic Fluency
	Inhibition/impulsiveness	Go/No-go
	Flexibility	Alternate Visuomotor Coordination
	Planning	Amusement park

Table 4. Subsample included in the test-retest analysis divided by sex and level of education.

Level of education	Boys	Girls	TOTAL
Elementary	19	18	37 (62.7%)
High School	5	7	12 (20.3%)
Pre-University	3	7	10 (16.9%)
TOTAL	27 (45.8%)	32 (54.2%)	59 (100%)

Table 5. Intraclass correlation coefficients of the 13 BENCI tests, Pearson correlations and Cronbach's alpha.

Test	ICC	CI 95%	*r*	Cronbach's alpha
Visuomotor Coordination (RT)	.554	0.349-0.708	.679	.739
Alternate Visuomotor Coordination (RT)	.661	0.489-0.784	.729	.796
Continuous Performance Test (CA)	.323	0.075-0.533	.343	.488
Verbal Memory Trial 1(CA)	.339	0.092-0.546	.339	.506
Verbal Memory Trial 2 (CA)	.505	0.287-0.673	.509	.671
Verbal Memory Trial 3 (CA)	.384	0.143-0.581	.392	.555
Verbal Delayed Memory (CA)	.518	0.304-0.683	.523	.683
Visual Immediate (CA)	.387	0.147-0.583	.395	.588
Visual Delayed (CA)	.486	0.265-0.659	.487	.654
Visual Recognition Memory (CA)	.531	0.320-0.692	.565	.694
Verbal Comprehension (Figures) (CA)	.136	-0.123-0.377	.136	.239
Verbal Comprehension (Images) (CA)	.260	0.006-0.482	.271	.439
Reasoning (CA)	.782	0.659-0.864	.786	.878
Semantic Fluency (CA)	.576	0.377-0.724	.598	.731
Phonetic Fluency (CA)	.677	0.511-0.795	.677	.808
Simple Reaction Time (RT)	.597	0.405-0.739	.598	.748
Planning (number of different rides)	.175	-0.083-0.411	.188	.297
Working Memory (CA)	.603	0.412-0.743	.624	.753

Note. ICC: Intraclass correlation coefficient; IC: Confidence interval; *r*: Pearson correlation coefficient; RT: reaction time; CA: Correct answers.

Table 6. Subsample included in the convergent validity test divided by sex and level of education

Level of education	Boys	Girls	TOTAL
Elementary	40	37	77 (57.5%)
High School	9	22	31 (23.1%)
Pre-University	6	20	26 (19.4%)
TOTAL	55 (41.0%)	79 (59.0%)	134 (100%)

Table 7. Correlations between the BENCI and other neuropsychological tests

BENCI TESTS	VALIDATION TEST	*r*
Verbal Memory Trial 1 (CA)	Luria Trial 1	.167
Verbal Memory Trial 2 (CA)	Luria Trial 2	.247**
Verbal Memory Trial 3 (CA)	Luria Trial 3	.295**
Verbal Delayed Memory (CA)	Delayed Luria	.217*
Reasoning (CA)	Raven	.781**
Working Memory (CA)	WISC-V Forward Digits	.182*
Working Memory (CA)	WISC-V Backward Digits	.296**
Working Memory (CA)	BRIEF-2 Working Memory tasks	-.269**
Alternate Visuomotor (Errors)	Flexibility (BRIEF-2)	-.125

Note. CA: Correct answers; *r*= Pearson correlation coefficient; *=*p*<.05; **=*p*<.01.

Table 8. Differences by educational level, sex and their interaction on the BENCI tests

Test	Elementary (6 to 12 years old)		High School (12 to 16 years old)		Pre-University (16 to 18 years old)		Comparison	*F*	Partial η2	Post-hoc
	Boys (n = 347) M (SD)	Girls (n = 353) M (SD)	Boys (n =234) M (SD)	Girls (n = 241) M (SD)	Boys (n = 196) M (SD)	Girls (n = 343) M (SD)				
Visual-motor coordination										
Visuomotor Coordination (TR)	37216.29 (18034.39)	37130.73 (20276.37)	25422.37 (8763.41)	24324.98 (7653.58)	20682.67 (6002.5)	21315.07 (6552.77)	Sex	0.08	.000	
							Level	237.99***	.218	1>2>3
							SxL	0.50	.001	
Alternate Visuomotor Coordination (RT)	71180.31 (43395.56)	66576.15 (44175.70)	49241.95 (32960.34)	45205.05 (28604.81)	40355.78 (18310.26)	40764.67 (20544.65)	Sex	2.61	.002	
							Level	113.86***	.118	1>2>3
							SxL	0.87	.001	
Attention										
Continuous Performance Test (CA)	48.31 (16.44)	46.56 (17.25)	53.80 (12.02)	54.43 (10.84)	56.14 (8.00)	54.43 (11.11)	Sex	1.92	.001	
							Level	54.38***	.065	1<(2=3)
							SxL	1.29	.002	
Simple Reaction Time (RT)	626.34 (113.51)	666.24 (127.72)	615.73 (115.61)	633.62 (116.29)	614.31 (133.11)	631.33 (119.80)	Sex	17.23***	.100	B<G
							Level	7.10***	.008	1>(2=3)
							SxL	1.75	.002	
Memory										
Verbal Memory Trial 1(CA)	4.63 (2.12)	4.89 (2.14)	5.25 (2.43)	5.23 (2.68)	5.70 (2.46)	5.45 (2.54)	Sex	0.00	.000	
							Level	17.62***	.020	1<(2=3)
							SxL	1.69	.002	
Verbal Memory	5.93 (2.44)	5.92 (2.40)	6.37 (2.98)	6.19 (3.13)	7.17 (2.74)	6.54 (2.90)	Sex	3.98	.002	

Trial 2(CA)							Level	16.78***	.019	(1=2)<3
							SxL	1.91	.002	
Verbal Memory	6.78 (2.88)	6.65 (2.74)	7.17 (3.31)	7.12 (3.47)	7.64 (2.92)	7.27 (3.20)	Sex	1.46	.001	
Trial 3(CA)							Level	8.67***	.010	1<3
							SxL	0.36	.000	
Verbal Delayed	6.02 (2.76)	6.24 (2.5)	6.98 (2.67)	6.82 (2.98)	6.88 (8.83)	6.50 (2.98)	Sex	0.61	.000	
Memory (CA)							Level	12.13***	.014	1<(2=3)
							SxL	1.75	.002	
Visual Immediate	6.61 (3.37)	6.89 (4.40)	7.78 (3.47)	7.62 (3.83)	8.02 (3.70)	7.80 (4.10)	Sex	0.32	.000	
Memory (CA)							Level	15.43***	.018	1<(2=3)
							SxL	0.74	.001	
Visual Delayed	4.98 (3.19)	4.91 (2.95)	6.47 (3.26)	6.18 (3.61)	6.49 (3.39)	6.12 (3.68)	Sex	2.11	.001	
Memory (CA)							Level	34.10***	.039	1<(2=3)
							GxL	0.32	.000	
Visual Recognition	43.99 (6.34)	45.25 (4.99)	45.82 (4.69)	45.21 (4.73)	45.27 (4.06)	45.55 (3.53)	Sex	1.64	.001	
Memory (CA)							Level	6.06**	.007	1<(2=3)
							SxL	5.24**	.006	L1, B<G
Comprehension										
Verbal	9.22 (1.07)	9.45 (0.76)	9.65 (0.64)	9.58 (0.70)	9.62 (0.65)	9.64 (0.69)	Sex	2.29	.001	
Comprehension							Level	26.75***	.031	1<(2=3)
(Figures) (CA)							SxL	5.51**	.006	L1, B<G
Verbal	9.20 (0.95)	9.16 (0.91)	9.57 (0.68)	9.61 (0.66)	9.77 (0.54)	9.62 (0.83)	Sex	1.76	.001	
Comprehension (Images)							Level	63.40***	.075	1<(2=3)
(CA)							SxL	1.67	.002	

Fluency										
Semantic Fluency	12.05 (5.80)	11.29 (4.90)	15.12 (6.12)	14.41 (5.92)	15.78 (7.03)	14.62 (8.57)	Sex	7.38**	.004	B>G
(CA)							Level	53.42***	.059	1<(2=3)
							SxL	0.83	.000	
Phonetic Fluency	4.66 (3.18)	5.01 (3.30)	7.06 (3.53)	7.97 (4.07)	8.85 (3.99)	8.44 (4.63)	Sex	2.22	.001	
(CA)							Level	160.16***	.158	1<2<3
							SxL	3.77	.023	
Inhibition										
Go-no-go h1	0.86 (0.22)	0.89 (0.19)	0.92 (0.19)	0.93 (0.16)	0.94(0.16)	0.92 (0.16)	Sex	1.65	.001	
							Level	17.26***	.200	1<(2=3)
							SxL	2.46	.003	
Go-no-go h2	0.90 (0.19)	0.93 (0.17)	0.95 (0.14)	0.97 (0.13)	0.96 (0.11)	0.95 (0.16)	Sex	1.18	.001	
							Level	18.17***	.021	1<(2=3)
							SxL	1.85	.002	
Go-no-go h3	0.90 (0.19)	0.91 (0.18)	0.97 (0.12)	0.97 (0.12)	0.97 (0.12)	0.96 (0.14)	Sex	0.06	.000	
							Level	29.26***	.033	1<(2=3)
							SxL	0.61	.001	
Go-no-go h4	0.91 (0.17)	0.91 (0.18)	0.95 (0.15)	0.96 (.13)	0.98 (0.92)	0.97 (.013)	Sex	0.00	.000	
							Level	26.01	.030	1<(2=3)
							SxL	0.44	.001	
Reasoning (CA)	15.57 (4.92)	15.46 (4.91)	18.93 (4.05)	18.34 (4.20)	20.18 (3.08)	19.33 (3.46)	Sex	5.96	.004	
							Level	160.81***	.159	1<2<3
							SxL	1.20	.001	
Planning (number	7.78 (1.69)	7.87 (1.27)	7.61 (1.75)	7.90 (1.36)	7.96 (1.39)	8.10 (1.14)	Sex	5.73	.003	

of different rides)							Level	5.03	.006	
							SxL	0.73	.001	
Working Memory	4.14 (2.66)	4.06 (2.57)	5.58 (2.98)	5.44 (3.09)	6.48 (3.13)	5.79 (3.20)	Sex	4.38	.003	
(CA)							Level	75.84***	.082	1<2<3
							SxL	1.74	.002	

Note. B: Boys; G: Girls; S: Sex; L: Educational level; RT: Reaction time in milliseconds; CA: Correct answers; M: Mean; SD: Standard deviation; **p< .005; ***p< .002

Table 9. Factor loading of the 4-Factor Exploratory Factor Analysis (EFA)

	Inhibition	Fluency	Flexibility and Reasoning	Memory
Go/No Go h (1_4)	**.658**			
Go/No Go h (2_4)	**.635**			
Go/No Go h (3_4)	**.592**			
Go/No Go h (4_4)	**.587**			
Semantic Fluency		**.728**		
Phonetic Fluency		**.712**		
Visual Memory		.424		**.341**
Working Memory		.341	**.302**	
Reasoning			**.674**	
Comprehension of Figures			**.409**	
Planning			**-.408**	
Comprehension of Images			**.385**	
Alternative Visuomotor			**-.342**	
Verbal Memory		.393		**.910**

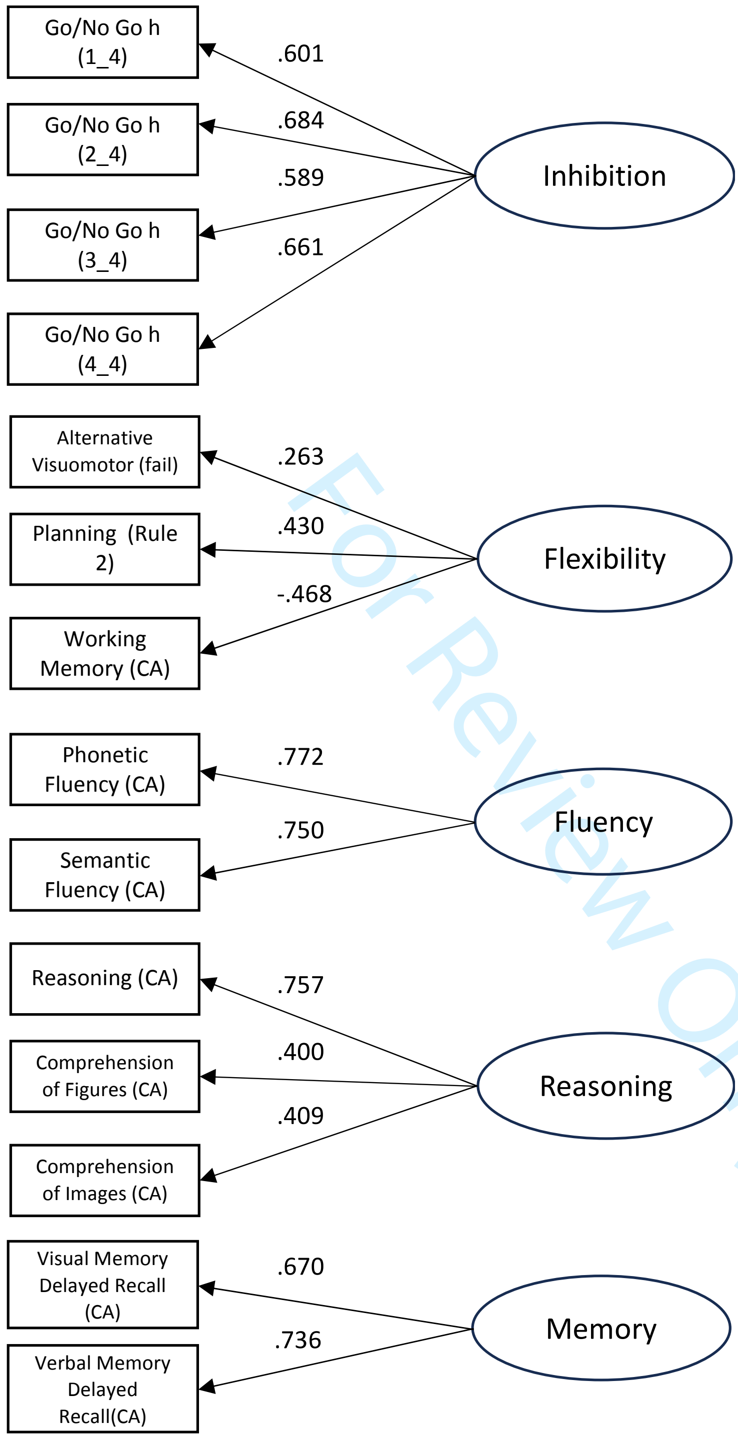


Figure 1. Factor loadings of the Cuban version of the BENCI in the Confirmatory Factor Analysis

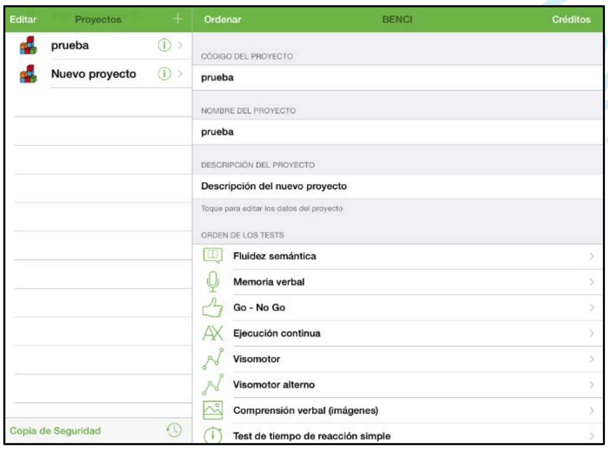
SUPPLEMENTARY FILE. THE BENCI COMPERIZED BATTERY FOR NEUROPSYCHOLOGICAL EVALUATION OF CHILDREN (Cruz-Quintana et al., 2013)

INSTALLATION AND USE INSTRUCTIONS

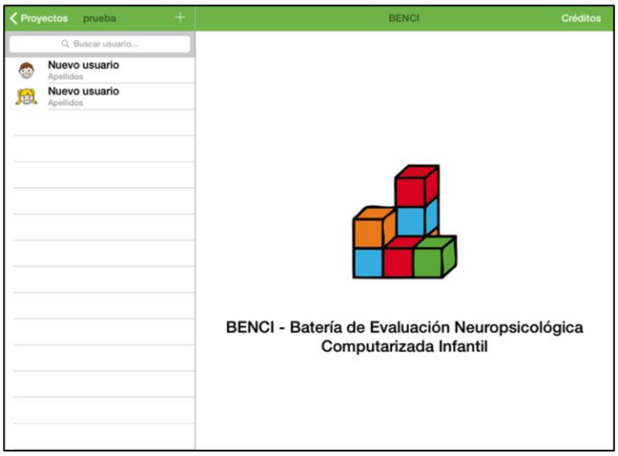
Once the manual has been downloaded, all that is required is to unzip it with WinRar and follow the installation instructions. If the whole process goes smoothly, the following icon should appear:

To run the program, double click on the BENCI icon. Next, the following screen will appear. Here, the first thing to do is to create a project (for research or health care). This is done by clicking on the "+" symbol that appears to the right of "Projects".

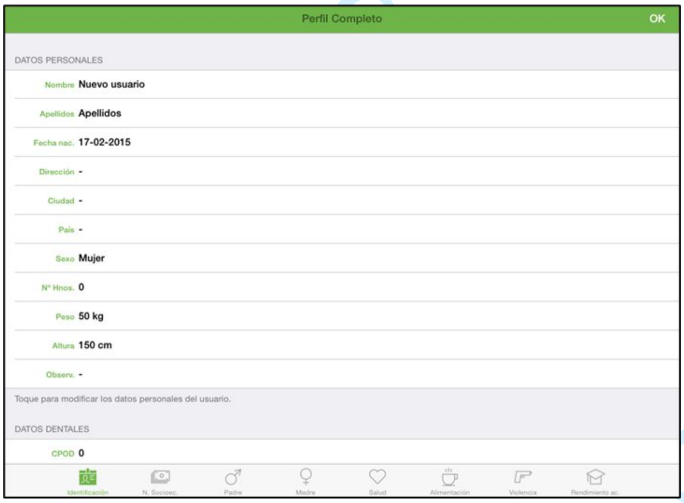
The tests and the configuration of the tests will be identical for all subjects in the same project. As an example, the project "test" has been created. As many projects as desired may be created.



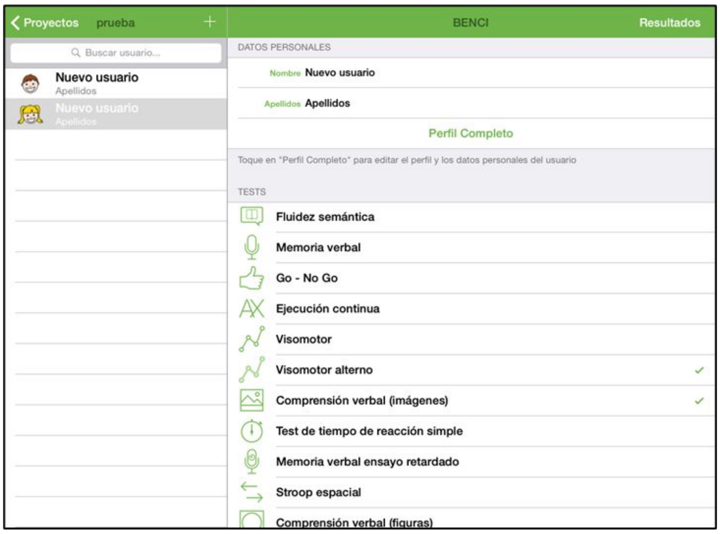
Once the new project has been created, subjects may be added. In order to do this, click on the name of the project – in this example, we click on "test" and the following screen will appear. On this screen subjects may be added by clicking on the "new subject" icon.



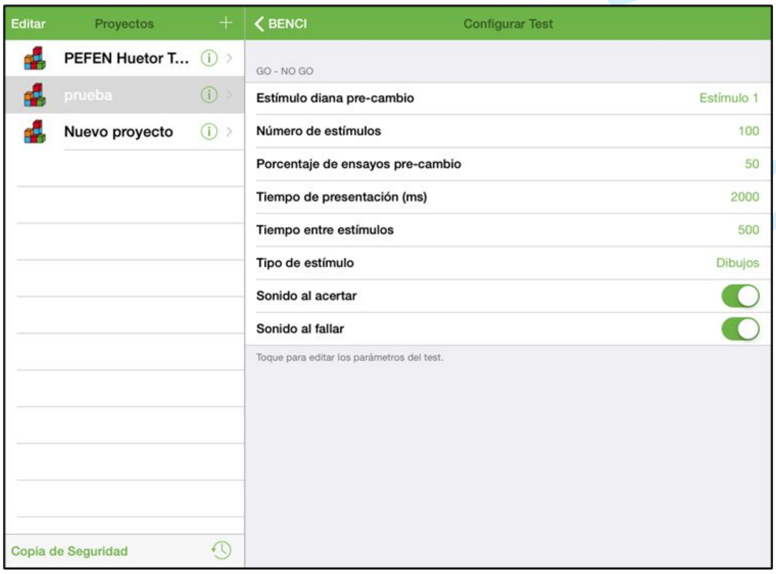
Once you have clicked on “new subject”, a screen appears for filling in the subject’s profile. Only the name is required, but a series of items may be added.



Once the subject’s profile has been created and edited, that person’s name appears on the list of subjects, and by clicking on the subject’s name, the list of tests to be administered to that subject appears.



Before commencing administration to the first subject, the parameters should be configured as well as the order the tests are to be administered in the new project. To do this, go back to the project created by clicking on “Projects”, and click on the information icon. Next, click on the test whose parameters are to be edited. The parameter edition screen appears, which will be different for each test.



Next, some parameters are recommended, although each neuropsychologist should specify the parameters and order of administration according to the aims of the assessment. IT IS STRONGLY ADVISED TO CHECK THAT THE PARAMETERS HAVE NOT CHANGED FROM ONE SESSION TO ANOTHER.

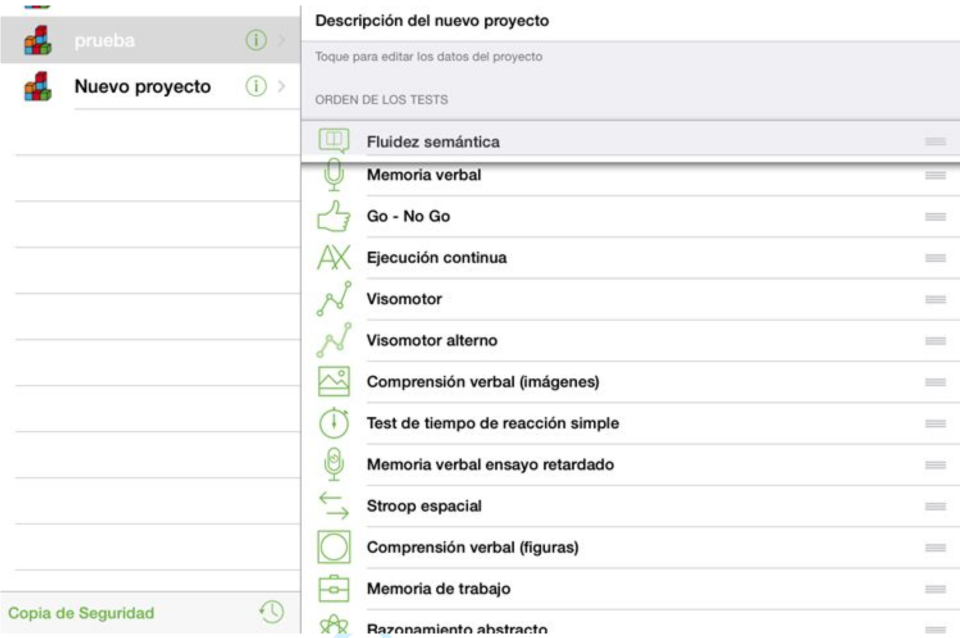
Comprensión verbal (figuras)	
Número de instrucciones	10
Comprensión verbal (imágenes)	
Número de instrucciones	10
Datos del proyecto	
Descripción	
Nombre	prueba
Ejecución continua	
Duración de la tarea	12'28''
Número de bloques	3
Número de ensayos por bloque	100
Porcentaje de estímulos diana	20%
Tiempo de presentación	500
Tiempo entre estímulos	2000
Fluidez fonética	
Letra	F
Tiempo de respueta	60
Fluidez semántica	

Comprensión verbal (figuras)	
Número de instrucciones	10
Comprensión verbal (imágenes)	
Número de instrucciones	10
Datos del proyecto	
Descripción	
Nombre	prueba
Ejecución continua	
Duración de la tarea	12'28''
Número de bloques	3
Número de ensayos por bloque	100
Porcentaje de estímulos diana	20%
Tiempo de presentación	500
Tiempo entre estímulos	2000
Fluidez fonética	
Letra	F
Tiempo de respueta	60
Fluidez semántica	

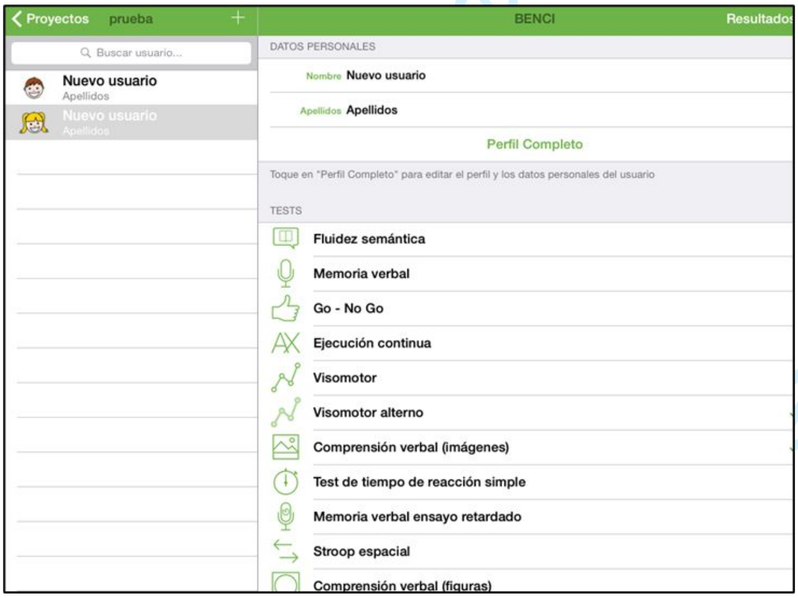
Memoria visual	
Tiempo de presentación	2000
Stroop espacial	
Tamaño del estímulo	35
Tiempo de presentación	2000
Tiempo punto de fijación	500
Test de tiempo de reacción simple	
Número de ensayos	100
Tiempo de presentación	500
Tiempo entre estímulos	2000
Visomotor	
Forma	Rectangular
Número de elementos	15
Ocultar elementos de la leyenda	True
Tipo	Animales
Visomotor alterno	
Número de elementos	15
Ocultar la leyenda	True
Tipo	Animales

Categoria	Animales
Tiempo de respuesta	60
Go-No go	
Estímulo diana pre-cambio	Estimulo1
Número de estímulos	100
Porcentaje de ensayos pre-cambio	50%
Tiempo de presentación	500
Tiempo entre estímulos	2000
Tipo de estímulo	Dibujos
Memoria de trabajo	
Secuencia secundaria	Colores
Memoria verbal	
Número de palabras	9
Memoria visual	
Tiempo de presentación	2000
Stroop espacial	
Tamaño del estímulo	35
Tiempo de presentación	2000
Tiempo punto de fijación	500

To put the tests in order, click on the "Organize" icon and then the symbol to move the tests (up or down). The order shown below is orientative and assumes that all the tests in the battery will be administered.

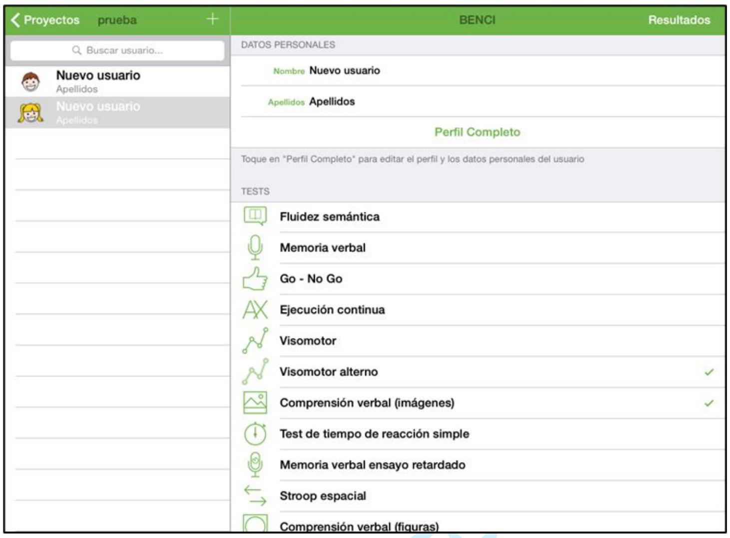


Once the tests have been put in order in the “Projects” section, this order will appear for all subjects in the project.



In order to administer a test, all that is needed is to double click on the name of the test to be administered. The opening screen of the test that has the instructions, the trial attempts and the start of the tests will appear. For example, for the verbal comprehension test based on drawings, the screen would be as below.

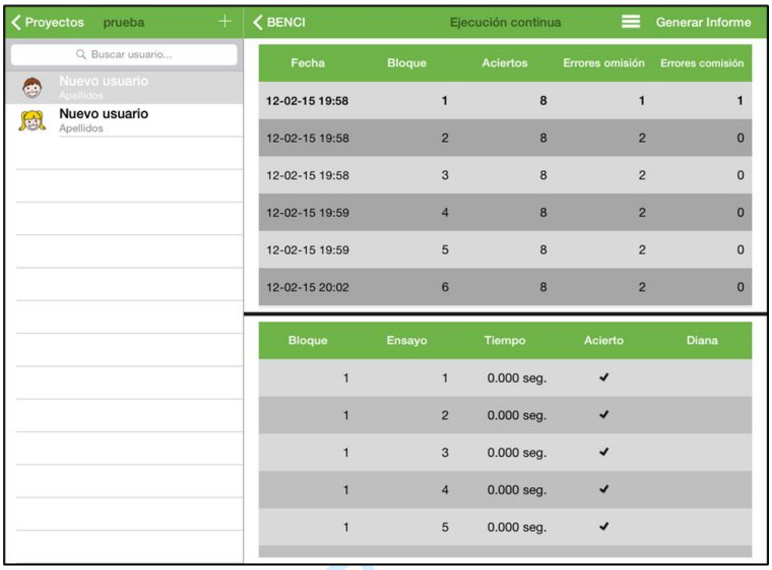
When the administration of a test is completed, the program moves on to the next test automatically. Each time a test is administered, the program records the results and will appear with a different mark on the list of tests for the subject, as seen in the following figure.



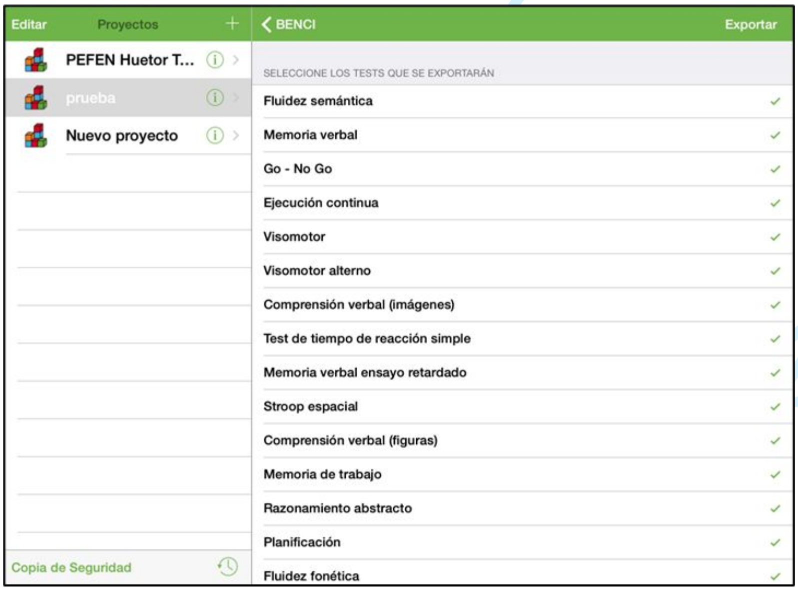
ANALYSIS AND PROCESSING OF RESULTS

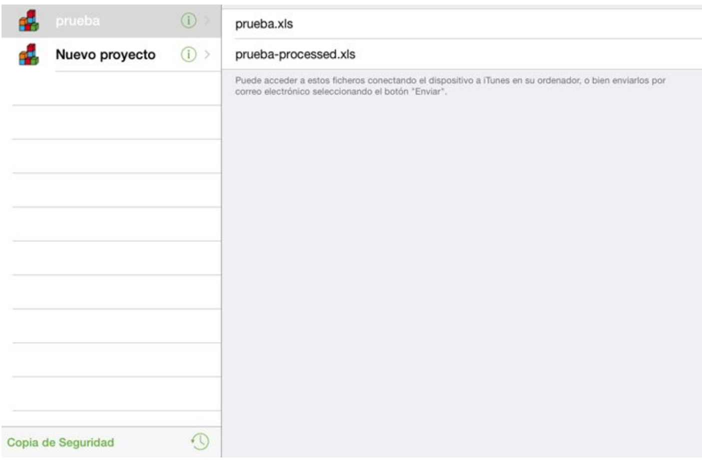
All the tests save the result internally and generate an Excel file in the option to export results. Likewise, the data may be recorded by clicking on the “Security copy” icon .

Apart from recording the personal information of each individual taking the tests, the system registers information about how each subject performed the tests: reaction times, number of correct answers, number of errors, number of errors by omission (for example, when the subject has to press a key when given a stimulus and fails to do so), etc.



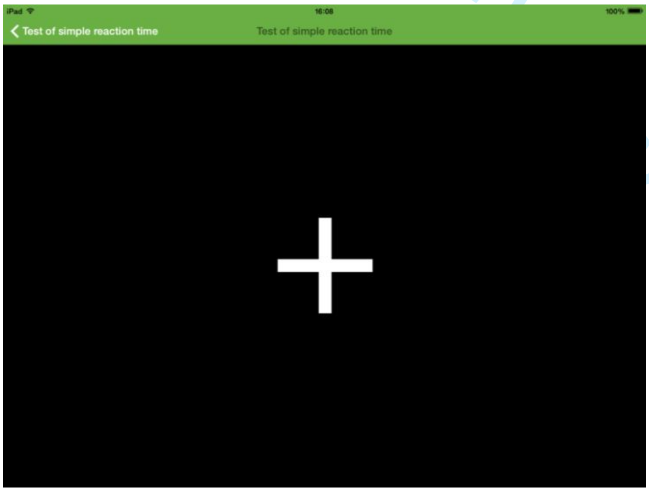
The tool combines the total information obtained from performing the tests for a wide number of individuals and allows it to be exported to a data sheet (extension .xls) compatible with statistics tools such as Microsoft Excel or SPSS using the “Export” key.





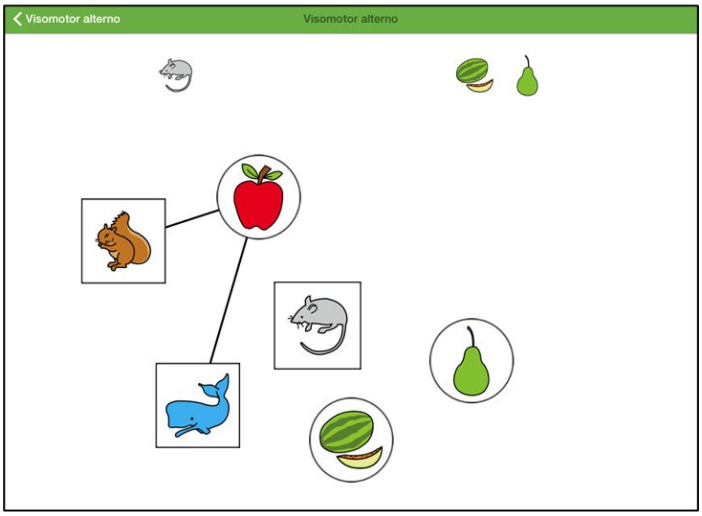
The 13 tests are detailed below:

1. Simple Reaction Time. This involves pressing any key as quickly as possible every time a cross (+) appears on the screen. Parameters recorded: Reaction Time (RT), measured in milliseconds (ms).



2. Visuomotor Coordination (A). This involves pressing the numbers or elements that appear jumbled up on the screen in ascending order or according to a prescribed sequence. Parameters recorded: RT (ms).

3.Alternate Visuomotor Coordination (B). This involves pressing the numbers and elements from two separate series, which are jumbled up on the screen, in alternate and ascending order. Parameters recorded: RT (ms).



4. Continuous Performance Test (CPT). Blocks of letters (trails) appear on the screen one after the other. Participants have to press a key every time the specified stimulus appears (e.g., an A after an X). All other letters are distractors. Parameters recorded: correct answers.

5. Verbal Memory. The participant listens to the same sequence of words three times (Verbal Memory trial 1, Verbal Memory trial 2 and Verbal Memory trial 3). At the end of each sequence, the participant must repeat aloud all the words that they can remember. Parameters recorded: correct answers.

Verbal Memory (Delayed test). Twenty minutes after the end of the Verbal Memory Test, the participant must repeat aloud all the words that they can remember from the list given in the test. Parameters recorded: correct answers.

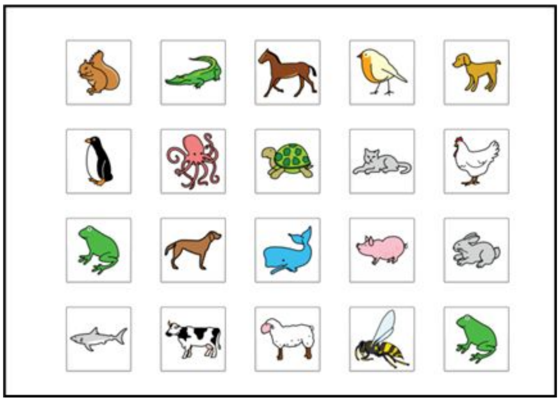
Verbal Memory (Recognition test). Immediately after the previous test, the participant listens to a set of words, half of which are from the list presented in the Verbal Memory test. The participant must indicate whether each of the words is on that list. Parameters recorded: correct answers.

6. Visual Memory. Images of common objects are presented and then the participant must verbally recall all the pictures they remember. Parameters recorded: correct answers.

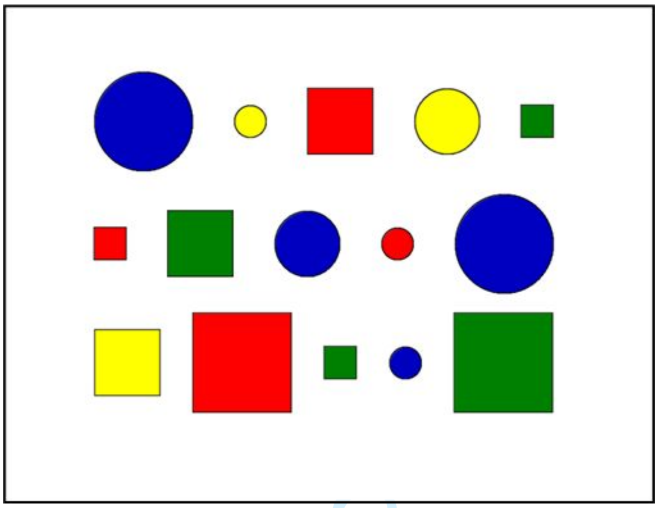
Visual Memory (Delayed test). Twenty minutes after the Visual Memory Test is completed, the participant is asked to verbally recall all of the images they remember from those presented in the test. Parameters recorded: correct answers.

Visual Memory (Recognition test). Immediately after the previous test, various images are shown, many of which appeared in the Visual Memory test. For each image, the person must indicate if it was one of those shown in the aforementioned task. Parameters recorded: correct answers.

7. Verbal Comprehension (Images). Participants are shown a set of images belonging to a particular category (e.g., animals). They then receive verbal instructions asking them to select an image that meets the conditions specified (type of animal, position, activity it can perform, and/or color: e.g., “touch the frog next to the dog”). Parameters recorded: correct answers.



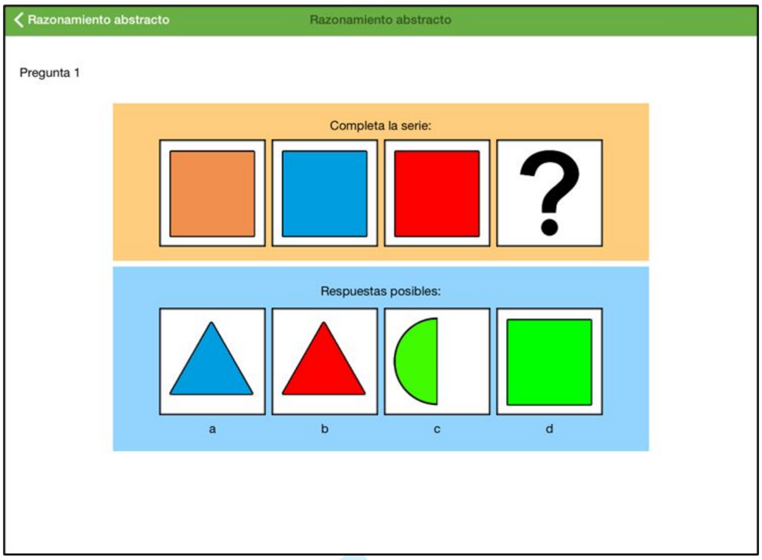
Verbal Comprehension (Figures). This is similar to the previous test, but involves images of geometric shapes (circles, triangles, and squares: small, medium, and large) of different colors. Participants must select those that meet the conditions specified (shape, size, position, and/or color: e.g., “touch a small blue circle”). Recorded parameters: correct answers.



8. Phonetic Fluency. A letter is given and the participant is asked to list all the words they know beginning with that letter. Parameters recorded: correct answers. Time: 60 seconds.

9. Working Memory. Participants listen to mixed sequences of numbers and colors and then have to repeat the numbers and colors stated; first the numbers in ascending order and then the colors, or vice-versa. Parameters recorded: correct answers.

10. Abstract Reasoning. A series of logical sequences are displayed on the screen. Participants have to select the item that completes the displayed sequence. Parameters recorded: RT (ms) and correct answers.



11. Semantic Fluency. Participants are given a semantic category (colors or animals) and are asked to list all the items they know belonging to that category. Parameters recorded: correct answers. Time: 60 seconds.

12. Inhibition: Go/No-go. Two items appear alternately on the screen. In the first phase, the participant must press a key when one item appears. Then, after hearing a tone signaling the transition to the second phase or halfway through the test, the participant must press a key when the other item appears. Parameters recorded: RT (ms) and correct answers.

13. Planning: Amusement park. The goal is to go on as many rides as possible in the allotted time with the money provided. Each ride has a different price and duration, and the same ride may not be chosen twice in a row. Parameters recorded: number and variety of rides visited.


Planificación
Planificación
TOMBOLA

Supplementary Information for Table 8.

Post-hoc Comparison depending on Educational Levels

	F	*p*	Post hoc comparisons Educational Levels					
			Elementary – High School		Elementary – Pre University		High School – Pre University	
			Difference of Means	*p*	Difference of Means	*p*	Difference of Means	*p*
Visual-motor coordination								
Visuomotor Coordination (TR)	237.99	<.001	12308.73	<.001	1088.46	<.001	3779.73	<.001
Alternate Visuomotor Coordination (RT)	113.86	<.001	21665.74	<.001	28239.47	<.001	6573.73	.007

Attention								
Continuous Performance Test (CA)	54.38	<.001	-6.70	<.001	-7.63	<.001	-.93	.796
Simple Reaction Time (RT)	7.10	<.001	21.67	.008	21.34	.006	-.33	1.000
Memory								
Verbal Memory Trial 1(CA)	17.62	<.001	-4.74	.002	-.78	<.001	-.31	.123
Verbal Memory Trial 2(CA)	16.78	<.001	-.35	.094	-.84	<.001	-.49	.013

Verbal Memory Trial 3(CA)	8.67	<.001	-.43	.060	-.69	<.001	-.27	.513
Verbal Delayed Memory (CA)	12.13	<.001	-.77	<.001	-.51	.005	.27	.397
Visual Immediate Memory (CA)	15.43	<.001	-.94	<.001	-1.12	<.001	-.18	1.000
Visual Delayed Memory (CA)	34.10	<.001	-1.49	<.001	-1.51	<.001	-.01	.964
Visual Recognition	6.06	.002	-1.83	<.001	-1.28	.004	.55	.251

Memory (CA)								
Comprehension								
Verbal Comprehension (Figures) (CA)	26.75	<.001	-.28	<.001	-.29	<.001	-.02	1.000
Verbal Comprehension (Images) (CA)	63.40	<.001	-.41	<.001	-.50	<.001	.05	.239
Fluency								
Semantic Fluency (CA)	53.42	<.001	-3.10	<.001	-3.37	<.001	-.27	1.000

Phonetic Fluency (CA)	160.16	<.001	-2.68	<.001	-3.75	<.001	-1.07	<.001
Inhibition								
Go-no-go h1	17.26	<.001	-.05	<.001	-.06	<.001	-.01	1.000
Go-no-go h2	18.17	<.001	-.05	<.001	-.04	<.001	.01	1.000
Go-no-go h3	29.26	<.001	-.06	<.001	-.05	<.001	.01	1.000
Go-no-go h4	26.01	<.001	-.04	<.001	-.06	<.001	-.01	. .513
Reasoning (CA)	160.81	<.001	-3.11	<.001	-4.13	<.001	-1.01	<.001
Planning (number of						.		.

different rides)	5.03	.007	.07	1.000	-.23	019	-.29	.004
Working Memory (CA)	75.84	<.001	-1.41	<.001	-1.93	<.001	-.52	.014