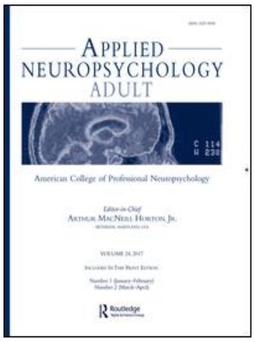

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# The IFS (INECO Frontal Screening) and level of education: Normative data

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**ABSTRACT**

Level of education is known to confound neuropsychological test performance. The INECO Frontal Screening (IFS) is an easy-to-use and brief measure of several domains of executive function, which has previously shown reliably clinical usefulness and superior psychometric performance when compared to other frontal screening instruments. However, previous studies with the IFS have been limited to participants with high levels of education, preventing its generalizability to populations with less than 12 years of formal education. This is crucial, as less than half of the Latin American population and a large percentage of immigrants in developed countries attain high school education. The aim of this study was to generate IFS normative data in a sample stratified by age and education levels. One hundred and sixty one healthy adults were assessed with the IFS as well as measures of global cognitive screening, namely, the Addenbrooke Cognitive Examination Revised and the Mini-Mental State Examination. Multiple lineal regression analysis showed significant effects for education and nonsignificant effects for age. A correction grid for IFS raw scores was developed and cut-off scores were calculated. The correction grid and cut-off scores may be useful in the interpretation of IFS scores in participants with low education.

**KEYWORDS**
Executive function; illiterate; INECO Frontal Screening; low education; normative data

## Introduction

The INECO Frontal Screening (IFS) is an easy-to-administer instrument to assess several domains of executive function in a short period of time. Importantly, it has previously shown good psychometric properties, including high internal consistency, strong concurrent validity with classic executive tests (e.g., phonological verbal fluency, Wisconsin Card Sorting Test, Trail Making Test part B), and clinical usefulness (by means of high sensitivity and specificity) in differentiating patients with behavioral variant frontotemporal dementia (bv-FTD) from those with Alzheimer disease (AD) and healthy controls (Moreira, Lima, & Vicente, 2014; Torralva, Roca, Gleichgerrcht, López, & Manes, 2009). The psychometric properties of the IFS have also been confirmed in independent samples (Ihnen, Antivilo, Muñoz-Neira, & Slachevsky, 2013) and shown to be superior to other brief screening tools directly assessing executive functions (Gleichgerrcht, Roca, Manes, & Torralva, 2011; Moreira et al., 2014). Thus, the IFS can be a useful clinical tool for the rapid and accurate assessment of executive functions in clinical settings.

Remarkably, performance on the IFS appears to be relatively independent of global cognitive functioning, suggesting specificity of IFS to executive functioning. For example, Torralva et al. (2009) found small nonsignificant correlation coefficients between IFS and both the Mini Mental State Examination (MMSE, $r = .17$) and the Addenbrooke Cognitive Examination (ACE, $r = .09$). Moreover, Roca et al. (2010) corroborated that performance on the IFS in patients with frontal lesions was still impaired after controlling for the effect of fluid intelligence, a finding that was not observed for other classic executive tests, suggesting that the IFS measures executive performance beyond the effect of fluid intelligence.

Previous studies have reported the influence of age on executive tests (Allain et al., 2005; Treitz, Heyder, & Daum, 2007; Van der Elst, Van Boxtel, Van Breukelen, & Jolles, 2006a, 2006b). While some research has found that advanced age predicts lower scores in some executive screening tests like the *Frontal Assessment Battery* (FAB) (Appollonio et al., 2005; Iavarone et al., 2004; Lima, Meirelles, Fonseca, Castro, & Garret, 2008) and the IFS (Moreira et al., 2014), Ihnen

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et al. (2013) found low and nonsignificant correlation between age and IFS performance. More studies focused on the influence of age on executive screening test remain to be performed.

Years of formal education is known to mediate performance of neuropsychological tests in adults: participants with higher levels of education outperform those with lower levels in a wide array of executive tests (Acevedo, Loewenstein, Agrón, & Duara, 2007; Ardila, Rosselli, & Ostrosky, 1992; Ganguli et al., 2010; Heaton, Grant, & Matthews, 1986; Llorente, 2008; Manly et al., 1999; Matute, Leal, Zarobozo, Robles, & Cedillo, 2000; Ostrosky-Solis, Ramirez, & Ardila, 2004; Pavão, Maruta, Freitas, & Mares, 2013; Reis & Castro-Caldas, 1997; Rosselli, Ardila, & Rosas, 1990). Along these lines, Acevedo et al. (2007) found that level of education on different neuropsychological executive tests explained up to 28% of the variance in Spanish-speaking elders. Significant negative association between performance in different executive tests and lower levels of education have been consistently reported (e.g., Ardila, Ostrosky-Solis, Rosselli, & Gomez, 2000; Pavão Martins, Maruta, Freitas, & Mares, 2013; Yassuda et al. 2009). For instance, Lin, Chan, Zheng, Yang, and Wang (2007) reported that educational level explains a large proportion of the variance on the Hayling test (25%), word fluency, and Wisconsin Card Sorting Test (WCST) (21%), as well as letter-number span (24%). More recently, Moreira et al. (2014) reported that the IFS scores were positively affected by education in healthy participants. Taken together, these findings highlight the need for education-adjusted norms in interpreting executive test performance.

The aforesaid is crucial when considering that 80% of the world's population lives in developing countries (World Bank, 2014). The average years of schooling completed in the world is 7.6 with regional dichotomy: the average is 7.09 in developing countries but as high as 9.64 in Europe and Central Asia. In Latin America and the Caribbean region in particular, people attain 8.26 years of formal education on average (Barro & Lee, 2013). The average is lower for Latin-American immigrants living in the United States (Llorente, 2008). However, the majority of studies presenting normative data on screening cognitive tools have been performed on populations with an average of 10 or more years of education (Busch & Chapin, 2008). In fact, previous studies suggesting cut-off scores of the IFS have been performed on individuals with higher-than-average level of education.

Moreira et al. (2014) published an IFS normative data stratified by age and education developed from a sample of 204 healthy participants from Portugal, 59% of whom had less than 12 years of education. In their approach, the authors used an arbitrary age cut-off to determine their norms. For example, a score of 16 points (out of 30) by a 64 year old person with 4 years of education was considered low (z: −1,6), but if the age was 65 years with the same level of education, the score was considered normal (z: −0,7). This poses a challenge, since arbitrary age cut offs can mask graded performance and confounders. An alternative to overcome this problem, which has been applied by other authors for other tests (Benton, Varney, & Hamsher, 1983; Capitani, 1997; Capitani and Laiacona, 1997) and employed for the standardization of about 80 neuropsychological tests (for partial list, see Bianchi, 2008), is to calculate the contribution of each demographic variable through multiple regression in a undivided demographically composite sample and then adjust the original score by adding/subtracting that contribution in order to calculate norms on the adjusted score.

Due to global migration and the growth of populations of low level educated adults (e.g., refugees, displaced workers, etc.), it is increasingly important for neuropsychologists to have access to context-sensitive assessment tools in order to work with individuals from different cultural groups and education levels. This is particularly relevant given the fact that low level educated individuals might be more vulnerable to cognitive decline (Brayne et al., 2010; Brickman et al., 2011). The aim of this study was therefore to evaluate the impact of demographic variables (specifically, age and level of education) on IFS performance to generate normative scores for clinical purposes.

## Methods

### *Participants*

One hundred and sixty one community subjects of different age, gender (102 women, 59 men) and level of education participated in the study (Table 1). Participants were volunteers, recruited at shopping centers, social organizations, and by word-of-mouth. They did not receive any financial remuneration for

**Table 1.** Demographic distribution of the sample as a function of education and age.

| Education | Age | | | | |
|---|---|---|---|---|---|
| (years) | 20–34 (22 f–11 m) | 35–49 (21 f–21 m) | 50–64 (28 f–9 m) | 65–88 (31 f–18 m) | Total |
| 2–7 | 7 | 14 | 15 | 20 | 56 |
| 8–11 | 18 | 20 | 15 | 19 | 72 |
| >12 | 8 | 8 | 7 | 10 | 33 |
| Total | 33 | 42 | 37 | 49 | 161 |

*Notes.* f = female; m = male.

participating in the study, and they were all active and functionally independent. A self-reported questionnaire about history of medical and psychiatric problems was obtained from each participant. Based on the self-reported questionnaire, each participant was screened for the following exclusion criteria: (a) diagnosis of neurological or psychiatric conditions that affect cognitive functions (e.g., stroke, electroconvulsive treatment, epilepsy, brain injury, encephalitis, meningitis, multiple sclerosis, Parkinson disease dementia, Huntington chorea, Alzheimer-type dementia, schizophrenia, bipolar disorder, or depression); (b) currently in treatment with antidepressant or antipsychotic medications; (c) visual or auditory impairment not compensated; (d) adult episode of loss of consciousness for more than 5 minutes; (e) adult episode of traumatic brain injury leading to hospitalization; (e) history of alcohol or drug abuse; and (f) Mini-Mental State Examination score below 24 or Addenbrooke Cognitive Examination bellow cut-off according to level of education (García-Caballero et al., 2006; Sarasola et al., 2005), as these scores are indicative of global dementia. Individuals with mild hypertension or type II diabetes with a satisfactory drug treatment were not excluded.

### Procedure

Participants signed informed consent forms at the beginning of the study and filled in a questionnaire regarding their health and demographic information, as previously described.

All participants were tested with the three following instruments: the MMSE (Butman et al., 2001; Folstein, Folstein, & McHugh, 1975), the ACE-R (Mioshi, Dawson, Mitchell, Arnold, & Hodges, 2006; Torralva et al., 2011); and the IFS.

The MMSE and ACE-R were applied in order to screen for cognitive impairment. Of note, ACE-R is a broader cognitive screening than the MMSE and assesses five cognitive domains (orientation −10 points, attention −8 points, memory −26 points, verbal fluency −14 points, language −26 points and visuospatial abilities −16 points, for a maximum total of 100 points). It has been adapted to the local population and has cut-off scores validated for persons with low levels of education.

The IFS includes 8 subtests (Torralva et al., 2009), administered in the following order: Motor Programming (MP, 3 points); Conflicting Instructions (CI, 3 points); Go – No go (GNg, 3 points); Backward Digit Span (BDS, 6 points); Verbal Working memory (VWM, 2 points); Spatial Working Memory (SWM, 4 points); Proverb Interpretation (PI, 3 points) and Verbal Inhibitory Control (VIC, 6 points) for a total of 30 points.

### Data analysis

In order to examine the influence of age and education on the IFS scores, a hierarchical regression analysis was run including age and education as independent variables. The significance of age and education was tested over and above each other on the final step of the hierarchy using $R^2$ change statistics. Any variable that did not impact significantly ($p < .001$) on the IFS scores was excluded from the equation. Age in years and years of education were entered as continuous variables. An adjusted score was calculated for each sample subject by adding or subtracting the contribution of the significant variables from the original score. After ranking the adjusted scores from the worst to the best performance, we computed inner and outer tolerance limits (Capitani & Laiacona, 2017).

To test the impact of education on IFS sub-test scores, we divided the sample into three education groups and ran a one way ANOVA and post-hoc paired analysis with Bonferroni correction.

## Results

Table 2 shows the IFS mean and standard deviation, stratified by age and education. The IFS score was remarkably similar with increasing age but progressively declined with decreasing years of education, suggesting poorer IFS performance among less educated subjects.

Table 3 shows the frequency (percentage of the sample in square brackets) of IFS subtest scores. More than 80% of the sample showed ceiling effects in the Motor Programming (MP), Conflicting Instructions Subtest (CI), and Verbal Working Memory (VWM) subtests.

We divided the sample into three education groups (Group 1: complete or incomplete basic elementary school, between 2 and 7 years; Group 2: incomplete high school, between 8 and 11 years; Group 3: formal college education after completing high school, 12 or more years). No significant differences were found between the groups on the Motor Programming subtest,

**Table 2.** INECO Frontal Screening mean score and standard deviation (in brackets) by age and education.

| Education | Age | | | | |
|---|---|---|---|---|---|
| (years) | 20–34 | 35–49 | 50–64 | 65–88 | Total |
| 2–7 | 19.6 (5.2) | 19.2 (5.0) | 20.1 (4.3) | 19.4 (3.2) | 19.5 (4.1) |
| 8–12 | 22.1 (3.3) | 23.2 (3.0) | 24.5 (2.9) | 23.7 (2.3) | 23.6 (2.9) |
| >12 | 27.6 (1.6) | 24.9 (2.8) | 26.3 (2.2) | 23.7 (3.1) | 25.5 (2.9) |
| Total | 23.5 (4.4) | 22.2 (4.2) | 23.0 (4.2) | 21.9 (3.5) | 22.6 (4.1) |

**Table 3.** Frequency distribution (percentage of the sample in parentheses) of the INECO Frontal Screening subtest scores for the entire sample.

| Score | Motor programming | Conflicting Instructions | Go no-Go task | Backward digit span | Verbal working memory | Spatial working memory | Proverb interpretation | Verbal inhibitory control |
|---|---|---|---|---|---|---|---|---|
| 0 | 1 (.6) | 1 (.6) | 10 (6.2) | 1 (.6) | 13 (8.1) | 1 (.6) | 11 (6.8) | 1 (.6) |
| 0.5 | ND | ND | ND | ND | ND | ND | 10 (6.2) | ND |
| 1.0 | 5 (3.1) | 2 (1.2) | 9 (5.6) | 1 (.6) | 14 (8.7) | 48 (29.8) | 13 (8.1) | 5 (3.1) |
| 1.5 | ND | ND | ND | ND | ND | ND | 13 (8.1) | ND |
| 2.0 | 17 (10.6) | 18 (11.2) | 36 (22.4) | 14 (8.7) | 134 (83.2) | 34 (21.1) | 28 (17.4) | 7 (4.3) |
| 2.5 | ND | ND | ND | ND | ND | ND | 47 (29.2) | ND |
| 3.0 | 138 (85.7) | 140 (87) | 106 (65.8) | 40 (24.8) | ND | 58 (36) | 39 (24.2) | 29 (18) |
| 4.0 | ND | ND | ND | 52 (32.3) | ND | 20 (12.5) | ND | 32 (19.9) |
| 5.0 | ND | ND | ND | 27 (16.8) | ND | ND | ND | 50 (31.1) |
| 6.0 | ND | ND | ND | 26 (16.2) | ND | ND | ND | 37 (23) |

*Note*. ND = no data due to being out of range.

**Table 4.** Frequency distribution (percentage of the sample in parentheses) of the INECO Frontal Screening subtest scores by education group.

| | Group 1 | Group 2 | Group 3 | *P* |
|---|---|---|---|---|
| Motor Programming | | | | |
| 0 | 1 (1.8) | 0 | 0 | |
| 1 | 3 (5.4) | 2 (2.8) | 0 | .006 |
| 2 | 10 (17.9) | 7 (9.7) | 0 | |
| 3 | 42 (75) | 63 (87.5) | 33 (100) | |
| Conflicting Instructions | | | | |
| 0 | 0 | 0 | 0 | |
| 1 | 2 (3.6) | 1 (1.4) | 0 | .030 |
| 2 | 10 (17.9) | 8 (11.1) | 0 | |
| 3 | 44 (78.6) | 63 (87.5) | 33 (100) | |
| Motor Inhibitory Control | | | | |
| 0 | 6 (10.7) | 3 (4.2) | 1 (3) | |
| 1 | 8 (14.3) | 1 (1.4) | 0 | ** |
| 2 | 14 (25) | 18 (25) | 4 (12.1) | |
| 3 | 28 (59) | 50 (69.4) | 28 (84.8) | |
| Backward digit span | | | | |
| 0 | 1 (1.8) | 0 | 0 | |
| 1 | 1 (1.8) | 0 | 0 | |
| 2 | 8 (14.3) | 4 (5.6) | 2 (6.1) | |
| 3 | 24 (42.9) | 15 (20.8) | 1 (3) | ** |
| 4 | 14 (25) | 31 (43.1) | 7 (21.2) | |
| 5 | 5 (8.9) | 15 (20.8) | 7 (21.2) | |
| 6 | 3 (5.4) | 7 (9.7) | 16 (48.5) | |
| Verbal working memory | | | | |
| 0 | 12 (21.4) | 1 (1.4) | 0 | |
| 1 | 6 (10.7) | 7 (9.7) | 1 (3) | ** |
| 2 | 38 (67.9) | 64 (88.9) | 32 (97) | |
| Spatial working memory | | | | |
| 0 | 0 | 0 | 1 (3) | |
| 1 | 27 (48.2) | 14 (19.4) | 7 (21.2) | |
| 2 | 13 (23.2) | 16 (22.2) | 5 (15.2) | ** |
| 3 | 13 (23.2) | 28 (38.9) | 17 (51.5) | |
| 4 | 3 (5.4) | 14 (19.4) | 3 (9.1) | |
| Proverb interpretation | | | | |
| 0 | 8 (14.3) | 3 (4.2) | 0 | |
| 0.5 | 7 (12.5) | 3 (4.2) | 0 | |
| 1.0 | 11 (19.6) | 0 | 2 (6.1) | |
| 1,5 | 6 (10.7) | 6 (8.3) | 1 (3) | ** |
| 2.0 | 9 (16.1) | 17 (23.6) | 2 (6.1) | |
| 2,5 | 11 (19.6) | 25 (34.7) | 1 (3) | |
| 3.0 | 4 (7.1) | 18 (25) | 17 (51.5) | |
| Verbal Inhibitory Control | | | | |
| 0 | 1 (1.8) | 0 | 0 | |
| 1 | 3 (5.4) | 0 | 2 (6.1) | |
| 2 | 5 (8.9) | 2 (2.8) | 0 | |
| 3 | 12 (21.4) | 12 (16.7) | 5 (15.2) | .008 |
| 4 | 13 (23.2) | 16 (22.2) | 3 (9.1) | |
| 5 | 12 (21.4) | 28 (38.9) | 10 (30.3) | |
| 6 | 10 (17.9) | 14 (19.4) | 13 (39.4) | |

$F(2, 158) = 5.29$, $p = .006$, Conflicting Instructions subtest, $F(2, 158) = 3.44$, $p = .03$ and Verbal Inhibitory Control (VIC) subtest, $F(2, 158) = 5.01$, $p = .008$. There were significant differences between the groups on the Go No-Go task (GN-G), $F(2, 158) = 7.69$, $p < .000$, Backward Digit Span (BDS) subtest, $F(2, 158) = 23.93$, $p < .000$, VWM subtest, $F(2, 158) = 11.80$, $p < .000$, Spatial Working Memory (SWM) subtest, $F(2, 158) = 8.61$, $p < .000$ and Proverb Interpretation (PI) subtest, $F(2, 158) = 26.07$, $p < .000$ (Table 4).

Using post-hoc paired analysis with Bonferroni correction (Table 5), significant differences were found in GN-G, BDS, VWM and PI between groups 1 and 3, only the BDS subtest was significantly different between groups 2 and 3, and significant differences were found in BDS, VWM, SWM and PI between group 1 and 2.

No differences were found between sex in age ($t(159) = .32$, $p = .75$), education ($t(159) = -.43$, $p = .67$) or IFS total score ($t(159) = -1.09$, $p = .28$). A hierarchical regression analysis was run including age

**Table 5.** The *p* value and effect size in multiple comparisons.

| INECO Frontal Screening Subtests | Education level: Group 1 vs. Group 2 | Group 1 vs. Group 3 | Group 2 vs. Group 3 | ETA squared |
|---|---|---|---|---|
| Go- No go | .007 | ** | .821 | .09 |
| BDS | ** | ** | ** | .23 |
| VWM | ** | ** | 1 | .13 |
| SWM | ** | .032 | 1.000 | .30 |
| PI | ** | ** | .086 | .10 |

*Note*. ** $p < .001$.

**Table 6.** Linear Regression Model and Derived Regression Equation for the INECO Frontal Screening scores.

| Model | *B* | Std. Error | Beta | *t* | *P* Value | Std. Error Estimate | $R^2$ |
|---|---|---|---|---|---|---|---|
| 1 (constant) | 17.432 | .664 | | 26.270 | .000 | | |
| Years of education | .488 | .058 | .558 | 8.478 | .000 | 3.40367 | .31 |

*Note*. Regression equation: IFS raw score = 17.432 + (.488*years of education).

**Table 7.** Conversion grid from the INECO Frontal Screening (IFS) Raw Score (IFSRS) to IFS score corrected by years of education.

| | Years of education | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IFSRS | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 8 | 7.024 | 6.536 | 6.048 | 5.56 | 5.072 | 4.584 | 4.096 | 3.608 | 3.12 | 2.632 | 2.144 | 1.656 | 1.168 | 0.68 | 0.192 | −0.296 | −0.784 | −1.272 | −1.76 |
| 9 | 8.024 | 7.536 | 7.048 | 6.56 | 6.072 | 5.584 | 5.096 | 4.608 | 4.12 | 3.632 | 3.144 | 2.656 | 2.168 | 1.68 | 1.192 | 0.704 | 0.216 | −0.272 | −0.76 |
| 10 | 9.024 | 8.536 | 8.048 | 7.56 | 7.072 | 6.584 | 6.096 | 5.608 | 5.12 | 4.632 | 4.144 | 3.656 | 3.168 | 2.68 | 2.192 | 1.704 | 1.216 | 0.728 | 0.24 |
| 11 | 10.024 | 9.536 | 9.048 | 8.56 | 8.072 | 7.584 | 7.096 | 6.608 | 6.12 | 5.632 | 5.144 | 4.656 | 4.168 | 3.68 | 3.192 | 2.704 | 2.216 | 1.728 | 1.24 |
| 12 | 11.024 | 10.536 | 10.048 | 9.56 | 9.072 | 8.584 | 8.096 | 7.608 | 7.12 | 6.632 | 6.144 | 5.656 | 5.168 | 4.68 | 4.192 | 3.704 | 3.216 | 2.728 | 2.24 |
| 13 | 12.024 | 11.536 | 11.048 | 10.56 | 10.072 | 9.584 | 9.096 | 8.608 | 8.12 | 7.632 | 7.144 | 6.656 | 6.168 | 5.68 | 5.192 | 4.704 | 4.216 | 3.728 | 3.24 |
| 14 | 13.024 | 12.536 | 12.048 | 11.56 | 11.072 | 10.584 | 10.096 | 9.608 | 9.12 | 8.632 | 8.144 | 7.656 | 7.168 | 6.68 | 6.192 | 5.704 | 5.216 | 4.728 | 4.24 |
| 15 | 14.024 | 13.536 | 13.048 | 12.56 | 12.072 | 11.584 | 11.096 | 10.608 | 10.12 | 9.632 | 9.144 | 8.656 | 8.168 | 7.68 | 7.192 | 6.704 | 6.216 | 5.728 | 5.24 |
| 16 | 15.024 | 14.536 | 14.048 | 13.56 | 13.072 | 12.584 | 12.096 | 11.608 | 11.12 | 10.632 | 10.144 | 9.656 | 9.168 | 8.68 | 8.192 | 7.704 | 7.216 | 6.728 | 6.24 |
| 17 | 16.024 | 15.536 | 15.048 | 14.56 | 14.072 | 13.584 | 13.096 | 12.608 | 12.12 | 11.632 | 11.144 | 10.656 | 10.168 | 9.68 | 9.192 | 8.704 | 8.216 | 7.728 | 7.24 |
| 18 | 17.024 | 16.536 | 16.048 | 15.56 | 15.072 | 14.584 | 14.096 | 13.608 | 13.12 | 12.632 | 12.144 | 11.656 | 11.168 | 10.68 | 10.192 | 9.704 | 9.216 | 8.728 | 8.24 |
| 19 | 18.024 | 17.536 | 17.048 | 16.56 | 16.072 | 15.584 | 15.096 | 14.608 | 14.12 | 13.632 | 13.144 | 12.656 | 12.168 | 11.68 | 11.192 | 10.704 | 10.216 | 9.728 | 9.24 |
| 20 | 19.024 | 18.536 | 18.048 | 17.56 | 17.072 | 16.584 | 16.096 | 15.608 | 15.12 | 14.632 | 14.144 | 13.656 | 13.168 | 12.68 | 12.192 | 11.704 | 11.216 | 10.728 | 10.24 |
| 21 | 20.024 | 19.536 | 19.048 | 18.56 | 18.072 | 17.584 | 17.096 | 16.608 | 16.12 | 15.632 | 15.144 | 14.656 | 14.168 | 13.68 | 13.192 | 12.704 | 12.216 | 11.728 | 11.24 |
| 22 | 21.024 | 20.536 | 20.048 | 19.56 | 19.072 | 18.584 | 18.096 | 17.608 | 17.12 | 16.632 | 16.144 | 15.656 | 15.168 | 14.68 | 14.192 | 13.704 | 13.216 | 12.728 | 12.24 |
| 23 | 22.024 | 21.536 | 21.048 | 20.56 | 20.072 | 19.584 | 19.096 | 18.608 | 18.12 | 17.632 | 17.144 | 16.656 | 16.168 | 15.68 | 15.192 | 14.704 | 14.216 | 13.728 | 13.24 |
| 24 | 23.024 | 22.536 | 22.048 | 21.56 | 21.072 | 20.584 | 20.096 | 19.608 | 19.12 | 18.632 | 18.144 | 17.656 | 17.168 | 16.68 | 16.192 | 15.704 | 15.216 | 14.728 | 14.24 |
| 25 | 24.024 | 23.536 | 23.048 | 22.56 | 22.072 | 21.584 | 21.096 | 20.608 | 20.12 | 19.632 | 19.144 | 18.656 | 18.168 | 17.68 | 17.192 | 16.704 | 16.216 | 15.728 | 15.24 |
| 26 | 25.024 | 24.536 | 24.048 | 23.56 | 23.072 | 22.584 | 22.096 | 21.608 | 21.12 | 20.632 | 20.144 | 19.656 | 19.168 | 18.68 | 18.192 | 17.704 | 17.216 | 16.728 | 16.24 |
| 27 | 26.024 | 25.536 | 25.048 | 24.56 | 24.072 | 23.584 | 23.096 | 22.608 | 22.12 | 21.632 | 21.144 | 20.656 | 20.168 | 19.68 | 19.192 | 18.704 | 18.216 | 17.728 | 17.24 |
| 28 | 27.024 | 26.536 | 26.048 | 25.56 | 25.072 | 24.584 | 24.096 | 23.608 | 23.12 | 22.632 | 22.144 | 21.656 | 21.168 | 20.68 | 20.192 | 19.704 | 19.216 | 18.728 | 18.24 |
| 29 | 28.024 | 27.536 | 27.048 | 26.56 | 26.072 | 25.584 | 25.096 | 24.608 | 24.12 | 23.632 | 23.144 | 22.656 | 22.168 | 21.68 | 21.192 | 20.704 | 20.216 | 19.728 | 19.24 |
| 30 | 29.024 | 28.536 | 28.048 | 27.56 | 27.072 | 26.584 | 26.096 | 25.608 | 25.12 | 24.632 | 24.144 | 23.656 | 23.168 | 22.68 | 22.192 | 21.704 | 21.216 | 20.728 | 20.24 |

*Note*. Formula for calculation: IFS corrrected = IFSRS - (.488*years of education).

and education as independent variables. Education significantly accounted for 31% of the IFS variance ($R^2 = .31$, $t = 26.27$, $p < .001$) and age was excluded ($t = -.89$, $p = .376$) (Table 6). A grid for the conversion from the IFS raw score to the IFS score corrected by years of education is presented in Table 7.

We ranked the adjusted scores in ascending order and computed inner and outer tolerance limits. We set the confidence interval at 95%. For a sample of 161 subjects, using nonparametric unidirectional limits of tolerance, the region of uncertainty was defined by values corresponding to the 4th and 9th worst observations. The outer and inner tolerance limits obtained for the IFS were 8.58 and 11.19. This means that if a patient's adjusted IFS score was lower than 8.58 (outer tolerance limit), this would be considered an abnormal performance (cut-off point). Instead, if the adjusted score was higher than 11.19 (inner tolerance limit), it would be considered normal, whereas a score between 8.58 and 11.19 would be a borderline performance.

## Discussion

In this study, we evaluated the impact of demographic variables (particularly, age and education) on IFS overall performance in order to develop normative data adjusted for education levels.

Age did not predict frontal functioning. This might be explained due to a ceiling effect of the measure. Previous studies have shown limited effects of age on neuropsychological performance among healthy adults (Acevedo et al., 2007; Ardila et al., 2000; Pineda et al., 2000; Zimmermann, Cardoso, Trentini, Grassi-Oliveira, & Fonseca, 2015) and a differential sensitivity of different executive measures to aging has been published (Cepeda, Kramer, & Gonzalez de Sather, 2001; Ostrosky-Solís & Lozano, 2006; Williams, Ponesse, Schachar, Logan & Tannock, 1999).

In accordance with the effect of education found on other executive tests (Acevedo et al., 2007; Ardila et al., 1992; Ganguli et al., 2010; Heaton et al., 1986; Klenberg, Korkman, & Lahti-Nuuttila, 2001; Llorente, 2008; Manly et al., 1999; Matute et al., 2000; Ostrosky-Solis et al., 2004; Reis & Castro-Caldas, 1997; Rosselli et al., 1990; Unverzagt et al., 1996), the IFS showed a moderate and significant correlation with years of education. No differences were found between different levels of education on the motor-programming, conflicting instructions, and verbal inhibitory control subtests. Motor-programming and conflicting instructions subtests showed ceiling effects, suggesting that those subtests are less sensitive to low levels of education; that is, errors on these subtests are unlikely to occur in healthy adults who attained low levels of formal education. A ceiling effect has been described in healthy adults on different subtests of executive screening test, like "prehension behavior" subtest of the FAB (Iavarone, Ronga, Pellegrino et al., 2004; Appollonio et al., 2005; Kim et al., 2010; Lima et al., 2008), and motor programming and conflicting instructions of the FAB (Iavarone et al., 2004; Appollonio et al., 2005; Kim et al., 2010; Lima et al., 2008) and IFS (Ihnen et al., 2013). This is important given that previous studies suggest that motor programming and conflicting instructions begin to decline at a very mild stage of Alzheimer's type of dementia (Kim et al., 2010; Moreira et al., 2014).

Participants with less than 7 years of education differed in all of the remaining IFS subtests except Spatial Working Memory when compared to those with more than 11 years. In addition, the backward digit span subtest showed significant differences between subjects with less than 7 years of education and 8 to 11 years of education, suggesting that it is perhaps the IFS sub-score most strongly driven by education levels. Our finding is in line with previous research showing that education explains 31% of the variance on digit backward test (Ostrosky-Solís & Lozano, 2006).

A regression analysis was performed with education as a predictor variable of the IFS total score outcome. Consistent with other studies (Hsieh & Tori, 2007; Pontón et al., 1996), the number of years of education had a strong predictive effect on IFS. Thus, this finding suggests that it is important to adjust the IFS total score according to education attainment, and we provide here a table to assist in such an endeavor. Some variables might explain the effect of education on neuropsychological test performance and particularly on IFS performance: normal global cognitive capacity is needed to succeed in school, also, lower scores in less educated subjects could be due to different learning opportunities/nurture (Ardila et al., 2000; Brandt, 2007; Van der Elst et al., 2006a, 2006b), school achievement being the result of complex social-economic variables. We were unable to measure socio-economic variables, such as functional illiteracy or poverty; nevertheless, we showed that adjusting for years of education provides a useful contribution to IFS interpretation. Thus, an IFS raw score in a low level educated patient could be misinterpreted as a sign of impaired executive functions if educational level is not considered. Taking into consideration our cut-off scores adjusted by years of education, the same raw score may be interpreted as normal.

One of the limitations of the present study is the reduced sample size in some of the cells, which limits generalizability to a larger sample. Nevertheless, several normative studies derived from a similar sample size have been published and being useful in clinical practice (Abou-Mrad et al., 2017; Anselmetti et al., 2008; Gerstenecker, Martin, Marson, Bashir, & Triebel, 2016; Laiacona, Inzaghi, De Tanti, & Capitani, 2000; Poreh & Teaford, 2017; Van der Elst, Molenberghs, Van Tetering, & Jolles, 2017; Zimmermann et al., 2015). Future studies should explore the impact of age and education in a larger sample including a more varied population in terms of years of education, and contemplating other socio-economic confounders.

This research study underlines the importance of obtaining normative data according to different years of education in order to prevent biased interpretations of raw scores and to avoid false-positive or false-negative cases. Lack of norms for individuals with low levels of education may lead to wrongly label them as cognitive impaired. This research also suggests that the IFS subtest—backward digits—is the most strongly driven by education levels, and errors on motor-programming and conflicting instructions subtests are unlikely to occur in healthy adults who attained low levels of formal education. This might help the interpretation of IFS in low level educated patients at clinical practice.

## Disclosure of interest

The authors report no conflicts of interest.

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