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Cultural Differences in Neuropsychological Abilities Required to Perform Intelligence Tasks

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Abstract

Different studies have demonstrated that culture has a basic role in intelligence tests performance. Nevertheless, the specific neuropsychological abilities used by different cultures to perform an intelligence test have never been explored. In this study, we examine the differences between Spaniards and Moroccans in the neuropsychological abilities utilized to perform the Beta III as a non-verbal intelligence test. The results showed that the Spaniard group obtained a higher IQ than the Moroccan group in the Beta III. Moreover, the neuropsychological abilities that predicted scores for the Beta III were dependent on the country of origin and were different for each subtest. Besides showing the cultural effect on non-verbal intelligence test performance, our results suggest that a single test may measure different functions, depending on the subject's cultural background.

Keywords: Culture; Non-verbal test; IQ; Cognitive functions; Moroccan; Spaniards

Introduction

Cultural differences in intelligence tests performance are widely accepted (Herrnstein & Murray, 1994; Kaufman, Mclean, & Reynolds, 1988; Neisser et al., 1996), and several studies have shown differences in the intelligence quotient (IQ) among different cultural groups (i.e., Rushton & Skuy, 2000). It is accepted that the concept of intelligence may differ for various cultures (Sternberg & Grigorenko, 2004; Sternberg & Kaufman 1998) and that to measure intelligence, we must understand it within its cultural context (Sternberg & Grigorenko, 2004).

On a related note, the fundamental role of culture in developing cognitive abilities is well known (Luria, 1973, 1976). The cognitive abilities developed may vary from one culture to another. Thus, people from different cultures may perform differently on the same cognitive test according to the importance of this specific cognitive ability in their own culture (Bakos, Denburg, Fonseca, & Parente, 2010; Ostrosky-Solís, Ramirez, & Ardila, 2004). Furthermore, recent studies show that cultural factors may not only influence cognitive functions, but also neural function (Gutchess, Welsh, Boduroglu, & Park, 2006; Park & Huang, 2010) and neuronal structure (Zilles, Kawashima, Dabringhaus, Fukuda, & Schormann, 2001).

Numerous studies have shown a positive correlation between IQ and neuropsychological performance; people with a high IQ tend to have higher performance on neuropsychological tests compared with people with a lower IQ (Diaz-Asper, Schretlen, & Pearlson, 2004; Tremont, Hoffman, Scott, & Adams, 1998). Nevertheless, there is a lack of consensus about what specific neuropsychological functions and/or tests are related to intelligence. Thus, processing speed (Neisser et al., 1996; Sheppard & Vernon, 2008), long-term memory (Unsworth, 2010), or working memory (Colom, Flores-Mendoza, & Rebollo, 2003; Conway, Cowan, Bunting, Therriault, & Minkoff, 2002; Kane, Hambrick, & Conway, 2005) have been related to fluid intelligence. As an example,

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the intelligence matrix test has been related with working memory (i.e., Conway et al., 2002), but the matrix subtest of the WAIS-III is included into the visual perceptive index (Wechsler, 1997).

Although the relationship between intelligence and performance in neuropsychological tests has been investigated in various studies (Conway et al., 2002; Diaz-Asper et al., 2004), researchers have not yet studied the cognitive abilities that people with different cultural backgrounds use to perform the same intelligence test or whether these abilities are different for each culture. Such studies could be of great interest and would reveal not only what intelligence tests are measuring in each culture but also whether the cognitive processes used to carry out these tests are the same in all cultures.

Thus, our objective is to study whether there are differences between the Spaniard and Moroccan groups in the neuropsychological abilities used to perform the same intelligence test. In accordance with previous studies mentioned above that have shown relation between neuropsychological and intelligence tests and the influence of culture on various cognitive areas (i.e., Rule, Freeman, & Ambady, 2013), we hypothesize that the cognitive processes will differ for participants based upon their cultural background.

Method

Participants

As this study was conducted in Spain, we selected a group of Spaniards and also a group of Moroccans because the Arab is one of the largest minorities in Spain (Instituto Nacional de Estadística - Spain, 2012). This group selection guarantees cultural differences, since both have different languages (Arabic vs. Spanish), religions (Muslim vs. Christian), traditions, and radically different geographies (Africa vs. Europe).

The study included 54 healthy adults with a mean age of 26.67 years (SD = 4.39 years). A total of 27 participants were from Spain, and 27 participants were Moroccan immigrants living in Spain. Most of Moroccan participants (77.8%) were University students that attend to classes taught in Spanish language. Also, according to the initial interview with the participants, 46.7% of the Moroccan group speaks Spanish since they were children, 55.6% speak Spanish at home, and 48.1% normally think in Spanish. Thus, Spanish language proficiency was quite high in this sample.

To select the participants, we considered the following inclusion criteria: a range between 18 and 55 years old; the ability to read and write in Spanish sufficient to understand the instructions and tests; and no history of mental disorders, neurological disorders, or substance abuse.

The participants received verbal and written information about the study objectives and details and provided informed consent to be included in the study. The confidentiality of personal information was guaranteed in accordance with Spanish legislation on personal data protection (Organic Law 15/1999, December 13). The Ethics Committee of the University of Granada approved the present study. The volunteers received €20 for participating in this study.

Instruments

The Beta III was selected to assess intelligence because it is a non-verbal test supposedly not influenced by language influences and minimally influenced by culture (Kellogg & Morton, 1999). To evaluate neuropsychological components, we used a comprehensive neuropsychological battery with instruments typically used in our laboratory because they are commonly used for the Spanish population. Most of these instruments are used internationally in neuropsychological cross-cultural studies (Agranovich & Puente, 2007; Bakos et al., 2010; Boone, Victor, Wen, Razani, & Pontón, 2007; Ostrosky-Solis, Gutierrez, Flores, & Ardila, 2007). All tests were administered in Spanish in the following order:

First, non-verbal intelligence test:

(i) Beta III (Kellogg & Morton, 1999) is a non-verbal intelligence test composed of five subtests: Coding, picture completion, clerical checking, picture absurdities, and matrix reasoning. The duration for the Beta III test is 20–25 min. Various studies have demonstrated the validity of Beta III as well as its correlation with WAIS-III and progressive matrices (Kellogg & Morton, 1999).

Second, neuropsychological tests: A comprehensive neuropsychological battery of tests was administered to all participants.

(ii) Hooper Visual Organization Test (Hooper, 1958, revised in 1983): This test evaluates the capacity of an individual to visually integrate information.

(iii) Color Trails Test (CTT-A&B; D'Elia, Satz, Uchiyama, & White, 1999): To assess motor function and cognitive flexibility.
(iv) Test of Attention (d2; Brickenkamp, 1962): This test concisely measures selective attention and mental concentration.
(v) Hopkins Verbal Learning Test (HVLT; Benedict, Schrotlen, Groninger, & Brandt, 1998): To measure learning and verbal memory capacity. We used the Spanish version by Bilbao and colleagues (2007).
(vi) Rey Complex Test and Figure Test and Recognition Trial (Meyers and Meyers, 1995): This test measures visual memory capacity.
(vii) Semantic Verbal Fluency Test (Valencia et al., 2000): This test was included to assess verbal fluency.
(viii) Ruff Figural Fluency Test (RFFT; Ruff, 1996): This test is for non-verbal fluency.
(ix) Backward Digit Span (WAIS-III; Wechsler, 1999): To evaluate working memory.
(x) Iowa Gambling Task (IGT; Bechara, Damasio, Damasio, & Anderson, 1994): This computerized test evaluates decision-making.

Procedure

The participants were recruited as volunteers from January 2009 to July 2011 from various non-profit organizations working with immigrants in Granada and among the University of Granada students. Assessments were conducted in Spanish, and the total duration of the evaluation was approximately 2 h 30 min per participant, including a 15-min break at the middle of the session and an initial interview to collect socio-demographic information and to guarantee the inclusion/exclusion criteria.

Statistical analysis

First, either the Student's *t*-test or contingency analysis (chi-squared) was performed as appropriate to compare the principal socio-demographic variables between the two groups.

Second, the Student's *t*-test was used to study whether the Moroccan and Spanish groups were different for the intelligence and cognitive variables.

Third, we analyzed whether the neuropsychological performance predicted the Beta III scores based on the country of origin. Thus, five regression analyses were performed, one for each Beta III subtest. Neuropsychological scores and their relationship with the country of origin variable were used as predictors, and the dependent variables were the Beta III subtest scores. The relationships were identified by multiplying the neuropsychological scores using a different constant for each group. Because the total score for Beta III is a linear sum of the subtest scores, this process was not performed for the total score. The level of significance was adjusted to 0.01 in accordance with the Bonferroni correction.

Finally, to understand the variance and predictors using the Beta III test, 10 regression analyses were performed—five for each country—using only the neuropsychological variables related to the country of origin variable as predictors for each subtest.

Results

First, we compare the socio-demographic variables between Moroccan and Spaniards participants. Results indicate no difference between groups in age, gender, education level, and monthly income (Table 1).

Table 1. Descriptive statistics and analysis for the different groups on the socio-demographic variables

Characteristics	Moroccan ($n = 27$)	Spaniards ($n = 27$)	χ^2/t	*p*-value
Men	48.1% (13)	48.1% (13)	0.074	.79
Women	51.9% (14)	51.9% (14)		
Age (years)	27.77 (5.1)	25.63 (3.33)	1.77	.08
Elementary education	14.8% (4)	0% (0)	4.53	.209
Secondary education	7.4% (2)	11.1% (3)		
Undergraduate education	44.4% (12)	55.5% (15)		
Graduate education	33.4% (9)	33.4% (9)		
Income/month <€360	37% (10)	48.1% (13)	0.216	.642
Between €361 and €900	51.9% (14)	51.9% (14)		

Note: The monthly income is low because the majority of participants are students.

Table 2. Differences between Moroccan and Spaniards groups in intelligence and neuropsychological tests

Tests	Spaniards *M* (*SD*)	Morrocan *M* (*SD*)	*t*	*p*-value	*d*
HVOT	26.72 (2.04)	18.30 (5.23)	−7.799	**<.001****	2.32
CTT -A	33.04 (10.28)	57.26 (30.31)	3.932	**<.001****	1.19
CTT-B	64.11 (12.32)	96.41 (38.06)	4.195	**<.001****	1.28
d2	472.56 (70.48)	419.07 (72.63)	−2.746	**.008****	0.75
HVLT	28.63 (3.96)	23.41 (3.90)	−4.883	**<.001****	1.33
RCFT-C	35.37 (1.08)	32.78 (3.93)	−3.303	**.002****	1.03
RCFT-DR	27.46 (4.43)	20.28 (6.67)	−4.663	**<.001****	1.29
RCFT-IR	26.59 (5.32)	20.17 (6.16)	−4.102	**<.001****	1.19
VFT-ANIMALS	25.23 (5.54)	12.22 (4.59)	−8.997	**<.001****	2.59
VFT-FRUITS	14.41 (3.12)	11.26 (3.35)	−3.367	**.002****	0.97
RFFT	100.22 (17.61)	95.41 (30.39)	−0.712	.480	0.2
BDS	7.04 (1.70)	5.52 (1.70)	−3.288	**.002****	0.89
IGT	24.74 (27.76)	6.37 (22.17)	−2.687	**.010****	0.74
Coding[a]	82.15 (12.57)	64.30 (18.13)	−4.205	**<.001****	1.16
Picture completion [a]	14.52 (3.53)	10.56 (2.72)	−4.616	**<.001****	1.27
Clerical checking [a]	41.70 (3.59)	35.96 (7.50)	−3.586	**.001****	1.04
Picture absurdities [a]	21.41 (2.33)	16.33 (4.37)	−5.329	**<.001****	1.52
Matrix reasoning [a]	21.07 (2.50)	16.15 (4.70)	−4.807	**<.001****	1.34
Beta - IQ	105.52 (11.48)	87.00 (11.82)	−5.980	**<.001****	1.59

Notes: HVOT = total scores in Hooper Visual Organization Test; CTT-A = completion time of Color Trails Test-A; CTT-B = completion time of Color Trails Test-B; d2 = d2 total score; HVLT = total scores in Hopkins Verbal Learning Test; RCFT-C = Complex Test and Figure Test and Recognition-copy: RCFT-DR = delayed recall; RCFT-IR = immediate recall; VFT = Verbal Fluency Test; RFFT = Ruff Figural Fluency Test; BDS = Backward Digit Span; IGT = total score in Iowa Gambling Task.
[a]Beta subtests.
**$p < .01$.

Table 3. Regression models to analyze whether neuropsychological test results predict IQ scores based on the country of origin

Beta III subtests	Interaction			Spaniards			Moroccan		
	Variables	Adj. R^2	*p*-value	Variables	Adj. R^2	*p*-value	Variables	Adj. R^2	*p*-value
Coding	Country d2 BDS **Int_BDS**	.661	**<.001****			**.018***	BDS	.357	**.001****
Picture Completion	Country CTTA d2 HVOT **int_CTTA** **int_CTTB** **int_HVLT**	.664	**<.001****	CTTA HVLT	.525	**.001****	CTTB	.315	**.014***
Clerical Checking	Country CTTA d2 **int_CTTB** **int_d2**	.558	**<.001****	CTTB	.204	**.016***	d2	.221	**.012***
Picture Absurdities	Educational Level HVOT	.532	**<.001****						
Matrix Reasoning	CTTA d2 BDS IGT **int_CTTA** **int_CTTB** **int_BDS** **int_HVOT** **int_IGT**	.786	**<.001****	CTTA	.409	**.011***	CTTB BDS IGT	.555	**.034*** **.003**** **.024***

Notes: Adj. = Adjusted; d2 = d2 total score; BDS = Backward Digit Span; int = interaction with country (i.e., int_BDS = interaction between country and BDS is significant); CTTA = completion time of Color Trails Test-A; HVOT = total scores in Hooper Visual Organization Test; CTTB = completion time of Color Trails Test-B; HVLT = Hopkins Verbal Learning Test; IGT = total score in Iowa Gambling Task.
*$p < 0.05$.
**$p < 0.01$.

Differences in Intelligence and Neuropsychological Tests Between Spaniards and Moroccans

The results showed significant differences in the Beta III subtests and the total score between both groups in favor of the Spanish group. Also, results indicate that the Spaniard group significantly outperformed the Moroccan one in all of the neuropsychological tests, with the exception of the Ruff Figural Fluency. Cohen's *d* was calculated to obtain the effect sizes (Table 2).

Which Neuropsychological Variables Predict Beta III Performance?

The results showed that the neuropsychological variables that predicted scores for the Beta III were dependent on the country of origin and were different for each subtest, except for subtest 4 (picture absurdities). The level of prediction for each variable was between 0.558 and 0.786 (Table 3). For Beta III subtest 1 (coding), the performance on backward digit span was a predictor for the Moroccan group's score, $t = 3.93$, $p = .001$. However, none of the neuropsychological tests were predictive of the Spanish group's score.

For subtest 2 (picture completion), performances on the CTT-A, $t = -2.54$, $p = .018$, and Hopkins Verbal and Learning Test, $t = 3.92$, $p = .001$, were predictive for the Spanish group, whereas performance on the CTT (A and B) was the predictor for the Moroccan group, $t = -2.65$, $p = .014$.

For Beta III subtest 3 (clerical checking), the CTT (trail 2) performance was a predictor for the Spanish group, $t = -2.60$, $p = .016$, and d2 was the predictor for the Moroccan group, $t = 2.70$, $p = .012$.

Finally, the CTT (trail 1) performance was a subtest 5 predictor (matrix reasoning) of performance for the Spanish group, $t = -2.79$, $p = .011$, whereas performance on the CTT (trail 2), $t = -2.27$, $p = .034$, backwards digit span, $t = 3.41$, $p = .003$, and IGT, $t = 2.43$, $p = .024$, were the three predictors of the matrix reasoning subtest for the Moroccan group (*see* Table 3).

Discussion

The present study aimed to explore differences between two different cultural groups (Spaniards and Moroccans) in non-verbal IQ (measured by the Beta III) and the cognitive skills used to perform this test for these two different cultures. The results showed significant differences between the Spanish and Moroccan groups for Beta III subtests and total IQ as well as for all of the cognitive tests except for the RFFT. The neuropsychological tests that predicted IQ were different for each cultural group.

Although the Spanish and Moroccan groups were similar in terms of age, sex, economic status, and educational level, the cognitive performance of the Spaniards was better than that of the Moroccans. This is the first study that compares these groups on a comprehensive neuropsychological battery, and the results support the vast literature demonstrating cultural differences on cognitive tests (Agranovich, Panter, Puente, & Touradji, 2011; Bakos et al., 2010; Boone et al., 2007; Rosselli & Ardila 2003). Also, total IQ for the Spanish group was significantly higher compared with the Moroccan group. These results are consistent with previous literature to confirm the cultural difference in IQ. And agree with certain studies conducted in the Netherlands, where Moroccan immigrants generated a lower IQ than the Dutch (te Nijenhuis & van der Flier, 1997, 2001). Our results are also consistent with another study that used the Raven test (a non-verbal test) to compare Spaniards living in Spain with Moroccans living in Morocco (Díaz, Sellami, Infanzón, Lanzón, & Lynn, 2012). Also, similar to other studies (Ardila, 2005; Agranovich & Puente, 2007; Rosselli & Ardila, 2003), our results emphasize the notion that non-verbal tests are not necessarily free of cultural influence.

The performance on various neuropsychological tests was correlated with the performance on intelligence tests, which is consistent with the results of previous studies (Colom et al., 2003; Diaz-Asper et al., 2004). However, the principal novelty for this study herein is that the neuropsychological test performances that predict Beta III scores (except for picture absurdities) differed between the Spaniard and Moroccan groups. For the Moroccan group, the cognitive tasks that predict performance on Beta III are Backward Digit Span (working memory), Color Trail Test-B (shifting), d2 (attention), and IGT (decision-making). In contrast, CTT-A and B (motor coordination, shifting) and HVLT (verbal memory) predicted Beta III scores for the Spanish group. Those differences could be due to familiarity with psychological tests and timed testing (Agranovich et al., 2011; Agranovich & Puente, 2007; Ardila, 2005; Puente, Perez-Garcia, Vilar-Lopez, Hidalgo-Ruzzante, & Fasfous, 2013). Processing of novelty stimulus has been related with an increased cognitive control and activation of prefrontal cortex (Barcelo, Escera, Corral, & Periáñez, 2006; Kishiyama, Yonelinas, & Knight, 2009; Løvstad et al., 2011). Thus, coping with unfamiliar task could require using more complex neuropsychological processes.

In our study, 80% of the Moroccan and 20% of the Spaniard participants never performed a psychological test, according to one of the questions included in the socio-demographic interview. This difference in familiarity may have impacted in the group performance (Díaz et al., 2012), so that Moroccans rely on more complex skills related to executive function compared with Spaniards to execute the same non-verbal intelligence task. This hypothesis is consistent with other studies that show differences

in cognitive processes for Western and Eastern people (Nisbett & Masuda, 2003; Nisbett, Peng, Choi, & Norenzayan, 2001). This could be explored in future studies, including groups from different cultures with different ranks of familiarity with neuropsychological testing.

Among the limitations herein, the sample size is small, which may limit the data's statistical power and generalization. However, the Cohen's *d* showed moderate to large effect sizes. Another limitation is that we are comparing an immigrant group with a non-immigrant, but the two groups had similar educational and economic levels. In the future, it would be interesting to study the relationship between neuropsychological and intelligence test performances for people from different cultures who reside in their country of origin.

Despite the limitations, this study is one of the first to investigate the cognitive processes used to perform an intelligence test in two different cultures. Also, the groups studied here are under-represented in the cross-cultural neuropsychology research, mostly dominated by the various ethnic groups that co-exist in the United States; we believe that studying other backgrounds will broaden our knowledge of the effect of culture on cognitive performance. In conclusion, besides showing the cultural effect on non-verbal intelligence test performance, our results suggest that a single test may measure different functions, depending on the subject's cultural background.

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Conflict of Interest

None declared.

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